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MACHINERY FOR DOUBLE-ENDED FERRY STEAMERS.

(BY RUSSELL SINCLAIR.)

This paper is a brief statement of the principal dimensions of the hull and description of the machinery of the recently-built double-ended ferry steamer "Kookooburra."

The principal dimensions of hull are :—

Length, overall	138ft.
Beam, over planking	28ft.
Beam, over sponsons	27ft. 3in.
Depth, moulded	10ft. 6in.
Draft	7ft. 9in.
Freeboard	3ft.

The construction of the hull is briefly :—

Keel, of ironbark, sided 14in., moulded 10in.

Keelson, ,, ,, 12in. x 12in.

Floors are natural grown crooks, with special long arms, doubled under machinery and boilers. Frames are bent timbers of spotted gum. Sister keelsons, forming machinery beds, are 70ft. long and 14in. x 12in. ironbark. Stringers, garboards and lower strakes of outside planking are of hardwood in long lengths; the upper planking of kauri. Stern posts are of colonial teak. Decking is of kauri. There are five bulkheads, all of them being watertight. The rudders are gunmetal throughout and partially balanced. The keel is connected to hull by gunmetal rudder post, oval in section.

The general arrangement of hull, showing cabin accommodation, upper deck, with positions of wheel-houses, are shown on drawing exhibited (Plate I.); also the plan of the lines of hull (Plate II.)

The conditions which were kept in view in designing the hull being that the draft was to be 7ft. 9in. when ready for the service, with steam up, and to have a freeboard amidships of 3ft., and that the draft was not to exceed 8ft. It was also a necessity that the height of the vessel above—wheelhouses funnel and ventilators—in order to enable the vessel to pass, under the bridge on the Parramatta River, must not exceed 21ft. 6in. above load line. The passenger accommodation aimed at was 650, but it may be mentioned that the vessel has been certified for 816.

It was calculated that the machinery should be capable of developing 650 I.H.P. and it was stipulated that the boilers must be below deck not to interfere with deck space for passenger accommodation, also that the fore and aft space occupied by engines above deck should not exceed 24ft. 6in. for the same reason, and with the limit of height of funnel not to exceed 21ft. 6in above the light load line of the vessel to allow the vessel passing under bridges, it led to the introduction of one or two novel features in the design of the arrangement of the machinery, which has been considered might be of sufficient interest to the members of the Association to warrant bringing it before their notice.

The engines are of the ordinery triple expansion, inverted surface condensing type, with the condenser forming part of the framing, and present no very special features. The cylinders are 13in., 21in., 35in. with a common stroke of 21in. The cylinders are arranged with H.P. leading intermediate and L.P. following. The H.P valve is of the piston type, the I.P. and L.P. are double ported slide valves. The cranks are set at 120 degrees, the shaft of the built type with solid forged couplings at each end. The surface condenser is fitted with $\frac{3}{4}$in. tinned brass tubes, having a total cooling surface of 1100 square feet, which gives an allowance of 1·69 square feet per calculated maximum I.H.P. The circulating pump is an independent centrifugal pump, 7in. suction and delivery, driven by a vertical steam engine 6in. by 5in. and the circulating water passes twice

through the tubes. This pump can be regulated from the starting platform. The air feed and bilge pumps are placed at back of the condenser and operated by levers and links from the intermediate cross head in the usual manner. Being a double-ended vessel with a propeller at each end and arranged to run equally either way the guides are of equal dimensions with slippers on back and front columns.

At each end of crank shaft and attached to the bed plates are placed the thrust blocks, of the horse shoe type, with shoes adjustable in fore and aft directions, and faced with white metal. The total surface in the two thrust blocks is 237 square inches, which gives a pressure of 48lbs. per square inch at estimated I.H.P. of 650.

The propeller shafts are carried through in convenient lengths with solid forged couplings, and supported on cast iron blocks lined with white metal to each end. The propeller shafts are covered with brass liners the full length from propellers to inside of stern tube glands. The stern tubes are of brass entirely, and the outer bearings are lined with lignum vitae.

The lining up of the shaft previous to boring out the dead wood for the correct alignment of the stern tubes and the shafting, while the vessel was on the stocks, is, in a double-ended vessel, always a matter of serious importance, as on the correct judgment after consideration of the structural design and strength of the hull, will depend the final result as to whether the shaft, which is rigidly connected through its entire length, will run free or not. The centre line of the shaft was kept as low as practicable to allow of the connecting rod bottom end bolts clearing the keelson, and after a line was stretched from stem post to stem post, and sighted at the height decided on, it was depressed $1\frac{3}{4}$in. at midships, and the tubes bored to that. It was found by measurement that after the vessel was launched, and the machinery put on board, that she came back $1\frac{5}{8}$in,, so that the allowance made was almost

correct, and the results of trials and running since have shown there is no friction, and an absence of heating throughout the shaft bearings. The propellers are of gunmetal, and were designed for a speed of 175 revolutions, and are 6ft. 6in. dia., 10 feet pitch, four blades each with 15.2 square feet of surface, or a total of 30.4 square feet. The shape of the blades and boss are as in drawing, Plate III.

The auxiliary machinery consists of a vertical duplex automatic feed pump, $5\frac{1}{4}$ x $3\frac{1}{2}$ x 6in., the water end being of gunmetal throughout. This pump has attached to it an automatic control tank, provided with a float which controls a special cock admitting steam to the pump, there being also a direct steam connection from the boiler, for use when main engine is stopped, the pump on the main engines draws from the hotwell and discharges to this tank, the duplex pump operating according to the height of the float, discharging to the boiler through a combined feed water heater and filter, provided with bye pass valves to enable the feed water to be passed direct to the boilers if necessary at any time. The arrangement of the automatic feed donkey and combined feed heater and filter being designed to occupy as little space as possible. The automatic pump is also provided with a suction connection to bottom of air pump for draining the condenser when vessel is lying at wharf. A vertical duplex pump, of similar size and design to the feed pump is provided for general service such as bilge suctions, wash decks, and also connected to feed boilers, through separate feed check valves on boilers. The general arrangements of the machinery and piping are shown on Plate IV. and V.

To meet the conditions of getting the boilers under deck, and not interfering with the passenger accommodation, and at the same time provide steam for the estimated I.H.P. of 650, the boilers adopted were of the navy type, through multitubular, designed for a working pressure of 180lbs per square inch, and as the maximum dimensions for which space could be provided in the vessel, would not allow of a greater diameter than

7ft. 6in., and 18ft. length, taken in conjunction with the extremely short funnel of 23ft. 4in. above fire grate, which was the utmost that could be allowed, it was decided to adopt a system of forced or induced draft. The latter was decided on account of its simplicity and its convenience to control by the engineer handling the machinery from the starting platform.

The design of the boilers and the arrangement of the induced draft fan are shown on Plates VI. and VII.

The boilers are each 7ft. 6in. external diameter, by 18ft. external length, having one corrugated furnace 48in. inside diameter, by 6ft. 9in. long. In each boiler there are 124 3in. tubes, 8ft. 6in. long. The shell plates are $\frac{13}{16}$in. thick; treble riveted, butt strapped. The shells are in four plates, each plate the full length of the boiler, there being no circumferential seams except at the ends. The total heating surface of the two boilers is 1872 square feet. The tube surface is 1656, and the total grate surface is 44 square feet. These give ratios of

$$\text{Heating surface to grate} \quad = \frac{1872}{44} = 42{\cdot}5$$

$$\text{Tube surface to grate} \quad = \frac{1656}{44} = 37{\cdot}5$$

$$\text{Heating surface to total I.H.P.} \quad = \frac{1872}{650} = 2{\cdot}88$$

In designing the induced draft arrangement it was calculated that provision must be made for the combustion of 29·6lbs. of coal per square foot of grate for maximum power, and that this would require a draft of $\frac{7}{8}$in. at the grate, and that the volume of cold air entering the furnaces should be 6820 cubic feet, and that the volume of heated gasses to be handled by the fan would be 19,000 cubic feet per minute. As the space available for the fan was very limited it required some ingenuity to arrive at a satisfactory arrangement. The type of fan adopted was the Sirocco, having a spinner 30in. diameter, direct coupled to a high speed forced lubrication engine, 4in. diameter by 4in. stroke, designed to run at 550

revolutions and provided with a water-cooled bearing. The fan is placed at the base of the funnel, with the engine on the starting platform, and the water-gauge showing the intensity of the draft in the uptake at suction side of the fan is in front of the engineer, so that any required intensity of draft can be obtained by him without leaving his post, by merely regulating the speed of the fan engine. The tubes of the boilers are fitted with retarders, 4ft. long, placed at the smoke-box end of the tubes, these retarders having a spiral twist of 1ft. pitch. The damper gear arrangement is shown on drawing (Plate VII.), and is designed to allow of the change from induced draft to natural draft being made from the starting platform. There is a large damper swing on through shaft and provided with balance weights, and so arranged that when under natural draft conditions this damper closes the aperture to the fan, and when under induced draft conditions this damper is swung upwards to a horizontal position closing against a stop bar fixed round uptake, thus shutting off communication to the funnel and opening to the fan. This damper can also be used as an ordinary damper for controlling the natural draft. On the discharge from the fan to the funnel there is also provided a damper, which is closed when under natural draft conditions and open when fan is working.

As the space available for the boiler mountings in the steam space was very limited, and it was a matter of importance to have as few holes in the boiler shell as possible, there was in addition to one main steam stop valve on each boiler, only one auxiliary steam valve, the steam pipe being led to a distributing box placed in engine room, from the valves on which pipes are led to the various auxiliaries, steam steering gears, etc., the whistle pipe being led from the breeches pipe connecting the auxiliary stop valves on boilers.

The vessel is lighted with about 90 16 candle power lights, the current being generated by a combined high speed engine and dynamo 60 amperes 110 volts. The engine exhausts to the atmosphere. The side lights are electric and provided

with automatic cut offs, controlled from the wheelhouses, and tell-tale pilot lights of 2½ C.P. coloured respectively green and red are fixed in the engine room, visible on starting platform and also wheel houses. The automatic switches are actuated by the rudder locking gear, so that the proper side lights must be switched on according to the rudder which is free.

The steering of the vessel is by a combined steam and hand gear in each wheel house, the steering engines being about 5ft. 5½ins., taking steam from a reducing valve at 100lbs. pressure in pipes led up over the top of the awning to each end, well lagged and covered in a wooden trough. The exhausts being led back to the main engine condenser.

Propellers—As a result of the trials which were held it has been decided to make and fit new propellers with the view of reducing the bow wave. These propellers will be 18in. less in diameter, that is 5ft. 6ins. by the same pitch and with 28 square feet surface, and it is anticipated these will attain a greater speed.

Mr. James Shirra then read the report of the committee as follows:—

By the courtesy of the directors of the Sydney Ferries Co. Limited, their new steamer "Kookooburra" was placed at the disposal of the Engineering Association on the 23rd March last, for inspection and the making of power and speed trials. The Council appointed a committee to carry these out and furnish a report on same, consisting of Messrs. Sinclair (President), Shirra (vice-president), Hector Kidd, James Kidd and Walter Reeks, while Messrs. Borthwick, Borland and other members gave valuable assistance at the trials; Mr. Shirra to generally supervise and draw up the report.

The "Kookooburra" is a double-ended double-screw steamer, built by Messrs. Morrison & Sinclair, Balmain, engined by Messrs. Wildridge & Sinclair, the main engines being made by Messrs. Campbell & Calderwood, Paisley, N.B., and the boilers by Mort's Dock and Engineering Co. Ltd., Sydney. She

is a wooden vessel 120ft. long b.p., 25ft. extreme breadth, or 24ft. 3in. outside skin at water line at 7ft. 9in. draft, which is what she drew on trial being on an even keel. The displacement at this draft is 303 tons, and her block co-efficient is ·467. Area of immersed midships section is 130 square feet, and prismatic co-efficient ·68. The engines are triple expansion; cylinders, 13in., 21in., 35in. diameter, by 21in. stroke. There are two boilers of the direct tube marine or gunboat type, 7ft. 6in. external diameter and 18ft. long, with Deighton corrugated furnaces, each boiler having 936 square feet heating surface, and 22 square feet fire grate; working pressure being 180lb. per square inch. There is a "Sirocco" fan worked by a small independent engine, fitted with forced lubrication, in the funnel, to provide induced draft, by-pass valves being fitted in the uptake so that the boilers can be worked under natural draft also. This provision is necessary, as the height of the funnel is limited to about 23ft. above grate only, by the Parramatta River bridges, under which the vessel will ply. The propellers are of gunmetal, right-handed, 6ft. 6in. diameter, and 10ft. pitch, blade surface of each being 15·2 square feet. The auxiliary machinery comprises a single cylinder vertical engine driving the centrifugal circulating pump, a double cylinder Lamont feed pump, a similar double cylinder pump for general purposes, a small horizontal steam pump for circulating water round the fan bearing and for sanitary purposes, two "Sentinel" steam steering engines, one for each end, a high speed dynamo and engine of about 6 kilowatts, and the fan engine above mentioned.

The builder's wharf was left about 10-10 a.m. on the 23rd March, there being a representative company of the Association's members on board, and of the University Engineering Association, who gave useful assistance taking diagrams and so on. She proceeded down the harbour, and was taken over the measured mile first at about 100 revolutions per minute (run B on table) a run down and up being made at the same speed, subsequently the speeds were increased by consecutive rises of

20 revolutions per minute, and runs down and up made at 120 140 and 160 revolutions. The vessel was turned round at each end, so that all runs were made bow end leading, but as the hull is symmetrical and was on an even keel, the result of the trials save for possible slight inequalities of the valve motions would be the same either way. High water occurred at 3-36 p.m. so that the run was made about half flood. There was a slight S.E. blowing, the water being practically smooth.

Indicator diagrams were taken on each run, three sets each way, by Mr. Sinclair and staff assisted by Mr. F. Stowe and University visitors. Mr. Hector Kidd took the record of the induced draft gauge fitted to the smoke box, and observations of the draft or partial vacuum over the fire, by a portable gauge, also the revolutions of the fan engine, pressure of oil pump in same and state of the fires. The boiler pressure, on intermediate, low pressure, and vacuum gauge, and main engine revolutions were taken by Mr. James Kidd and observers. The times in the mile by Messrs. Reeks, Borland, and Shirra. A synopsis of these observations is given in table I.

The boat returned to Messrs. Begg & Greig's wharf about 1 p.m., and went out again at 2.30 p.m. with a larger company of our members aboard. The first item in the afternoon's programme was to run the mile again at a slow speed, 83 revolutions, to increase the range of speeds for comparative purposes (run A in table). It will be observed from the table that the maximum revolutions attained were 162 per minute, maximum I.H.P. 661, and maximum speed 12.3 knots. The curves showing the I.H.P. and revolutions required at any speed are prepared from the means of the up and down runs at each speed. The induction or partial vacuum observed over the fire and in the smoke box, in negative inclus of water pressure, are given in Table II., also the data derived from the fan engine observations. The air pressures over the fire are somewhat irregular, being much affected by the firing, they have been plotted on squared paper to show the general trend of the curve, with I.H.P. as abscissae.