tensile-steel plates is less than 40 seconds, and the holes are of course exactly in the required position. No punching-machine with its attendant gang can rival this performance. A large increase in the drilling-tackle of the yard is necessarily involved; but when driven by electricity or compressed air the tools are both simple and inexpensive.

In conclusion, the Author is convinced that the drilling of holes in destroyers, which has been initiated by the Admiralty, will in the early future become, as in boiler-work, the method to be adopted in all the best classes of marine construction, not only in destroyers but also in other classes of shipbuilding work; and the sooner naval architects and insurance companies take this method into serious consideration, the better. So far as his own experience goes, he looks upon this change of practice as one of the many instances of progress initiated by the Admiralty; and he is confident that the drilling of holes in the hulls of ships, especially for those subject to severe strains, is a move in the right direction.

The following speakers took part in the discussion of the subject:—Mr. A. Denny, Sir William White, and Messrs. H. H. West, J. List, A. E. Seaton, H. F. Swan, and R. T. Napier.

“Express Steamers for Short Voyages.”¹

By ALBERT EDWARD SEATON, M. Inst. C.E.

So long as the majority of mankind are subject to sea-sickness, the favourite route between any two places will be that which involves the shortest sea passage. Such sea passages therefore as are the shortest between country and country, or between one part of a country and another, separated by water, may be regarded as of the first importance. As examples may be instanced—Stranraer to Larne; Dover to Calais; Holyhead to Kingstown; and Barrow to the Isle of Man. Second in importance are those routes which compete with the foregoing, but involve a somewhat longer sea passage. Such are—Folkestone to Boulogne, Newhaven to Dieppe, Dover to Ostend, Queenborough to Flushing, Harwich to the Hook of Holland, and Harwich to Antwerp, as competing with Dover to

¹ *The Engineer*, vol. xcvi. p. 8. *Engineering*, vol. lxxvi. pp. 5 and 30.

Calais; Holyhead to Dublin, Liverpool to Dublin, and Milford Haven to Waterford, as competing with Holyhead to Kingstown; Fleetwood to the Isle of Man, and Liverpool to the Isle of Man, as competing with the Barrow route; Fleetwood to Belfast, Barrow to Belfast, Glasgow to Belfast, Liverpool to Belfast, and Holyhead to Greenore, as competing with Stranraer to Larne. The third in importance are the longer sea passages chiefly affecting second-class traffic: such as Southampton to Havre; Weymouth to St. Malo; Bristol to Cork; and coast voyages, such as those from the Firth of Forth to London, and from Glasgow and Oban to the West Coast of Scotland. Finally comes what may be taken as summer or excursion traffic: of which numerous examples can be instanced from the Firth of Clyde to the West Coast of Scotland, and from the Port of London coastwards and to the Continent.

In importance of traffic the old trade routes of Dover and Calais, Harwich and Holland, Holyhead and Dublin, will always take the lead. On all these routes there has been from time to time increase in size of ships, as well as in speed and comfort; but on nearly all of them there are limitations and special conditions which necessitate differences in the steamers employed: so that on hardly any two of them are vessels found of precisely the same size and build. The causes of these differences it is the object of the present Paper to point out particularly.

Table of Routes.—First of all, the harbours used by these ships are all tidal; and although much has been done in recent years to make some of them more convenient and commodious, there is still a definite limit to the draught of the steamers using them for a time-service. A tidal service is highly inconvenient, and cannot compete with a time-service. All express routes (Table I.) are now run on a time-table, the boats leaving the harbour at a fixed time, night or day: which is effected by using boats restricted in draught of water, and by choosing a time which is never low-water of spring-tides. Many of the harbours are such as to limit the length of a ship using them; but generally this restriction is not now of great importance, except that at Calais the big boats must be double-ended, or else lose time by turning round outside the harbour. Many harbours are situated close to, or actually on the sea: so that the steamer on leaving her moorings is quickly on the open sea. This affects the design and properties of a ship. For example, at such harbours as Dover, Calais, and Folkestone, the ship must continue at full speed until she is quite close to her berth; her engines therefore should not only reverse quickly, but should also develop sufficient resistance to check her way and act as

TABLE I.—EXPRESS STEAMER ROUTES.

Designation.	Distances.					Scheduled Time.	Possibilities.		
	On Land.	On Sea.		Total.	Ratio, Sea to Total.		Time if Speeds are 50 and 20 Miles an hr.	Time if Speeds are 50 and 23 Miles an hr.	Time if Speeds are 55 and 25 Miles an hr.
	Statute Miles.	Nautical Miles.	Statute Miles.	Statute Miles.	Per Cent.	Hours.	Hours.	Hours.	Hours.
London to Calais <i>viâ</i> Dover . . .	76·25	21·0	24·2	100·45	24·1	3·333	2·985	2·825	2·600
„ „ Boulogne „ Folkestone .	70·00	26·0	30·0	100·00	30·0	3·500	3·150	2·950	2·723
„ „ Dieppe „ Newhaven .	56·00	66·0	76·0	132·00	57·6	5·567	5·170	4·670	4·310
„ „ Ostend „ Dover. . .	76·25	60·0	69·0	145·25	47·6	..	5·225	4·775	4·396
„ „ Flushing „ Queenborough	49·50	108·0	124·4	173·90	71·5	9·083	7·460	6·640	6·130
„ „ Hook of Holland <i>viâ</i> Harwich	68·00	101·0	116·3	184·30	63·1	8·583	7·423	6·660	6·118
London to Dublin <i>viâ</i> Kingstown . .	270·30	64·0	73·8	344·10	21·5	9·000	9·346	8·856	8·117
„ „ „ „ North Wall. .	263·50	70·0	80·6	344·10	23·4	9·250	9·550	9·020	8·265
„ „ „ „ Liverpool . .	201·00	137·0	157·8	358·80	44·0	16·500	12·160	11·120	10·217
London to Belfast <i>viâ</i> Stranraer . .	429·00	39·0	45·0	474·00	9·5	12·500	11·080	10·780	9·850
„ „ „ „ Barrow . . .	264·50	107·0	123·3	387·80	31·8	17·000	11·705	10·890	9·992
„ „ „ „ Fleetwood . . .	229·50	113·0	130·1	359·60	36·2	15·000	11·345	10·490	9·627
„ „ „ „ Liverpool . . .	201·00	156·0	180·0	381·00	47·2	16·000	13·270	12·070	11·105
„ „ „ „ Greenore . . .	323·00	87·0	100·2	423·20	23·7	..	11·714	11·060	10·131

The above Table shows the distances on land and sea of certain routes with express service. The scheduled time is that advertised, and, as a general rule, adhered to. The possibilities of the route are therefore shown by figures in the last three columns. The first assumes an average speed of 50 miles per hour on land and 20 miles per hour (equal to 17·4 knots) at sea, and an allowance of $\frac{1}{2}$ hour for transshipment, getting under weigh and getting alongside. The second, an average speed of 50 miles per hour on land and 23 miles per hour (equal to 20 knots) at sea. The third, 55 miles per hour on land and 25 miles per hour (equal to 21·7 knots) at sea.

powerful brakes. On leaving such ports, especially in bad weather, the ship must keep her course and get to full speed quickly, in order to shorten the voyage as much as possible.

Length of voyage is an important factor in determining design. If the night-service exceeds 3 hours, the accommodation necessary for the passengers' comfort is different from that in a ship whose passage is shorter. In the latter, large numbers of state-rooms with beds are quite unnecessary. Good deck-space with plenty of shelter, and a cabin provided with sofas, are sufficient. In ships performing a longer passage, more sleeping-cabins and hot meals are required; hence the cooking apparatus and saloon, etc., are more elaborate. The quantity of coal and stores carried is larger, and usually includes sufficient for the return voyage; each additional hour of passage requires 15 tons additional displacement in a 20-knot steamer of this class.

Speed, though always of first importance, is often governed by circumstances not always obvious; and although the tendency in all directions is to go faster, there are certain routes on which little or no advantage is gained by so doing. For example, in the Fleetwood and Belfast, and the Hook of Holland service, passengers leave Fleetwood and Harwich at 10 o'clock at night and reach the port at 5 o'clock next morning, whereby they get a proper night's rest. Were the voyage appreciably shortened, the increase in speed would have to be considerable, without gain in real comfort to the passengers. On the other hand, on competing routes from one big town to another—say London to Paris *via* Dover *versus via* Newhaven—the sea passages differ greatly, but the longer sea passage has the shorter land journey: so that the whole distance is less, and the journey may be done in something like the same time if the steamship is of high speed. Here however the sea passage is not long enough to permit of “turning in.”

The determining factors for dealing with the steamships engaged in these services are:—first, speed on trial, and speed per schedule; second, greatest number of passengers to be carried; third, night- or day-services. The limitations are:—first, draught of water; second, length of ship; third, length of passage; and fourth, nature of passage. In Table II. are given particulars of the largest and most modern express boats on the chief routes; and for comparison are added in Table III. the corresponding particulars of express steamers which were on service forty and twenty years ago.

Dover and Calais.—Here the service is practically that of a ferry taking passengers backwards and forwards several times a

day. The harbour at Calais does not permit of a time-service with vessels drawing more than 10 feet of water; and vessels exceeding 200 feet in length must be either double-ended or lose time by turning outside. The larger number of passengers travel in the day-time; consequently the largest boats are designed for day-service. Hitherto the service has been carried on solely with paddle-boats, because the paddle suits both harbours better than the twin-screw, for reasons already explained.

Folkestone and Boulogne.—Since the two railways have amalgamated, there is now no real competition in the boat-service. Folkestone harbour does not admit such large steamers as Dover harbour; but otherwise the service is similar in nature, for, although the sea-passage is somewhat longer, the land journey on both sides is shorter.

Newhaven and Dieppe.—Here the sea-passage is three times that from Dover, but it is not long enough to require proper sleeping service, and the land journey is considerably less on both sides. The harbour or harbours permit of 9 feet draught of water; and the service can be conducted advantageously with twin screws, since the traffic does not require nearly such large boats as on the Calais route. The draught of water permits of sufficiently large propellers.

Dover and Ostend.—The shallow harbour at Ostend, and the high speed required with such large steamers, necessitate their being driven by paddles. The service is a comparatively short one, and therefore no sleeping accommodation is required.

Harwich and Hook of Holland.—This route, competing as it does successfully with the Queenborough and Flushing route for the Berlin and Eastern traffic, conveys a large number of passengers yearly, but always at night-time. Here the harbours permit of a draught of water of 14 feet. The scheduled speed is moderate, although the boats are capable of attaining much greater speeds. It is necessary for these vessels to have full night-accommodation, and means for preparing and serving hot meals as well as cold. The passage is often a rough one in winter, and is undertaken successfully in all weathers; hence the ships must be strongly built, of good reserve power, and, as far as possible, having everything in duplicate. The whole of the Harwich boats are now twin-screws, experience having demonstrated the superiority of this method of propulsion for that service. The Queenborough and Flushing boats are all paddle-boats.

Holyhead and Kingstown.—The draught of water permitted here is 13 to 14 feet. The traffic is heavy, and the distance such as

TABLE II.—PARTICULARS OF PRESENT EXPRESS STEAMERS ON CHIEF ROUTES.

Route.	Name of Ship.	Paddle or Screw.	Tonnage.		Dimensions.				When Built.	Cylinders.			Indi- cated Horse- Power.	Speed.	
			Gross Register.	Dis- place- ment.	Length.	Beam.	Depth of Hold.	Draft of Water.		No.	Diameter.	Stroke.		Trial Trip.	Schedule Service.
Dover to Calais . .	Le Nord	Paddle	Tons. 2,004	Tons. 1,700	Feet. 338·0	Feet. 34·9	Feet. 16·3	Feet. 9·0	1898	3	Inches. 42-59-86·6	Inches. 88·6	I.H.P. 7,000	Knots 21·5	per Hour. 15·8
Folkestone to . .	Mabel Grace	„	1,815	1,500	300·0	36·1	15·3	9·0	1899	3	77½-55-77½	72·0	..	19·5	15·3
Boulogne . .	Princess Clementine	„	1,474	1,900	341·3	37·8	14·2	9·0	1896	2	60-108	84·0	8,100	22·2	..
Dover to Ostend .	Koningin Regentes	„	1,947	2,300	320·0	35·8	16·0	12·0	1895	3	51-75-112	78·0	9,000	21·2	14·1
Queenborough to Flushing	Dresden	{ Twin screw }	1,805	2,400	302·0	38·0	16·3	14·0	1897	6	26-39½-63	36·0	5,250	18·5	14·4
Harwich to Hook of Holland	Arundel	„	1,067	1,370	269·0	34·1	14·1	9·0	1900	8	{ 23½-35½- 37½-37½ }	27·0	4,000	21·0	16·2
Newhaven to Dieppe	Alberta	„	1,240	1,900	270·0	35·6	14·6	12·0	1900	8	{ 19½-31½- 36½-36½ }	30·0	4,500	19·0	17·0
Southampton to . .	Roebuck	„	1,300	1,740	280·0	34·6	16·8	12·5	1897	6	23-36-56	33·0	6,000	20·0	15·5
Havre and Jersey .	Great Western	„	..	..	..	..	..	..	1902	8	{ 19-29½- 33-33 }	30·0	..	..	..
Weymouth to Jersey	Ulster	„	2,632	2,950	360·0	41·5	27·3	13·5	1896	8	{ 29-45- 48-48 }	33·0	9,500	23·8	21·5
Milford to Waterford	Anglia	„	1,862	2,300	329·0	39·1	15·7	12·0	1900	8	{ 26-40- 43-43 }	33·0	7,000	21·0	20·0
Holyhead to Kingst'n	Duke of Cornwall	„	1,540	2,050	325·5	37·0	16·5	12·0	1898	8	{ 22½-34- 38½-38½ }	33·0	5,600	20·0	17·5
„ Dublin .	Magic	„	1,640	2,200	310·0	38·3	15·0	12·0	1893	6	19-31-52	36·0	4,200	19·0	15·5
Fleetwood to Belfast	Duchess of Devonshire	„	1,265	1,800	300·0	35·0	15·7	10·3	1897	6	21-32-50	30·0	5,000	19·5	..
Liverpool „	Princess Victoria	{ Paddle }	1,096	1,650	280·0	35·5	14·0	10·0	1890	2	51-90	66·0	5,000	19·7	19·5
Barrow „	King Edward	3 Screws	500	750	250·0	30·0	10·6	6·0	1901	..	{ 3Parsons turbines }	..	..	19·5	..
Stranraer to Larne .	Columba	Paddle	602	700	301·4	27·1	9·4	5·0	1878	2	53	66·0	..	18·0	..
Greenock to Campbel- town	Empress Queen	„	2,140	..	360·1	42·3	17·0	..	1897	3	92-68-92	84·0	11,500	21·7	20·0
Glasgow to Ardrishaig	La Marguerite	„	2,205	1,868	330·0	40·0	13·6	8·75	1894	2	56-110	72·0	7,500	22·3	20·5
Liverpool to I. of Man															
Thames Excursion .															

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TABLE III.—PARTICULARS OF EXPRESS STEAMERS ON SERVICE FORTY YEARS AGO.

Route.	Name of Ship.	Paddle or Screw.	Gross Tonnage.	Dimensions.				When Built.	Cylinders.			Indicated Horse-Power.	Speed on Trial.	Boiler Pressure per Sq. In.
				Length.	Beam.	Depth of Hold.	Draught Water.		No.	Diameter.	Stroke.			
			Tons.	Feet.	Feet.	Feet.	Feet.			Inches.	Ins.	I.H.P.	Knots per Hr.	Lbs.
Dover and Calais . . .	Samphire	Paddle	340	191·7	24·8	11·9	6·8	1861	2	50	45	..	..	28
" " " " " "	John Penn	"	..	171·8	18·7	11·5	6·8	..	2	46	50	800	15·3	22
Folkestone and Boulogne .	Victoria	"	374	208·5	24·0	11·5	6·0	1861	2	58	54	..	16·0	30
Newhaven and Dieppe .	Lyons	"	269	189·2	21·8	9·9	6·0	1856	2	52	54	..	..	..
Harwich and Rotterdam .	Pacific	"	712	236·0	26·6	11·6	..	1864	2	48	54	..	13·0	30
Milford and Waterford .	Vulture	"	798	243·0	25·7	17·3	..	1864	2	54	60	..	..	..
Holyhead and Kingstown .	Ulster	"	1,477	327·0	35·2	18·8	13·0	1860	2	96	84	4,700	17·8	30
" " " " " "	Admiral Moorsom	"	794	219·0	30·2	15·1	..	1860	2	73	72	..	..	20
Fleetwood and Belfast .	Royal Consort	"	796	216·0	29·2	16·0	..	1844	2	71½	66	..	..	..
Liverpool and Isle of Man	Mona's Isle	"	339	201·0	22·2	10·7	..	1860	2	44	88	..	..	..
" " " " " "	Voltaic	Single S.	591	210·0	26·7	14·3	..	1867	2	30-57	36	..	..	80
Southampton and Havre or Jersey	Brittany	Paddle	529	216·0	25·6	13·1	..	1864	2	60	60	..	..	30
PARTICULARS OF EXPRESS STEAMERS ON SERVICE TWENTY YEARS AGO.														
Dover and Calais . . .	Invicta	Paddle	1,236	312·0	33·6	16·0	8·5	1882	2	80	78	4,000	17·00	30
Folkestone and Boulogne .	Mary Beatrice	"	803	255·0	29·2	14·3	8·0	1882	2	72	60	3,200	17·00	30
Newhaven and Dieppe .	Brittany	"	579	231·0	27·7	10·7	..	1882	2	46-83	60	..	17·00	110
Southampton and Havre .	Ella	Single S.	820	236·0	29·1	14·2	..	1881	2	37-68	39	..	14·00	..
Queenboro' and Flushing .	Princess Marie	Paddle	1,618	280·0	35·0	16·5	12·0	1877	2	60-104	84	..	17·00	80
Harwich and Rotterdam .	Adelaide	"	969	254·0	32·3	13·0	10·0	1880	2	45-87	72	1,750	13·50	80
" " " " " "	Antwerp	Twin S.	1,062	260·0	31·4	15·1	14·0	1883	4	30-57	36	2,000	14·00	80
Milford and Waterford .	Pembroke	Paddle	927	254·0	30·9	15·0	..	1880	2	53-91	84	..	13·00	75
Holyhead and Dublin .	Lily	"	1,035	300·0	33·1	14·4	11·0	1880	2	78	84	..	17·50	30
Fleetwood and Belfast .	Earl of Ulster	"	1,107	275·0	30·2	14·5	10·0	1878	4	34-64	72	..	..	70
Liverpool and Isle of Man	Mona's Isle	"	1,420	331·0	38·2	15·1	..	1882	2	65-112	90	..	18·50	90

to warrant a high speed. Moreover the speed must be maintained throughout the year: so that the boats must be good sea-boats, with considerable reserve of power. For many years the four paddle-steamers engaged on this route were far in advance of ships on similar routes elsewhere; and to-day the finest vessels of their kind are engaged in this trade. Their speed is higher than that of any similar steamers; and the accommodation offers every comfort to passengers, so that those who wish to do so can sleep on board.

Stranraer and Larne.—This is a night and day service, performed by paddle-steamers of moderate size and good speed. The length of sea-passage compared with that of the other routes is so short that competition will probably never force the sea-speed to be higher than it is.

Fleetwood and Barrow.—Here are tidal harbours that permit of a time-service only by the boats leaving at a particular hour each night, and drawing only about 12 feet of water. Their size and speed have permitted them to be twin-screws. The length of journey requires them to have full night-accommodation, and the passage is of such a nature as to necessitate their being thoroughly good sea-boats. They have also to lie aground, and so must have good local as well as structural strength.

Liverpool and Isle of Man.—This is practically an excursion service during the summer, carried on by two or three magnificent paddle-steamers, supplemented by a second fleet of somewhat older and inferior ships. The chief service is a day one, and the speed is important in order to compete with the shorter routes from Fleetwood and Barrow. The "Empress Queen" is perhaps the finest example of such a steamer that has ever been built. She can carry three thousand passengers, and is generally crowded during the season.

Thames Excursion Traffic.—This traffic is now carried on by fine paddle-steamers, whose draught permits them to enter Boulogne, Ostend, and several of the East Coast harbours, at any time of tide. Their speed is high, 20 to 21 knots. The accommodation is only that suitable for excursionists; and they do not go to sea except in summer, and in fine weather.

Few, if any, of these express steamers are classed at Lloyd's or any other registry. They are designed to suit their own particular service, and experience has proved in nearly every case that they have been suitable and satisfactory. The hull however, as well as the machinery, is under the jurisdiction of the Board of Trade, who take great pains to ensure the safety of the travelling

public, by seeing not only that the hulls and machinery are strong and safe, but also that all the appliances are provided which experience has proved to be for the safety of the passengers in case of accident. These ships must have stability sufficient to carry all their passengers on deck, but at the same time not so much as to make them roll uneasily when the passengers are only in part on the upper deck. In order that they may have lines suitable for their high speeds on such light draughts, it is necessary to make the hull and machinery as light as possible; hence they are all built of steel. The engines also are made as light as possible, and consequently run at a high speed of revolution; and the boilers are worked with forced draught.

The following speakers took part in the discussion of the subject:—Messrs. H. H. West, R. R. Bevis, R. T. Napier, W. J. Harding, and V. Pendred.

“Steam Turbines.”¹

By Professor RATEAU, Paris.

As is generally known, it is to the Hon. C. A. Parsons principally, and to the Swedish Engineer de Laval, that is due the general introduction of the steam-turbine into practical engineering during the last ten years. It should not be forgotten however that the idea of this kind of motor had already taken form in the minds of several inventors, among whom the French engineer, Tournaire, is entitled to particular mention as having in 1853, just half a century ago, indicated the capabilities of the steam-turbine. The arrangement he proposed is almost exactly that developed 32 years later by Mr. Parsons, with, it is true, some highly ingenious improvements, which have assured the success of the engine. Tournaire also conceived the helicoidal gearing since adopted in the de Laval plan.

In common with reciprocating steam-engines, steam-turbines are heat-engines, converting the calorific energy of the steam into mechanical energy directly available. From another point of view they are analogous to hydraulic turbines, and form part of the general class which may be called “turbo-machines.” With a knowledge of the thermo-dynamic properties of steam, and of the theory of the hydraulic turbine, it would be easy to design, with

¹ *The Engineer*, vol. xcvi. p. 9. *Engineering*, vol. lxxvi. pp. 6 and 32.