DISCUSSION

ON

PADDLE WHEELS,

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, MARCH 14th, 1898.

CHAIRMAN:

MR. J. FORTESCUE FLANNERY, M.P. (PAST PRESIDENT).

Mr. J. T. SMITH (Member of Council): I think it a pity that the author has not told us more about the construction of paddle wheels; it would have been more interesting to the members generally. He does not say much about the setting of the eccentrics, whether it should be above or below the centre of the shaft, and about how much forward. Another important point is the lining of the eccentrics and also the lining of the pinion—whether you have iron working in brass, or whether lignum vitæ may be tried. These are some of the points which the author might tell us something about.

Mr. W. MCLAREN (Member): It would be very interesting if the author would tell us something on the subject of the eccentrics setting.

Mr. T. F. AUKLAND (Companion): I have been looking over the records of the Institution of Naval

Architects to see if I could find anything that would be likely to be an acceptable addition to the information contained in the paper, but up to the present I have not been able to find anything. Although I have travelled in a great number of paddle steamers I have not studied the subject sufficiently to be able to say anything about them.

Mr. A. H. MATHER (Member): The idea seems to be that everybody is seeking information. We have several drawings here, and if anything is known about them it would be interesting if they could be explained.

The CHAIRMAN: The first idea that occurs to one in listening to this paper is that we, as marine engineers, are likely in the course of our daily practice to forget the importance which still attaches to paddle wheels and paddle-wheel steamers and their proper design, because many of us are so completely immersed in dealing with screw steamers, and have had no experience, or scarcely any experience, with paddle vessels. At the same time there is no doubt that the paddle-wheel steamer still plays a most important part in marine construction, because there are many services which paddle-wheel steamers can perform which cannot be performed nearly so well by screw steamers. The use of the paddle wheel for tug boats survived longer than its use for some other purposes, but of late years we have discovered that screw vessels are as effective as tugs in the mere act of towing, and are very superior to them as sea-going vessels in heavy weather for long tows. The result is that while a few years ago none but paddle tugs were built for the purposes of towing, to-day we have scarcely any new vessels under construction, for the purposes of towing, which are fitted with paddle wheels. But there are still some uses for which the paddle-wheel vessel survives, and which are likely to continue. Any vessel which requires an adaptation for propulsion by sails is undoubtedly unsuitable for a paddle-wheel vessel, and it is only a screw vessel that can be adapted to combine steam with sailing power. But for ferry purposes, for channel services, and for services in which high speed is combined with light draught, the paddle wheel still survives, and is likely to survive. The only method by which extremely light draught can be combined with high speed in a screw vessel is a vessel constructed like the one that was patented by Mr. Thornycroft, in which a kind of trough was constructed leading aft along the bottom, the top of this trough rising considerably above the level of the water-line outside the ship. The propeller revolves in this trough, the upper blade of the propeller being considerably out of the water when the vessel is at rest, but as the vessel obtains her high speed the channel or trough becomes filled with water, which mounts to the top of it, and the propeller, although still at its upper part above the level of the water outside, obtains the supply of water that enables it to develop the whole of its power in pushing the vessel ahead. But if you eliminate from your consideration that very ingenious kind of structure, you come back to the elementary truth that unless you were to multiply the number of propellers even beyond twin screws you cannot absorb upon the water the necessary power to drive the vessel at a very high speed with shallow draught except with paddle wheels. It is a fact, indeed, that some shipbuilders are almost exclusively engaged, even at the present time, in the construction of paddle-wheel steamers for the special purposes I have named. On the Thames we have now a continually increasing fleet of pleasure passenger steamers of high speed and shallow draught. On the Clyde we probably find the home of paddle steamers of the very highest class. There is one remark made by the author of the paper as to the wave hollow and the wave crest in relation to the fore and aft measurement of the vessel, which applies very strongly in practice; and which was indeed the subject of a very considerable difficulty which followed the career of some vessels recently built for the Channel service between this country and the Continent. Anyone who will look at the picture in this room of the *City of Paris* will see the alteration of level in the water-line fore and aft. At the stem the level of the water is rather higher than the normal line; then just forward of the boilers you reach a hollow; further aft, in the way of the engines, you have a very considerable crest, and then at the after part you have a very considerable depression. Well, now, there are certainly very few skilled naval architects or marine engineers who are able to predict beforehand where those hollows and waves will come in any particular ship of any particular design; and some of the more advanced of our shipbuilders have so recognised the importance of locating these crests and hollows that they have made exhaustive experiments in tanks specially for the purpose of finding out where these hollows and crests will occur. If the propeller happens to find itself in a hollow the result in the speed of the vessel will be entirely different from what it would have heen if the paddle-wheel had found itself in the crest of a wave. In the case of the two Channel steamers to which I have already referred there was a very considerable falling off in speed, as compared with the anticipated performance or guarantee, and it was only after a very great deal of experimenting that the required speed was obtained, the deficiency having been solely due to the fact that where a crest was expected a hollow was established. While I speak I am reminded of an interesting circumstance of which I was myself, as a lad, a witness, in connection with a vessel which I think is at this moment in the river Thames. At all events the vessel, at the time to which I refer, was very well known as the paddle-wheel steamer *Scotia*, and she was running in the Cunard Line out of Liverpool. She was at that time under the command of the celebrated Captain Judkins, who was bringing her out of dock over the dock sill, at a time of neap tides. There was scarcely any margin of water under the vessel, and as Captain Judkins attempted to take her over the dock sill she just touched and stopped. The position was a critical one, because had the ship remained there, as the tide fell she would have been hung up amidships, and would probably have broken her back. It was very interesting, therefore, to notice how Captain Judkins rose to the emergency. He rang the telegraph for the engines to be put full speed ahead, and the enormous floats of the paddle-wheels of the vessel had the effect of driving a quantity of water from the river up in the dock. He then stopped the engines, and the momentary rise in the level of the water on the sill, owing to the reaction or return of the water that had been forced into the dock, floated the ship into the river. You cannot but admire such pluck and skill upon the part of the captain, and you see that even with old-fashioned methods of construction there were opportunities which do not exist mechanically at the present time. There were some remarks made by Mr. Smith upon the question of bushes which are of considerable practical importance. I myself have found that pins of iron or steel if worked naked in brass bushes are bad, because most paddle vessels are laid up more or less during the winter, and when fitted out for service in the following summer the pins are very frequently found corroded and require renewal. In conjunction with my partner I am responsible for many of the paddle steamers which run on the river Mersey; and with regard to some of the steamers recently built for service between Eastham, at the entrance to the Manchester Ship Canal, and the Liverpool landing stage, we found that the foul water of the Manchester Ship Canal fouling the upper waters of the Mersey, had so serious an effect upon the pins that we have had to coat them with gun metal and then let them work in bushes protected by white metal or lignum vitæ. I hardly know yet the result, but we are rather expecting that the steel pins coated with gun-metal sleeves working in lignum vitæ will probably prove the best method in practice. In the course of his paper the author referred to the shrouding of floats. I do not myself remember any instance of the floats of a paddle being shrouded, and I am inclined to think that by preventing the lateral outflow of the water at the sides of the floats you would cause the paddle wheel to labour. I think it is necessary for the free action of the floats in the water, and therefore for the most efficient action, that the water should be allowed some amount of lateral action as the float pushes it astern, and I should expect myself that the shrouded float would have the effect of decreasing the revolutions without proportionately increasing the percentage of propulsive effect. The author does not give us any figures on this point, which perhaps he might have done. He does state that the area of the floats is equal to the area of the immersed part of the midship section. That is a very general rule which I am afraid is a little too general to be entirely applicable. In the case of a steamer for river service the proportions would differ from those of a steamer for Channel service, and also in the case of a vessel for high speed there would be a considerable difference from those of a vessel for low speed. The statement also about 50 per cent. of the indicated horse-power being utilised for propulsion, the remaining 50 per cent. being taken up by the various causes referred to, is a general statement which the author, in the course of his reply, will be able to amplify, for the assistance of those who may read his paper. I am not making these criticisms in any spirit other than that the Institute may have the benefit of further details from Mr. Mills, who has evidently studied this subject very closely, and studied it with very great benefit to himself. I do hope, however, that he will be able to add information useful to those who read his paper—details that will make the paper still more valuable to the institution. We are very much obliged to Mr. Mills for his valuable paper, which is one that may be read with great advantage and instruction.

Mr. TUCKER (Visitor) then called attention to the principal features of the drawings of paddle wheels used for illustration purposes, and on the invitation of the Chairman he also pointed out the most important differences between a drawing dated 1855 and another dated 1897.

Mr. T. F. AUKLAND (Companion): I have had a good deal to do commercially with a number of steamers which trade on the river Magdalena. Those steamers are propelled by stern wheels, and I should like to know if there is any similarity between the construction of those stern wheels and the construction of the side wheels of an ordinary paddle steamer. Possibly, you, Mr. Chairman, can tell us something about them.

The CHAIRMAN: Stern-wheel steamers constitute a type of vessel that has been almost entirely forgotten in the course of this discussion. Undoubtedly stern-wheel steamers are capable of work on inland rivers which no other class of steamer can perform, because they can work on the very lightest draught, and without the inconvenient increase of extreme breadth inseparable from the use of side wheels. There are certain portions of the Nile, for instance, which can be navigated by stern-wheel steamers and by nothing else. They are most useful for inland navigation, but the great wheel at the stern, the position of the engines, and the necessity for having the boiler right forward, prevents their mode of construction being seaworthy for the open sea. For river purposes inland, and for the purposes of towing they are found most excellent. There are always some under construction in the Thames, and generally speaking they have their place which no other type of vessel can fill. With regard to the construction of these stern wheels their principal difference from the ordinary side wheels of paddle steamers is that they are fitted with fixed instead of feathering floats. Indeed, one might almost say that the use of fixed floats as distinguished from feathering floats is confined to stern-wheel steamers. Practically you find that no other vessels are fitted with wheels having fixed floats.

Mr. BASIL JOY (Associate Member): With reference to the question of bushes, the Chairman has referred to the trouble arising from foul water, and his remarks on that and another point have suggested one or two matters that have come within my own knowledge. In the case of two steamers with which my firm were connected, that were sent out to China, or Japan, or somewhere out in the East, the nature of the water was so sandy that they had to take off the eccentrics of the feathering floats and link gear, and substitute another form of gear altogether. With reference to stern wheelers, the President mentioned just now that there were certain difficulties connected with the necessary arrangement of the engines and boilers, the engines having to be aft and the boilers forward. My firm have had to do with some stern wheel steamers in which both the engines and the boilers were amidships, and the motion was conveyed aft by means of a piston rod, which I think was about 50 ft. long. The gear was a curious arrangement, and was all above deck.

The CHAIRMAN: How long was that ago?

Mr. JOY: About five years ago.

The CHAIRMAN: Has it ever been repeated?

Mr. JOY: Yes. There were six boats altogether, I think. Two boats were first built, and then four more were constructed.

The CHAIRMAN: Then evidently their performance was satisfactory?

Mr. JOY: I believe it was. This arrangement of the weights was adopted to do away with trussing the vessel to obviate the hogging due to having the weights at both ends.

Some conversation then took place as to certain details of the plans before the meeting, especially with reference to the turning gear fitted to paddle wheels; and it being proposed that the discussion on the paper should be adjourned until another evening,

Mr. BASIL JOY said he thought the discussion on the subject should be now closed, as it scarcely appeared probable that there would be sufficient discussion on the paper to occupy another evening.

The HONORARY SECRETARY: May I suggest that this discussion be adjourned until the next regular meeting night, Monday, March 28th, when we may also have a paper by Mr. Hawthorn on "Incrustation in Boilers," so that if there is no desire to continue the discussion on "Paddle Wheels" we could proceed with the reading of Mr. Hawthorn's paper.

This suggestion was accepted by the meeting and the discussion was adjourned accordingly.

The usual votes of thanks concluded the proceedings.

THE AUTHOR'S REPLY ON THE DISCUSSION AT 58 ROMFORD ROAD.

The position of the star centre or eccentric depends upon the angles given to the entering and emerging floats. If these angles are found, as previously explained in the paper and shown upon the diagram, by finding the direction of the resulting velocity of the speed of the boat and the speed of the wheel, then the lengths of the radius rods, measuring from the centre of the bell cranks attached to the floats to the centre of the star centre—which are equal to the distance between the float journals and the centre of the wheel —will give the correct position.

If, however, upon a trial of the boat more or less slip be found to take place than calculated upon, it would be advisable to alter the angle of entry of the float, and consequently the position of the star centre, to something near the altered conditions.

As regards the pins and bushes, I do not think there is anything better than casting a good hard gun-metal lining upon the rough turned pins and let them work in bushes of the same hard metal. Lignum vitæ is very good, but not equal to the gun metal. Pins bushed with gun metal, working in white metal bushes, would not last long, on account of the galvanic action set up between the two eating away the white metal.

If the gun-metal bushes be only shrunk upon the pins they will soon get loose, either on account of the continual hammering when slightly worn or else on account of their being improperly put on.

In casting on the brass bushes, however, great care has to be taken to ensure the brass being properly attached to the iron pin, and that the metal is not porous next the iron, conditions which necessitate the use of some special flux

In regard to the horse-power, it is evident that the resistance to the progress of the boat must be equal to the power applied to overcome it, which must be equal to the mass of water sent astern multiplied by its velocity. Now the mass of water sent astern is equal to the area of two floats multiplied by the velocity of the boat, and the weight of a cubic foot of water divided by g, and its velocity is equal to the difference between the velocity of the centre of a float and the velocity of the boat. Hence the resistance

$$R=\frac{2\ AWV(V-v)}{g},$$

and the horse-power $=\frac{60\ RVL}{33{,}000\ l}$.

Where L = Length of crank

l = Distance between point of suspension of float and centre of wheel,

$$\text{or H.P.} =\frac{4\ AV^2(V-v)L}{550l}.$$

Substituting in this equation the values for the wheel given, we have

$$\text{H.P.} =\frac{4\times 3{\cdot}5\times 10{\cdot}5\times 40{\cdot}6^2\ (40{\cdot}6-30{\cdot}6)\ 2{\cdot}75}{550\times 7{\cdot}75}=1452,$$

whereas the I.H.P. = 2450, consequently the actual horse-power expended in propelling the boat is only 59 per cent. of the total.

The energy lost by slip is equal to $\frac{Mv^2}{2}$, where

$$m=\frac{2\ AV\times 64}{2\times 32}\quad\text{and}\quad v^2=(V-v)^2;$$

so that the horse-power expended and lost by slip

$$=\frac{2\ AV(V-v)^2}{550};$$

and substituting values, we have

$$\frac{2\times 3{\cdot}5\times 10{\cdot}5\times 40{\cdot}6\times 100}{550}=542{\cdot}56.$$

But as the direction of the water acted upon by the floats is at an angle to the surface, and is continually varying, it follows that part of this loss is really due to the obliquity of the floats, and if it be assumed that the float enters the surface of the water at an angle of 60° it follows that the loss due to obliquity must vary as the cotangents of the angles from 60° to 90°, so that we must multiply the 542·56 by the mean cotangent,

$$\text{or, loss due to obliquity} = 542{\cdot}56 \int_{90^\circ}^{60^\circ} \frac{\text{Cot}\, x dx}{\frac{\pi}{2}}$$

$$= 542{\cdot}56 \left(\frac{1}{\text{Sin}^2\, 60} - \frac{1}{\text{Sin}^2\, 90} \right) \frac{2}{\pi}$$

$$= 114 \text{ H.P. or } 4{\cdot}65 \text{ per cent.}$$

The loss from slip must also vary as the mean cosine of the complements of the before-mentioned angles, or from 30° to 0°,

$$\text{or loss due to slip} = 542{\cdot}56 \int_{0^\circ}^{30^\circ} \frac{\text{Cos}\, x dx}{\frac{\pi}{6}}$$

$$= 542{\cdot}56\ (\sin 30^\circ - \sin 0^\circ) \frac{6}{\pi}$$

$$= 515 \text{ H.P. or } 21{\cdot}02 \text{ per cent.};$$

so that we have horse-power absorbed by

Propulsion of boat	59·26
Slip	21·02
Oblique action of wheels ...	4·65
Friction of engines, wheels, and loss by eddies, etc.	15·07
	100·00

In the paper, the area of the floats is mentioned as being about equal to the area of the immersed midship section, but what was intended was, that the total area of the floats and parts of the floats immersed was about equal to the area of the immersed midship section, the particulars of some passenger steamers engaged in river, coasting, and occasional channel service being as follows:

Midship section ...	140	140	110	80
Floats	138	146	100	70
Length of boat ...	230	225	210	206
Beam	26·6	26·1	25	20
Horse-power ...	2,450	2,200	1,620	800
Speed in knots ...	$19\frac{1}{2}$	$19\frac{3}{4}$	$16\frac{1}{2}$	15

When a float is moving through the water there is a following stream set up, the velocity of which is less than that of the float on account of the water closing in from the sides, and also from the water flowing from the advancing side of the float around the ends; so that not only is there a reverse current to the float, but the velocity of the following stream, which would prevent shock to the following float, and so be more efficient, is reduced. On the other hand, if the floats were shrouded the reverse current would be lessened, and consequently the velocity of the following stream would be better maintained, and so be the means of lessening the shock of the entering float, and the loss in power due to the production of foam.