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A NOTE ON MARINE PROPULSION IN 1914.

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In writing this note I realise that it is not a suitable subject for a short paper, but having been disappointed with regard to some matter which I think would have proved more satisfactory in this respect, it occurred to me that it might be interesting to try and epitomise the wonderful and diverse developments that have taken place during the last few years in the means for propelling commercial ships.

It is practically a century since Bell laid the foundation of mechanical propulsion with his 3-h.p. reciprocating steam engine in the "Comet," and until 15 years ago, when the Turbinia demonstrated the eminent suitability of the turbine for marine work, the reciprocating steam engine held an almost unchallenged field.

For about 11 years the turbine rapidly grew in efficiency, and consequently in favour, until at the end of it might fairly be said that it shared the honors with the reciprocating engine for marine propulsion.

During the last few years, however, developments that surely justify some wonderment at the remarkable extension of successful means for marine propulsion have taken place, and perhaps the most forcible way in which to illustrate this is to show side by side the leading particulars of certain ships that have been launched during the last two years. These particulars are tabulated below:—

TABLE I.

Some Machinery Installations in Commercial Vessels Launched in 1913-1914.

Name of Vessel	S.S. Kron Princessin Cecile	S.S. Aquitania	S.S. Britannic	S.S. Transylvania	S.S. Jupiter	Admiral Von Tirpitz	M.S. Annam	G.S. Zeearend	M.L. Aerotug.
Length B.P.... ...	682	865	900	567	520	650	410	150	30
Displacement in Tons	27,000	53,000	53,000	19,400	19,250	25,000	9700	630	4
I H.P.	45,000	60,000	50,000	9500	6,300	23,000	3000	300	15
Number of Propellors	4	4	3	2	2	2	2	2	1
Prime Mover ...	Reciprocating Steam Engine	Steam Turbines	Mixed Turbine and Reciprocating	Turbines	Turbines	Turbines	Diesel Oil Engines.	Suction Gas Engines,	Oil Engine
Transmission to Propellors	Direct	Direct	Direct	Gear Wheels	Cent.Elect. Gentr. to Motors.	Föttinger Hydraulic	Direct	Direct	Chain Drive to Aerial Propellor
Type of Boilers ...	Scotch R.T.	Scotch R.T.	Scotch R.T.	Scotch R.T.	Scotch R.T.	—	—	—	—
Fired by	Coal	Coal	Coal	Coal	Oil	—	—	Coal	—
Revolutions of Prime Mover	82	155	2 – 77 1 – 170	1630	2000	600	123	280	—
Revolutions of Propellors	82	155	3 – 77 1 – 170	130	110	100	123	280	—
Speed in Knots ..	23·5	23·5	21	16·5	14	23	11·25	8	8 not tow'g 2 towing

If all the forms of marine propulsion shown above had proved practically successful, were applicable to ships of every size, and approximately equal in economy of running, what a very complex problem indeed would confront the shipowner. But whilst these developments are surely indicative of much activity and inventive capacity on the part of the members of our profession, we, as Engineers, living on the shores of the fifth port of the Empire, and up to the present time unable for economic reasons to build our own large ships, are perhaps mainly concerned to know in what respects they have proved so successful as to be beneficially applied to our own mercantile marine.

It will, perhaps, be fair to briefly consider each of the new developments in turn, and in order approximately according to the extent of their actual application up to the present.

Commencing with the least known commercially, viz., Aerial Propulsion, obviously a development of the sea-plane, it will be realised that this form will only be commercially useful for moderate-sized craft, and again only in cases where submerged propellers are not feasible, but for navigation in shallow waterways there is a reasonably large field here in Australia. The vessel referred to in the above table, and illustrated in figure 1, only draws 9 inches of water, it is capable of towing 16 tons at 4 miles per hour, and is fitted with a 15-h.p. oil engine, driving an aerial propeller by chain-drive. It has not quite come up to expectations in actual use, but it is doubtless only a matter of time when the initial difficulties inseparable from early development will be overcome. An aero propelled vessel of 50-h.p. is now running a river passenger service in India.

Gas Power for marine work has been left to Dutch engineers to establish successfully, and after the failure of the various small vessels from which so much has been expected during the last ten years, it is worthy of note that, following upon a 300-h.p. sea-going vessel, which has been in regular use for four years, the owners have had built another vessel of the same size. This seems good evidence of dependability and satisfaction from a financial aspect, and although it is impossible to devote more time to the subject in this brief summary, the actual consumption of this gas boat of only .77lbs. of coal (Anthracite) per S.H.P. certainly provides food for thought, even though Australian coals are not really suitable for direct use in producers. It seems that the

Fig. 1.

gas vessel has an advantage in the fuel bill of from two to three times that of the steam vessel, and that crude oil would require to be not more than 25/- per ton if a hot bulb engine is to have the same fuel bill as the gas engine using coal at 18/- per ton.

As to electrical transmission between motive power and propeller, in spite of all that has been said with regard to its advantages during the last ten years, and the actual trials it is only during the last few years that this form of transmission has taken very definite shape, and in the

American naval collier, s.s. "Jupiter," illustrated in Fig. 2, we have a large vessel which has successfully completed a 13,000-mile journey, and for which is claimed a 27 per cent. saving in fuel consumption as compared with her sister ship, the s.s. "Cyclops," fitted with direct triple expansion engines.

In the absence of actual data, one cannot accept this figure without some doubts, for electrical transmission can hardly be claimed to improve the efficiency of the turbine

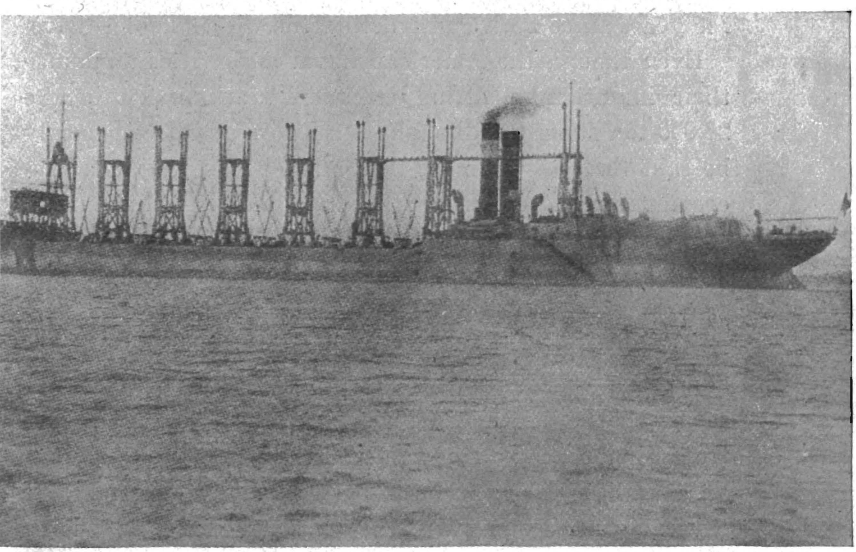

Fig. 2

itself, and even the greatest enthusiast would not claim that the best turbine installation would show such a saving over the best reciprocating plant or mixed installation.

It is also reported that the "Jupiter" showed a greater economy in fuel consumption than her second sister ship, the "Neptune," fitted with geared turbines, but again, and perhaps more decisively, we should have to await some authenticated data before it would be possible to make even an approximate comparison.

I might have included in my table another combination which has been adopted for marine work, namely, Diesel engines and electrical transmission, as exemplified by the motor ship "Tynemount," and by a vessel built by Nobel Bros. for the Volga River service ten years ago. To what extent these vessels have been successful we are somewhat in the dark, but there is no doubt that much delay and trouble was experienced before the Tynemount was able to take to the sea, whilst Messrs. Nobel Bros. have for years since been constructing the direct Diesel drive.

Even though the American naval authorities announce their intention of fitting electrical transmission in the 28,000-ton superdreadnought, "California," it can hardly be said that this form of transmission has yet quite emerged from the experimental stage, and it is difficult to see how the system, which requires two stages of transmission, each a unit in itself, can compete successfully for commercial vessels, at all events, with the simple transmission by a pair of gear wheels now being so largely adopted in the Parson's Geared Turbine sets. Indeed, it seems that even the comparatively inefficient hydraulic transmission of Fottinger design, for which is claimed an overall efficiency of 92 to 94 per cent., would compare favorably in economy with electrical transmission, whereas the former has the same advantage in permitting of reversal of propellers without reversing the prime mover. For naval purposes the electrical gear might certainly be arranged to provide for an economical variation in speed, but this advantage would not enhance its value for commercial vessels.

You have recently had an excellent paper upon the Parson's Geared Turbine, and upon which I would not attempt to enlarge, but it is quite evident from Lloyd's Annual Report for 1914, wherein it is stated that no less that 23 commercial ships were under construction with geared sets, as against six with direct turbines, this form of transmission has emerged from the experimental and reached a practical and successful stage for almost all classes of ship.

The following diagram, taken from a paper recently read before the Institute of Shipbuilders, Scotland, furnishes some interesting comparisons of the steam consumption of geared turbines and direct reciprocating sets.

When we come to the "Diesel" motor ship, a typical example of which is shown in the next figure, 3, we are unquestionably facing the most remarkable development in marine engineering of recent times, and although it would perhaps be incorrect to say that the motor ship

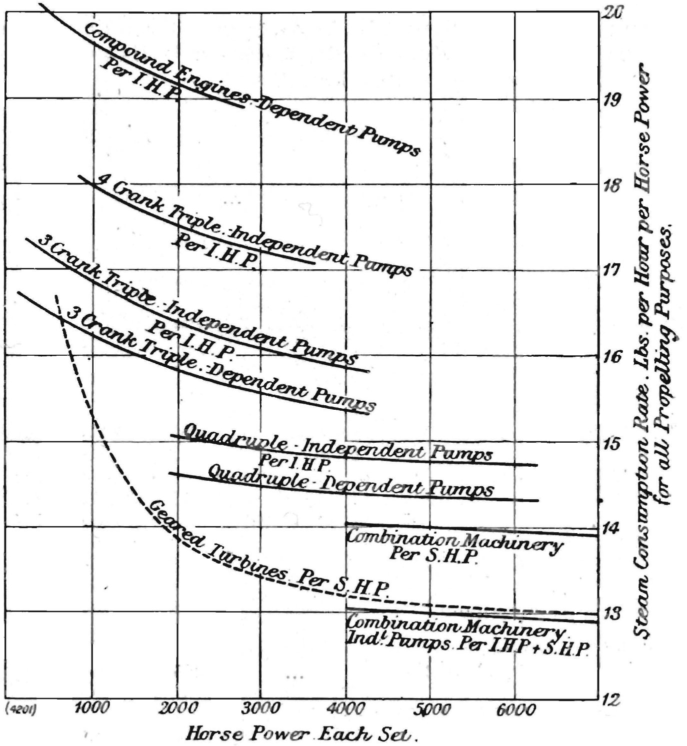

Fig. 3.

has won complete acceptance, the progress made during 1913 and 1914 is astounding, and has put to flight any serious doubts as to its ultimate absolute success.

Although it is difficult to obtain actual data, the following figures (see tables 2 and 3) will serve to show that the relative consumption of coal and oil, i.e., ton for ton for modern steam and oil ships worked under exactly similar conditions is, approximately, as 4 is to 1. For a ship of, say, 9,000 tons dead weight capacity, the engine-room staffs are, approximately, as 19 is to 13, and for the same overall sizes the motor ship, on account of the higher value and reduced consumption of fuel, will carry

TABLE II.

Comparative costs of Diesel Oil Engines and Steam Engines for Marine Purposes given by Mr. Milton, in Wells and Wallis-Taylor's work on the Diesel Engine.

	Oil Ship.	Steam Ship.
Fuel capacity	1000 tons	1000 tons
Sufficient for voyage of	28,800 miles	6850 miles
Cargo D.W.	7105 tons	6210 tons
Cargo capacity... ...	351,000 cubic feet ...	304,000 cubic feet
Coal Consumption per day	10 tons	42 tons
Cost of Fuel per month	Oil at 40/– per ton, £600.	Coal at 14/– per ton, £882
Cost of Engine-room Staff per month ...	8 hands (4 Engineers 4 Assistants) £86	16 hands (4 Engineers 12 Firemen) £114
Food for Engine-room Staff per month ...	£24	£39
Total cost per month ...	£710	£1035
*Cost of Transporting 1 ton of Cargo 6,850 miles	2/-	3/4

*This figure is based on the oil ship carrying sufficient oil for a voyage of 6850 miles.

TABLE III.

Relative Operating Costs of Some Diesel-Engined and Steam Engined Boats of the Nobel Bros. Naptha Production Co.

Diesel or Steam.	Year of Construction	Name of Vessel	Tpye	I.H.P.	Seasons Transport in Ton—Miles	Fuel Consumption. Tons	ANNUAL EXPENDITURE Wages £	Maintenance £	Lubrication £	Light & Heat.	Fuel £	Sundries £	Total Annual Outlay £	Capital Cost of Ship £	Total Annual outlay including Interest & Depr. at 7 per cent	Remarks
							River-	going	Vessels							
D	1909	"Malaross"	Paddle Tug	950	66,000,000	507	1113	630	168	37	1160	84	3192	26,250	5029	Fuel at 45/8 per ton.
S	1912	"Volga"	,,	1000	67,000,000	1656	1124	473	73	47	3785	89	5591	16,800	6767	,,
D	1910	"Kalmuk"	,,	750	55 000,000	410	1050	504	105	37	940	74	2710	21,000	4180	,,
S	1911	"Djuschi"	,,	700	51,000,000	1592	1071	473	73	47	3638	84	5386	14,175	6375	,,
D	1909	"Samayed"	,,	400	Special Service	169	630	388	79	29	441	116	1683	12,600	2565	Fuel at 52/6 per ton.
S	—	"Anna"	,,	350	27,000,000	965	861	326	37	42	2530	63	3859	9,450	4517	,,
							Sea-	going	Vessels							
D	1910	"Robert Nobel"	Tank-ship.	1000	59,000,000	701	2100	1155	226	58	1376	252	5167	39,400	7925	Fuel at 39/2 per ton.
S	—	"Talmut"	,,	500	28,000,000	1769	1890	893	73	53	3465	200	6594	18,375	7875	,,

perhaps 10 per cent. more cargo. On the other hand, the motor ship, at present, costs considerably more than a steam ship, perhaps 10 per cent. Lubrication, although not a very important factor, is from three to four times more expensive. Maintenance is, if anything, higher, and will probably become greater as the motor ships grow older. It is obvious, therefore, that

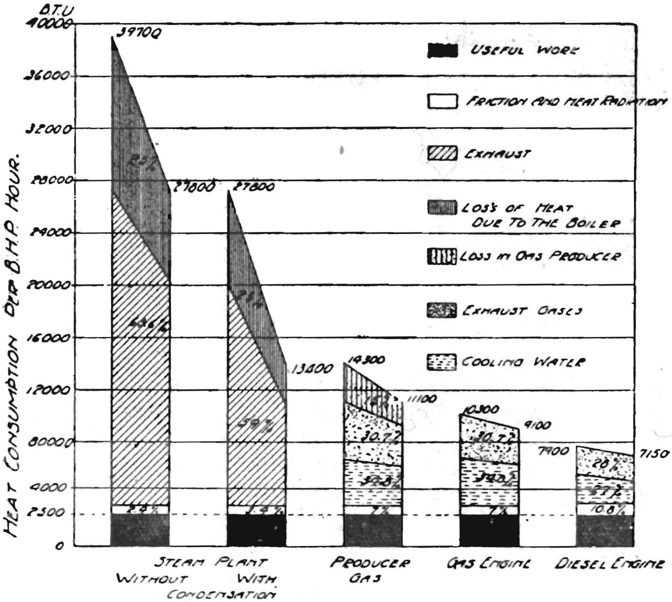

Fig. 4.

the factor of greatest importance is not so much one of engineering as of fuel supply, and in order to determine the approximate price at which oil would have to be available before an oil ship could be run more profitably than a steam ship in Australian waters, I have set down a case for a vessel trading between here and Fiji, and find that, with coal at 10/- per ton, and making liberal allowance for all the factors concerned, oil would require to cost less than 60/- per ton before any financial benefit would result. Until Australia has developed her known oil deposits, or research has enabled us to make more economical use of our coal, it seems that for our Australian commerce, i.e., for ships not trading to countries wherein oil is available at a low price, the motor ship will not displace the steam ship. Fig. 4 contains nothing new, but will serve to emphasise the relative heat consumption of steam, gas and Diesel engines of moderate size.

Further developments will doubtless take place, and perhaps can be expected to favor the oil ship; particularly must this be with regard to the size and power of the Diesel engine, for at present 2,000-h.p. is approximately the maximum so far developed on one shaft. When it is remembered that during the last ten years there has been an increase from 20 to 60,000-h.p. in our commercial ships, it will be seen that the Diesel has far to go before it can be generally applied.

Of the direct reciprocating, direct turbine, or mixed reciprocating and turbine drives, so much is known that it is needless to comment here.

What, then, is the development most likely to be of the greatest immediate benefit to Australian shipowners? Is it not the turbine with geared transmission, and which has vastly increased the classes of ships in which the turbine can compete with the reciprocating engine?

Until this form of transmission was available the direct reciprocating engine certainly had a field which it promised to hold against all comers here in Australia. I refer to the passenger and cargo carrier of moderate size and speed, and it has been asserted by many shipowners that a single deck cargo steamer of about 10,000 tons carrying capacity, and 12 to 14 knots speed, is for most cargoes about the most economical type yet evolved. Even now it will be many, many years, if at all, before the reciprocating engine is displaced, for there is no doubt that for reliability, regularity of running, simplicity, and all-round economy, it has been a great success. Many large shipowners might be quoted who have not yet installed turbines, even in vessels for which it might be said they would be most suitable.

A century with the reciprocating engine has served to educate our marine engineers up to a very thorough understanding of this type, and I think it must be admitted that no other can be compared with it so far as being independent of the "shore gang" in case of breakdown or ordinary repair.

So far as the consumption of coal is concerned, we have actual data to show that 1.1lbs. of coal per B.H.P. hour for the main engines is obtained in good practice, and it has been estimated that if certain improvements could be brought about the consumption of mixed reciprocating engines and steam turbine installations would be 8 to 9 lbs. of steam per B.H.P.

Up to 15 years ago we know that the reciprocating steam engine practically stood alone; and now, but a few years after, we are in the midst of developments of an extraordinary nature. It is difficult, indeed, to foresee what the future holds.

The experience being gained during the present war may do much to still further alter our ideas of marine propulsion, and even now it may be fully accepted that for naval purposes oil is essential to success whether for internal or external propulsion.

The British Empire is poor in oil, but rich in coal, which we are now using much in the same way as we did in the beginning of its history 700 years ago.

Scientists have studied the possibility of substitutes for our primary fuel without success, and oil is the apparent successor to coal.

The many advantages of oil are manifestly obvious, so that it would appear that the distillation of oil from coal seems to hold the greatest imaginable possibilities for progress.

Although the production of oil from coal is now being carried out successfully in several ways, none of these so far show that our knowledge of the matter is sufficient to enable oil to displace coal as the primary fuel.

Estimates show that our coal resources are ample for about two centuries, but we cannot afford to be careless on this account, and it should not be necessary for it to become an acute problem before we consider the matter from a progressive point of view.

With the knowledge that internal combustion engines have proved capable of utilising thermal energy to a degree far beyond that of any other prime mover, we should continually have before us the endeavor to use our coal resources more economically.

In conclusion, I would say that although it may reasonably be claimed that we have reached a high stage in the realisation of the known methods of marine propulsion, the developments of the last fifteen years should surely be enough to quench the desire of any one to speak in a prophetic manner as to what our methods may be in, say, fifteen years hence. I certainly have neither the inclination nor the ability to do so.