THE CUNARD ROYAL MAIL TWIN-SCREW STEAMERS "CAMPANIA" AND "LUCANIA."

The two new Cunard steamers Campania and Lucania may be accepted as embodying the results of 75 years' experience of marine construction gained in the evolution of the steamship of to-day —that rare masterpiece by which human genius not only "aspires," as Scott has put it, "to surmount the waves and contend with the wind," but which as matter of fact may now be said truly to "sail in a fearless scorn of scathe or overthrow." The beginning was the Savannah, built in 1818; but the end is not yet. We are but entering on a new era. The steam engine was adopted, with fear, in the American barque in her voyage in 1819. Steam was but an auxiliary, and the crew took the paddles on board when prudence suggested, relying solely on the time-tried, although fickle, breeze. In the Campania, on the other hand, the steam engine is adopted as the only means of propulsion. She courts not the fitful breeze, but moves onwards in scorn of the hurricane. The Savannah might be one of her twenty lifeboats, yet the great Cunarder does not carry as much canvas as did that historical craft. Indeed, sails would, as a rule, but retard her course, and only with a wind of great force would there be any gain in hoisting a sail at all. Her masts are but signalling posts, affording in the crow's nest a necessary vantage point from whence to scan the horizon, which otherwise would be but a few minutes' distance, in view of the great speed to be attained. But withal, it is not difficult to trace from that timidly adopted engine of the Savannah, and from other pioneer steam craft, the evolution of the Campanias and Lucanias of to-day.

The fact that the Savannah, during her 25 days' voyage, used the engine and paddles for 18 days, and managed to carry enough pitch pine to keep her boiler fires alight, settled a doubtful point, double assurance being given by the trip of 113 days' duration of the Enterprise to Calcutta six years later (1825). It was recognised that long-distance voyages could be made quite as satisfactorily as short coasting trips, so that there was, after all, not so much heroism in the venture of the Rhadamanthus, of 800 tons, to Jamaica in 1833, in the voyage of the Canadian-built vessel, King William, from Quebec to Liverpool in 1833, or in the simultaneous trip of Brunel's steamer, the Great Western, and the Leith-built steamer, the Sirius, to the States in 1838. That was the first Atlantic race.*

The credit for the origin of a regular service belongs to the Cunard Line, however, although the inspiration doubtless came from these first successes. As early as 1830 Mr. (afterwards Sir Samuel) Cunard watched the progress of steam propulsion, and later conceived the idea of establishing an ocean line of steamers, so built that they could traverse the thousands of miles of ocean with the same certainty of departure and arrival as in railway service. The steamship was to be the railway train without rails, which, he used to observe, were only needed on the "ugly, uneven land," with its excrescences of high hills and deep valleys, while the "beautiful level sea" needed them not. Cunard, with his coadjutors, Mr.—afterwards Sir George—Burns, who also was honoured by the Queen for his great services to shipping, and Mr. McIver, of Liverpool, lived to see the desire realised, for one feature which has characterised the Cunard line for many years has been the regularity of the steamships and the almost entire freedom from accident. And now, whatever may be their best performances, passengers may rest assured that the voyage by the Campania and Lucania, in summer or in winter, in storms as in sunshine and calm, will be completed within six days from Liverpool to New York. The Duke of Connaught, when Prince Arthur, attended service in Queenstown on a Sunday in 1869, embarked on the City of Paris of that day, and was in time for service on the following Sunday in Halifax. Our soldier Prince, or any peasant, may now attend service in Westminster and be in New York for service on the corresponding day in the succeeding week. The increased distance traversed during the seven days—something like 1000 miles, or about 40 per cent.—is a measure of the 25 years' progress.

Towards the close of the fourth decade the Admiralty recognised the superior advantages of steamships over sailing craft, for the steamship crossed the Atlantic in half the time, although great speed was made when running with favourable winds by many of the ships, particularly those built by the Americans, who excelled in designing as well as constructing sailing ships, and nearly 400 nautical miles were sometimes made in a day.

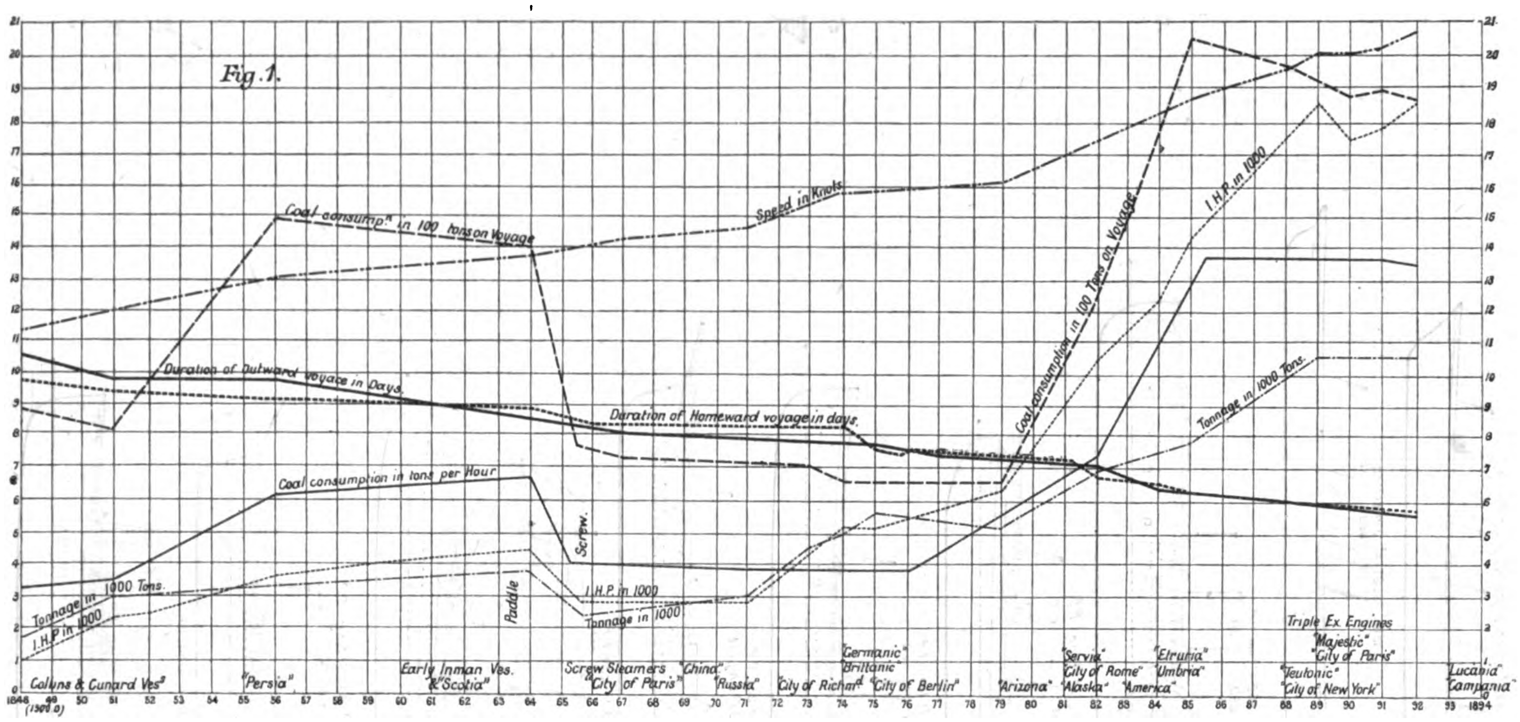


Fig. 1. Diagram showing Tonnage, Power, Coal Consumption, and Performances of Atlantic Liners, 1848-93.

* A series of articles on the history of the "Atlantic Record" appeared in Engineering (1891), vol. li., pages 420, 483, 517, 545.

THE DEVELOPMENT OF ATLANTIC STEAMSHIPS.

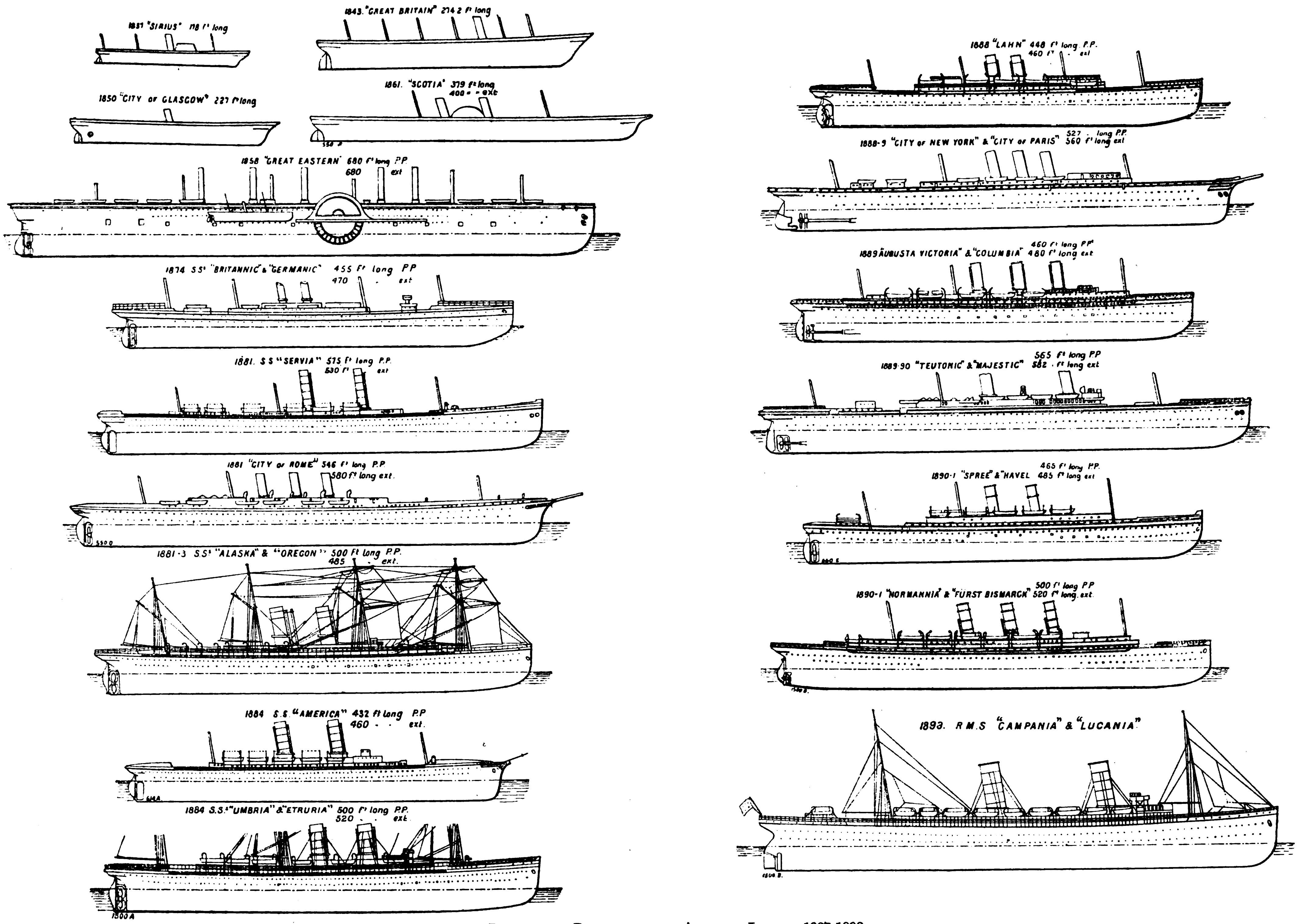
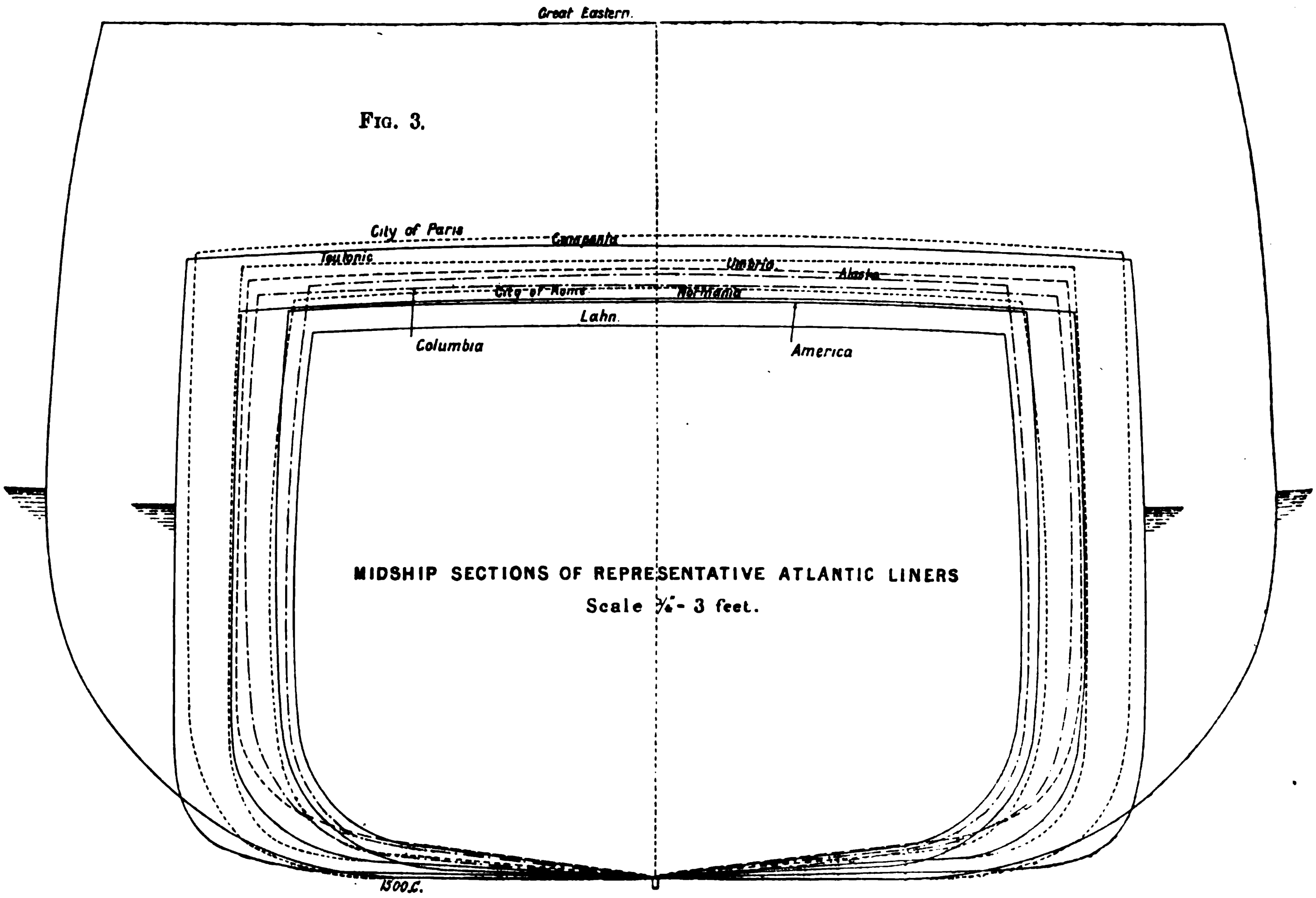


FIG. 2. PROFILES OF REPRESENTATIVE ATLANTIC LINERS, 1837-1893.

It was therefore decided to send the mails by steamer. Cunard then recognised that the time had come for action, and failing to gain support from his fellow-townsmen in Halifax, came to London, met Robert Napier, by whom he was introduced to George Burns, who, with his brother, was closely associated with the steam service from 230,000 indicated horse-power, the expenditure running to several millions sterling. And this does not include the Mediterranean fleet, built since 1853, which includes 19 vessels, of 26,000 tons. It is worth mentioning further that the Burns family have had built for coasting, deep sea, or yachting services about 200 vessels in all, aggregating nearly mate size of ship to which their enterprise may attain.

The Admiralty accepted the tender of the new Cunard Company, their competitors being the Great Western Railway Company, the owners of the Great Western, designed by Brunel, so that the first Cunarder sailed on her maiden trip as a

FIG. 3.



DIMENSIONS, &c., OF SOME NOTABLE ATLANTIC STEAMERS.

Steamer's Name.	Builders.	Date.	Moulded Dimensions.					Proportion of Length		Draught.		Displacement.	Gross Tonnage.	Cylinders.		Boilers.			Indicated Horse-Power.	Speed on Trial.	Admiralty Coefficient.
			Length.	Breadth.		Depth.		To Beam.	To Depth.					Diameter in Inches.	Stroke.	Heating Surface.	Grate Area.	Working Pressure.			
			ft.	ft.	in.	ft.	in.			ft.	in.				in.						
Great Eastern	Mr. Scott Russell ..	1858	680	83	0	57	6	8.192	11.826	25	6	27,000	24,360	.. ..	..	..	..	..	7,650	14.5	359
Britannic ..	Messrs. Harland and Wolff	1874	455	45	0	36	0	10.111	12.640	23	6	8,500	5,004	Two 48 in., two 83 in.	60	..	..	70	5,500	16	312
Arizona ..	Fairfield Company ..	1879	450	45	2	37	6	9.955	12.000	22	0	..	5,147	One 62 in., two 90 in.	66	..	..	90	6,300	17	269
Servia.. ..	Messrs. Thomson ..	1881	515	52	0	40	6	9.903	12.716	23	3	9,900	7,392	One 72 in., two 100 in.	78	27,483	1014	90	10,300	17	231
Alaska ..	Fairfield Company ..	1881	500	50	0	39	8	10	12.607	22	0	..	6,932	One 68 in., two 100 in.	72	..	..	100	10,500	18	245
City of Rome	Barrow Company ..	1881	542.6	52	0	38	9	10.432	14.000	22	0	11,230	8,141	Three 46 in., three 86 in.	72	29,286	1398	90	11,900	18.23	255
Aurania ..	Messrs. Thomson ..	1882	470	57	0	39	0	8.245	12.051	..		..	7,269	One 68 in., two 91 in.	72	23,284	1001	90	8,500	17.5	266
Oregon ..	Fairfield Company ..	1883	500	54	0	40	0	9.259	12.500	23	0	..	7,375	One 70 in., two 104 in.	72	..	..	110	13,300	18.3	228
America ..	Messrs. Thomson ..	1884	432	51	0	38	0	8.470	11.520	23	0	9,300	6,500	One 63 in., two 91 in.	66	22,750	882	95	7,354	17.8	310
Umbria ..	Fairfield Company ..	1884	500	57	0	40	0	8.772	12.500	22	6	10,500	7,718	One 71 in., two 105 in.	72	38,817	1606	110	14,321	20.18	260
Lahn	,, ,,	1887	448	48	10	36	6	9.174	12.274	23	0	7,700	5,661	Two 32½ in., one 68 in., two 85 in.	72	..	..	150	8,900	17.78	252
Paris	Messrs. Thomson ..	1888	527.6	63	0	41*	10	8.373	12.610	23	0	13,000	10,499	Two 45 in., two 71 in., two 113 in.	60	50,265	1293*	150	20,600	21.8	278
Augusta-Victoria ..	Vulcan Co., Stettin..	1889	460	55	6	39	0	8.288	11.795	22	9	9,500	7,661	Two $41\frac{5}{16}$ in., two $66\frac{15}{16}$ in., two $106\frac{5}{16}$ in.	63	36,000	1120	150	14,110	18.31	195
Columbia ..	Messrs. Laird Bros...	1889	462.6	55	6	39	0	8.333	11.860	22	9	9,500	7,578	Two 41 in., two 66 in., two 101 in.	66	34,916	1226	150	13,680	19.15	225
Teutonic ..	Messrs. Harland and Wolff	1890	565	57	6	42	2	9.826	13.425	22	0	12,000	9,686	Two 43 in., two 68 in., two 110 in.	60	40,072	1154	180	19,500	21	245
Normannia ..	Fairfield Company ..	1890	500	57	3	38	0	8.730	13.150	22	0	10,500	8,716	Two 40 in., two 67 in., two 106 in.	66	46,490	1452	100	16,352	20.78	266
Spree	Vulcan Co., Stettin..	1890	463	51	6	37	6	9	12.346	22	0	8,900	6,963	Two 38 in., one 75 in., two 100 in.	72	..	..	165	13,000	19.6	249
Fürst Bismarck	,, ,,	1891	502.6	57	3	38	0	8.777	13.224	22	6	10,200	8,000	Two 43⅜ in., two 67 in., two 106¼ in.	63	47,000	1450	157	16,412	20.7	254
Campania ..	Fairfield Company ..	1893	600	65	0	41‡	6	9.231	14.457	23	0	—	12,500	Four 37 in., two 79 in., four 98 in.	69	—	—	165	—	—	—

The Etruria is practically the same as Umbria, the Paris and New York are alike, so also are the Teutonic and Majestic, and the Spree and Havel, while the Campania and Lucania are also similar. The differences in the case of each pair are not important. * The introduction of Howden's system of forced draught into the Paris has resulted in the shortening of the firebars by 13 in., bringing the firegrate area to 1026 square feet. The results are under the closed stokehold system of forced draught.

the Clyde to England and Ireland. Progressive in spirit, he soon, as he himself said, began to see daylight through the scheme, and the Glasgow citizens, having faith in his enterprise and native shrewdness, readily subscribed, at his request, the necessary 270,000*l.*; and here it may be remarked that Glasgow has ever profited, for practically all the 61 Cunard Atlantic vessels constructed during the past fifty years have been built on the Clyde. They total something approaching 190,000 tons and 300,000 tons, and 350,000 indicated horse-power. In fact, a year seldom passes without a ship of some sort being under construction for them. They began in 1824 with a vessel of 296 tons; now they have got to one of about 12,500 tons; but the vitality and business capacity have increased almost in the same ratio, and, with a third and fourth generation of the original founders of the various concerns growing with the progressive spirit of the times, it is quite impossible to predict the ulti- Royal mail steamer. The fortnightly service was conducted by four steamers, all remarkable craft for their day; but the four might almost be placed in one of the latest liners. Certainly they could be accommodated in a dock which would not admit the new vessels, for the length of the Campania is equal to three of these pioneers, while the breadth is about equal to two. To convey a week's supply of fuel for the 102 furnaces in each of the two new steamers 12 boats of equal cargo capacity with these pioneer

Cunarders would be needed. The first trip of the Britannia, curiously enough, was commenced on "Celebration Day," 1840, and when the vessel arrived at Boston 14 days 8 hours later, Mr. Cunard had 1873 invitations to dinner. The average speed of the vessel was 8½ knots. The Campania may increase this to the extent of 150 per cent.; but this addition of 1½ times to speed requires 40 times the power, a pretty clear indication that the power increases at an enormously greater ratio than the speed. Mechanical engineers, however, have made immense progress, and the common side lever engine of the Britannia has passed through many successive stages of advancement to the triple-compound five-cylinder type which propels the new ships—an advance largely resulting from the use of higher steam pressures in the boilers, constructed of steel; so that the fuel consumption relative to power is less than a third what it was 50 years ago. In other words, although the power is 40 times greater, the quantity of coal burned on the voyage is not more than five times greater, for the new ship would only require coal for 5½ or 6 days, against 15 days in the case of the Britannia. That is an indication of 50 years' progress.

There is another side to the picture. Only 115 cabin passengers could then be carried. Now the Campania will take 600 first-class, 400 second-class, and from 700 to 1000 third-class. She will almost take as many passengers to America in one voyage as did the whole four pioneer steamers in a year. The minimum fare is now much less than it was 50 years ago. It was then 30 guineas, and for a separate room over 50*l*. was paid. Now first-class quarters may be got for 12*l*. to 15*l*., and the emigrant fare is as low as 4*l*. and 4*l*. 10s. But at the same time the demand for luxurious quarters has necessitated a special class, and thus high rates are paid, in some cases approaching 150*l*. for accommodation for a single voyage. It thus follows that some of the ships of to-day receive more passage money in one voyage than did the four pioneer vessels in a year, perhaps more than the total first cost of those early ships. The Teutonic, for instance, in seven voyages in 1890 had an average of 1400 passengers per trip, the minimum number being 1350 and the maximum 1507, while the Majestic, in nine trips, had an average of 1357, the minimum number being 1200. The Paris—then the "City of Paris"—in one trip is said to have had a gross revenue of 13,500*l*. from passengers, having had 550 in the first class, 200 in the second, and 450 in the steerage. The Campania and Lucania can carry many more, and, in view of the great popularity of the line, it is very probable that before many months elapse they may have a record performance specially for the benefit of the shareholders.

The progress we have indicated has been in well-defined eras, and these may almost always be recognised by the advent of new competing agencies, all successively directing their energies to capture the laurels from the Cunard Company; but, owing to the wise and liberal administration of Sir George Burns and his *confrères*, they easily overcame their early competitors, while for the last 30 years the business has eminently prospered under the guiding care of Sir John Burns, who has inherited from his father all his business aptitude and shrewdness.

In the fifth decade of the present century, Brunel sought once more, this time with his great triumph, the Great Britain, to prove superiority to the first Cunarders. Thus early, too, one finds evidence of that extremely prudent yet sure spirit of advancement which has always characterised the Cunard line management and distinguished them from many of their opponents. They preferred, and still incline, to move forward by slow stages, hazarding little. Brunel, on the other hand, wished to move by giant strides, and at this distance of time there cannot be anything but admiration for his perspicacity. Laird, of Birkenhead, had but a few years previously (1829) built the first iron steamer —a lighter—followed four years later by a small paddle steamer and other craft, when Brunel in 1840 boldly adopted the new material in his great liner of 3500 tons. Again, only four years had elapsed since Ericsson first tried his screw propeller in the Francis B. Ogden, which made 10 miles an hour on the Thames, while Pettit Smith had in Brunel's presence run experimental trials with the Archimedes. This determined him, and the Great Britain, then in course of construction, was altered to suit the screw propeller. She had two geared engines by Boulton and Watt, bilge keels, and had an unusual method of lapping the plates. She was, therefore, a remarkable craft, apart altogether from her great size. One crank in the Campania, however, weighs more than the whole shafting in this early screw steamer, while she was but half the length and her displacement was less than one-fifth that of the Campania. She maintained a speed of 9¼ knots. Her design and the choice of material were soon justified, for after stranding on the coast of Ireland and lying for about a year on the beach at Dundrum Bay, she was salved, and for many years engaged in the Australian trade.

The Cunard Company built more vessels larger than, but generally on the same lines as, the pioneer steamers; and still further reduced the time of transit across the Atlantic. The withdrawal of the Great Britain left them masters of the situation, for although the beautifully modelled sailing ships of the Americans managed with a fair wind to attain a high rate of speed, the periods during which they were becalmed or had to contend against head winds militated against them. Ericsson, who had found the Americans readier to consider the suggestions of the inventor—still a strong national characteristic—tried to improve matters by placing auxiliary screw propelling engines in some of the ships; but the success was indifferent.

With the advent, in 1850, of the Collins line, supported with heavy subsidies by the American Government—amounting ultimately to 178,750*l*. per annum, against the mail freightage of 81,000*l*. paid to the Cunard Company — a new era commenced, and brought lively times for a few years. The Collins line placed on their service four new vessels of 3000 tons, while the Cunard built two new steamers of 2226 tons and 2000 indicated horse-power, and two years later a still larger vessel was constructed for the Cunard fleet. All were paddle steamers, and one of the latter averaged a speed of 303 nautical miles per day. By this time, too, the average passage by all the steamers was reduced to 11 or 12 days, while the record time was under 10 days, as will be seen from the diagram of Atlantic line performances, Fig. 1, page 463. The service by the Cunard steamers, to quote from a report by a Select Committee of Parliament, was conducted with great regularity, speed, and certainty.

The Collins line built the Adriatic, which far surpassed anything afloat; but Napier built for the British company the Persia—an exceptionally fine iron paddle steamer, which, with her side lever engines of 3600 indicated horse-power, attained a speed of 13 knots with a coal consumption of 150 tons a day, and reduced the passage to 9 days 3 hours in 1856, 15 hours less than the duration of the passage in 1852. Ignoring for the moment the want of economy in the type of engines used, the paddle steamer may indeed be said to have reached its highest degree of excellence at this period. The reduction made in 16 years in the time taken in crossing the Atlantic was nearly a week, the speed being increased by 50 per cent.; but to attain the 13 knots the power required was fivefold, yet the increase in steam pressure from 9 lb. to 33 lb. to the square inch resulted in the quantity of coal used being only treble, the consumption relative to power being considerably less, although still vastly in excess of more modern results. The number of passengers carried and the extent of cargo capacity had likewise about trebled, but it is doubtful if the revenue had increased at the same ratio. The Cunard Company, however, had their great reputa-

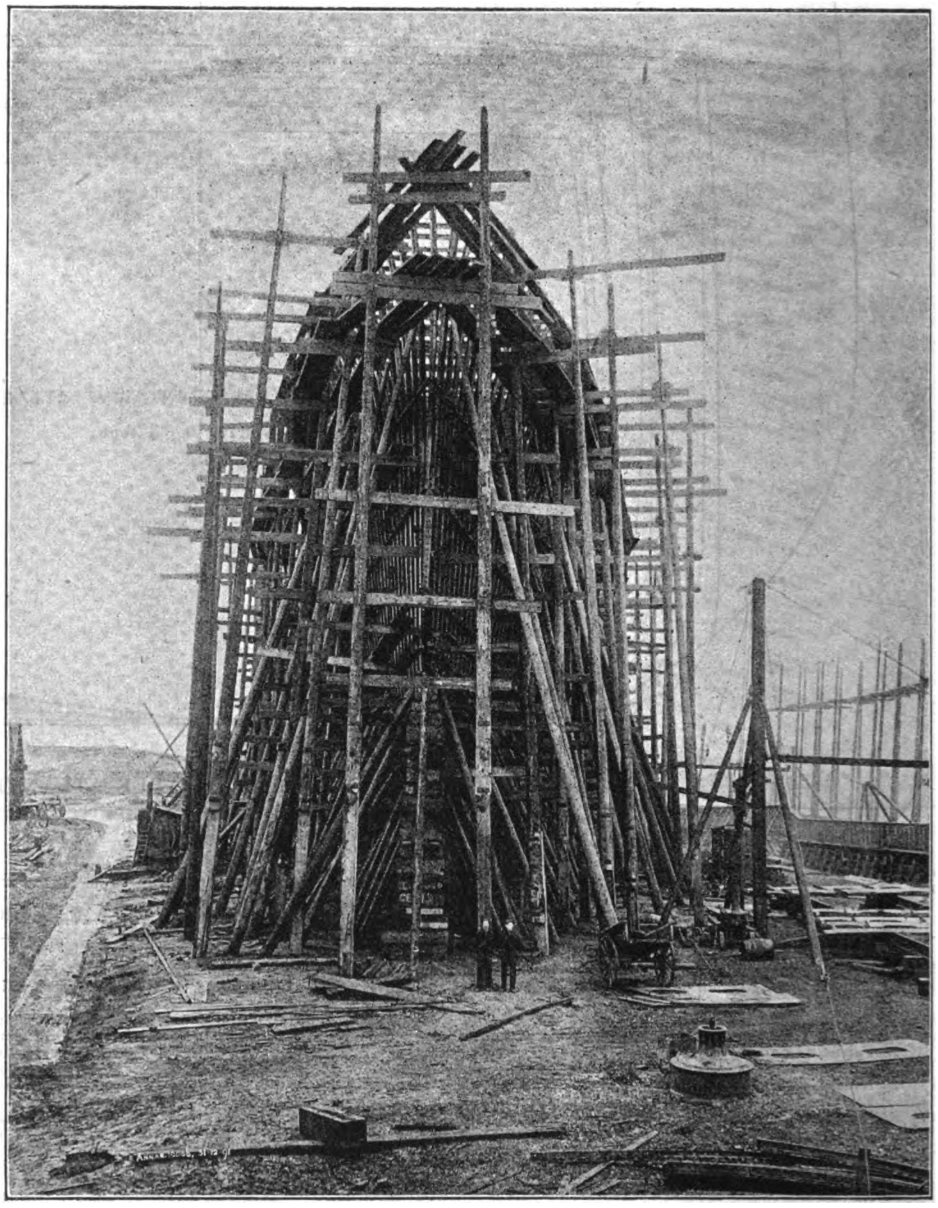


FIG. 4. BOW FRAMING OF "CAMPANIA" AND KEEL PLATING OF "LUCANIA," DECEMBER 31, 1891.

CONSTRUCTING THE HULL OF THE "CAMPANIA."

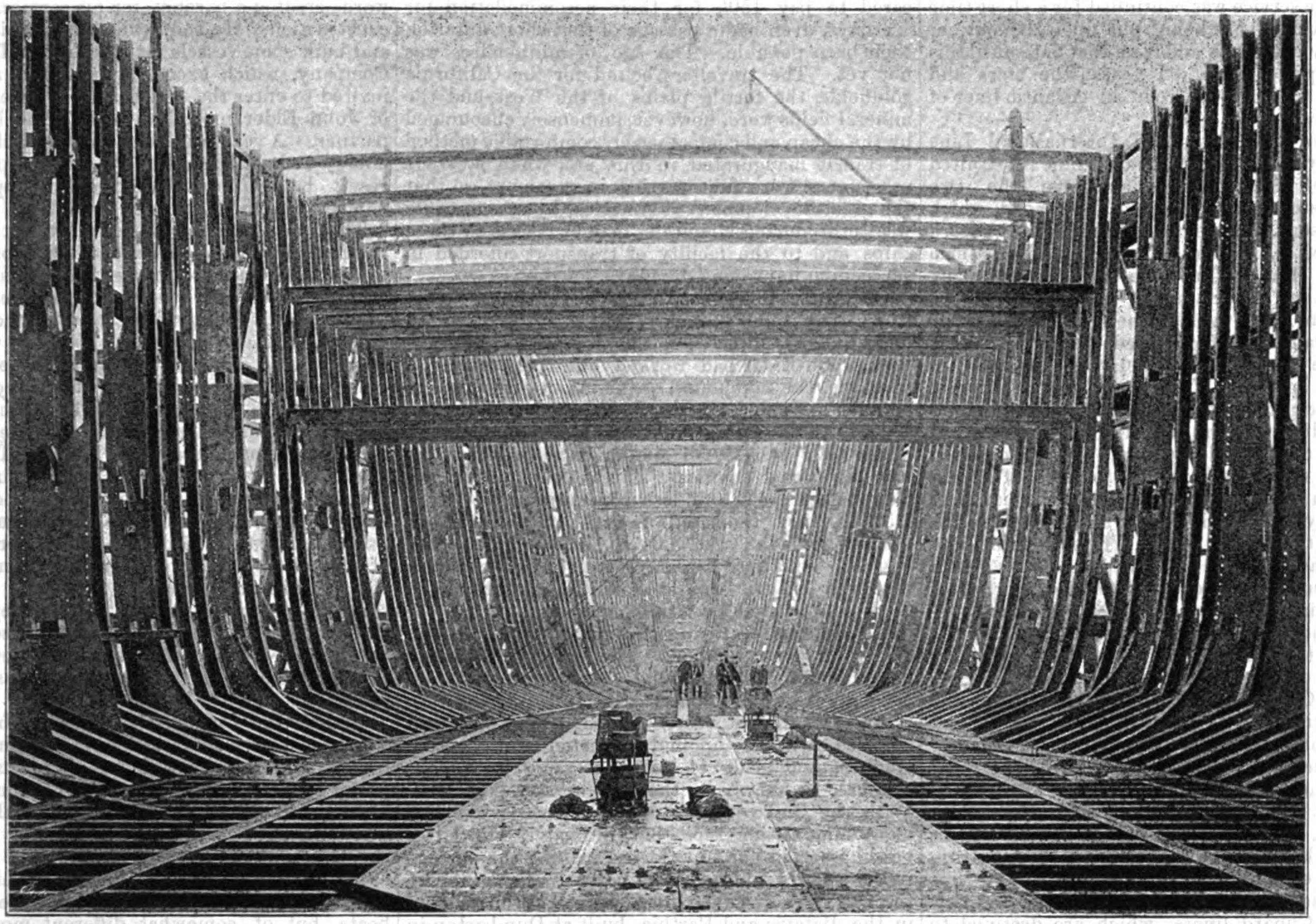


FIG. 5. BOW FRAMING, LOOKING FORWARD, DECEMBER 31, 1891.

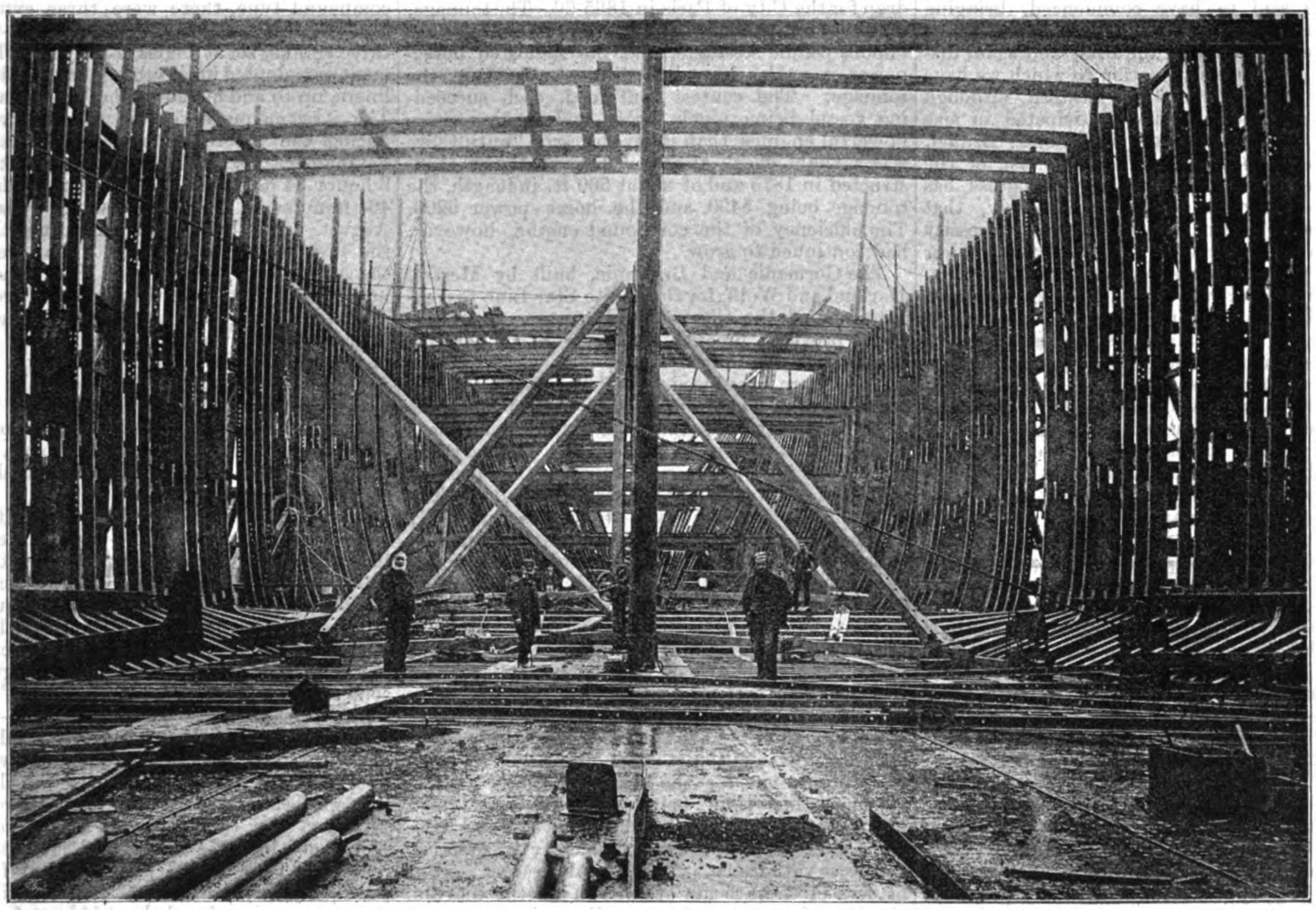


FIG. 6. STERN FRAMING, LOOKING AFT, DECEMBER 31, 1891.

tion to support them in the competition. Disaster determined the day. The Collins line, as is now well known, lost two ships—one in collision, while the other was never heard of after leaving the Mersey. Although the service was continued for a short time thereafter, a new boat being put upon the station, the company collapsed, and from that date until this spring—a lapse of about 35 years—the stars and stripes have not floated from an Atlantic liner of the first class.

Now from the Inman and International Line has been evolved the American Line of United States Mail Steamers. They have the two Clyde-built steamers, Paris and New York, which have at present the credit of making the record performance, while the management is on a firm foundation. But withal the Cunard Company recognises the importance of the contest to be entered upon alike against these vessels and the new American Line high-speed ships now being built on the banks of the Delaware, as well as against the splendid White Star boats, Majestic and Teutonic; and it is the laudable desire to maintain the traditions of the flag with the lion rampant that has led to the building of the two magnificent vessels with which we have now to deal. The contest between the rival lines, be it noted, has ever been friendly. The evidence is to be found in the presence of the Ismays of the White Star line, and the Spences and Taylors of the Inman line, as guests at Castle Wemyss, the Scotch seat of the chairman of the Cunard line, when the City of New York was preparing for her trials, while only the other day the chairman of the White Star Line telegraphed to Sir John Burns on the occasion of the launch, "Success to the Campania! May her career sustain the good reputation of the famous Cunard Line." And what of the builders? The chains, curiously enough, which served as a drag to check the great vessels in their plunge into the River Clyde, had been used at the launch of the Great Eastern many years before. They belong, part to the Thomsons of Clydebank, and part to the Fairfield Company, who lend to each other as occasion arises, and thus they were used for the great Inman liners and now for the new Cunard liners, which are destined to compete with the former for the blue riband of the Atlantic.

This good feeling between the various owners and builders has been maintained since the keen competitions started in the sixth decade, when another era may be said to have commenced, bringing many competing lines under British management. Brunel once again entered the lists, and again displayed that power of anticipation to which we have already referred, for the Great Eastern, although enormously great for her time, anticipated in size at least the length of the new Cunarders. Brunel, however, seems to have failed in the case of the Great Eastern to grasp what slow progress has taught the designers of to-day, namely, that with increase of size of hull there was a necessity also for an improvement in the motive power arrangements in order to secure successful results. Without mild steel and the high steam pressures made possible thereby, and without the improvements in engine design and construction necessary to utilise efficiently these high pressures, the great power and consequently the great speed now possible could not be attained. The Great Eastern, therefore, although a great achievement, particularly in the structural details of her hull, was not the pronounced success at which her famous designer aimed, and the most formidable competitor of the Cunard Company for many years was the Inman Line, which started with the screw steamer City of Glasgow, a profile of which is shown, with other notable Atlantic liners, on page 464. A comparison of the series of profiles just referred to and of the midship cross-sections and the Table of dimensions on page 465 will give a clear idea of the progress made in the construction of steamers for the Atlantic service.

After the Scotia, the last great Atlantic paddle steamer, which reduced the duration of the passage to 8 days 22 hours, attaining a speed of over 13 knots, the Cunard Company also adopted the screw propeller, the first vessel so fitted being the China, of 1862, with oscillating geared surface-condensing engines. Both companies continued in keen competition, each steamer built being an advance in all respects—in speed, increased steam pressure, and economy of coal consumption relative to power developed. And it was not altogether a matter of speed. The aim was to secure passengers, and comfort became an important consideration in design. The vessels of that day, however, were far from having all the luxuries to be found in a modern ship, and few passengers would have cared to pay 150*l*. for their accommodation for six days, even had a passage of that short duration then been possible. The age of millionaires was not yet. The travellers bound for the California goldfields, the fertile plains of the West, and the mineral fields were, however, immensely encouraged by the cheap and comparatively comfortable method of transit inaugurated in this era, when steerage passengers were first carried in steamers, so that the great development of America, by reason of its wealth-producing labourers, may be traced to those ships and to the facility of transport afforded in succeeding improving decades.

Of course there could not be cheap rates of transport without economy, and soon the attention of owners was directed to this necessity. At Fairfield, John Elder had worked out the problem of adapting the compound principle to the marine engine, and demonstrated its efficiency to the British Admiralty by the running in competition of three navy vessels, all similar excepting that one had compound engines. This vessel showing not only better speed but less consumption of fuel—2.51 lb. per indicated horse-power per hour against 3.17 lb. and 3.64 lb. in the other two vessels. And here it is interesting to note parenthetically that it was at Fairfield, too, that Dr. Kirk constructed his triple-compound engines for the Propontis, carrying the principle of expansion one step further. The Pacific Company first adopted the compound engine, but two years after the Admiralty contest the Inman vessel City of Paris (their first vessel of that name) was constructed with compound inverted direct-acting engines, and made 14 knots, crossing in 8 days 4 hours, as shown in the diagram on page 463. With the Cunard screw steamer Russia she had many an exciting race, but ultimately the latter vessel asserted her superiority, making the passage in 8 days 28 minutes. The compound engine, by the way, was first introduced into the Cunard fleet in the Batavia and Parthia, built at Dumbarton in 1869-70. The effect of the general change is clearly shown on the diagram of performances, for while the line showing the speed in knots continues to rise on a steady upward grade, the coal expenditure shows a very pronounced drop for the City of Paris in 1865-66. The tonnage, of course, is slightly less than in the case of the famous paddle steamers, and the indicated horse-power was also less, but still greater than the tonnage. The contest continued, each succeeding vessel being much larger and having more powerful engines than its predecessor, until there was a slight check after the City of Berlin, constructed in 1875 and of about 500 ft. in length, the tonnage being 5490 and the horse-power 5200. The efficiency of the compound engine, however, had continued to grow.

The Germanic and Britannic, built by Messrs. Harland and Wolff, for the White Star Line to compete against the City of Berlin, were a departure from previous practice. They were of extreme length relative to the beam, and various other features were introduced, first-class passengers being located in the centre of the ship instead of at the stern, the latter being a survival of the arrangement obligatory in the paddle steamers; but now objectionable in large measure owing to the vibration set up by the working of the screw propeller. The change thus inaugurated was afterwards universally adopted. In these White Star boats, the pressure of steam carried was 70 lb. per square inch, and their engines—constructed by Messrs. Maudslay, Messrs. Harland and Wolff not then building engines—were of the compound tandem type, having two high-pressure cylinders arranged above the two low-pressure. In the case of the Britannic also, there was fitted an arrangement whereby the propeller and a portion of the shaft could be raised while still remaining connected to the rest of the screw shafting by a universal joint. The object was to get a deep immersion for the propeller while at sea, at the same time being able to work in a moderate draught while in port. The arrangement, however, proved unsatisfactory in practice, and was withdrawn. The splendid record performances of these boats are shown on the diagram already referred to, while the dimensions, &c., are given in the Table on page 465. The speed was 16 knots, and the time of trip $7\frac{1}{2}$ days. The advent of Sir Edward Harland was almost contemporaneous with that of another master mind, who, also so largely shared the credit for the progress of the past fifteen years—Mr. William Pearce, afterwards created a baronet for his services to marine construction. He had, while with Napier, designed and built some vessels for the French Transatlantic Company, which excited admiration, and he was invited to enter the Fairfield firm after the death of John Elder in 1869. In 1878 he became sole partner. A year later he entered with characteristic energy and skill into the Atlantic competition, the result being the creation of the appropriately named "greyhounds of the Atlantic."

The time which had elapsed between the advent of the Britannic and Germanic, the City of Berlin and City of Richmond—nearly five years—had been devoted to careful study with the view of entering on a still more exciting and keen competition. Messrs. Harland and Wolff, however, who had for the first time entered the lists with the White Star vessels, gaining great credit by them, were not again represented in the contest until 1890, when they produced the Teutonic and Majestic. Indeed, for some time the competitors were Messrs. Thomson, of Clydebank, and Sir William Pearce's firm (now the Fairfield Company). The eminent position then held by these companies has been more than maintained. It was, indeed, sometimes more a question of shipbuilders than of steamship companies, but there can be no question of the desire of the latter to secure the fastest vessels, so that they share with the builders the credit of the enterprise which has resulted in nearly two days being deducted from the duration of the Transatlantic passage in 14 years.

In 1879 the Cunard Company got from Messrs. Thomson the Gallia, which had engines of 5000 indicated horse-power, being more than 1 horse-power to 1 ton gross, and yet she consumed only 97 tons of coal per day. To compete with the Gallia, Sir William Pearce constructed the Arizona for the Guion Line, formed in 1863, and evolved out of Guion's old-established Black Ball Line of ships. The Gallia was not much larger than the White Star boats, but of somewhat different model—not so broad, but deeper proportionately to length—and was of 5147 tons. She had greater power, however, than all her predecessors, namely, 6300 indicated horse-power—it was 6630 indicated horse-power on trial. Although the engines were of the compound type, there were three cylinders—two low-pressure and one high-pressure—working on three cranks, set at angles of 120 deg. This arrangement was adopted in all subsequent Fairfield Atlantic liners, up to and including the Umbria and Etruria. The Arizona made several splendid voyages, reducing the record in successive passages until September, 1881, when she went out in 7 days 8 hours 34 minutes, and home in 7 days 7 hours 46 minutes. A better passage was made in August, 1884, but before this came the Alaska, the first vessel to be styled "the greyhound of the Atlantic." With her in 1881 came two other new vessels, the Cunard liner Servia from Messrs. Thomson's yard, and the City of Rome from the Barrow works, while the Alaska was a creation of Fairfield. The City of Rome was the largest vessel of her day, being 8141 tons; the Servia was of 7392 tons, and was the first Cunard vessel built of steel. The Alaska was the smallest of the three. The City of Rome was of narrow beam relative to her great length, while the Alaska was slightly finer than the Arizona.

The Alaska worked with steam at 100 lb. pressure—the others at 90 lb.—and marked a departure in respect of her great power; for, while of 3000 tons less displacement, when in seagoing trim loaded, than her competitors, she had equally, if not more, powerful engines, reaching to the hitherto unapproached proportion of 1.514 indicated horse-power per ton gross. She soon distinguished herself, meriting her title of "greyhound," for during the first season in each successive trip—the fourth to the eighth—she beat her own and all other performances. It is true the differences were but an hour or two on each run; but ere the Alaska in her turn was beaten, she reduced the outward record by 11 hours, and the homeward record by 13 hours. Her speed was $17\frac{1}{4}$ knots, and she is said to have burnt 253 tons of coal per day; but for this expenditure she steamed 430 nautical miles, making the consumption of coal about $11\frac{3}{4}$ cwt. for each mile. The Teutonic and Inman steamers cover a much greater distance in the 24 hours; but the greater ratio of power to speed counterbalances the advantage of the more economical triple compound engines, so that the coal consumption per mile is but 2 cwt. or so less than in the case of the Alaska.

The Servia in her third year made the passage in 6 days 23 hours 57 minutes, maintaining a speed of 16.7 knots throughout, but this was only second to the Alaska's performance in September, 1883. So quickly did these fast vessels follow each other from the Fairfield and Clydebank yards, that before the Alaska was more than two years on her station she was beaten by the Oregon, built on the slip from which the Alaska had been launched. Again, before the Servia was out of Messrs. Thomson's yard the Cunard Company contracted with that firm for the vessel subsequently named Aurania, and although the speed guaranteed was half a knot less than that of the Servia, she crossed the Atlantic at a slightly faster pace. But she was not destined to break the record, for at the same time Fairfield, as we have already indicated, turned out for the Guion line the Oregon, and a little later Messrs. Thomson constructed the National liner America, the first fine-ended Atlantic steamer.

The Oregon belonged practically to the same type as the Arizona and Alaska, but she had more beam relative to length than those two vessels. The America, on the other hand, was a departure, the idea being evidently to continue the development of speed without adding so much to the dimensions of the vessels, and consequently to the great expenditure involved in the working. The idea was probably similar to that which suggested the Britannic and Germanic to Sir Edward Harland; but Messrs. Thomson adopted different methods. The desiderata were to reduce displacement and the immersed area of the ship, so as to minimise resistance. It was, therefore, determined to make the ship short, but of great beam relative to length, and with a flat floor. In the Aurania this idea had been partially tried, her proportion of length to beam being only 8.24 to 1; in the America it was 8.47; whereas in the Oregon it was 9.259, and, as the sections and dimensions of notable vessels on page 465 show, this principle has been carried out in most of the large vessels excepting in the case of the Teutonic and Majestic. The vessels, indeed, seem to have grown in beam in groups, representing the competitors for each contest, and it is scarcely necessary to say they also grew correspondingly in length. Excepting the Teutonic, none of the later vessels approach a proportion of 10 ft. of length to 1 ft of beam. Indeed, relatively few exceed 9 ft. It is not, therefore, surprising that the Campania and Lucania follow generally on the lines of the recent Fairfield vessels, having a proportion of 9.23, practically the same as the Lahn, but rather less of beam than the Umbria and Etruria. The Oregon's engines, too, showed a further development, being equal to 1.678 indicated horse-power per ton, while the America had only 1.13, a difference of nearly 33 per cent., which, of course, made a material decrease in the amount of coal burned. The America made good speed, breaking the record on her first trip homewards, but was sold later to the Italian Government as a cruiser. The Oregon, on the other hand, continued to reduce the record, making it 6 days 9 hours 42 minutes outwards, and 6 days 10 hours 40 minutes homewards; but misfortune overtook her, and she therefore, like her competitor, drops from our narrative.

The Umbria and Etruria followed from the Fairfield yard for the Cunard Company, being the first vessels constructed by Sir William Pearce to the order of the company, although they latterly owned the Oregon. For five years these vessels retained supremacy on the Atlantic, although many competitors — principally German and French owned—entered the lists against them. The two resembled the Alaska and Oregon; but the inclination to increased beam, shown in the latter, was still further carried out in them, the proportion of length to beam having in these successive steamers been 10 of length to 1 of beam, 9.25 to 1, and 8.77 to 1. Fairfield has since gone back to rather less beam, notably in the new vessels, but Clydebank still stands by the great breadth, particularly in the Inman liners. The new White Star boats come nearer the proportion of the Alaska. The indicated horse-power in the Umbria and Etruria is in the proportion of 1.85 to 1 of gross tonnage. The association of these facts suggests the following particulars, which, although only prophetic in the case of the Campania, are interesting:

—	"Britannia." 1840.	"Persia." 1856.	"Gallia." 1879.	"Umbria." 1884.	"Campania." 1893.
Coal necessary to steam to New York tons	570	1400	836	1900	2900
Cargo carried ,,	224	750	1700	1000	1620
Passengers	115	250	320	1225	1700
Indicated horse-power	710	3600	5000	14,500	30,000
Pressure .. lb.	9	33	75	110	165
Coal per indicated horse-power lb.	5.1	3.8	1.9	1.9	1.5
Speed .. .. knots	8.5	13.1	15½	19	22

In 1840 the Britannia burned 2.4 tons of coal on the voyage for each ton she carried, and took over 14 days; the Persia, in 1856, burned nearly 2 tons of coal for every ton carried, crossing in about 10 days; the Gallia, in 1879, built with large cargo capacity, burned less than half a ton of coal per voyage for every ton delivered, accomplishing the voyage in about 8 days; and the Umbria in 1889 consumed 2 tons per voyage for each ton of cargo, crossing in slightly over 6 days; while the new steamers, notwithstanding that they have more economical engines, will burn as much relative to cargo as did the Umbria. The two new vessels, like the Umbria and Etruria, are distinctly for passenger trade and only carry a limited cargo, so that the result is satisfactory. For every cabin passenger carried the Britannia burned per trip 4.7 tons of coal, the Persia 5.1 tons, the Umbria 3.8 tons, but the Campania and Lucania will only burn about 2¾ tons. Moreover the latter vessels carry a large number of steerage passengers, and the last-named boats will cross in less than half the time taken by the first-named.

The Etruria and Umbria reduced the record to close upon six days—to be precise, the outward record was 6 days 1 hour 44 minutes, the mean speed being 19.3 knots, and the best day's run 501 miles, while the homeward record was 6 days 3 hours 12 minutes, the speed having been 19.1 knots, the former by the Etruria and the latter by the Umbria. More recently, both vessels have made the voyage not only with great regularity, but once or twice within the six days, the Umbria in her 82nd voyage crossing westwards in 5 days 22 hours; but the Inman vessels, which commenced the era of twin-screw steamers in 1888, and later the White Star boats, to the proportions and characteristics of which we have referred,* have since then reduced the record time on several occasions, and now the Paris holds the laurels for the outward run, the best time having been made in October, 1892. The duration of the ocean passage was on this occasion 5 days 14 hours 24 minutes,† equal to a mean speed over the distance covered (2782 miles) of 20.7 knots, the longest day's run being 530 nautical miles, or 610 land miles. The sister ship New York made the homeward passage in the shortest time on record in August, 1892, the time taken being 5 days 19 hours 57 minutes, the mean speed maintained for 2814 nautical miles having been 20.10 knots. It is therefore apparent that recent additions to the Atlantic service have in four or five years reduced the outward record of the Cunarders by nearly 12 hours (11 hours 20 minutes), but the recent run home of the Umbria in 5 days 22 hours 20 minutes makes the actual difference only 8 hours; while the homeward record has been reduced 7½ hours.

* For full descriptions of these vessels, see Engineering, vol. xlv., page 248; vol. xlvi., page 123; and vol. l., page 722.

† See Engineering, vol. liv., page 521, also pages 148, 180, 295.

THE DESIGN OF THE NEW CUNARD VESSELS.

The fact that the public expected the Cunard Company to enter the market for one or two high-speed steamers to maintain the position they have held for 50 years is but an indication of their appreciation of the spirit of progress which animates the management. That the Cunard Company would again have their new vessel from the Fairfield works was also anticipated, for not only had the Umbria and Etruria in their running borne testimony to the character of the work done at Fairfield, but there was abundant evidence to show that the establishment was advancing with the requirements of the times. Before his death in 1888 Sir William Pearce had organised a staff at the works which is actuated by that same spirit of energy and perseverance that raised the Fairfield establishment to a premier position. Sir William G. Pearce, son of the first baronet, continues to occupy his father's position as chairman of the company formed in 1886, and which in 1889 became a public limited liability company. The same geniality and confidence which characterised the father in his relation with the staff is displayed by the son, and thus the *esprit de corps* is a marked feature. Mr. Richard Barnwell, who was assumed by Sir William Pearce as a partner in 1885, continues as managing director, and the same signal success continues to be manifested. The works have been reorganised, and their producing power is enormously greater than it ever was, a fact which will be clearly shown by our narrative of the construction of the two new ships and their engines. Mr. R. Saxton White, who was installed as manager of the shipbuilding department in 1887, with a seat at the directors' board, had a training eminently fitting him for undertaking the designing and construction of these great ships, for he was engaged successively in the works of Messrs. Denny, Napier, Sir William G. Armstrong, Mitchell, and Co., and the Barrow Shipbuilding Company, being intimately associated with the designing of ships, as well as the management of the various works. Mr. Andrew Laing, the manager of the engine works, and also a director of the company, has been at Fairfield since 1877, and has taken an intimate and creditable part in many of Sir William Pearce's triumphs in marine construction. Indeed, he has since 1881—the date of his appointment as chief draughtsman—been responsible for the design of the engines of all the notable steamers built at Fairfield for the Atlantic, Eastern, and other services, and which have added so much to the renown of the firm as engineers as well as shipbuilders. With such experience, it became a relatively easy matter to determine all details of design to suit the requirements laid down by the directors of the Cunard Company, with that exactitude and method of which thorough acquaintance with shipbuilding has made them masters.

We have already incidentally mentioned the necessity for a large revenue, not only to meet interest on first cost, which is a very considerable

CONSTRUCTING THE HULL OF THE "CAMPANIA."

FIG. 7. MIDSHIP FRAMING, AS SEEN FROM BOW, DECEMBER 31, 1891.

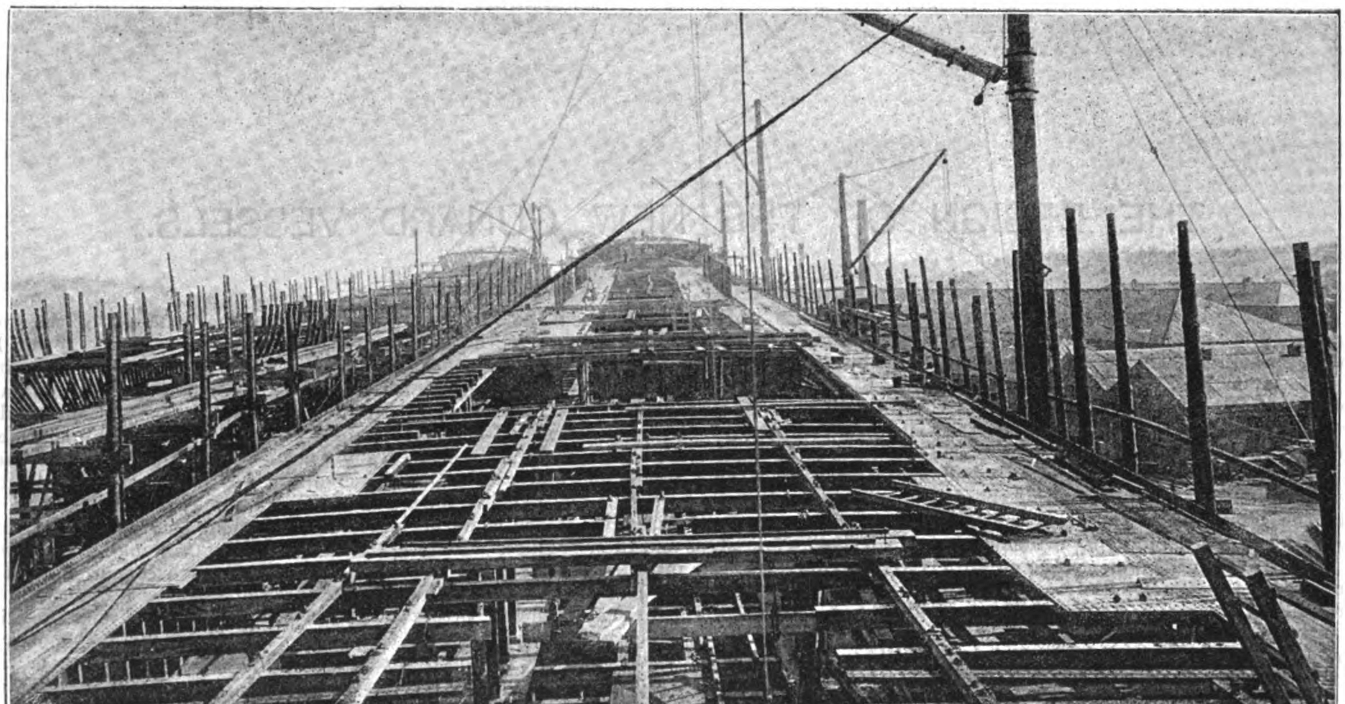


FIG. 9. GENERAL VIEW OF UPPER DECK FRAMING, LOOKING FORWARD, MARCH 31, 1892.

BUILDING THE DECK STRUCTURES ON THE "CAMPANIA."

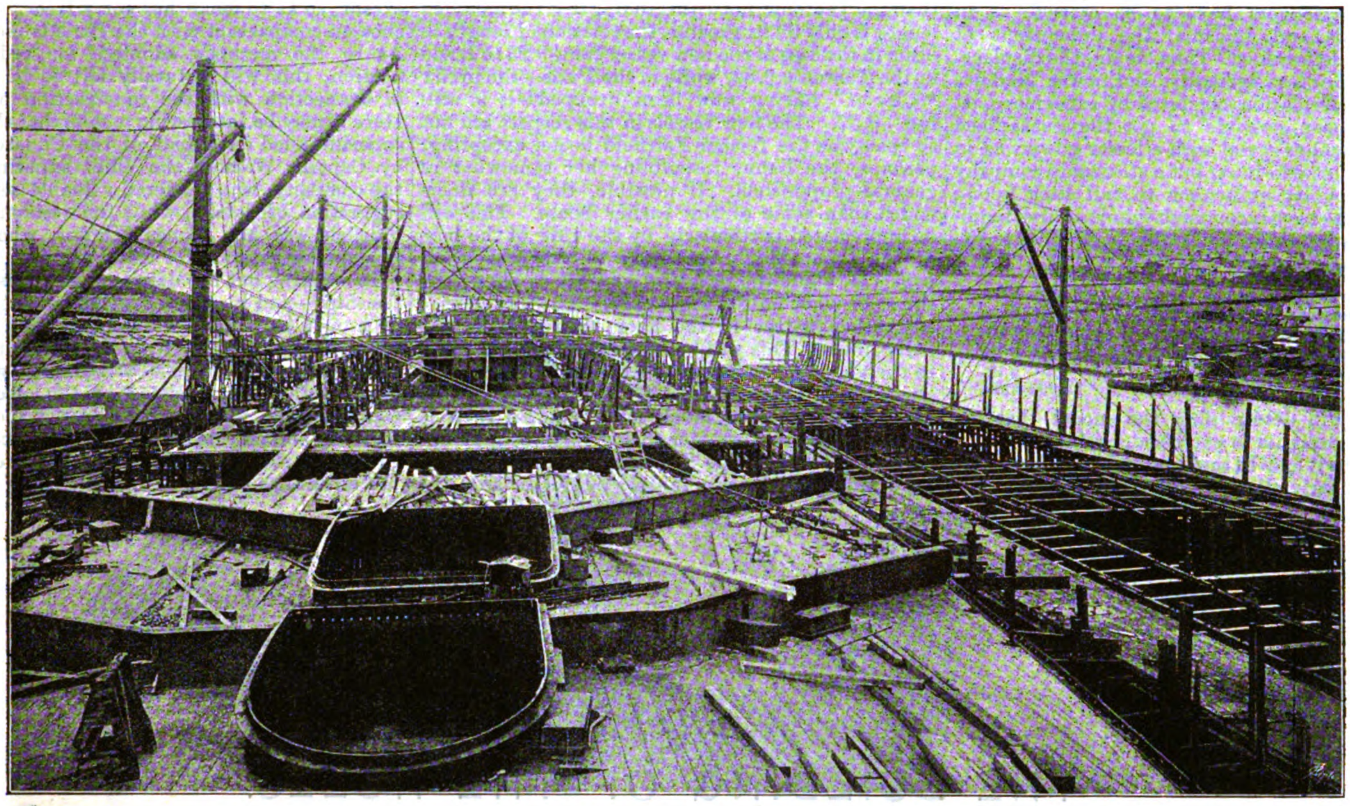


Fig. 10. View of Promenade Deck, Looking Aft, June 30, 1892.

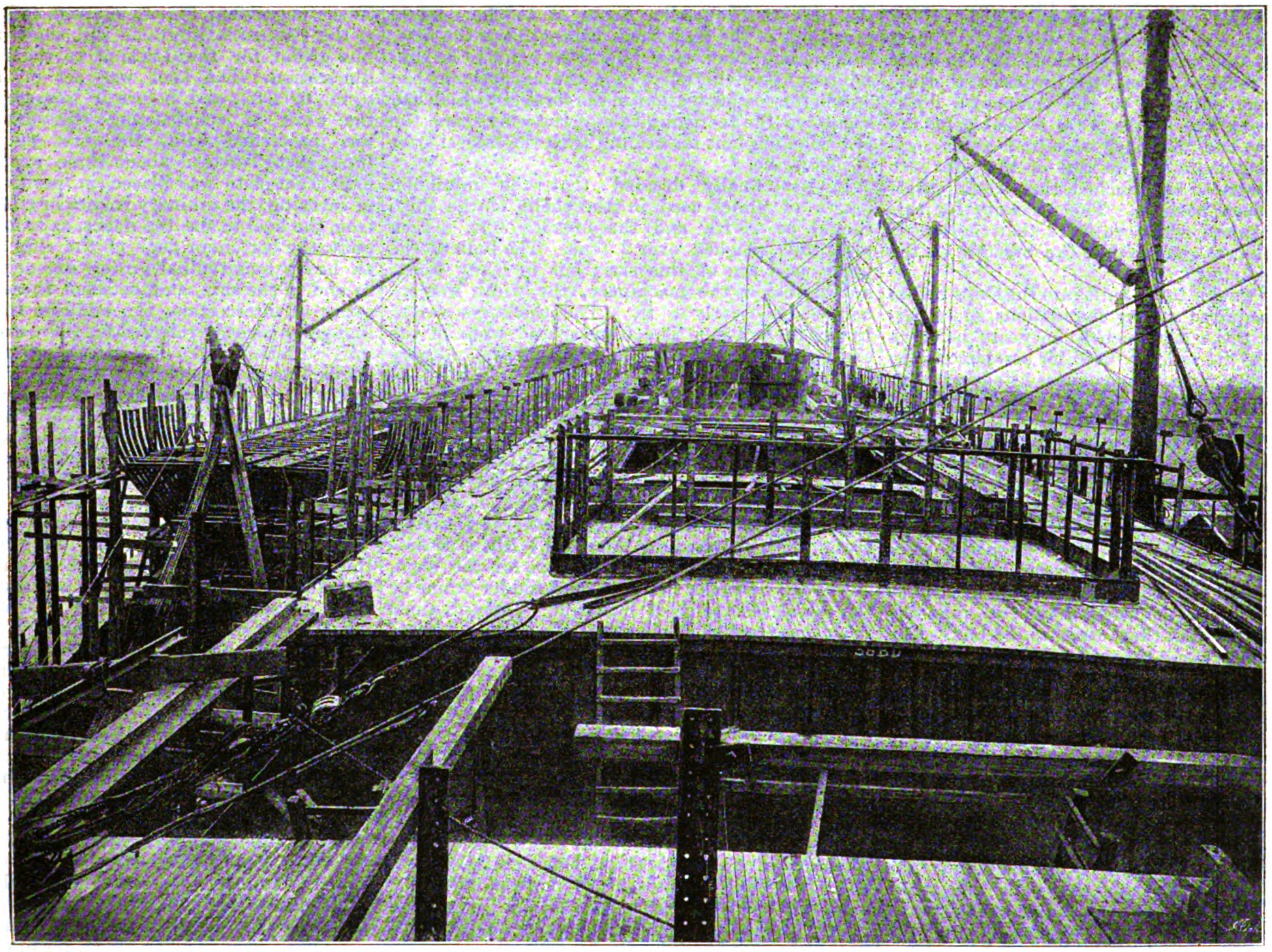


Fig. 11. View of Promenade Deck, Looking Forward, June 30, 1892.

B

amount, now totalling for the two new ships something like one and a quarter million sterling. And this necessity largely influences the size of vessels, for where 600 first, 400 second, and 700 to 1000 third class passengers have to be carried, as in the Campania and Lucania, the dimensions of the ship are determined. Thus, again, the displacement is more or less arbitrary, and power becomes a matter of calculation suggested by experience. It might have been possible to get the guaranteed speed in a smaller vessel with a lesser power, as in a cruiser or torpedo-boat, but a steamship company has not a public exchequer to fall back upon; therefore passenger accommodation is a first requisite. It was thus determined to make the dimensions as follows:

Length over all...	622 ft. 0 in.
Length between perpendiculars	600 ft. 0 in.
Breadth, extreme	65 ft. 3 in.
Depth from upper deck	41 ft. 6 in.
Depth from shade deck	59 ft. 6 in.
Tonnage, about	13,000 tons.

It is really in determining the model that the skill of the designer is exercised, rather than in size, and here it may be said that the new Cunarders differ from nearly all other vessels in many points. The midship sections of representative Atlantic liners on page 465 may enable the reader to appreciate the difference in one respect at least. In the first place, the Campania is of much greater beam than the Teutonic, notwithstanding that the moulded length is only 35 ft. greater, the relation of length to beam in the case of the new vessel being 9.23 to 1, and in the Teutonic 9.82, while in the Paris—the prefix "City of" having now been dropped—it is still less—8.37. The new vessels in this respect are not so beamy as the former Fairfield boats, excepting, perhaps, the Lahn, resembling her somewhat in general proportions. If possible, they are finer-ended than some of the earlier boats. This will be appreciated particularly by the view of the bow of the Campania, preparatory to the launch, on page 474, while the beautiful run aft is shown by the stern view on the same page. The new vessels are rather flatter in the floor than most of the early liners. This will be understood by reference to the views of the interior of the hull under construction on pages 467 and 470. The rise of floor from bilge to keel is much more gradual than in the Paris, but not greater (being only about 24 in.) than in the case of the Teutonic. The new boats have slightly more of a tumble home towards the top than the Paris. The form of hull will be seen from the small profile on page 464, showing that the stem is not quite vertical, as in the Teutonic, but has not the forefoot cut away to the same extent, so as to make her entry freer. The difference on comparison with the Paris is most marked. As to the methods adopted for reducing skin friction, this will naturally fall to be dealt with in connection with the construction of the hull. Here it may be interesting to note that the work was superintended on behalf of the Cunard Company by Captain Watson, the chief superintendent of the company, who rendered valuable service in the suggestion of details, while the resident official at Fairfield was Mr. James Hunter, who has acted in a similar capacity for many years.

In working out the details in the construction of the ships—and it must be remembered that the sum of human happiness, whether on land or on shipboard, is made up by little details being properly attended to—the officials at Fairfield were, as we have said, greatly assisted by the officials of the Cunard Company. Any one experienced in shipbuilding and marine engineering practice privileged to inspect the ships must readily see evidences of the advantage of this co-operation.

THE BUILDING OF THE HULLS.

The contract for the building of the two steamers was signed in August, 1891,* and the preliminaries necessary before the actual work of construction was commenced at once engaged the attention of the chiefs of the various departments. On account of the extreme length of the ships, it was necessary to rearrange the building berths. Formerly big ships had been constructed in the eastern part of the yard, but it was determined to construct these two leviathans on the western berths, adjoining the entrance to the company's dock. By this means five berths were available for the two steamers, and thus they were built at an angle approximating more to the line of the river into which they were to be launched, than would otherwise have been possible. The necessity for this will be recognised when we state that the length of the vessels was greater than the breadth of the river at this point.

The great weight to be built into the ships before launching required strong foundations, more particularly as there had been some years before a small dock in the vicinity, used for accommodating ships while they were having boilers fitted on board. In this dock, by the way, H.M.S. Hydra was constructed. The building berths of the two new Cunarders crossed the site of this dock, and it was considered necessary to drive piles at short intervals over the entire area to be occupied by the steamers. For the first ship part of the ground had to be removed to a depth of 7 ft. below surface, and bedded down upon the piles were laid a series of wooden logs primarily to support the ship on the keel blocks. The logs, however, were made of sufficient length to take the launching ways when they came to be laid. The provision thus made proved satisfactory, as is illustrated by the result, ascertained when the ship was completed, namely, that the variation from the straight line did not exceed ½ in.

The conditions just described were exactly reversed in preparing the site for the Lucania, for, owing to the contour of the ground, it had to be raised amidships in some cases by from 6 ft. to 7 ft. The piling and the underground cross log system of foundation were also carried out in this case, with the addition of logs placed longitudinally under the line of the keel and the launching ways. As in the first ship, the precautions proved eminently satisfactory, for notwithstanding the new ground, the variation in the keel of the completed ship was practically within the range of that of the first. As shall be shown later, pronounced success attended the launching of both vessels, due in great measure to the care taken in the making of the foundations.

While these preliminaries were being carried out, the important question arose as to the general scantlings of the steamers. Strength was the first, and, we might say, most important point to be considered. In giving effect to it, the management had reason for congratulation on the foresight which had suggested the reorganisation of the works, and the provision of plant for dealing with the largest sizes of plates, &c.

It was finally decided that the minimum length of plates used in the shells of the ships should be 25 ft., and the breadth 6 ft. Each plate thus weighed over 2 tons. The bulk of the plates used are of this size; but in many cases, notably below the machinery, the width was increased to nearly 8 ft. The thickness varied from ¾ in. to 1 in. The frames used were of the channel bar section, and the beams of the ordinary Butterley bulb section.

The contract for the supply of the whole of the steel for both vessels was placed with Messrs. P. and W. Maclellan, Limited, Glasgow, and it has been supplied by some of the best firms, the bulk of the plates having been rolled by the Consett Company, the Steel Company of Scotland, Messrs. D. Colville and Son, and other makers; the steel rivets were supplied by Messrs. William Beardmore and Co., and the steel castings for the stem, sternpost, propeller brackets, and rudder frame by the Steel Company of Scotland. Tests obtained from these castings gave splendid results. A piece of each one of the castings, 1 in. square, was, while cold, doubled upon itself by pressure without exhibiting any fracture.

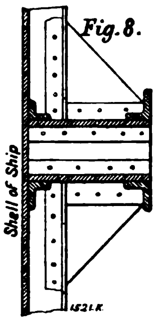
The first keel-plate of the Campania was laid on September 22, 1891, and here it may be convenient to state that we propose to describe the construction of the first vessel only, since both are alike in all respects. The time occupied in the work was remarkably short in both cases. The keel is not of the bar external form, which is now being discarded in most large ships, but is entirely internal. It is built of plates 4 ft. 6 in. deep, extending right fore and aft, and having on the upper and lower edges at either side very strong angles. The keel-plate was formed of a broad plate 54 in. by 1 in., with a doubling plate about ⅞ in. thick on the inside. These plates are connected to the bottom of the vertical internal keel-plate, and together they form the main centre-line girder of the ship.

Under the engines this girder is increased not only in strength, but in depth to about 8 ft., and forms the base for the engine seating. A reference to the engraving, Fig. 4, on page 466, of the bow of the Campania in frame will show this centre-line girder for the Lucania to the right of the illustration. The keel was set on a grade of $\frac{7}{16}$ in. to 1 ft., and before it was completely laid the work of constructing the double bottom was proceeded with, the first double bottom frame being erected about three weeks after the first keel-plate was placed in position. Instead of carrying the ordinary frames or ribs of the ship from the keel to the top decks, as is usual in small craft, the bottom or floor of the ship is supported on heavy longitudinal girders extending from end to end of the ship, and between these again run a series of intercostals. In addition to the centre-line gider already referred to, there are four built-up I girders, two about 15 ft. on either side of the centre line at the middle of the ship, and two close to the bilge, or about 30 ft. on either side of the keel, these latter forming the outer edges of the double bottom. These girders are of vertical plates with double angles like the centre one. In the intermediate spaces between the longitudinal girders are two pairs of intercostals fitted between the floor-plates, and carrying these up to their work.

As in the case of the centre-line girder, each of the other girders is of greater depth under the machinery space, extra longitudinals being also fitted in this part, to give the necessary strength for the carrying of the engines. This increase in depth will be appreciated by a reference to the keel of the Lucania, shown to the right in the engraving on page 466. The whole of the riveting within the range of this double-bottom framing was done by hydraulic machinery. The extreme depth of the girders under the machinery space involved difficulties in the carrying out of this idea, but as much importance was attached to the absolute rigidity of the construction under the engines, special appliances, involving new large riveting machines, were obtained. To insure perfect workmanship, too, the holes in all cases under the machinery space were drilled or rimered perfectly true; while the angle irons were joggled and welded, forming continuous frames. The extreme care indicated by this specially careful system of construction has doubt-

* See Engineering, vol. lii., p. 192.

less rendered the engine seat sufficiently homogeneous as to minimise the possibilities of future trouble. In view of the great power to be



Section of Orlop Deck Stringer.

developed by the engines, the importance of strength at this point cannot be overrated.

The double bottom having been sufficiently far advanced to admit of the upper frames being erected, this work was started, and here one recognises the time-honoured ribs, for the shipbuilder has been accused of taking his model from nature, the keel being the vertebræ or spine with its iron or steel ribs and skin; but the Cunard boats have, so to speak, five spines, which we have described as longitudinal girders, to which, with the intermediate intercostals, the skin or shell-plating is attached. The frames extend from a margin-plate on the outer girders to the upper deck. The frames are of channel section, and thus combine the ordinary angle and reverse frame in one section, without the necessity of joining the two separate angles together.

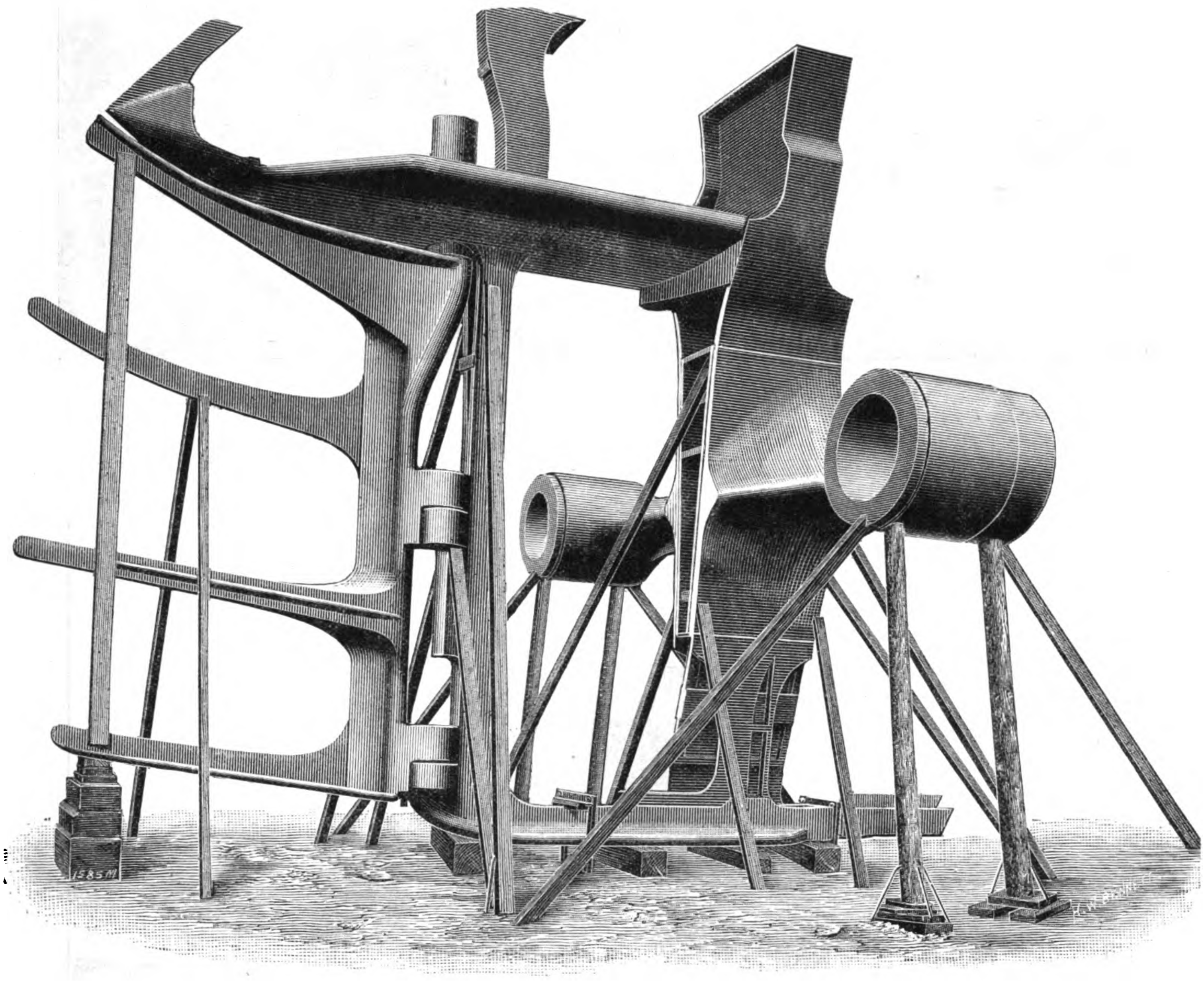


Fig. 12. Model of Stern Framing.

For the purpose of working these channel bars, the Fairfield Company had a special tool constructed which we illustrated recently (see Engineering, vol. lv., page 155). The frames are placed 30 in. apart, and extend in one length from the margin plate of the double bottom to the upper deck stringer plate, and to the poop and forecastle stringers at the ends of the ship. The maximum length of channel bar used was about 50 ft., in one continuous length. These channel frames were strengthened at intervals fore and aft the ship by solid web frames, or partial bulkheads, and these are shown clearly on the internal views of the ship in frames on page 467, which also show the inner floor of the double bottom. These web frames are built up of plates with double angles on the inside edge, and connected by double angles to each of the deck stringers. They vary from 2 ft. to 3 ft. in breadth. In the machinery spaces, again, these web frames are greatly increased in number, the channel frames being also of heavier section in the wake of the engines.

Upon each alternate channel frame were fastened the Butterley bulb beams carrying the deck platforms. These beams are of the largest section that has yet been rolled for this purpose. The orlop, lower, main, and upper decks were constructed with the main scantlings, whilst above these the scantlings tapered on the promenade, forecastle, and poop decks, and the shade or boat deck. In the case of the orlop deck beams it was considered necessary, on account of the space for the boilers and machinery, to make the stringers of special form to maintain the stiffness of the structure. The plan adopted was to use an open girder instead of the old-fashioned box girder, which, being permanently closed, prevents inspection or re-painting. The open girders are built up with double stringers having brackets above and below, with diaphragm plates between, and strong face angles on the inner edge, as shown by Fig. 8 annexed. On the lower, main, and upper decks the stringer plates take the ordinary form, with the exception that the connection to the shell plate is made by double angles instead of single angles as is usual.

This work of erecting the frames, and the fitting of the deck beams in place, was completed by December 30, 1891, the last upper frame being erected on that day, so that the time taken from starting the keel to completing the framing was 85 working days only. The condition of the vessels at the close of 1891 is shown in the four engravings on pages 466, 467, and 470, prepared from photographs then taken. And here it may be stated that all our illustrations of the new vessels and of the propelling engines have, with the exception of that showing the Campania completed and ready for trial, been prepared from excellent photographs taken by Messrs. Annan, of Glasgow.

The illustration on page 466 shows an external view of the bow in frame, and from this one can realise the great height of the vessel. The three views of the interior on pages 467 and 470 show the framing and the inner floor of the double bottom, with some of the deck beams in position. The enormous size of the vessel may be measured by the great width, while the distant perspective affords evidence of length, and yet the view looking forward indicates even thus early that the ship is very finely modelled. Again, the flat floor—for the rise from keel to bilge is only 2 ft.—indicates every prospect of a steady sea-going craft.

On resumption of work after the New Year holidays in 1892, preparations were made for plating the ship, and on January 21 the first shell-plate

THE "CAMPANIA" BEFORE THE LAUNCH.

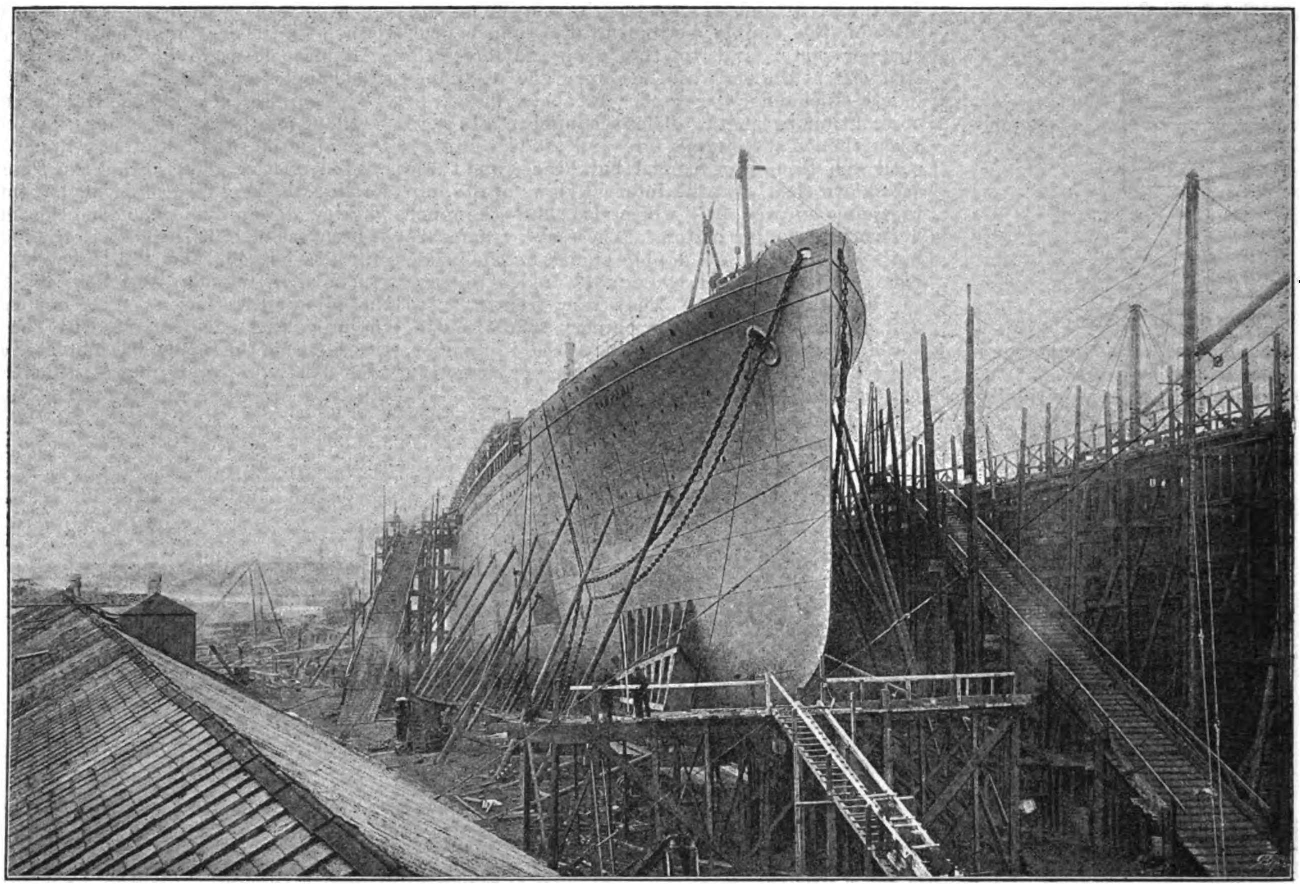


FIG. 13. BOW VIEW BEFORE THE LAUNCH, SEPTEMBER 8, 1892.

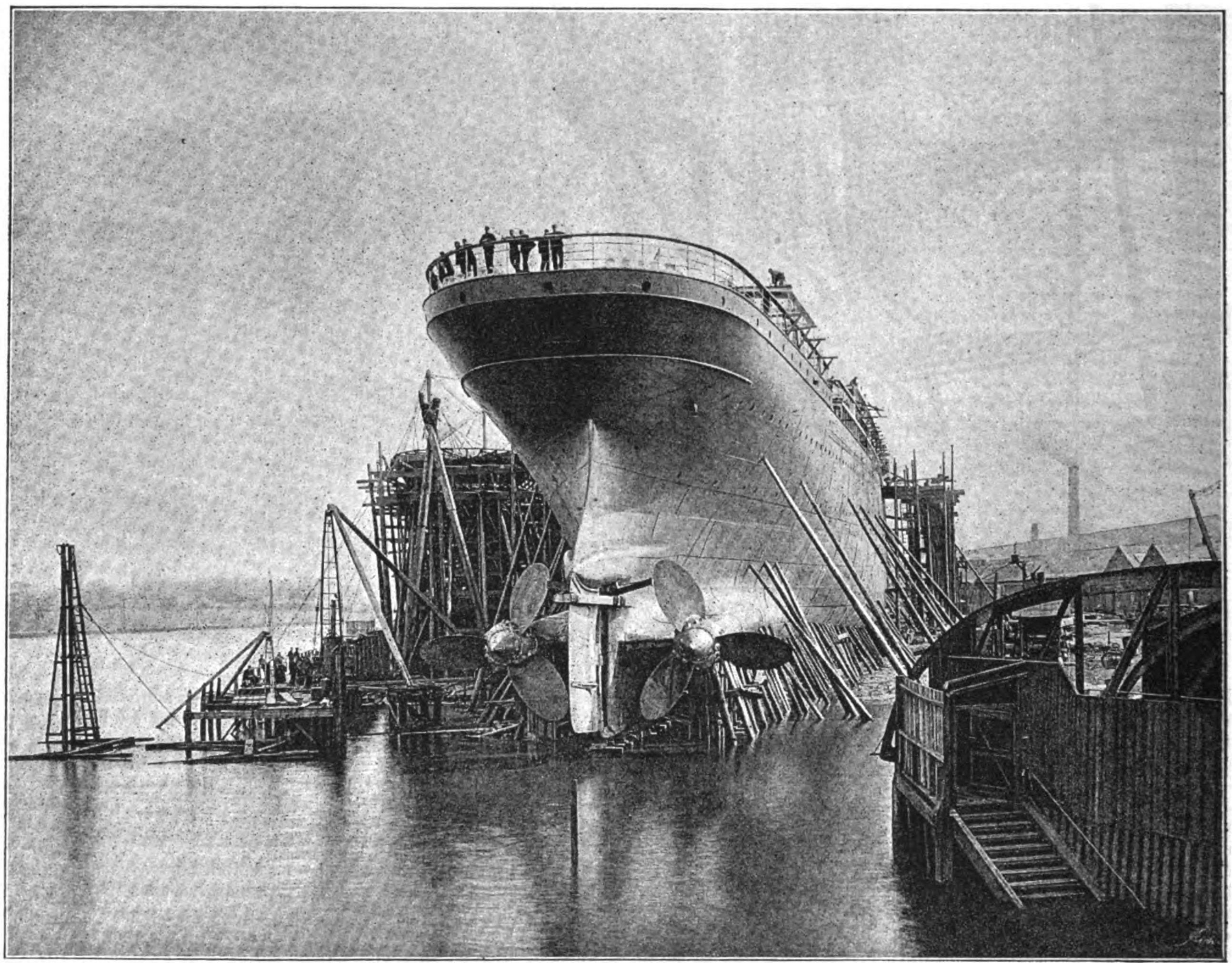


FIG. 14. STERN VIEW BEFORE THE LAUNCH, SEPTEMBER 8, 1892.

THE LAUNCHING OF THE "CAMPANIA."

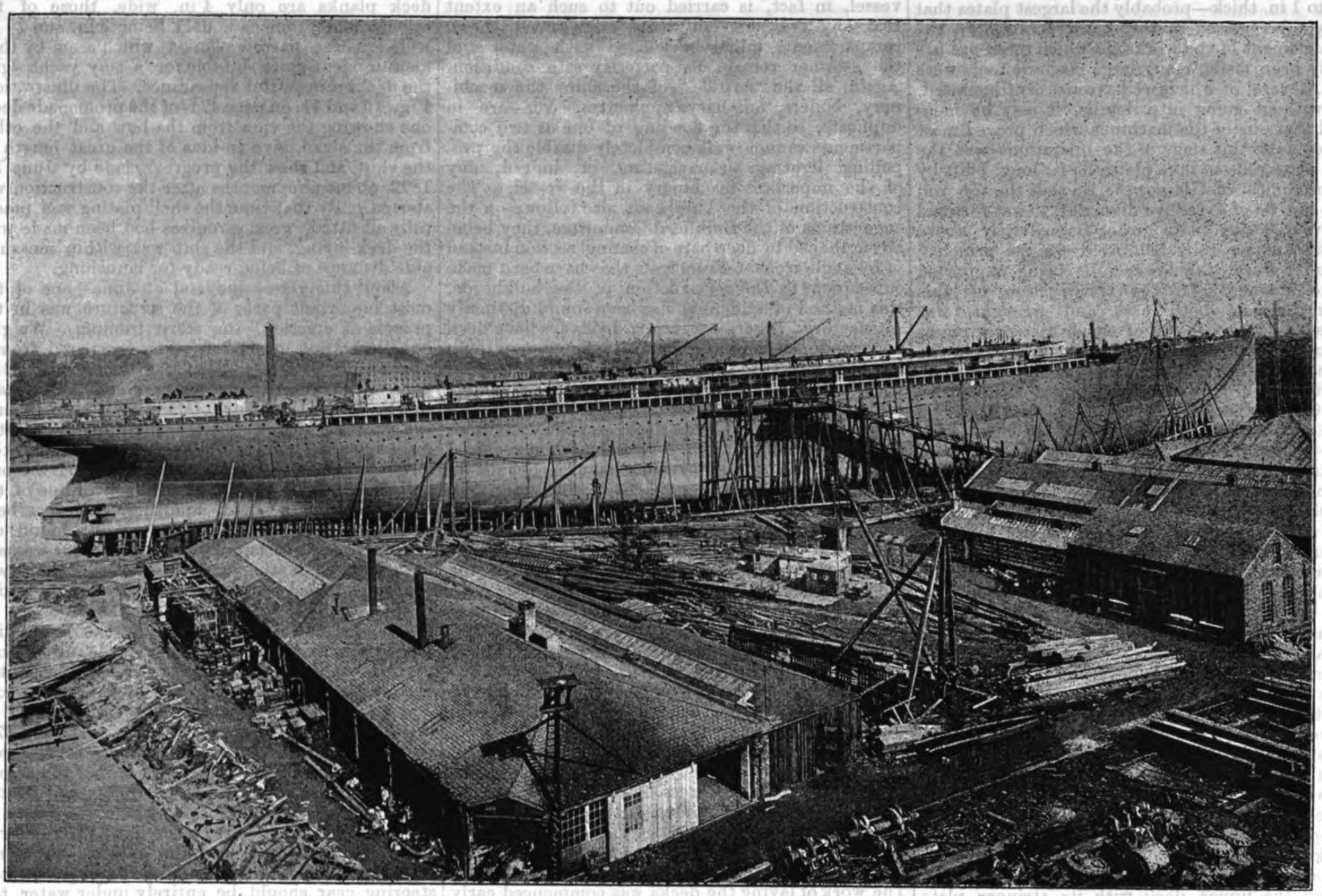


FIG. 15. VIEW OF SHIP BEFORE THE LAUNCH, SEPTEMBER 8, 1892.

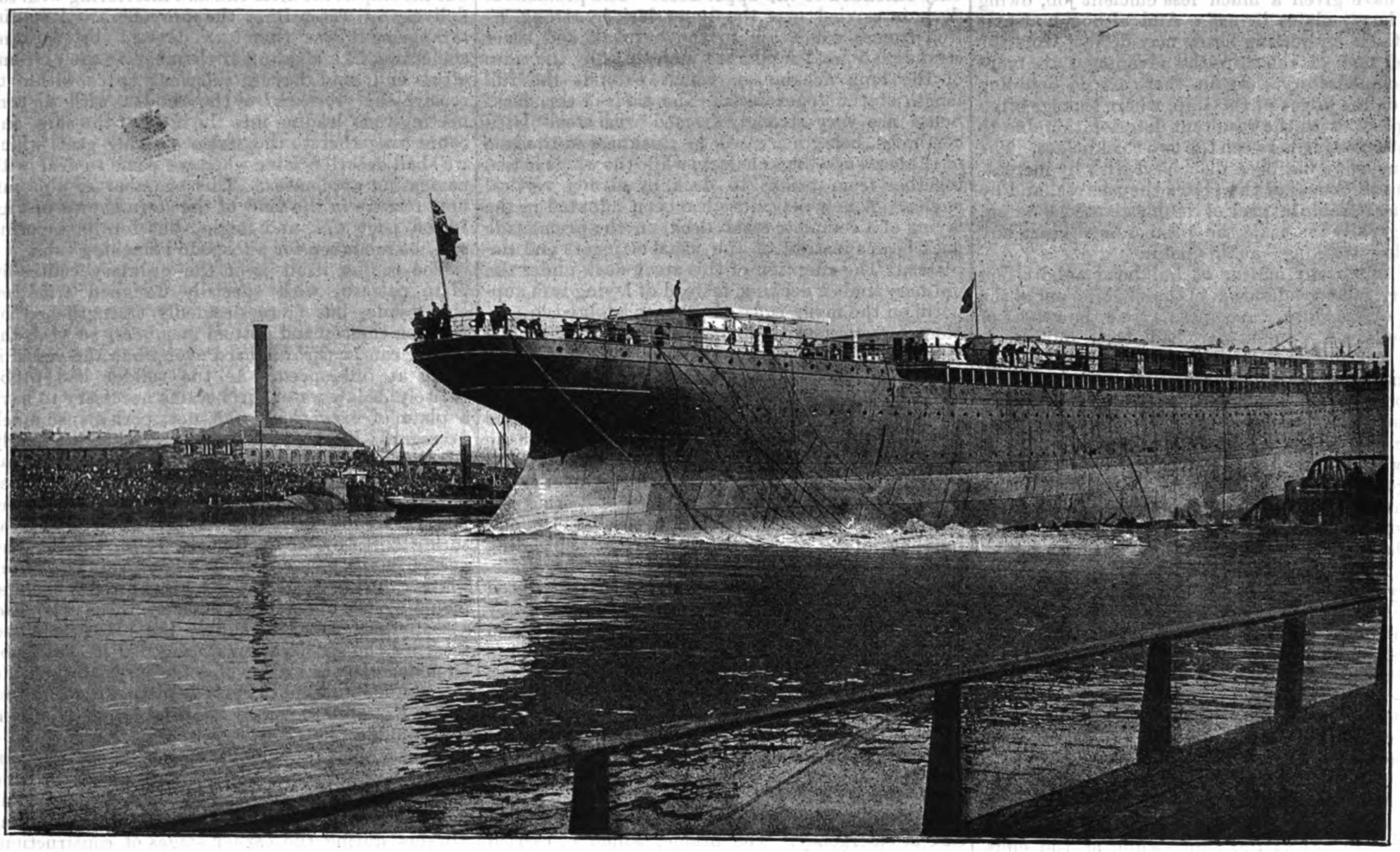


FIG. 16. VIEW OF VESSEL TAKEN DURING THE LAUNCH, SEPTEMBER 8, 1892.

was fitted in position. As we have already indicated, the normal size adopted in the construction of the ship was 25 ft. long by 6 ft. wide by from ⅞ in. to 1 in. thick—probably the largest plates that have yet been used in ship construction. In the earrangement of the works, to which reference has already been made, many large machine tools were added, several of which we have already illustrated, and, without going into details, it may be mentioned that one of the machines which proved most serviceable at this stage of the operations was the set of plate rolls to take plates 35 ft. long, built by Messrs. Smith, of Glasgow.* So that the top roll might not be of excessive diameter, it was fortified by a very heavy plate girder immediately above it, with quarter rolls holding down the principal roll to its work, the lower rolls being supported in like manner. In the construction of this machine, steel, both cast and wrought, was adopted, to the exclusion of either cast or wrought iron, not only in the rollers themselves, but in the framing and gear. Other large machines include punching machines by Messrs. James Bennie and Sons, Glasgow, capable of taking plates 32 ft. by 7 ft., and punching 1½-in. holes through 1½-in. plates; special scarfing machines by Messrs. Shanks, of Johnstone; countersinking, planing, flanging machines, and other tools for dealing with plates of the dimensions just given. Of some of the special machines here referred to, we hope on a future occasion to give detailed descriptions, including also an account of the special hydraulic riveting plant supplied by Mr. R. H. Tweddell.

The plating of the ship is arranged on the overlap system from the keel strake up to the underside of the main deck sheer strake—a system of plating first inaugurated, we believe, in smaller cargo vessels on the north-east coast, but since adopted in all types of steamers as being a most suitable butt connection. The butts of the upper and main sheer strakes and the strake between are connected by double butt straps—inside and out. In connection with this we may note the somewhat new feature indicated by the round-headed rivets along the upper edge of the sheer strake as evidence of a marked advance in the structural connections of large ships—namely, that the whole connection between the upper deck with its stringer plate and heavy deck plating is fixed to the sheer strake by strong angles riveted together in this case by hydraulic machinery instead of by hand, which would have given a much less efficient job, owing to the heavy plates in use. And although at first sight these projecting heads may detract from the graceful lines of the ship, the advantages are more than compensatory. Again, there are no doubling plates on the bilges of the ship, where leakage often takes place, with the resultant deterioration due to the water getting between the two thicknesses. The doubling plate has been dispensed with by increasing the thickness of the plates themselves, and by adopting a treble instead of double-riveted landing, which greatly increases the protection against any possible "working" at this point.

The important matter of bulkhead subdivision had very full consideration in the working out of the design of the ships. About this time the report of the Bulkhead Committee† had been published, and it was deemed advisable to fulfil all the suggestions made by the Committee as far as they were practicable. The subdivision is by thwartship bulkheads only, and of these there are eighteen. Centre-line bulkheads have not been adopted, as they would have interfered seriously with the arrangement of the boilers, and would have given no compensating advantage, for in the case of a ship divided by a centre-line bulkhead, the flooding of a large compartment, say on the port side, as the result of an accident would give the ship a heavy list, which is itself a danger, and would probably necessitate the filling of a corresponding compartment on the starboard side, so that the immersion of the ship would not be less than with a filled compartment the full width of the ship. The engine-room, it is true, is divided by a centre-line water-tight bulkhead having large doors on the lower platforms for the efficient control of the engines. The Fairfield Company have rather shortened the length of the compartments between the thwartship bulkheads. The maximum length is about 65 ft. amidships—or only about 10 per cent. of the total length of the ship—while at the ends, more especially forward, where the risk from collision is greatest, the distance between bulkheads is considerably reduced. The subdivision of the vessel, in fact, is carried out to such an extent that any two, and in many cases even three, compartments might be flooded with water and the steamer remain in perfectly safe condition. Again, all the "vitals" of the ship—the machinery, boilers, auxiliary appliances, &c.—are in duplicate, so that the flooding of one or two compartments cannot well completely disable the propelling, lighting, or navigating, or, indeed, any of the important machinery in the vessel. The construction of the bulkheads also follows on the suggestions of the Bulkhead Committee, they being strengthened by deep bars of channel section instead of by angle irons. From tests that have been made subsequent to the construction of the bulkheads, this method of stiffening has been found distinctly satisfactory. Where necessary, doorways have been made under the lower deck; but the number of these has been minimised, and they are in all cases fitted with water-tight doors. In the more vulnerable parts of the ship, however, these are dispensed with altogether below the main deck. As the vessels are classed as armed cruisers for service when required by the British Admiralty, they have been built to comply with their conditions as to strength, buoyancy under disastrous conditions, and coal endurance. They have, therefore, water-tight coal bunkers at the side of and over the top of the boiler compartments, forming a protection against the modern quick-firing gun.

The decks were all first laid with steel plating. To compensate for the large openings rendered necessary for boiler hatchways, and particularly for engine hatchways, special methods were adopted for supporting the deck, on the same principle as already described in connection with the orlop deck stringers.

The view (Fig. 9) of the upper deck framing, looking forward, which we give on page 470, shows the great progress made by the end of March 1892, with the construction of the ship. By this date the shell plating was far advanced, although, owing to a strike of six weeks' duration, it was not completed until the beginning of July. The work of laying the decks was commenced early in May, and by that time also the superstructure of the ship was commenced—that is to say, the decks, &c., above the moulded structure, which only extended to the upper deck. The promenade deck is carried over the upper deck by strong T-iron frames connected to the bulwark and sheer strake plate, and supported amidships by the sides of the long deckhouse, which extends the full length of the upper deck. The sides of this deckhouse are very strongly framed with steel-plated combings, being increased in thickness in the line of the large openings on deck, while the whole is tied together from beams to deck by strong vertical angles. A new departure has been adopted in the laying of a complete steel deck on the promenade deck beams instead of the usual stringers and tie-plates. The adoption of this steel deck under the ordinary timber decking, instead of laying iron supports on the many isolated parts as adopted in previous practice, will obviate the chances of the "working" of this superstructure, which in many vessels is far from comforting, especially if the timid passenger, while lying in his berth, hears the creaking and racking of his cabin amidst the tempest blowing outside. Upon the promenade deck is a second range of deckhouses, containing all the principal public rooms, and having over it the shade deck, which, while forming a permanent awning, serves as a platform for the lifeboats and for the support of ventilators and the ventilating engines and fans in connection with the stokehold. A special feature has been introduced in the construction of this shade deck, whereby the roofs of the public rooms have been raised 2 ft. or 3 ft. above the ordinary level in a slight curve, forming what may be termed omnibus roofs. By this means a height of something like 12 ft. is obtained in the public rooms, which enhances the appearance and improves the ventilation of these apartments. On the shade deck there is a deckhouse for the accommodation of the navigating officers, who are all located in the immediate vicinity of the main bridge, and at call in case of emergency. The bridge, which is carried on T-iron frames, extends the full width of the ship, and is 60 ft. above the water-line.

While the work of erecting the superstructure was in progress, the laying of the wooden decks was proceeding. Those forming weather decks are of teak, the remainder being of yellow pine. The deck planks are only 4 in. wide, those of the saloons and promenade deck being 3 in. and 2¾ in. wide. These narrow planks, which seem by their measurement more suitable for a tiny yacht, give the decks a beautiful appearance. The illustrations Figs. 10 and 11, on page 471, of the promenade deck, one showing the view from the bow and the other from the stern, give an idea of the great length of the ship, and show the progress made by June 30, 1892, about nine months after the construction was started. By that time the shell-plating was practically all fitted, great progress had been made with the deck-laying, and the ship was within measureable distance of being ready for launching.

About this time—the end of June—one of the most important parts of the structure was in the process of erection—the stern framing. We give an illustration of the framing (prepared from a photograph of the wooden pattern) in Fig. 12 on page 473. The frame is of cast steel, and made by the Steel Company of Scotland, who deserve the greatest credit for the high quality of the material. In arranging the propeller brackets it was decided, with the view of bringing the propellers as near as possible to the centre line of the ship, to have a small aperture. It has been suggested that the intention was, if found desirable, to use overlapping propellers; but we have authority for stating that no such intention was ever entertained by those responsible for the design of the Campania and Lucania.

The propellers are placed in the same line athwartship. The sternpost is made up of four parts. The propeller brackets are machine-jointed on to each side of the forward sternpost and connected thereto. The stern tubes are, as will be seen from Figs. 12 and 14, on pages 473 and 474, contained within the bossing, leaving them accessible for inspection at all times, whether the ship is at sea or in harbour. This is done by curving the shell plates and frames to suit the projection of the stern tube. The arrangement of the rudder is somewhat novel, although embodying no essentially new departure. In determining that the steering gear should be entirely under water, the better to conform to Admiralty requirements, it was felt that some concession should be made to ordinary appearance, without unnecessarily filling out the ship at the after end and interfering with the delivery of water from the propellers. A special arrangement was therefore devised by forming something like an annular chamber at the extreme after end, and having sufficient space within to receive the crosshead of the rudder, with its connecting-rods' leading into the body of the ship, and connecting thereto the steam steering gear, which we shall describe later when we come to deal with navigating appliances. This chamber is a prominent feature in the view of the stern shown in Fig. 14, on page 474, and might, but for its tapering end, be mistaken for a torpedo launching tube.

The rudder itself is of the ordinary centre-fin plate pattern, with specially designed arms on either side, but more decidedly strengthened by webs on the top and bottom members, so that the rudder can be thrown hard over when the vessel is going at full speed. As the rudder had to be entirely below water, it became necessary to have a plate of exceptional size, not, perhaps, so much as regards length as to width. On trying nearly all the principal makers in this country it was stated to be impracticable to get such a wide plate; but subsequently the Fairfield Company got it from Messrs. Krupp, of Essen, the plate delivered measuring 22 ft. by 11 ft. 6 in. by 1¼ in. thick. The necessity for going to a foreign firm was afterwards called in question by several English makers, including, we understand, some of those who had actually been asked to supply the plate, and had returned the specification stating that it could not be done. It was matter of some surprise that the German maker could supply a plate the rolling of which British millowners when asked did not then care to undertake.

Remarkable as was the speed of construction of these vessels, it is right to state that the time would have been considerably reduced but for unfortunate disputes and strikes, first with the ironworkers during the earlier stages of construction, extending to about six weeks, and latterly, when the first vessel was within a few weeks of completion by the joiners and other associated workers

* See Engineering, vol. l., pages 599 and 687
† See Engineering, vol. lii, page 392.

going out on strike for about two months against a reduction of wages, which reduction was accepted without any stoppage by the other important trades engaged in the shipbuilding industry. But for these unfortunate labour troubles, extending in the aggregate to over three months, the two ships would have been built in much less time, and would therefore have reflected the greater credit on the Clyde for rapidity in production. In view of American competition in the near future, there would have been the greater gain, a circumstance which the workmen would have done well to remember. The interest of all is to get work, and this can only be accomplished at any period, but especially at the present time, by amicable relationship being maintained, and mutual concessions being made when necessity demands.

THE LAUNCHING OF THE "CAMPANIA" AND "LUCANIA."

THE Campania was launched on September 8, 1892, and the engravings Figs. 13, 14, and 15, on pages 474 and 475, show the vessel prior to the launch, while Fig. 16, on the last-named page, shows the ship taking the water. The Lucania was launched on February 2, 1893. Unqualified success attended both launches, as a result of the most complete and thoughtful preparations made by Mr. White, who was responsible for the floating as well as for the designing and building of the vessels. As we have already mentioned incidentally, in dealing with the construction of the hull, the keel was laid at a declination of about seven-sixteenths of an inch to the foot of length, being supported on cross logs, which also took the launching way supports, thus forming one foundation for the transfer of the weights from the keel blocks to the launching blocks. That this was completely successful was clearly shown by the ease with which the keel blocks were "split" or rammed out on the morning of the launch.

The standing and sliding ways were of the ordinary flat form, with the usual "riband" on the inner side of the sliding way to prevent the ways spreading, and forming the "flange" of the ways or guide rail. In many yards this "riband" is on the outer side of the fixed or standing way projecting above, but the advantages are all with the system adopted at Fairfield, as a greater protection is afforded against any foreign body being inserted in the ways. It also acts as a "cover" to the ways where they are least seen, and there is the further advantage that, being fitted on the sliding way, it is necessarily very much shorter than it would be if fitted to the standing ways. The ways, both standing and sliding, were of English oak, about 4 ft. wide by 12 in. thick, scarphed and tabled together in the usual manner when the necessary breadth and area cannot be got with one log. The ways were set under the ship at, as we have said, about $\frac{7}{8}$ in. to the foot declivity, with a general "camber" and increasing declivity, amounting at the extreme end of the ways to about one inch to the foot of length. This decision as to camber, of the most vital importance to insure a successful launch, was pre-eminently proved to be a right one. The vessel appeared to be, and was, indeed, under perfect control up to the moment of launching, without any sign of "taking charge" or the ominous cracking, so frequently a source of anxiety to the uninitiated, and yet the declivity fixed upon was such that immediately the last dog-shores were knocked out there was no stoppage of the vessel for the slightest period of time. She at once started on her career, slowly at first and majestically, but not the less surely, and, gaining speed every second, was safely afloat on the Clyde, amid the plaudits of the assembled hundred thousand interested spectators, within about one minute from the time of starting.

The length of fixed ways over which the vessel had to travel was about 650 ft. in the case of the Campania, and about 700 ft. in that of the Lucania. The maximum speed of the vessel during the launch was about 10 to 12 knots, this speed being attained when the vessel had travelled about three-fourths of the length. So far as we can recall, this is about the maximum speed ever recorded of a vessel during her launch, and was due, of course to the great length of the vessel and the length of travel on the ways. The length of sliding ways was about 550 ft., and the width about 4 ft. This exceptionally long length was possible first by reason of the special arrangement of the stern tube bossing for carrying the shaft, which, extending as it did practically to the after end of the ship, as shown in Fig. 15, on page 475, gave a good abutment to the after poppets without making them of an undue height. Although it was not, perhaps, absolutely necessary to extend them so far aft, still the advantage obtained by their adoption in carrying up the long thin after end of the ship, with its attendant heavy weight of propellers and shafting, &c., was such as to fully justify the extension of them to the length decided upon. Not only was the local support gained very great, but the extra "area of way" secured reduced the pressure or weight per square foot to the very ordinary proportion of about 2 tons to the square foot, thus providing in the most effective way against any possible firing of the ways during the launch, and consequent danger of a "stick."

In like manner, for the same reasons, the sliding ways were carried well forward to the stem, the poppets and making up being specially arranged so that, no matter what weight was brought to bear on them, the tendency should be to "lock" or brace them up to their work instead of allowing them, when the weights came on, to fly out at the head and become practically useless, as is not unusual in such fine-lined ships.

To provide against this, the usual practice in the dockyard or naval service in the case of the fine-lined cruisers or battleships is to secure the heads of the poppets by riveting or bolting strong angle-iron frames on to the ship's side, to form the necessary abutments. This system was not admissible in this case, as it was the intention of the builder to run, at any rate, preliminary full speed trials before the ships could be docked at Liverpool, and there was no dock on the Clyde large enough to take in these vessels to allow of these angles being taken off after launching.* The system adopted, therefore, in the case of the Lucania and Campania, was a most ingenious arrangement of dovetailing, notching, and wedging, not only the upmaking, but also the poppets, which, instead of standing "plumb" as usual, were thrown in at the head, a most unusual and, at first sight, objectionable arrangement; but which, taken in conjunction with the devices we have already mentioned, together with others specially designed for the forward poppets, achieved the desired result with the most conspicuous success. Although under the great strain necessarily brought to bear upon the forward upmaking when the vessel was lifting aft during the launch, the most careful observation showed that these all stood up to their work without the slightest sign of splitting out. The whole design of the details of construction of the launching ways was interesting in the extreme to the initiated, and in no part more so than in these special self-locking arrangements to which we have referred.

The ways having been prepared, the important question of "lubricant" came to be considered, and it was determined to adopt the old-fashioned but reliable Russian tallow of the first quality, instead of the various "patented" launching lubricants, of which there are not a few. The thorough success of the launch certainly proves the wisdom of the decision.

In connection with the launch, we would point out—what does not, perhaps, strike the casual observer as he sees the ship sliding down the ways into the water—the important vertical drop through which the ship passes during her progress, in the case we are dealing with, amounting to about 35 ft. This, taken in conjunction with the launching weight of the vessel, will give an idea of the energy stored up, less the friction, and such energy has to be afterwards controlled by the drags, a description of which shall conclude our remarks on the launching of the Campania. In deciding to adopt large weights or bundles of chain cable ranged at suitable distances on the ground, to the exclusion of anchors buried in the ground, or other solid fixed weights, to control the immense energy stored up in the vessel during the launch, considerable courage was shown, as at first sight the drags certainly appeared, even to the initiated, to afford a very small power—they weighing about 500 tons — to control such a ship leaving the ways at a speed of about 10 to 12 knots, and to stop her within a distance of about 100 ft., this being the estimated travel allowed. But by using this system of drag many advantages presented themselves during the launch. First of all the weight is "cushioned" on to the cables, relieving them of all shock, with the subsequent wild flying of the cables into the air, which occurs when any "solid" weight or sudden strain is brought on to them, resulting, as is frequently the case, in a broken cable, in which event the whole value of the individual drag is lost. The cushioning of the strain is the result of the load being brought on very gradually, yet at the same time in successive stages within a very few seconds of each other. At the first tension of the cable, the component parts of the first pile or bundle of chain adjust themselves together; and before this pile is fairly in motion, the same thing goes on with the second and then with a third pile in quick succession, until the whole drag is in motion over the soft earth. Each link on the ground tier forms its own path, and the frictional resistance, together with the weight of the various piles constituting the entire set, is sufficient to bring the vessel to a complete standstill within the estimated distance without the breaking of the proverbial spunyarn. In the case of the Campania the launching cables numbered eight in all, four passing through the hawse pipes and four being connected to the ship's side by means of heavy forged plates. They were each and all so arranged as to come in tension not before, but immediately on the vessel leaving the ways. The maximum length of drag was about 75 ft., which shows the accuracy with which the calculations were made to insure that the length should not exceed 100 ft.

Every detail of the launches, indeed, had been worked out with most scrupulous care. The length and weight of the ship enormously increased the responsibilities, and these were still further augmented by the narrowness of the river into which the vessel was launched, its width being only about two-thirds the length of the ship. Yet everything worked so satisfactorily that each vessel was moored in the Fairfield Dock, which runs at right angles to the river, within about 40 minutes of the launch.

THE NAMING OF THE VESSELS.

The first of the two vessels launched, the Campania, was most appropriately released from her

* It may be stated, in fairness to the Clyde Trustees, that at present a new graving dock is being constructed which will take in even a much larger steamer than the Campania or Lucania. The width at bottom will be 74 ft., and at top 115 ft., while at the entrance the width will be 85 ft., and the depth on centre of sill 26 ft. The length will be 700 ft. The method of construction of the new dock is on triune cylinders, introduced by the Clyde Trust engineer, Mr. James Deas, who has prepared the drawings and is carrying out the works.

THE ENGINES OF THE "LUCANIA."

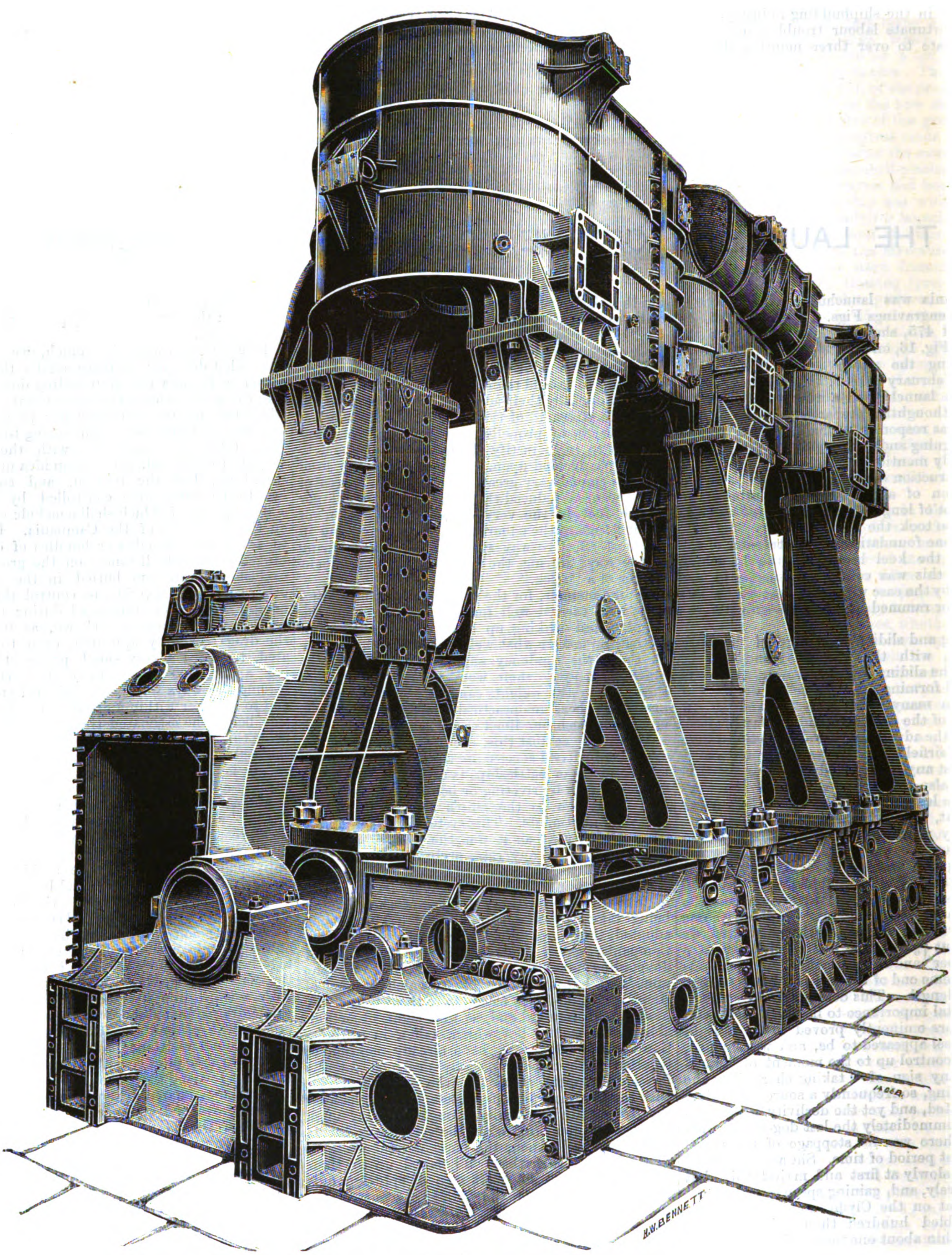


FIG. 23. ONE SET OF ENGINES OF S.S. "LUCANIA" IN COURSE OF ERECTION, JUNE 30, 1892.

position on the ways and named by Lady Burns, of Castle Wemyss, while the launch of the second vessel, the Lucania, was honoured by the presence in a similar capacity of the Countess of Eglinton. Naturally the names to be given to the two vessels excited discussion on the part of the general public very shortly after the construction was commenced, and the Cunard Company were not without suggestions on the subject. Amongst the names mentioned were the Britannia, Scotia, Caledonia, and Columbia. No doubt the directors would have gladly met the desire of the public in this as in other matters, particularly in the case of the latter name, in view of the consideration which suggested it, and which so largely occupies attention at the present time in Europe as well as North America. There is, however, an unwritten code of laws which regulates such matters—as, for instance, the colour of ships' funnels, which in the case of the Cunard is red with a black top; the lights shown at night, usually three of different colours burned to show passing ships to which line they respectively belong; companies' flags; and the names of the ships. Each company adopts a distinctive class. Thus the names of all Cunarders end in "ia;" those of White Star boats in "ic;" all Inman boats had "cities" for their titles; all North German Lloyd's steamers "rivers," and so with the vessels of different lines frequenting the same ocean tracks. It is therefore easy to recognise all ships. The objection to the very appropriate suggestion of calling one of the steamers Columbia was the existence of a Hamburg-American liner of

THE ENGINES OF THE "LUCANIA."

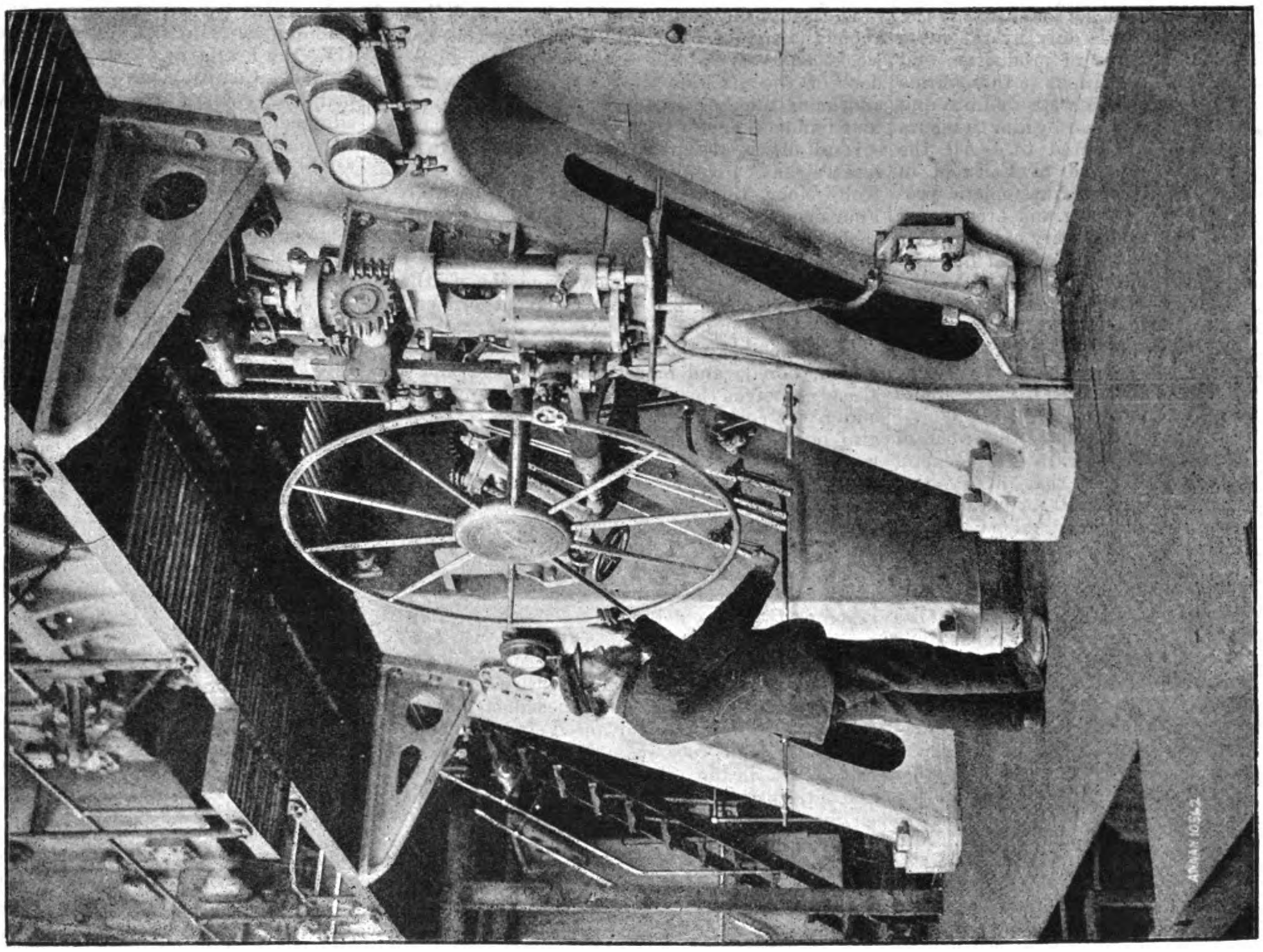


Fig. 24. Starting Gear, with Small Engine for Working Main Stop Valve.

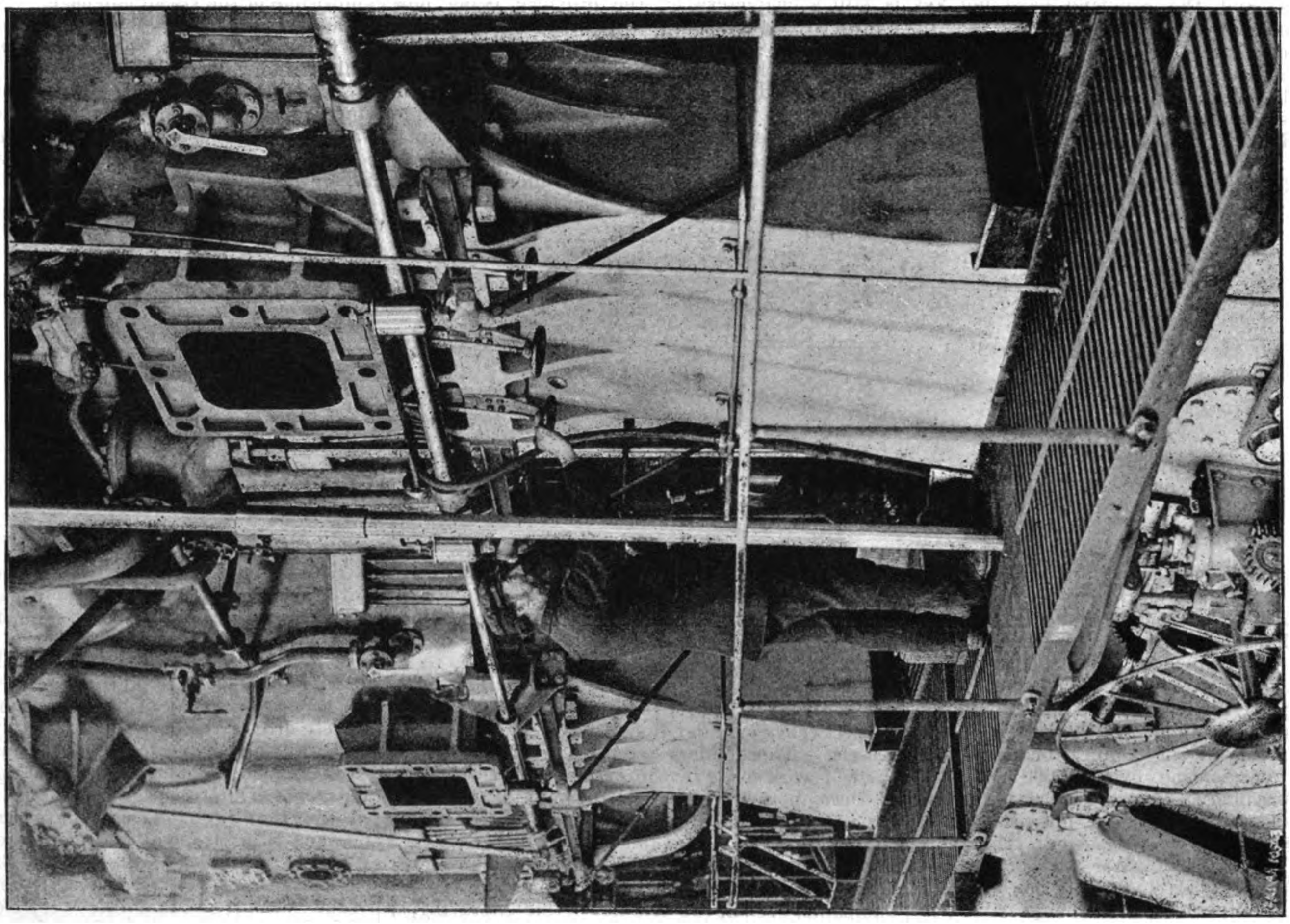


Fig. 25. Middle Platform for Access to Guides and Crossheads.

that name; while other titles suggested are in use on the Anchor Line or had already been used for Cunard ships, and the company have not yet adopted a name a second time. As in the case of the Umbria and Etruria, the Cunard directors have gone to ancient Italy for the names of the new additions to their fleet.

Campania is a felicitous name, promising much to the shareholders, for that ancient province on the west coast of Italy was distinctive from all other provinces before the Christian era for its fertility, being one of the most productive plains in the world, yielding an extraordinary abundance of corn, wine, and oil. The geniality of the climate is still a characteristic, the province being now known as the Campania di Roma, and including Naples. By Greek and Roman writers it is celebrated for its landscapes and its harbours, as well as for its soft and genial climate. In the history of the province from the fourth century wars occupy a large place, the Greeks being conquered by Etruscans, who succumbed in turn to the hardy Samnites, who finally yielded to the irrepressible valour of Rome in 340 B.C. Through all these vicissitudes of conquest the people remained, as at the beginning, essentially Oscan, and from them we have our knowledge of the Oscan language.

Lucania was a contiguous province, bordering on the Gulf of Tarentum. The people were also essentially Oscans. There was not the same rich soil, the Apennine Mountains passing through the province. The people, however, were more valiant in war than the inhabitants of Campania. The territory thus became the theatre of severe conflicts, Rome ultimately conquering the province in the social wars of 90-88 B.C.

THE CONSTRUCTION OF THE ENGINES.

THE Campania after her launch in September last was taken to the dock and berthed under the 130-ton sheerlegs, which were designed and constructed at Fairfield, to have her machinery placed on board; and in pursuance of the idea of describing the work as it progressed, we shall now describe the engines and boilers, deferring reference to the completion of the interior and equipment of the vessel.

The construction of the engines for each of the two vessels, representing over 60,000 indicated horse-power, was practically completed within twelve months of the order being placed, notwithstanding that the establishment was engaged on other work at the same time. The greater part of the machinery was not only erected in the shop, but was placed in the Campania within the year—a performance which at once testifies to the splendid organisation of the staff in the Fairfield engine department. One of the secrets of this dispatch was, we believe, the willing response of the various foundries and forges to Mr. Laing's wishes. His long experience in the Clyde district has enabled him to have a knowledge of the capacity of all the different forges and foundries for special work, and he apportioned the work in such a manner that the forgings and castings were made only by the firms most capable as regards power of production and speed in delivery. His instructions to these firms in regard to dates for deliveries were definite and binding, and measures were taken by him to insure that the dates would be adhered to. All the various parts, therefore, arrived at Fairfield in proper sequence, thus allowing of systematic progress being made in the finishing and erection of all parts of the machinery. The very extensive reconstruction of the engine works carried out two or three years ago also materially assisted in the general result. Indeed, the new machines which were then provided, and which have been illustrated and described in ENGINEERING,* were specially designed to deal with such large work as is now required in the construction of the Atlantic liners of the future.

So soon as the contract was fixed, the work of designing the engines was started. The general arrangement of the engines is that first introduced in the North German Lloyd's steamer Lahn, built at Fairfield in 1887, and which has given so much satisfaction that the North German Lloyd's have had it adopted in later vessels built at Stettin. The new Cunarders, however, are the first twin-screw steamers in which this type has been fitted. In this arrangement there are five cylinders, two high-pressure, one intermediate, and two low-pressure, but the great advantage of well-balanced parts of the three-crank engine is maintained by placing the high-pressure above the low-pressure cylinders, one pair of high-pressure and low-pressure being at the forward and the other pair at the after end of the engine, with the intermediate cylinder in the centre. The adoption of five cylinders, too, reduces the diameter of each low-pressure cylinder to more moderate dimensions: The diameters of the cylinders are as follows: high-pressure (two), 37 in.; intermediate (one), 79 in.; and low-pressure (two), 98 in. The stroke of piston in each case is 69 in.

The details of the engines were soon determined upon and patterns made, for within five or six weeks of the signing of the contract, or, to be precise, on September 15, 1891, the first casting was delivered at the Fairfield Works. It was one of the twenty cylinder liners required for the two vessels. These liners are all of cast iron. The show of work made in the fitting shop at the end of December, 1891, about four months after the design was determined upon, as indicated by our engraving, Fig. 17, on the two-page Plate No. I., is impressive, and at once bears evidence of the energy displayed. The actual condition of the engines of the Campania, seen in the distance in this engraving, is more clearly indicated by Fig. 18, from a photograph taken at the same time. From this it will be seen that in the case of one engine the whole foundation, A-frames and condensers, with the guides for the air and circulating pumps, had been placed in position ready for the cylinders, while in the case of the other engine the sole-plate, condenser, and other parts had been fitted.

The last of the castings and forgings was delivered about the end of February, and as in the closing weeks of 1891 and the early months of 1892 the floor of the machine shop was occupied with the enormous number of details which make up the four immense engines, as well as with the parts of several other engines, notably those of the twin-screw steamer Pole Star, and the fast paddle steamer Koh-i-Noor, the scene was one of great interest. Four engravings (Figs. 19 to 22) on our two-page Plate No. I. will give the reader some idea of the state of affairs at the end of March, 1892. One (Fig. 21) represents the view from the northern, and another (Fig. 22) from the southern end of the machine shop

By December, 1891, the sole-plates had been milled, bored, and fitted into position, and had already received the condensers, condenser columns, and front columns, while the three cranks had also been lowered into position. This within 15 weeks of receipt of the first casting is good work, in view of the great size of the various parts. The cylinders were then put in hand, and the whole of the machining finished by the end of March, 1892, the condition of the shop, as we have already stated, being shown by Figs. 21 and 22, Plate I. A view of the two engines of the Campania taken at the same date is also shown in Fig. 19, on the same plate. The cylinders were ready to be put in position, with the connecting-rods, &c., while the crankshaft and thrust shaft had already been fitted into their bearings. Both the engines were now in an advanced stage. This state of advancement, too, was not at the expense of the other work in the establishment, for at the other end of the fitting shop there were being completed the engines of the Koh-i-Noor, a steamer which attained such a degree of popularity last season—having a speed of 19½ knots—that the Fairfield Company were commissioned to build another and still faster vessel for this year. The other engines seen in the distance are those of the twin-screw steamer Pole Star, for the Northern Lighthouse Commissioners.

The reader will probably have noted that various parts are spoken of above as having been milled. Milling is now adopted very extensively at Fairfield, instead of the old methods of planing, &c., special machinery having been supplied. This is quite a new departure on the Clyde.

The two engines of the Campania were completely erected before the end of June. At that date probably an unprecedentedly large amount of work was on the floor of the fitting-out shop at Fairfield. Our two-page Plates Nos. II. and III., showing the completed engines, are from photographs taken at that date, while the engines of the Lucania were in a forward condition. Fig. 23, on page 478, shows the state of advancement of one of the engines of the Lucania, and illustrates very clearly the form of bed-plate, columns, and condenser adopted in the engines of both ships. The other engine of the Lucania was in a similar state of advancement. All the parts, too, were ready for fitting into position. At the same date also the engines of the Pole Star were completed, while the engines of the Koh-i-Noor* had only recently left the works. All this work was accomplished in 10 months.

From the base of the engines to the top of the cylinders, as shown on our two-page Plates II. and III., the height is 47 ft. As will be seen, the Fairfield Company have adhered to the type of bedplate, column, and condenser which has been adopted and proved satisfactory in so many of the notable vessels that have been constructed in their establishment. The bedplate is bolted down to the specially strong seating, which we have described in dealing with the construction of the hulls. The bedplate is 5 ft. 6 in. deep, and is of cast iron. The castings are of the box type. The fixing of the engines to the ship at the bottom and the staying at the top has had special attention. The cylinders are braced together by heavy stays running fore and aft. This staying has been introduced into the principal Fairfield-built engines within the last few years.†

We have stated that each set of engines of the new Cunarders has five cylinders, the high-pressure over the low-pressure, connected with the ordinary sleeve stuffing-box with metal packing, while the intermediate is in the centre. A piston valve is fitted to each of the high-pressure cylinders, Buckley's packing being used in the valves. A slide valve is fitted to the intermediate and to each of the low-pressure engines, the valve gear being of the usual double eccentric and link motion type. The bearing surfaces in all cases are large, as will be seen from Figs. 34 and 35, forming our two-page Plates Nos. II. and III. It is scarcely necessary to state that all the cylinders are steam-jacketed, and are fitted with automatic steam traps for the return of the water to the hotwell.

The condenser is rectangular in section, and fitted with ¾-in. brass tubes. It is built up in three parts, as is clearly shown in Fig. 18, on Plate I. It is divided into two portions, as indicated on the same engraving, so that each low-pressure engine has its own condenser. At the back of the condenser, as

* See ENGINEERING, vol. l., pages 336, 393, 485.

* See ENGINEERING, vol. liii., pages 654 and 656.

† See engravings of engines of Tynwald (ENGINEERING, vol. lii., page 155.)

shown on Plate III., there are two air and two circulating pumps, each driven by a lever from each of the crossheads of the fore and after engines. From the crosshead also are worked pumps for lifting the water from the condenser to the feed heater, to which we shall refer later.

maximum requirements for pumping the bilge, requiring a considerably larger engine than is necessary for the ordinary work of circulating, so that the efficiency relative to the work required under normal conditions is low. The engines for the Campania and Lucania, however, are constructed in such

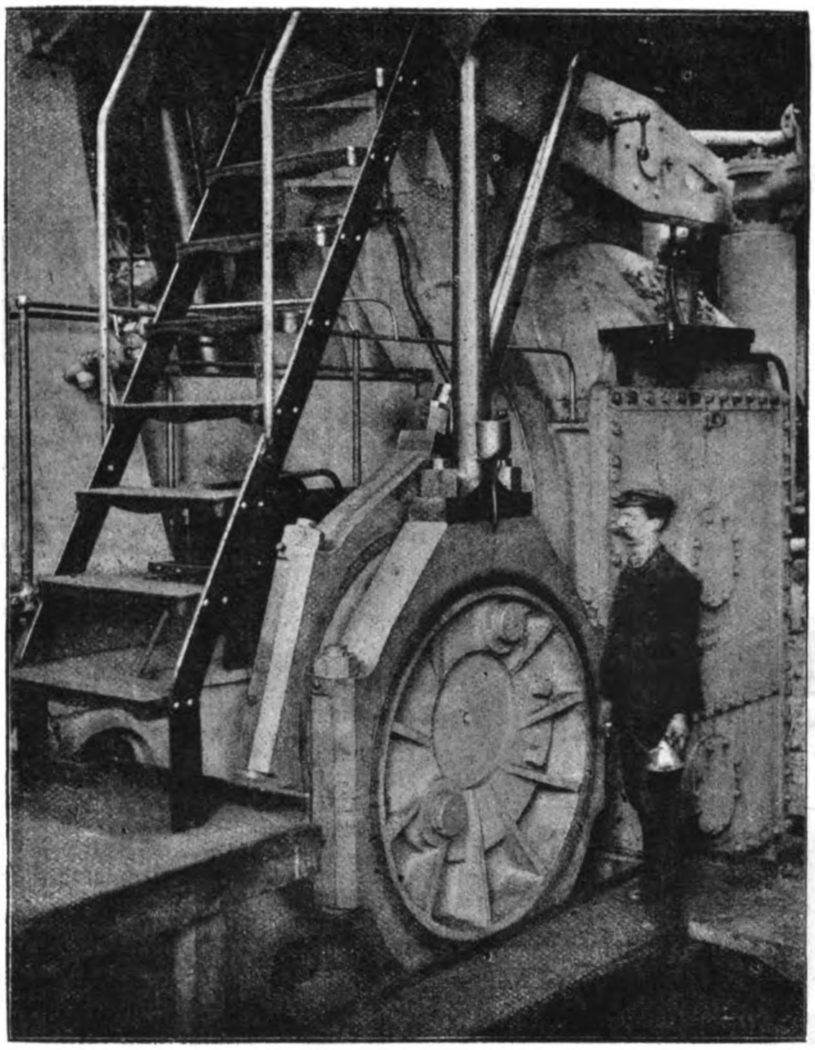


Fig. 26. Eccentric Pulley, Strap, and Rod.

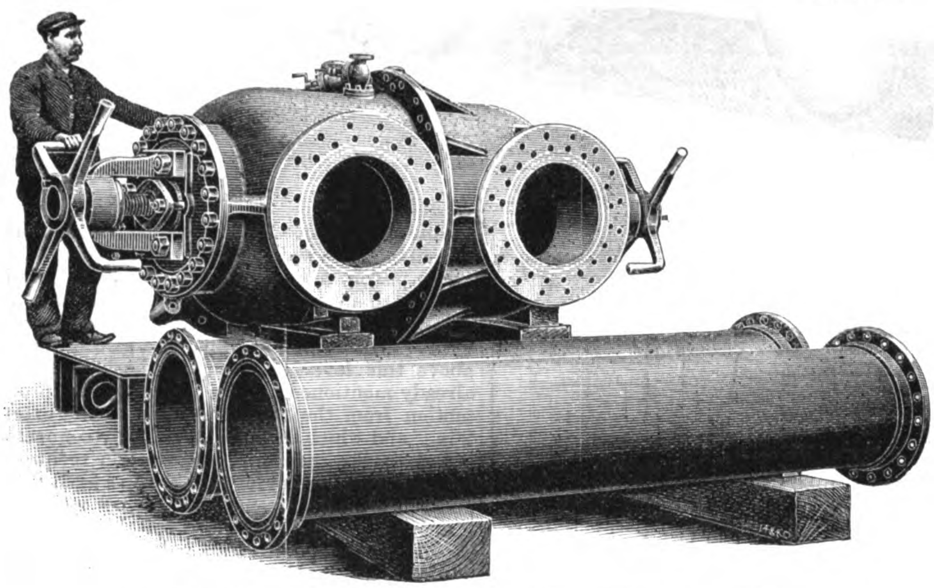


Fig. 27. Main Stop Valve and Lap-Welded Iron Steam-Pipes.

The circulating pumps and engines, of which an illustration is given in Fig. 28, on page 482, were manufactured by Messrs. W. H. Allen and Co., Lambeth. For the Campania and Lucania four pumps have been supplied for each ship. It has been usually the custom to construct circulating pump engines sufficiently powerful to meet the a manner that they will be equal to the work of circulating while working on the compound principle with steam at the full pressure, exhausting into the low-pressure steam chest or condenser at the option of the engineer, and at the same time with such an arrangement of the cylinders that by a simple hand slide valve both cylinders may receive the high-pressure steam whilst pumping from the bilge, and therefore working to suit the maximum requirements. By this method economy is effected while circulating, and the full power can be obtained for bilge pumping, the size and weight of the engines being at the same time considerably reduced. It is the first time that the system has been adopted for work of this kind, but it seems likely that it will be largely adopted in future. We give in Figs. 29 and 30, on page 482, views showing the slide valve just referred to, and from these it will be seen that by moving the valve by the hand gear the engines may be made to work either compound in the usual manner, or with both cylinders taking high-pressure steam. The engines are of a substantial pattern, the size of the main crankshaft having been kept up in order to withstand any possible strain that might come upon the engines while doing the work of bilging. The speed of the pumps when circulating is 100 revolutions per minute, and when bilging 250 revolutions. An auxiliary condenser is provided in each engine-room for the air and circulating pumps, and for use when the vessel is in port and the main engines lying idle.

Returning to the main engines, it may be noted first that the high-pressure pistons are fitted with Ramsbottom rings, while the intermediate and low-pressure pistons have each one ring fitted with Downie's packing. The piston and connecting-rods are made from steel ingots, that used for each of the connecting-rods weighing, rough, 25 tons, this weight being reduced to 10 tons.

The whole of the shafting throughout the two ships has been supplied by Messrs. Vickers, Sons, and Co., Limited, Sheffield. The crankshaft is 26 in. in diameter, and each of the three interchangeable parts weighs 27 tons, so that with the thrust shaft, which is 14 ft. long, the weight of each crankshaft is about 110 tons. Each thrust bearing has 14 rings of the ordinary horseshoe type. These bearings are in recesses at the after end of the engine-room bulkhead, but are tied direct to the foundations of the engines. The propeller shaft is 24 in. in diameter, and is fitted in about 24-ft. lengths, each length having two bearings. The pillow blocks are of cast iron lined with white metal. With the bossing out of the stern, as described in dealing with the building of the hull, it has been rendered possible to dispense with the usual outside shafting, and this enables the propeller shaft to be carried in the stern tube, as in the ordinary single-screw steamer. The stern bushes are of the usual design—brass lined with lignum vitæ, the shaft being sheathed at the bearing to suit. The propeller boss is also of Vickers steel, and the three blades are of manganese bronze cast at Fairfield. Each blade weighs about 8 tons, and a simple calculation brings out the interesting fact that, had pennies been used, 5½ millions would have gone into the casting of the six blades for each ship. At the after end of the propeller shaft there is fitted one of Dunlop's governors, while governors have also been fitted to the main engines.

Another safeguard is provided in the form of an emergency gear fitted in connection with Brown's steam and hydraulic starting and reversing gear. This emergency gear is such that the engines are stopped automatically if a predetermined rate of speed is exceeded. This gear, together with the starting gear, we illustrate by Figs. 31, 32, and 33, on page 483. The starting engine is of a well-known type introduced some 20 years ago by Messrs. Brown Brothers, and of which over 1000 have been made. The engine consists of a steam cylinder in which a piston and rod by one stroke handles the links, the movement being controlled by a water cylinder with automatic valve gear. The novelty in connection with this gear is the addition of a governor, by the operation of which, when a shaft breaks or dangerous racing takes place, the links will immediately be shifted into mid-gear.

It is well known that any attempt to control the speed of triple-expansion engines without operating on the distribution of steam in each cylinder, has up to the present not been satisfactory. With the ordinary governor, therefore, valves on each cylinder are necessary, and considerable complication is the result. It has, therefore, been considered much better to have marine engines strong enough to race up to, say, 50 to 100 per cent. over their normal speed, and after that to stop them or bring them to dead slow. The engineers' attention is thus at once called, and proper steps can be taken.

One or two recent accidents, notably that to the

CIRCULATING PUMPS AND ENGINES.

CONSTRUCTED BY MESSRS. W. H. ALLEN AND CO., ENGINEERS, LONDON.

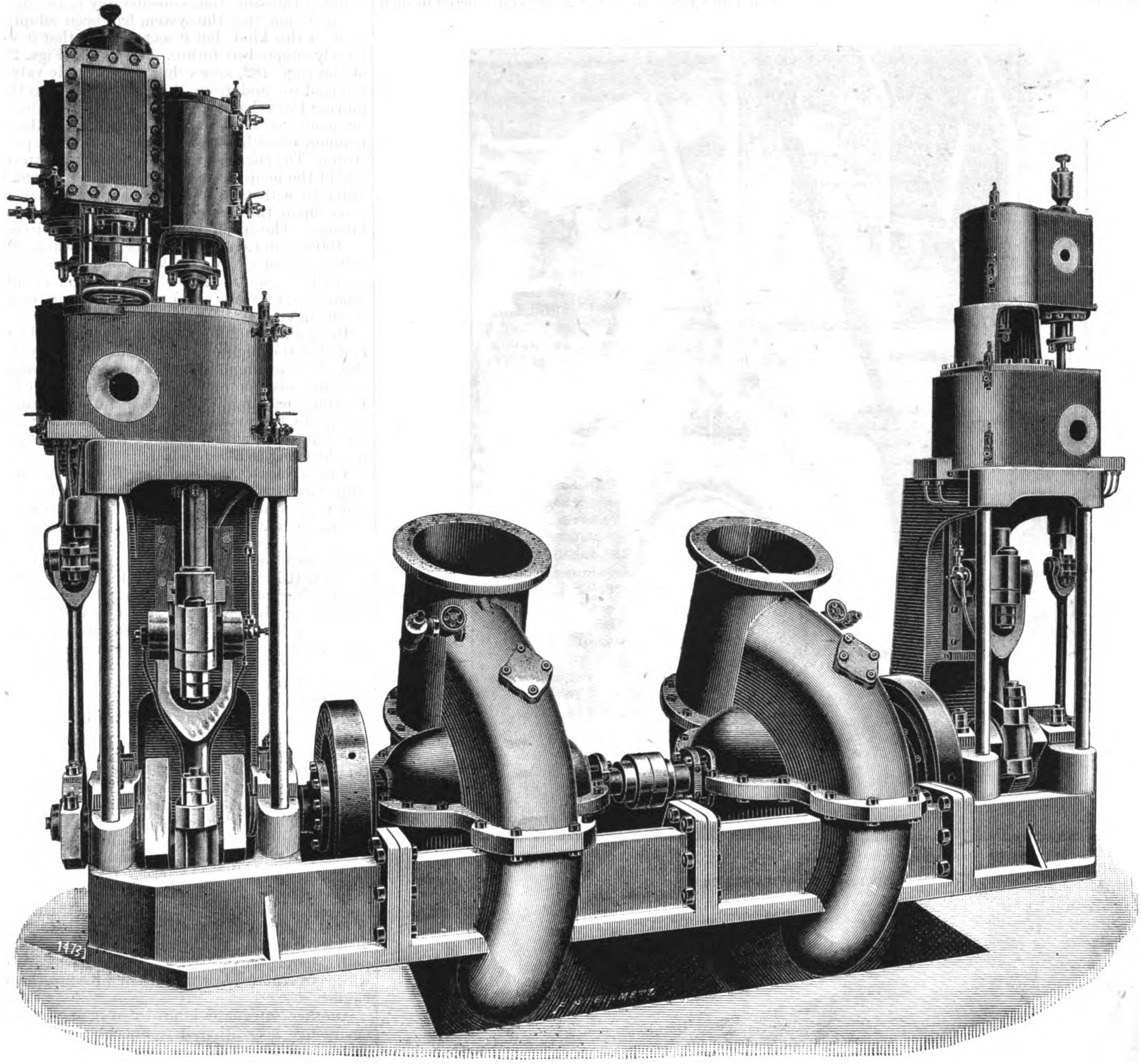
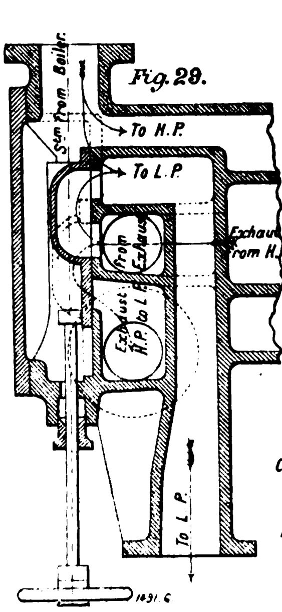
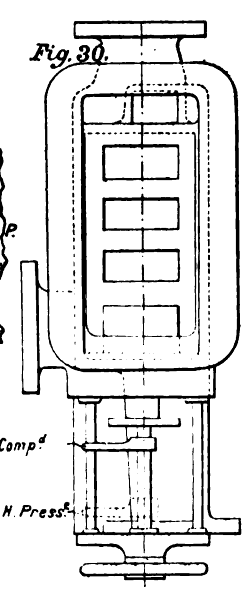


Fig. 28.

City of Paris, suggested the necessity of something being added to the reversing engine which, while simple, would be unfailing in action. Accordingly the Paris was fitted with such a governor as is now adopted on the Cunarders, and after prolonged tests, in which it frequently stopped the engines in excessively bad weather, the New York was also fitted, and now the engineers in charge are free to leave the reversing handle with confidence. We are informed that already 31 sets of the emergency gear are at work. The working of the gear in many cases dispenses with the fitting of the ordinary governor with a throttle valve on the steam pipe.

The reversing engine is of the oscillating type, the lower steam cylinder being attached to the column of the main engines, while the piston-rod is attached at its upper end to the weight shaft lever, which actuates the reversing links. The governor consists of a simple lever, which moves vertically with the main engines, and on which is mounted a weight supported by a spring so set that at normal speed little movement takes place. This is shown with the reversing mechanism on the hydraulic control cylinder in Fig. 32, and to a larger scale in Fig. 33. The usual reversing lever is here shown not working on a fixed fulcrum, but is attached to the end of a lever, its other end embracing and working the starting



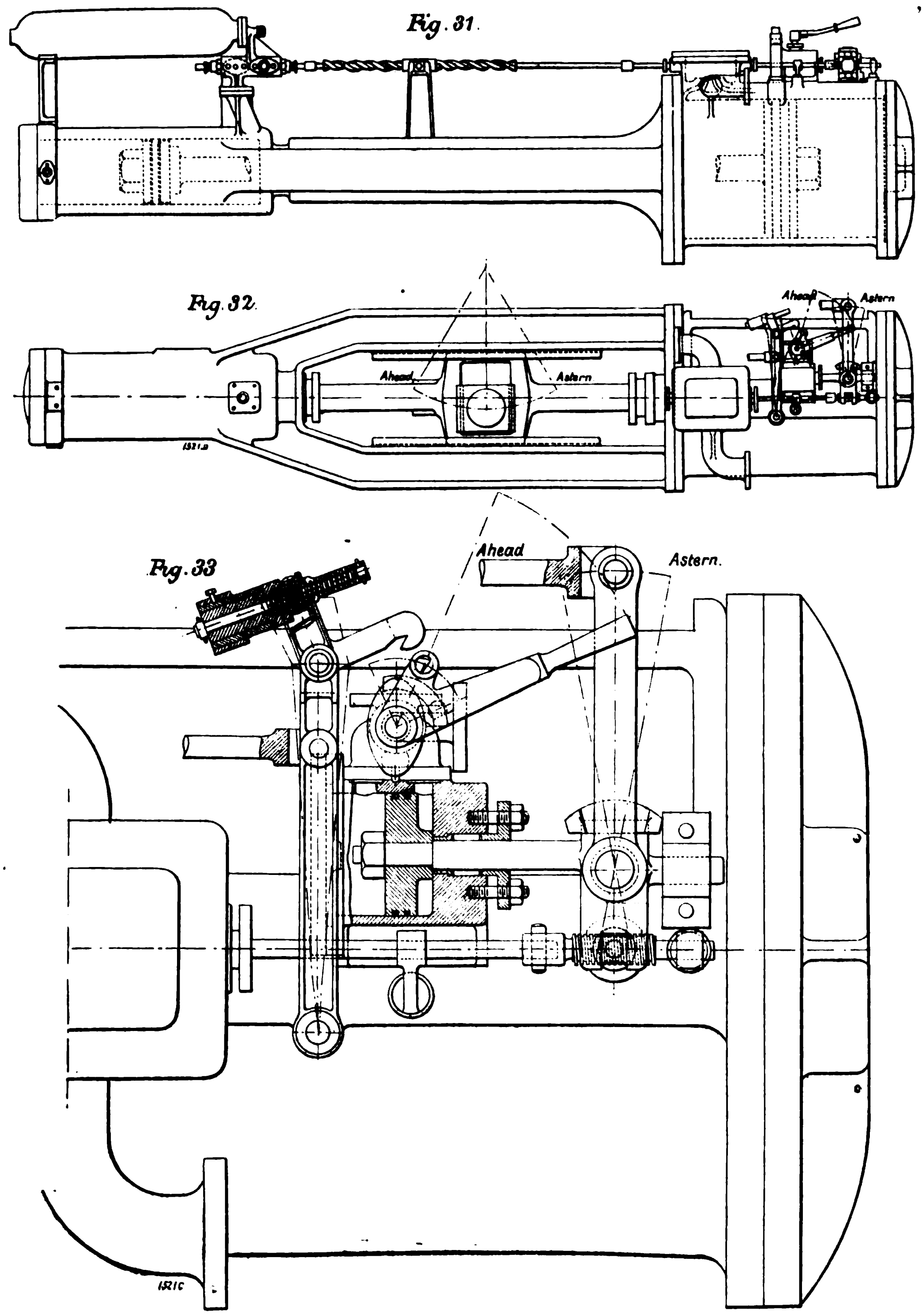


engine valve gear. The last-named lever works on a fixed fulcrum, while its other end is engaged with a steam piston and rod, working in a steam cylinder fitted with a three-way cock, so set that a constant pressure is exerted on the top of the piston when the marine engines are working at a safe speed. Just above this lever is arranged the governor lever already mentioned, which derives a reciprocating motion from the marine engines to the extent of 2 in., and which can be conveniently connected by a rod to the indicator gear or other reciprocating part. This governor lever works on a fixed fulcrum, and at its other extremity carries, as we have said, a small weight supported on a spiral spring in a box. The weight is guided by a rod and collar, and has a groove at its lower part, into which one arm of a bell-crank lever gears, while the other arm is formed like a hook and is ready on emergency to engage and move upwards the valve lever of the steam cylinder.

When the main engines are working at their normal or safe racing speeds in bad weather the spring is so set that the weight (which moves at each stroke of the engines in virtue of its momentum) shall not cause the hooked arm of the bell-crank lever to approach too near the valve lever. Should the main engines, from any cause whatever, exceed a safe limit, the weight, by an acceleration of speed, compresses the spring, causing the sharp hook to at once engage the valve lever. The result is that steam is admitted below the piston, exhausted from the top, lifting its end of the lever and depressing the fulcrum of the reversing lever, which, carrying with it the starting engine valve gear, turns steam on to the top of the piston of the starting engine, and so moves the links into, or somewhat past, mid-gear. By this device the motion of the main engines is arrested simultaneously in all the cylinders, which cannot be done by any closing of the stop valve, however quickly it may be effected. The controlling piston can be returned to its normal position when necessary to restart the engines.

THE BOILERS AND FEED ARRANGEMENTS.

The illustration, Fig. 36, on page 484, affords some indication of the steam-producing power provided in the new Cunarders. It shows the set of boilers for one of the vessels — the Campania.



Brown's Starting, Reversing, and Emergency Gear.

There are 12 large boilers, and two others for auxiliary purposes, the two latter occupying the foreground in the engraving. The total number of furnaces is 102. The 12 main boilers are double-ended, 18 ft. in diameter and 17 ft. long, each having eight of Fox's corrugated furnaces, four at each end. There is a combustion chamber common to each pair of furnaces. One of the smaller boilers, 18 ft. in diameter by 11 ft. long with four furnaces, is for the auxiliary machinery in the ship, while the smallest, 10 ft. in diameter by 10 ft. long, with two furnaces, is for donkey purposes when the vessel is in port, but all may be used in the propelling of the ship if considered desirable.

The boilers are fitted longitudinally, three in a row, and are placed in two groups in two water-tight compartments, separated from each other by a large coal bunker occupying the full width of the ship, and 65 ft. of its length, as shown in the sections on our two-page Plate No. IV. There are also coal bunkers over the boiler spaces, the floor of the bunkers curving to the sides in much the same way as the usual protective deck in cruisers. The fuel is passed on to the stoking floor by shoots at the side, fed from the main coal bunker between the boiler compartments. The total coal-carrying capacity of the bunkers is great, so that the vessels will, when employed as armed cruisers, be able to keep the sea for long periods, and be the more efficient for patrol duty. The bunkers, it may be stated, are coated with Messrs. Wailes, Dove, and Co.'s bitumistic enamels. The two auxiliary boilers are placed forward. The main boilers, it may be remarked, are the largest yet made for the pressure —165 lb. The plates for the Campania's set were supplied by the Steel Company of Scotland, and for the Lucania's from the Parkhead Works, and it may be worth noting that some of these plates measured 20 ft. long by 7 ft. broad, the thickness being $1\frac{1}{32}$ in. David Cockburn's safety valves are fitted to each boiler.

For each set of boilers there is a funnel, which has a double casing; the inside diameter exceeds 19 ft., while the top is 130 ft. from the bottom of the ship. In view of the space occupied by the boiler spaces and coal bunkers, the funnels are a great distance apart—about 130 ft.

The Fairfield Company have not in any of their fast mercantile steamers gone in for forced draught as a means of adding to speed. Nor is this due to lack of experience or of complete acquaintance with the system and its application, for one has but to recall the signal success of the trials of the first-class cruisers Edgar and Hawke, the engines and boilers of which were constructed at Fairfield,* to show that, even with relatively high air pressure in the stokehold, the boilers were found to work very satisfactorily, and without defect being subsequently disclosed, as has been too frequently the case. The Fairfield Company, however, as well as their clients, the Cunard Company, prefer to get their results without such aid, and the stokeholds of the Campania and Lucania have, therefore, been left open.

The boilers, occupying as they do the central part of the ship, would have taken up the best location for the public and principal state-rooms if the usual air hatches had been left, and to compensate for the partial closing up of these to add to the passenger accommodation on the upper deck, immense ventilators have been provided by Messrs. Mechan and Sons, Glasgow, supplemented by fans, mechanically driven, for use when necessary for efficient ventilation. The cowls revolve on wheels round a circular track moved by an endless chain winding round a drum which is turned by a lever. One man may therefore do this work; and here it may be stated that a deck hand will be told off for this duty, thus obviating the necessity and inconvenience of firemen going on deck for the purpose. This natural system of ventilation will be a great advantage to the men working in the stokeholds.

The whole of the fans for use in the stokeholds of the two ships were constructed by Messrs. W. H. Allen and Co., Lambeth, and are driven by their new patent triple-expansion single-acting engines having one crank. We give in Figs. 49 and 50, on page 488, illustrations of the arrangements. There are 12 of these engines and fans on board

* See Engineering, vol. liii., pages 12, 75, 80, and 330.

each ship. We hope soon to give detailed illustrations of this new type of engine, with particulars of a number of experiments which the makers are carrying out with their new condensing plant. The revolving parts work in a bath of oil in the usual way, and are constructed with extra large wearing surfaces. Messrs. Allen have constructed a number of these engines to comply with stringent conditions for running continuously without attendance, and these, we believe, have given considerable satisfaction.

The feed arrangements on the Campania and Lucania have been most carefully worked out, and, as in all other parts of the machinery, everything is in duplicate, to provide against contingencies. It is probably one of the most complete installations of Messrs. Weir's specialities yet placed in any vessel, comprising as it does feed heater, main feed, auxiliary feed, ballast, and general service pumps, and also evaporators, and it may therefore be described at some length. Illustrations of the various appliances are given in Figs. 37 to 48, on pages 486 and 487. The economy and efficiency of this system of feed heating is now recognised, and the *rationale* of the system may be briefly stated thus: The quantity of steam condensed by the feed water represents an amount of steam which has been worked in a theoretically perfect engine, because after doing work the whole remaining heat, both latent and specific, is returned to the boiler.

Fig. 46, page 487, shows a section of the feed heater. The cold feed water is discharged to the heater by the main engine pumps, and, passing through the spring-loaded valve on the cover of the heater in a thin sheet, is at once heated by contact with the steam taken from the intermediate cylinder exhaust, entering by the non-return valve on the side of the apparatus. A circular ring and conical spray-piece, with perforations, are fitted to mix the water and steam more uniformly. The water falls to the bottom of the heater, in which is placed a round galvanised iron float, with water-tight bottom and sides, but open on the top. This is suspended on two levers so as to move up and down with a parallel motion; the top lever spindle is carried through the door at one end, and is balanced by a lever and weight. The float is always full of water, and the weight is adjusted to balance it when one half is immersed in water. To the weight lever another lever is attached, which actuates the throttle valve and controls the supply of steam to the feed pumps. When the water in the heater rises, the float is raised and the throttle valve opened, and when the water level is lowered the float follows and the valve is closed; the level of the water is thus kept constant in the heater, and the pumps are completely filled with water and prevented from drawing air. The pressure on the water in the heater is always considerably less than before it passes through the inlet valve, and its temperature is almost instantly raised by contact to that of the steam. The effect of these two simultaneous actions is to cause the feed water to give up the air and gases in solution, and these are removed, either to the atmosphere or condenser, through the small cock on the top of the air vessel on the cover. The water is now at the boiling temperature due to the pressure in the heater, is freed from air, and is thus without corrosive effect on the boilers.

From the heater the feed water is drawn by the main feed pumps and discharged to the boilers. Two pairs of main feed pumps have been fitted, one of the pairs being illustrated by the engraving Fig. 37, on page 486. Each pump, when working at a moderate speed, is of such power that one pair of pumps, as shown, is capable of easily feeding all the boilers. These pumps have probably the most difficult task of any portion of the auxiliary machinery, as the average pressure on the pistons will probably be about 160 lb. per square inch, and the temperature of the water to be pumped will be over 200 deg. Fahr. Steam to these pumps is regulated by the valve controlled by the float in the heater, thus making the pumps automatic in their action. Noticeable features of these pumps are the steam valve, the suction and discharge valves. The steam valve consists of a main slide valve and an auxiliary slide valve. The main slide valve is made of a circular form, and is moved by steam. The auxiliary slide valve derives its motion from that of the piston-rod, and its work is to distribute the steam to the two ends of the main slide valve. There is also an arrangement whereby the steam can be cut off at about three-quarters stroke, and cause the piston to slow down to the end of the stroke, thus allowing the valves to close quietly and avoiding shock. The suction and discharge valves consist of a number of small valves in one seat, providing a large water area with a small lift. The small valves are of special design, and are milled out of cold-rolled manganese-bronze bars, to insure durability under the high pressure. The water ends of all the pumps are of gun-metal, and represent the latest and most approved practice.

The features enumerated are common to all the pumps of the Weir installation, and may be seen in Figs. 38 and 39, page 486, which represent sections of the auxiliary feed pump, of which two have been fitted. These are nearly similar in size to the main feed pumps, and are constructed to draw from the hotwell, sea, bilge, and boilers. They discharge to the boilers or overboard, and are also arranged to constitute fire-engines of a powerful type. Four auxiliary and general pumps have been fitted, having each about half the capacity of the main feed pumps. One of these, Figs. 40 and 41, page 486, is arranged horizontally on account of space requirements, and embodies the leading features of the vertical type. Two ballast pumps have also been supplied, and views of one of them are given in Figs. 42, 43, 44, and 45, page 487, from which the details will be seen. Each of these pumps is capable of dealing with 140 tons of water per hour.

It is now scarcely necessary to enumerate the various advantages to be derived from the use of evaporators, as these have for some time past been recognised as indispensable adjuncts of every well-equipped marine engine. Messrs. Weir have furnished to each of the new Cunarders four of their well-known type of evaporator, each capable of

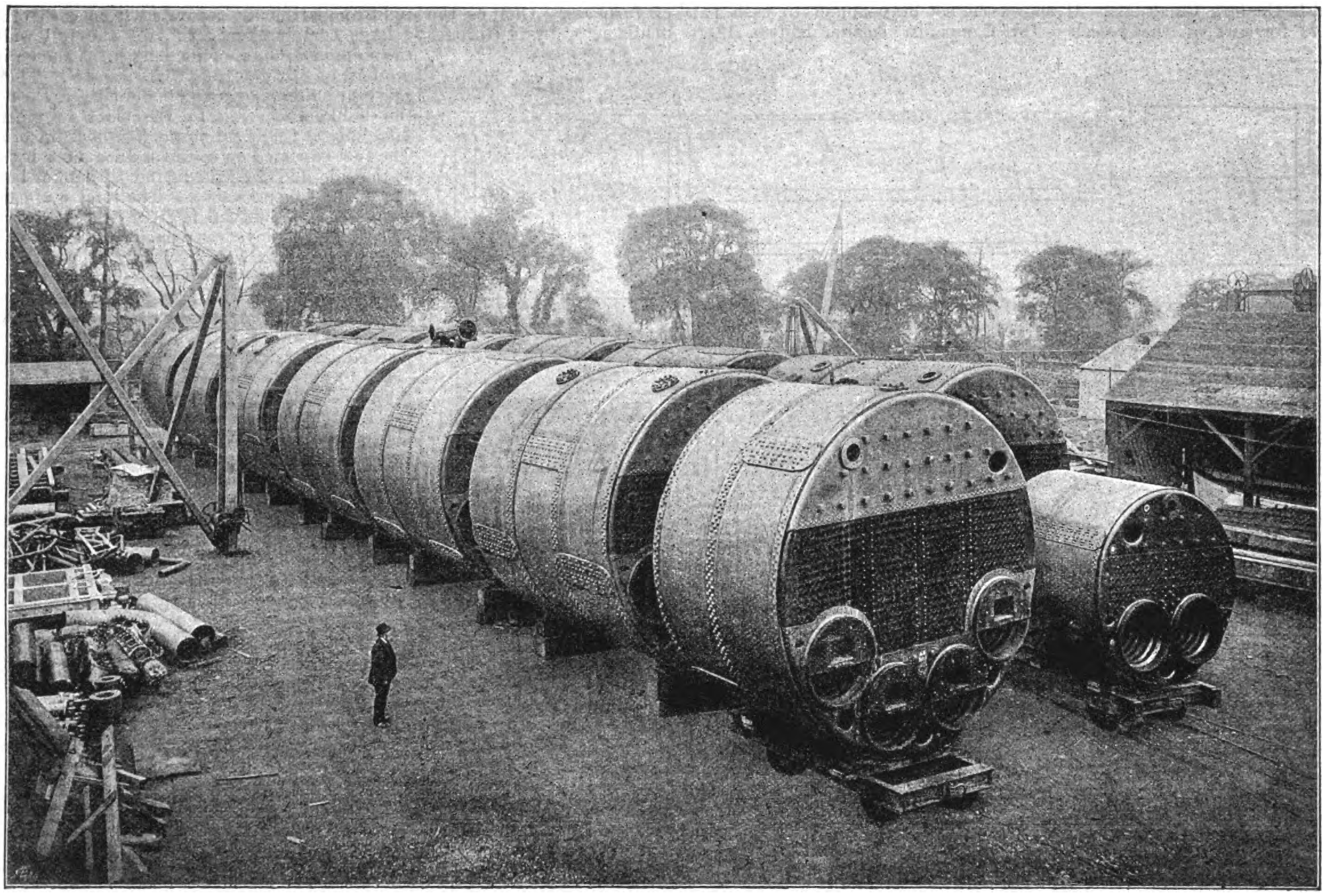


FIG. 36. COMPLETE SET OF BOILERS OF "CAMPANIA" READY TO BE PLACED ON BOARD, JUNE 30, 1892.

producing 30 tons of fresh water per day. One of these is shown by Figs. 47 and 48, on page 487, from which it will be seen that it consists of a cylindrical shell, in which the heating surface is composed of a series of U-shaped solid-drawn copper tubes expanded into a tubeplate, and placed in the lower portion of the shell. The method of making the tubes uniformly efficient is by means of a specially patented arrangement known as the "contracted ends and return tube," which gives this type of evaporator its high efficiency. The same firm have also supplied a couple of their small fly-wheel donkey pumps, Admiralty type, for pumping the fresh water from the tanks up to the pantry, &c. Pumps of the Navy type have also been supplied by Messrs. Broadfoot and Sons, Glasgow.

It is an easy transition from the feed arrangements of the boilers to the steam pipe connection with the engines. The whole of the main steam pipes in the two ships are wrought iron with lap-welded joints. These are the first Atlantic vessels fitted with these pipes, and the departure from copper has been determined upon after very careful tests carried out by Mr. Laing, which tests satisfied him that the wrought-iron pipes used gave greater security against mishaps. We published the results of these tests in a previous volume,* but it may be here stated that a pipe of 11¼ in. bore, with metal of $\frac{13}{32}$ in. thickness, was subjected to hydraulic pressure up to 800 lb. to the square inch without showing any effect, and it did not burst until the pressure reached 3100 lb. to the square inch. A much smaller pipe of 8 in. bore and of metal $\frac{5}{16}$ in. thick showed no movement nor leakage at 1600 lb. pressure, and only burst at 2800 lb. The compression and tensile tests gave results equally satisfactory. The pipes used in the Cunard steamers were all supplied by Messrs. Stewart and Clydesdale, Limited, Glasgow. The largest pipes are of 20 in. bore, and the thickness of metal is $\frac{9}{16}$ in. Examples of these pipes are seen in the foreground in Fig. 27, page 481. This illustration also shows the large double stop valve, which is placed conveniently for both engines, passing as it does through the fore-and-aft bulkhead dividing the two engines. As will be seen from our two-page Plate No. III., the steam pipes between the valve-chests, being wrought iron, had to be straight. They are in short lengths, and expansion and contraction are provided for by means of stuffing-boxes at the joints.

* See ENGINEERING, vol. lii., page 519.

The rapidity with which the twenty-eight boilers for the two vessels were constructed is attributable to the splendid equipment of the new boiler works recently erected at Fairfield. Amongst the heavy tools with which these works are provided is a vertical plate bender by Messrs. Shanks, of Johnstone, to bend, when cold, plates 12 ft. 6 in. wide and 1½ in. thick, and of course of illimitable length; and this suggests the remark that Fairfield has, in the case of ordinary-sized boilers, constructed the shell of one plate sufficient in length and width to complete the whole circumference, and only requiring the one joint. The roll of the machine in question is 23 in. in diameter. Another serviceable tool by the same makers drills and taps the holes for the screwed stays in boilers, having two drills carried by separate standards, and having a travel of 20 ft. and a vertical range of 10 ft., while the spindle is made to angle about 25 deg. Even the boilers of the Campania, unprecedentedly large as they are, did not unduly tax the range of these machines. The rivet-holes were all drilled by a machine made by Messrs. G. and A. Harvey, Govan, which has two horizontal mandrils carried on separate pillars, one carrying a face-plate and the other a radial drill. The travel of each mandril is 10 ft. 6 in. horizontally, and 3 ft. 4 in. vertically, so that the work could be done with the minimum of movement of the boiler being operated upon. In the same way the boiler tubeplate machines, shell drilling machines, and all tools are of unusual dimensions. The building itself is of great size, being 77 ft. high to the ridge of the roof, while the 100-ton travelling crane has a clear lift of 48 ft., and could easily have lifted one of the boilers filled with water, and in working condition, so that there is even here a margin for still further development, if that be necessary, when Fairfield are called upon to still further increase the propelling power and speed of Atlantic steamers.

The engines and boilers were all fitted in position on board the Campania by the end of the second week in December, 1892, and the engines were turned under their own steam on the 26th of that month, or 15 weeks after the vessel was launched. The joiners, who were started at their work before the ship left the stocks, continued their operations for several weeks, when an unfortunate strike put almost an entire stop to their portion of the work, this not being again resumed until the middle of February. There was not, however, any lack of industry on board, for meanwhile the deck and navigating machinery were being fitted.

THE ELECTRIC LIGHTING.

THE electric installations in these ships have been carried out by Messrs. Siemens Brothers and Co., Limited, London. The electric generating plant is in duplicate, so that in no case can there be an entire collapse, two sets being placed each side of the centre-line watertight bulkhead. There are in each ship about 1350 lights, and these require an output on the part of the dynamos of 42,000 watts; the current is distributed throughout the ship by about 50 miles of wire, thickly insulated in vulcanised indiarubber, and laid on the return conductor system in connection with Siemens' patent distributing boxes. The brilliancy of the illumination, and the ease with which it can be regulated, are in marked contrast to the candles and oil lamps of a few years ago. Then, apart altogether from the immunity from accident, there is the lesser room required, and the immense improvement in the atmosphere, due to the absence of products of combustion. The whole lamps in each ship would give a light equal to about 22,000 candles, absorbing 135 horse-power. In distributing the light the method adopted has been to retain the 16 candle-power unit, and to fit lamps in sufficient numbers to give the necessary power, rather than to increase the power of the separate lamps. The former method gives a more equal distribution. In mounting the various lights in the ship the general principle has been adopted of placing the lamp where it will not be inconvenient, but will afford the most diffused light. Thus nearly the whole of them are fixed to the roof. Generally speaking, the fittings are of plain but substantial design, the builders and owners acting on the experience that such retain their good appearance for a longer time, and are more easily kept clean, than the highly ornate fittings used in many first-class steamships. The globes are retained in position by a special arrangement which has long been adopted by Messrs. Siemens. On the bracket there is a movable cap, which by its form and weight holds the globe in position on the three prongs on which it rests. The whole of the lamp fittings are silver-plated by Elkington. All the engine and boiler-room fittings, and those for exposed parts, are watertight, the glass globes bedding on rubber rings and being held in position by metal straps. There are several portable lights, provided with flexible wires. In the engine-room oil has been a cause of trouble in the destruction of the indiarubber insulation of the wires, but here the flexible wires for the portable lamps in the machinery spaces have all been insulated with cotton impregnated with tallow. The reflectors for the hatchways, each with eight 16 candle-power lamps, have flexible wires, and may be hung up in any convenient positions. They may, indeed, be used for specially illuminating the promenade deck, should it be desired. It is easy to conceive that on a calm evening the broad expanse of beautifully laid and well-kept deck may occasionally become the scene of a brilliantly lighted ball. Under ordinary circumstances the decks will be lighted from an extensive array of lamps, of strong pattern and completely waterproof, arranged along the deckhouses.

The electric current is generated in each ship by four dynamos, each driven by a separate engine, and of one of these engines and dynamos we give engravings in Figs. 51 and 52, on page 490. All four are similar. Two are placed in the recess in the port engine-room bulkhead, formed primarily for the accommodation of the thrust shaft, and two in the same position in the starboard engine-room. Any two are equal to running the 1350 sixteen-candle-power lamps in the ship, including the large reflectors of eight lights each for working the cargo, together with the search-light for facilitating the navigation of the ship into port—picking up the moorings—and for scout purposes should the vessel be engaged as an armed cruiser.

The engines for driving the dynamos are of the open, vertical, compound "Crescent" type, manufactured by Messrs. G. E. Belliss and Co., Birmingham. Each engine is designed for an output of 70 brake horse-power when running at 275 revolutions per minute, and with 100 lb. steam pressure at the engine stop-valve. The cylinders are 9½ in. and 15 in. in diameter by 10 in. stroke, and are supported by strong cast-iron back standards, which also form the guides for the piston-rod crosshead shoe, and from the bedplate in front by two stout steel forged columns. The principal feature in these engines is the patent single slide valve placed centrally between the two cylinders, which does away with a complete set of valve gear, eccentric rods, &c., used in ordinary double-cylinder engines. Of this valve we give a cross-section in Fig. 52, on page 490. It is of the balanced piston type, and admits and exhausts the steam from both cylinders. The governor balls are controlled by springs, and the gear is arranged to operate the single eccentric directly. As there is only one slide valve, the powers in the high-pressure and low-pressure cylinders are maintained practically equal at all loads, this being unattainable when the governor acts only on the high-pressure slide valve. These engines are guaranteed to have a variation of speed between full and no load of not more than 2 per cent. The cranks are placed opposite each other, and the pistons are equally weighted, thereby making the engine perfectly balanced. The engines have been designed for long continuous running at full power, having specially large bearing surfaces, all pins being case-hardened, and working in phosphor-bronze bearings. The lubrication throughout is very thorough, the bearings all being supplied with oil from the three sight-feed oil boxes placed on the cylinder front.

The dynamos are of Siemens' well-known H B type, having drum armatures of 15 in. diameter. Each dynamo is capable of giving an output of 420 ampères under 100 volts pressure at 275 revolutions, and thus can run 700 sixteen candle-power lights. The magnets on the dynamos are supported on brass feet bolted to the engine baseplate, which is extended for the purpose as shown in the engraving (Fig. 51). The armature shaft is coupled by an ordinary flange coupling to the shaft of the Belliss engine.

The current from the dynamos is delivered into the principal wires which ascend to the main deck,

MAIN AND AUXILIARY FEED PUMPS.

CONSTRUCTED BY MESSRS. G. AND J. WEIR, CATHCART, GLASGOW.

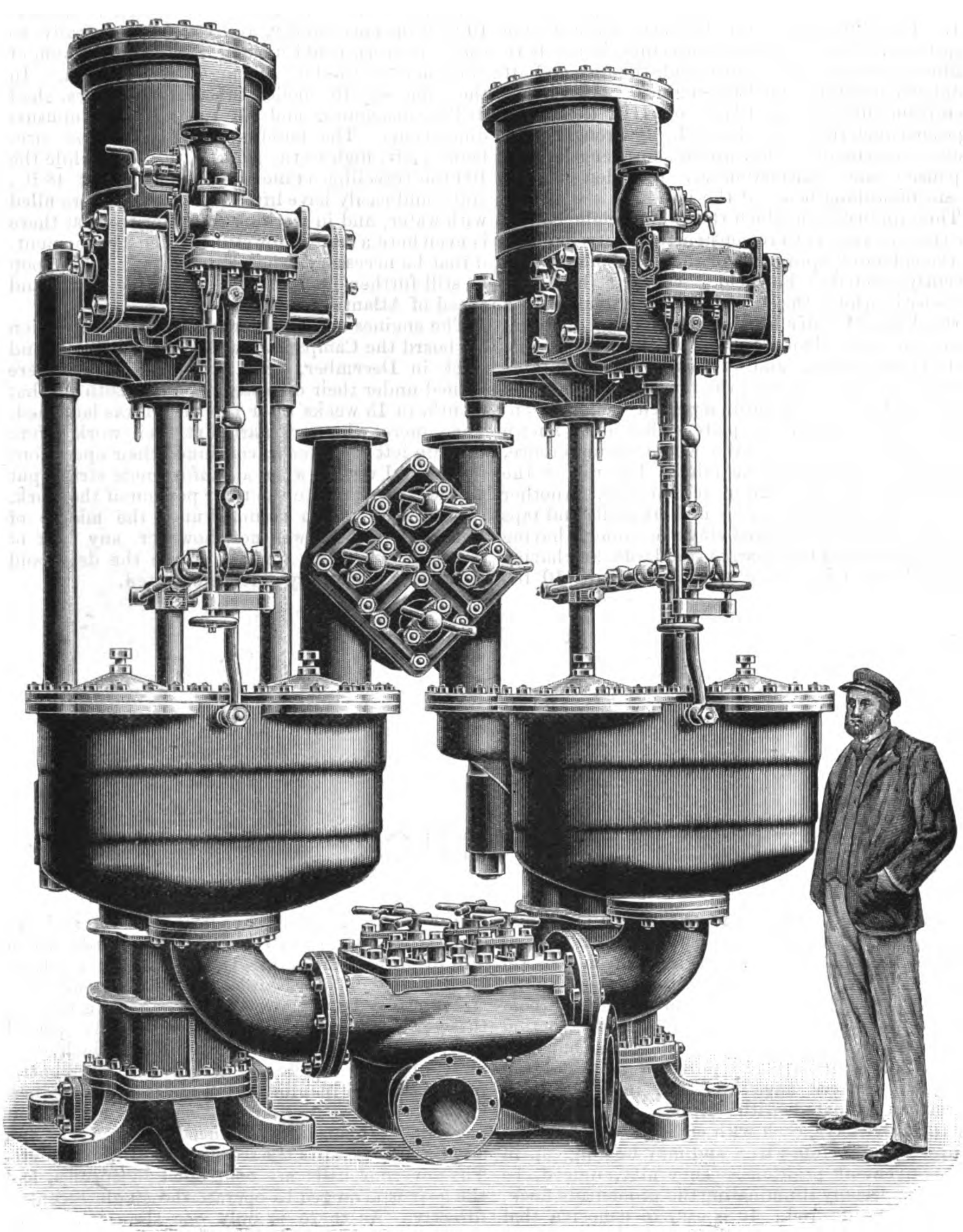


FIG. 37.

Fig 38

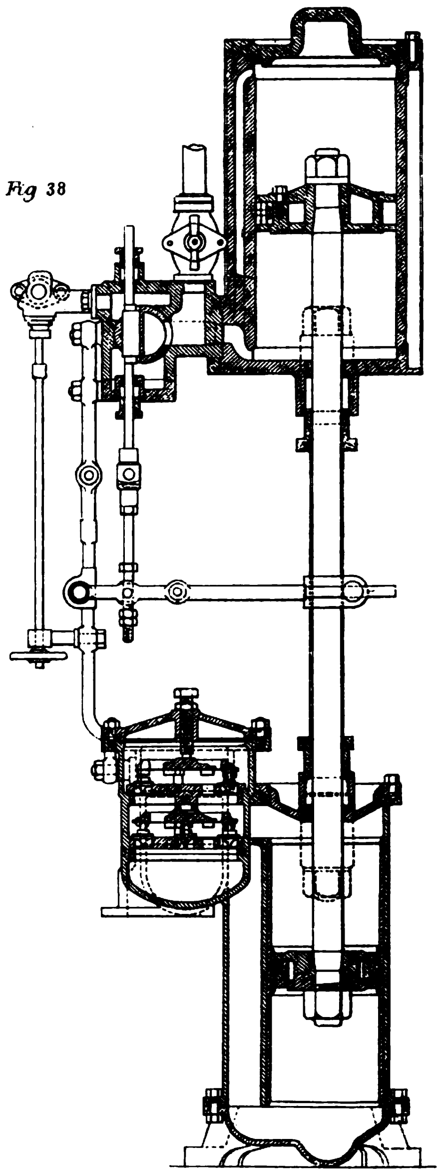


Fig. 39.

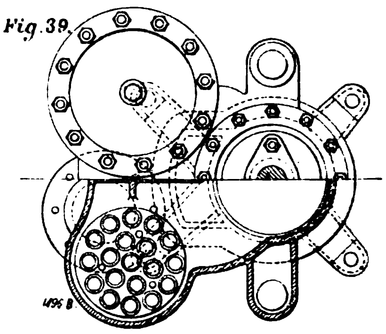


Fig 40

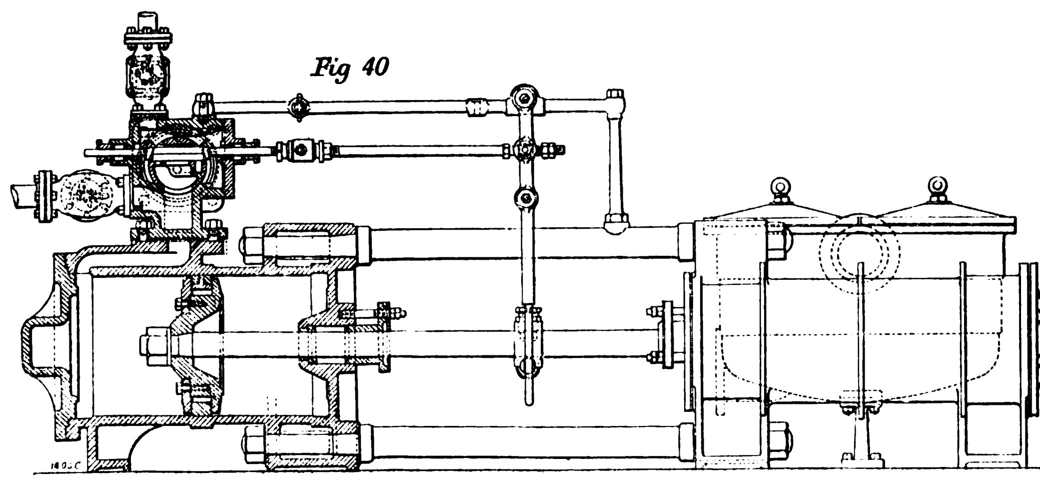
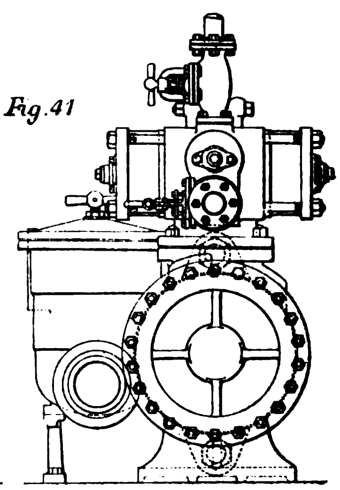


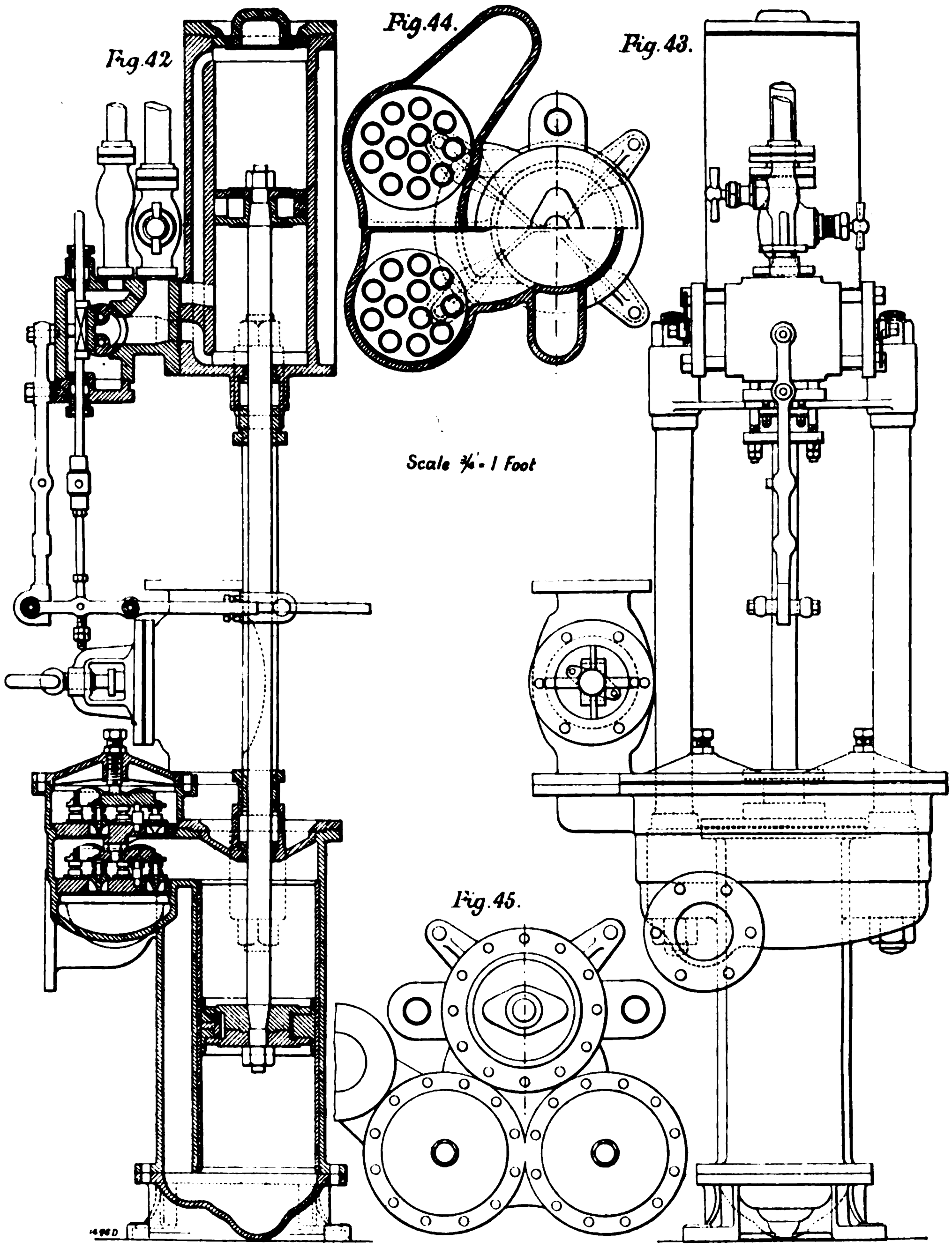
Fig. 41



BALLAST PUMPS, FEED-WATER HEATER, AND SEA-WATER EVAPORATOR.

CONSTRUCTED BY MESSRS. G. AND J. WEIR, CATHCART, GLASGOW.

Fig. 42. Fig. 44. Fig. 43.



Scale ¾" = 1 Foot

Fig. 45.

Fig. 46. Scale ⅙" = 1 Foot.

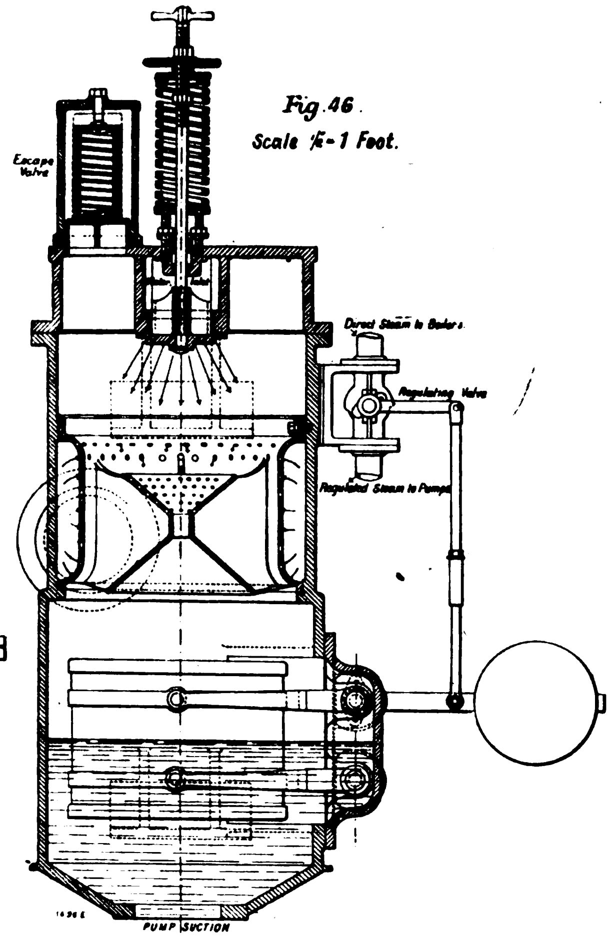
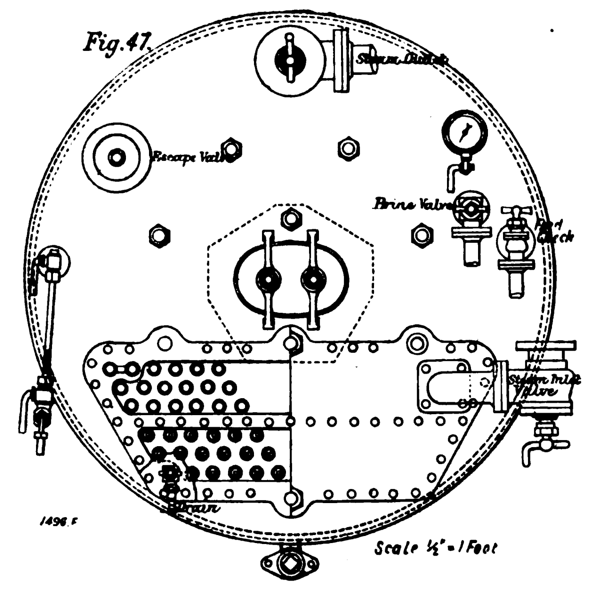
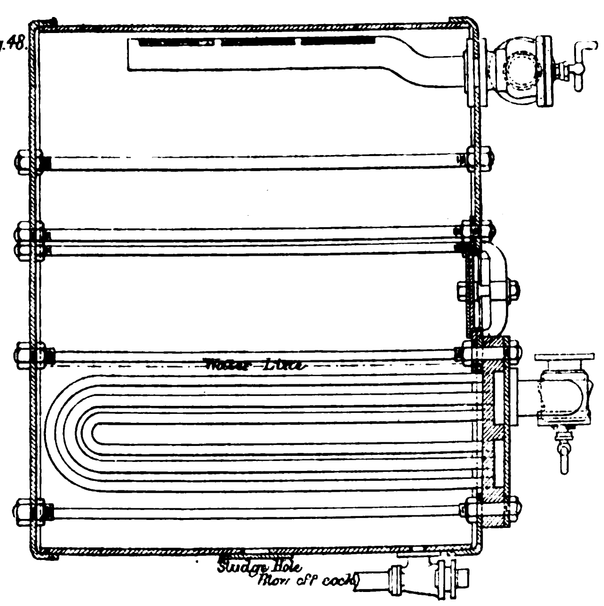


Fig. 47.



Scale ½" = 1 Foot

Fig. 48.



FAN, WITH TRIPLE-EXPANSION ENGINE, FOR VENTILATING STOKEHOLDS.

CONSTRUCTED BY MESSRS. W. H. ALLEN AND CO., ENGINEERS, LONDON.

FIG. 49.

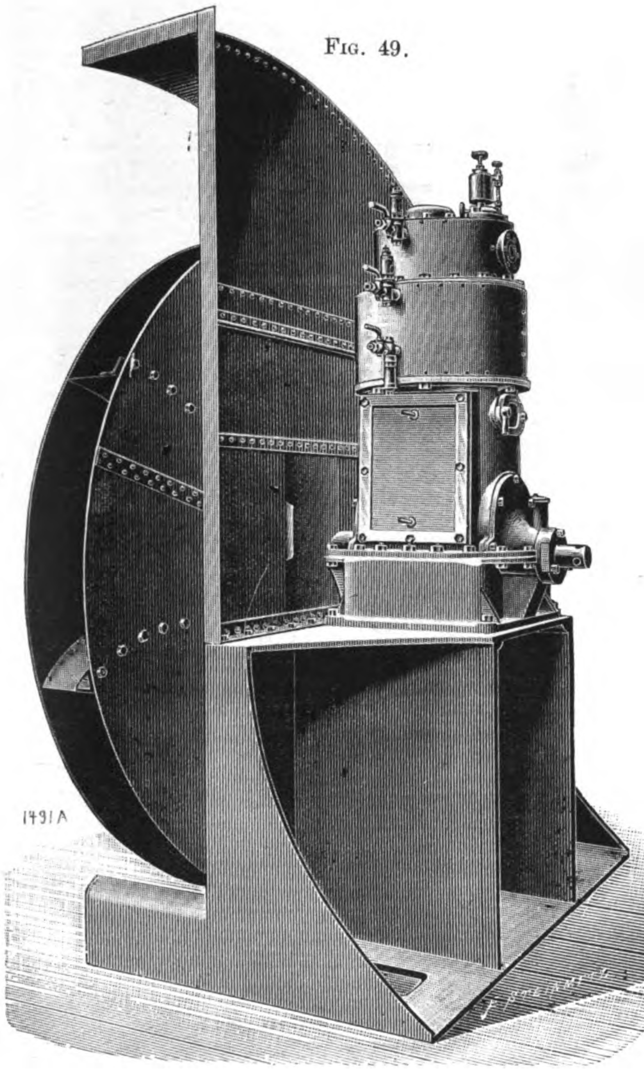
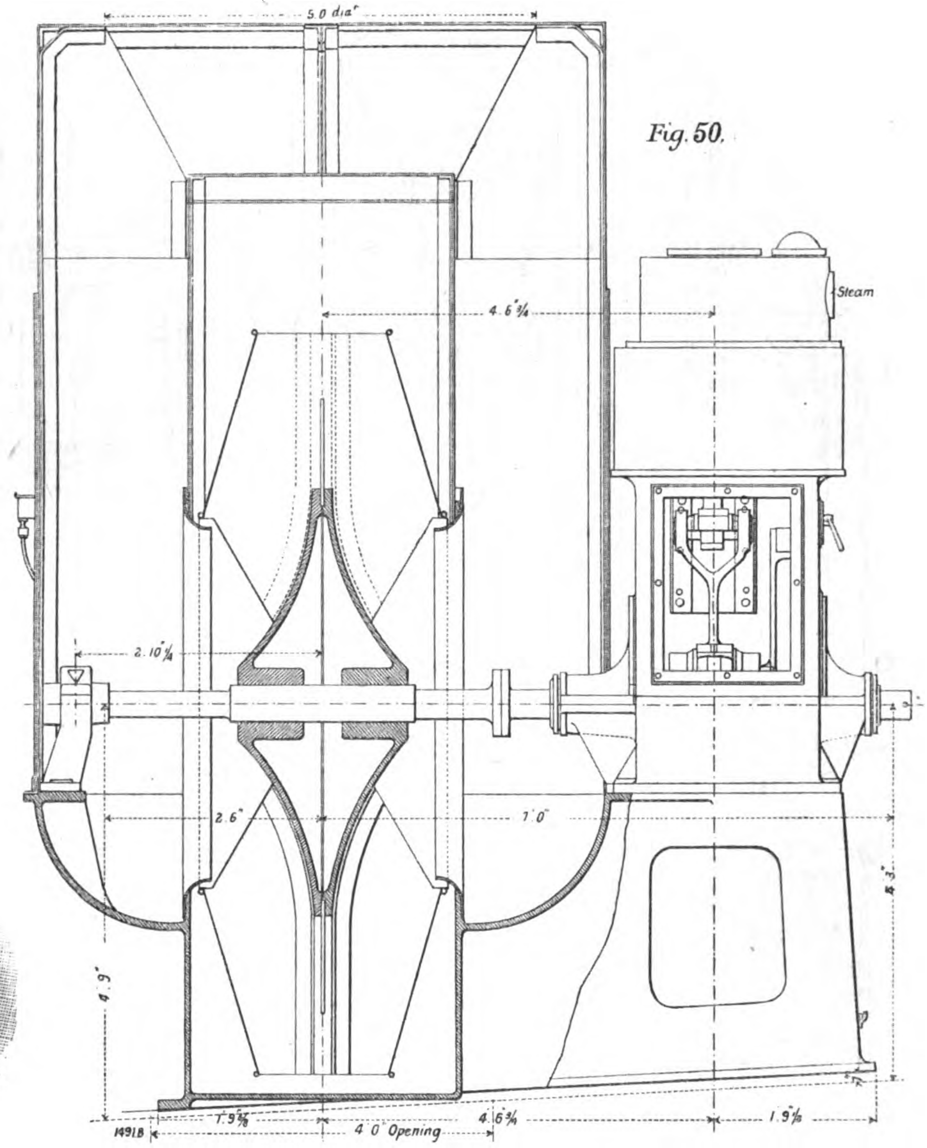


Fig. 50.



where the switchboard is situated in a room specially set apart. By the adoption of this means the risk of entire extinction of lights is eliminated, for should one set of generating plant get disabled, another is available, and the inconvenience to the user of the light is momentary. The switchboard consists of a polished white marble slab mounted in teak, and measuring about 7 ft. long by 5 ft. deep. As will be seen from the sketch of it given in Fig. 53, on page 490, it contains the cut-outs, main switches, and a set of four-way switches so arranged that any main wire can be connected to any dynamo; but no two dynamos can be put on the same main wire at the same time. The dynamo terminals are distinctly separate, and are grouped round each main wire terminal, so that the switch can but connect one of the dynamo terminals to the main. The ammeters, of which there is one to each dynamo, are mounted at the switchboard to enable the attendant to regulate the load on the dynamo; but the volt-meters, which are more useful at the dynamos, will be placed in the engine-room, so that the man at the stop-valve can regulate his speed by them. There are 12 mains, which generally pass from the switchboard forward or aft on each deck, and in addition there is a supplementary main for the projector (16 in. in diameter), taking a current of 50 ampères.

The wiring is on the return conductor system, and Siemens patent distributing cut-out boxes are in use. The main wires vary from $\frac{19}{24}$ — 19 wires of 14 standard gauge — to $\frac{7}{16}$. Of the first-named 380 yards has a resistance of $\frac{1}{10}$ ohm. The wires have all been tested under water before being fitted into the ship, and the average insulation resistance is about 1000 megohms per mile. Of the cut-out boxes we give an illustration in Figs. 54 and 55, on page 490. They each consist of a teak case containing a porcelain insulating base, on which is mounted a switch for breaking the circuit, and a set of 10 single-light cut-outs arranged five on each side on a vertical bar. Messrs. Siemens' cut-out is slightly different from that ordinarily applied. The plan adopted is to bring the ends of the wire up through the insulating base; the conductor is laid bare for a certain distance, and the fusible bridge is then clamped against the bare portion of the conductor at the one end, and in contact with the central bar of the box at the other end. In this way intermediate contacts are dispensed with, and the officer having charge of the key of a particular distributing box may effectually control the lights. The police lights are grouped together, and while the central part of the distributing box may be entirely disconnected, a special connection is made with the main past the switch, so that the police lights remain in circuit. The return wires are brought to a separate division in the box, whence they are connected to the return main.

In addition to the electric light, Messrs. Siemens have fitted an elaborate installation of electric bells, comprising 13 bell indicators, with an aggregate of 370 transmitters, the power being supplied by Siemens' dry batteries. The motor for the barbers' shop is driven from the electric light mains.

THE NAVIGATING APPLIANCES ON THE SHIPS.

THE great speed to be attained by the new steamers, and the necessity, therefore, of the ships being under full control under all circumstances, have been fully recognised. The look-out is perched in the crow's nest on the foremast, as will be seen from the general view of the Campania on our two-page Plate No. VIII. It has been placed sufficiently high to allow the look-out to get in from the ratlings, which are much more convenient than the usual small ladder fitted close up against the mast. The crow's nest is about 100 ft. from the water level, so that there is a splendid command of the horizon; indeed, the look-out man can see all round within a radius of 15 nautical miles if the atmospherical conditions be favourable. As the fog frequently extends relatively but a few feet above the water surface, it will sometimes occur that he may see the masts and sails or funnels and smoke of approaching vessels even when the hull is obscured. Notwithstanding his great height, he is within hailing distance of the bridge of the steamer.

The bridge has been built of great strength, immediately before the forward funnel, so that it is as far aft as practicable, and therefore clear of the heavy seas which break on board in the season of hurricanes. The framework of the bridge is entirely of steel, and has upon it only a small house for the shelter of the seamen at the telemotor operating the steering gear at the after end of the ship, while a small compartment of the same erection serves as a working chart-room (see Fig. 68, Plate No. V.) It is not much larger than a sentry-box, but is built with the strength, although not exactly with the solidity, of a conning tower. The whole surroundings suggest duty, for there is but a gangway without any great shelter, and no refuge from the storm. On the bridge is a double set of instruments for directing the complete staff forming the watch, a telegraph for communicating with both engine-rooms, and for replies to signify compliance with orders. The steersman in the tower has the telemotor at hand for moving by hydraulic power the heavy steam tiller gear aft under the water line; but lest this connecting gear should get out of order, there is a telegraph communicating direct with the steering-house below. There are also telegraphs to the deck machinery, warping capstans, windlass, &c., so that when the ship is being moored the attendants are under the direct orders of the commander on the bridge.

All the compasses on board the ship are by Lord Kelvin, and have been constructed with all the care and precision which marks the work of his lordship's constructive establishment. The standard compass is placed amidships between the two funnels. In addition to the main bridge there is a supplementary bridge aft above the poop deckhouses, from which, in the event of any serious accident to the fore bridge, the ship can be navigated with almost equal convenience.

The Steering Gear.

The most important item in the navigating appliances of the ship is clearly the steering gear, which has been provided by Messrs. Brown Brothers and Co., Edinburgh.

On page 491 we give two views of the gear, taken before it left Messrs. Brown's Works. The general principle of this gear, now well known, is that the steering engine is attached to the rudder-head without the intervention of chains and ropes, which frequently get out of gear; that it lets go the rudder when unduly strained, allowing the rudder to return automatically to its former position when the abnormal strain has gone. The general principles and details were explained by Mr. A. Betts Brown, the patentee, in a paper read some years ago before the Institution of Naval Architects.* The rudder-head is turned by means of a tiller having at its after end a double jaw fitted with bearings, and carrying between the jaws a pinion running in a horizontal plane and engaging with a toothed quadrant bolted to the deck. The steering engine is, as stated, carried on the tiller and moved round with it, receiving and exhausting steam through a double stuffing-box arrangement mounted on the axis of the tiller. The cylinders have piston valves, and the reversing is effected by changing the direction of the steam entering the cylinders through a slide valve placed between the latter. The arrangement has been considerably modified to suit the limited space at disposal consequent on the fine lines of the new Cunarders and the fact that all the gear had to be below water-line, a condition insisted upon by the Admiralty for vessels which, as in the case of the Campania and Lucania, are destined to act as armed cruisers in times of war. The illustrations show the general arrangement of the gear, as well as the auxiliary gear, both of which are worked by steam, there being no hand gear. The space at the disposal of the designer was but 6 ft. wide at the rudder-head, gradually increasing with the curved lines of the ship to 22½ ft. wide at the centre line of the auxiliary gear, the length being 44 ft. Owing to the fineness of the after part of the ship, it was decided to fit connecting rods from the rudder crosshead to the steam tiller, which in this case works forward instead of aft, as in some previous arrangements.† These rods, being about 20 ft. long, enable the main steering gear to be placed in such a position as to work clear of the ship's frames. The tiller, which is of cast steel, is about 17 ft. long and acts upon a 4-ft. rudder crosshead. All the machinery involved is a bronze wormwheel, connected, by an internally expanding friction clutch with spring relieving gear, to a steel pinion about 18 in. in diameter working in the cast-steel segmental curved rack of about 13 ft. radius on the pitch line. The steering engines for driving the bronze wormwheel work in an inclosed oil-tight tank on the end of the tiller, having two valveless oil pumps, which throw a constant stream of oil over the working parts, the charge of oil being renewed about once in three months. The power of these engines and gearing is sufficient to strain the rudder-head to one-half its elastic limit.

In a ship of such size and speed as the Campania it was considered that any reasonable number of hand-steering wheels would not render it feasible to steer the ship when the steam steering gear was deranged, therefore auxiliary steam steering gear is fitted forward of the main steam tiller. The auxiliary engines are of one-third the power of the main engines, but are geared up by cast-steel gearing with pitch wheel and chain, which latter lays hold of the end of the tiller, so that the ship can be steered as efficiently with the auxiliary as with the main gear. The auxiliary gear is connected and disconnected by means of an internally expanding clutch in the same way as the steam tiller, so that two reliable brakes are always ready to be applied to the rudder in case of accident, and the engagement of either gear can be effected within a minute without involving the shipping of bolts or clutches. The efficiency of both brakes depends, of course, on the presumption that the steam tiller does not break, such an accident being a most remote possibility, as the latter is of a strength largely in excess of the resistance to torsion of the rudder head.

To guard against the possibility even of this accident, however, a pair of powerful hydraulic cylinders are provided, the rams of which lay hold of the connecting-rod pins at the steam tiller end. Water circulates between these cylinders, passing through a communicating valve, so that the attendant could at once shut the valve and arrest the motion of the rudder should such an extremely remote contingency occur as the breaking of the tiller. The side connecting-rods are also of such a section that one would be sufficient to steer the ship with perfect safety, and all the fittings connected therewith are sufficiently strong to resist the unbalanced strain due to steering with one rod only.

The valve gears on the main and auxiliary steering engines are operated upon by a hydraulic telemotor cylinder connected by two lines of ½ in. diameter copper pipes to the bridge, where the telemotor is placed. In addition to this steering station there is also one on the poop, which communicates by means of a vertical shaft with the valve gear. Finally, in the event of the ship being used as a cruiser, and the telemotor pipes being shot away, as well as the after steering station, there is an under-water steering station from which the vessel can be steered with the aid of telegraphic instruction from the bridge. It will be seen, therefore, that every contingency has been guarded against.

To afford the reader some idea of the strength and solidity of the construction, as illustrated by the two views of the gear on page 491, it may be mentioned that it weighs 45 tons, the bulk of it being of forged and cast steel. The rudder, as has been already noted, is of large area, being 12 ft. broad and 20 ft. deep, and with the assistance of the twin engines working in opposite directions, may turn the vessel in her own length. The necessity of a large and powerful rudder will be appreciated when the great speed is recalled; but the case has fully been met, and the vessel will veer from her course almost the moment the captain gives the word of command to the man at the telemotor on the bridge.

Windlass, Capstans, &c.

The general arrangement of the navigating and other auxiliary machinery on deck is extremely compact, more especially on the forecastle, where the stress from the seas continually breaking over the ship would render any complicated erections a source of trouble, if not of danger. Everything, too, is of the strongest make, as will be appreciated on reference to the deck view on Plate No. IX. The mechanism is all under deck, so that only very strong structures are visible—the two 5-ton hoods of the windlass, the warping capstans, the well battened down hatches over the fore hatchways, the cowls of the ventilators—so arranged that they can be conveniently closed—and two heavy breakwaters, formed of angles and plates, the latter bent over towards the bow the better to resis the sea, for the forecastle has only the ordinary galvanised rail. These breakwaters are well shown on the engraving of the Campania on the stocks given in Fig. 11, page 471.

The windlass is arranged, with all mechanism, as we have said, below deck, only the hoods projecting above deck. The design necessarily formed a subject of great consideration, and certainly everything connected with it is of a massive character, necessitating special strengthening of the deck where it is fixed. The power required will be appreciated when we state that the cable is 3 in. in diameter, while the anchors are of 10 ton weight. The windlass and gear were supplied by Messrs. Napier Brothers, Limited, Glasgow, and are somewhat similar to the arrangement adopted and giving satisfactory results in some of our larger battleships, notably in the Hood, tested recently. The engines, shown in Fig. 60, page 492, are of the vertical high-pressure type, exhausting into the condenser. The cylinders are 17 in. in diameter by 14 in. stroke, working with a steam pressure of 150 lb., the engines making 150 revolutions. The horse-power will be about 600 indicated. The piston valves are worked direct from the shaft by eccentrics. The reversing of the engines is controlled through a cylindrical reversing valve attached to the side of the steam casings, and actuated by a handwheel at the engines, and by a handwheel on the deck above.

Figs. 58 and 59, on page 492, show a vertical section and plan of the shafting and gearing from the engines to the cable-wheels. The arrangement is—as will be seen—for two cable-wheels. They can be worked independently of each other, or coupled together. The vertical shaft from the engines is geared to a cross-shaft, which drives a worm gearing into a wormwheel on each of the vertical spindles supporting and driving the cable-wheels. The worms are of phosphor-bronze, running in baths of oil, and the wormwheels are of steel. All the gearing wheels, indeed, are of steel, and all have machine-cut teeth. All the shafting and forgings of engines and cable gear are of steel.

The decks where the sole-plates of the cable-wheels rest have been stiffened by strong girders, so that they may carry the sole-plates, which each weigh five tons. The cable-wheels are loose upon the spindles, and instead of having the ordinary friction clutch arrangement, they are put into gear by a patent driving-pin device, consisting of two strong steel bars, supported on a steel disc, keyed on to the top of the cable-wheel spindles. These bars are slipped into suitable notches on the steel cable-wheels, the bars being locked by a hinged steel locking piece, when in gear and when out of gear. The brake gear is Napier's patent differential self-holding brake, and is shown in Fig. 59. In letting go the anchors, the driving pins are taken out of gear and the cables lowered by the brake. The brake is entirely self-holding, and the greater the strain on it the firmer it grips. In lowering, the attendant has simply to raise the lever, and can pay out cable inch by inch. In this way it is a most serviceable and convenient brake for riding by in a heavy sea. In other large vessels where this brake has been fitted to windlasses, they prefer to ride by the brake than by using the more clumsy method of riding bitts and bow stoppers. In the new vessels there are no riding bitts, but bow stoppers are fitted as a stand-by. An arrangement of shafts and clutches is made whereby the cable engines can work the capstans, or the capstan engines can work the cable-wheels, so that here, also, the possibility of complete breakdown is minimised. Altogether, the arrangement and details are capitally worked out.

It it interesting to note further that the diameter of the chain, 3 in., is the same as that used for the Great Eastern. We give dimensioned views of the links and joining shackles in Figs. 61 and 62, on page 492.

The hawse-pipes through which these chains drop are necessarily of great size. The steamers have been fitted with the heaviest bar anchors yet made, of 10 tons weight. They are on the Trotman patent, and, together with the 3-in. cables, have been supplied by Messrs. Wood, of Saltney, Cheshire, while stockless anchors have also been provided by Mr. Wasteneys Smith, Newcastle-on-Tyne. A small derrick is provided for lifting and stowing the anchors.

The warping capstans have been supplied by Messrs. Muir and Caldwell, Glasgow, and have

* See Engineering, vol. xlix., pages 434 and 491.
† See Engineering, vol. lii., page 89.

ELECTRIC LIGHTING INSTALLATION.

ENGINES CONSTRUCTED BY MESSRS. G. E. BELLISS AND CO.; DYNAMOS, &c., BY MESSRS. SIEMENS BROTHERS, LIMITED

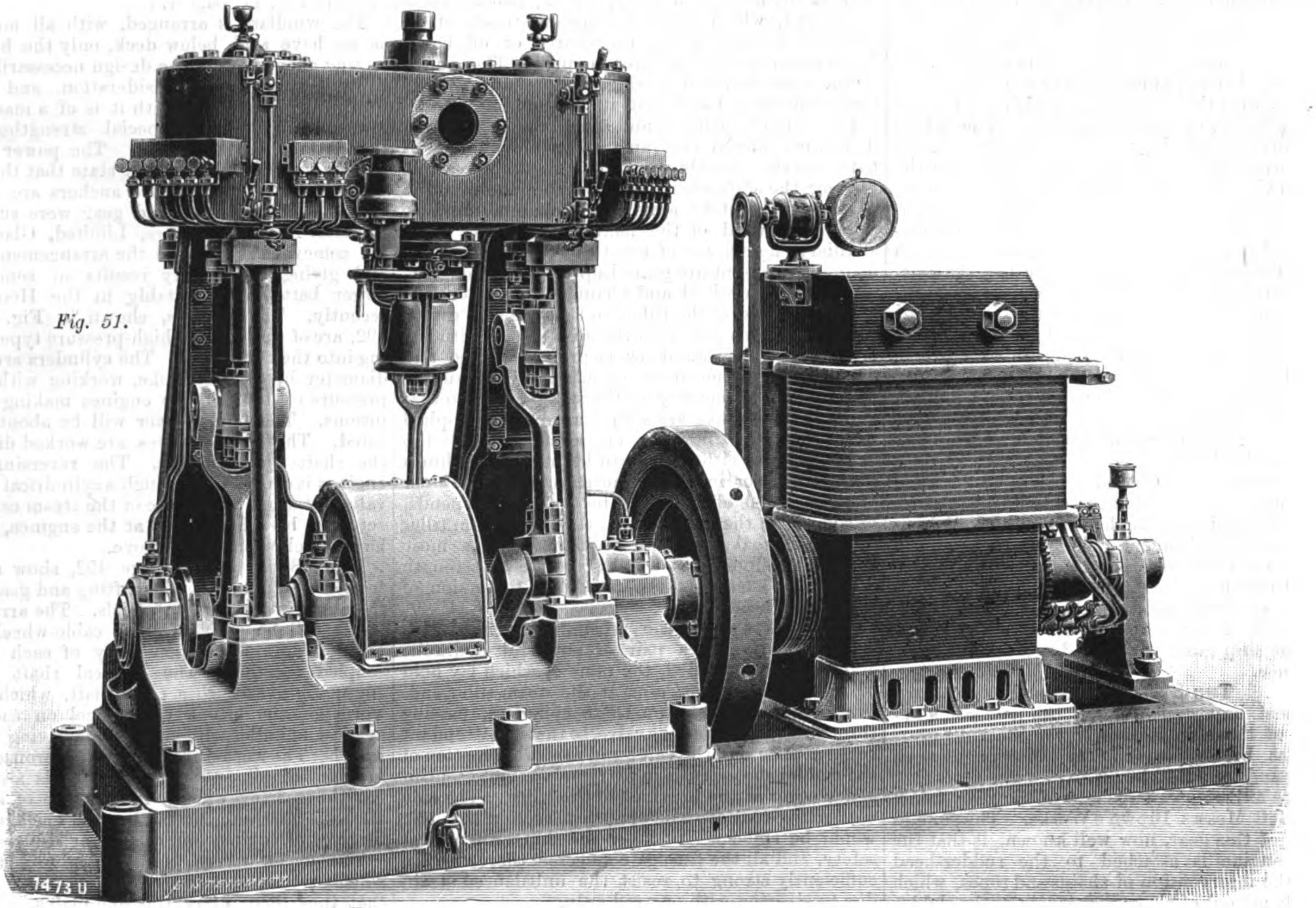


Fig. 51.

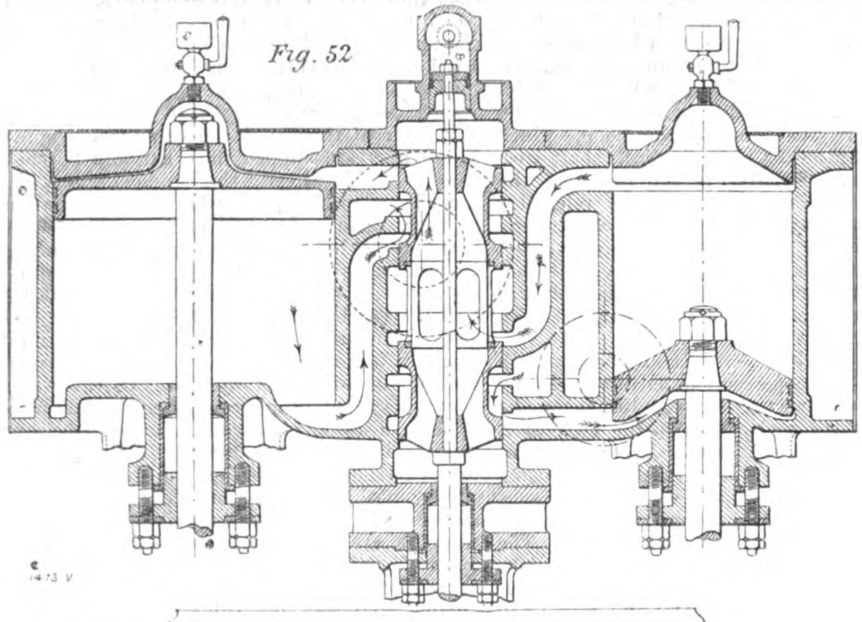


Fig. 52

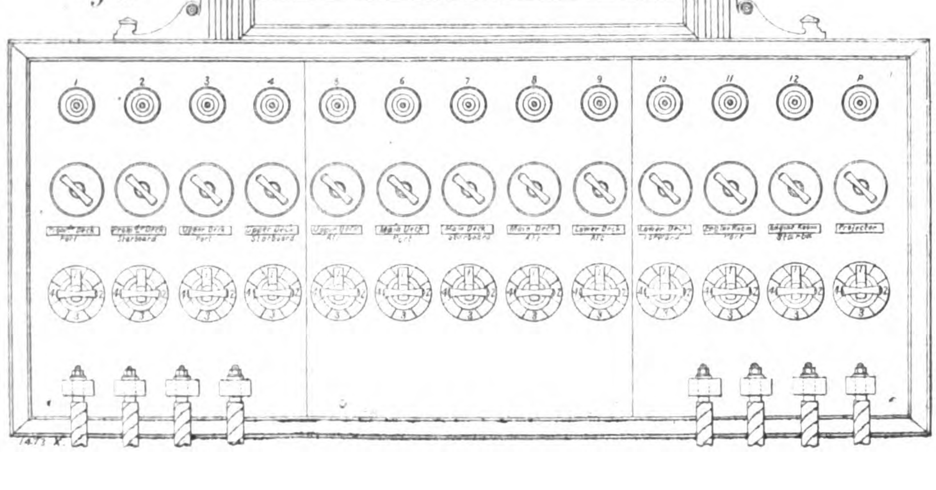


Fig. 53

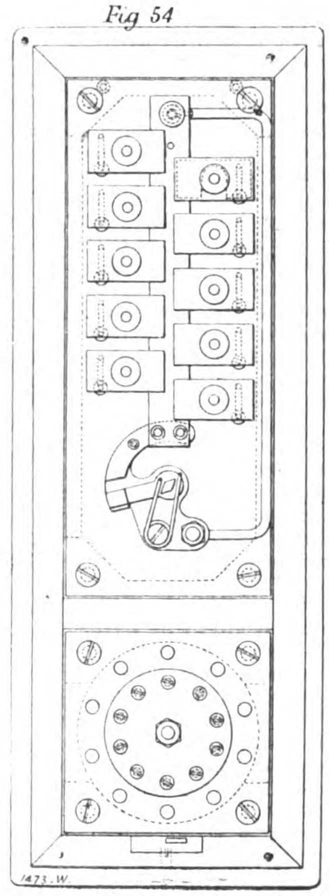


Fig. 54

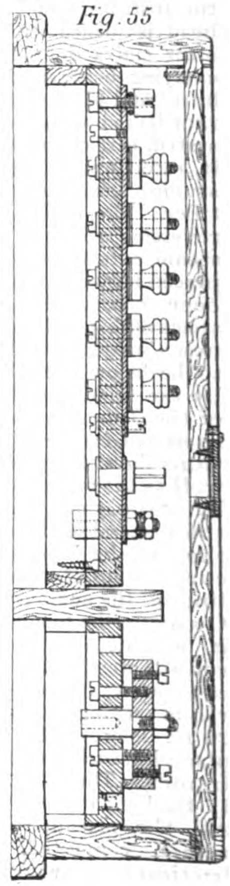


Fig. 55

STEAM TILLER STEERING GEAR.

CONSTRUCTED BY MESSRS. BROWN BROTHERS AND CO. ENGINEERS, EDINBURGH.

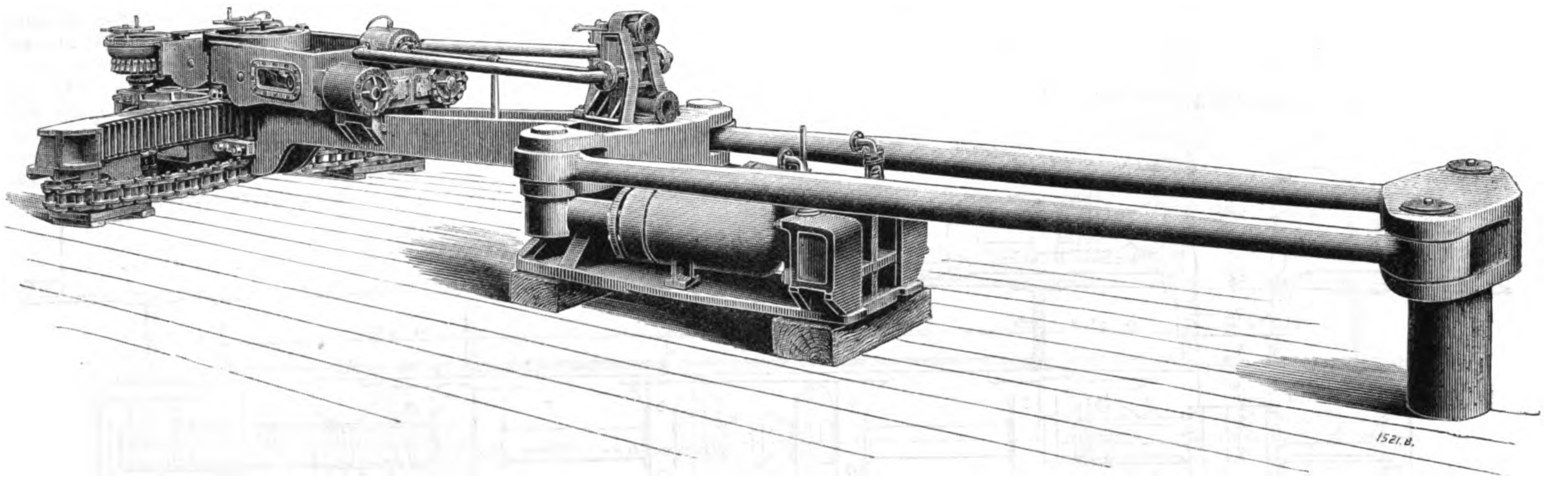


FIG. 56.

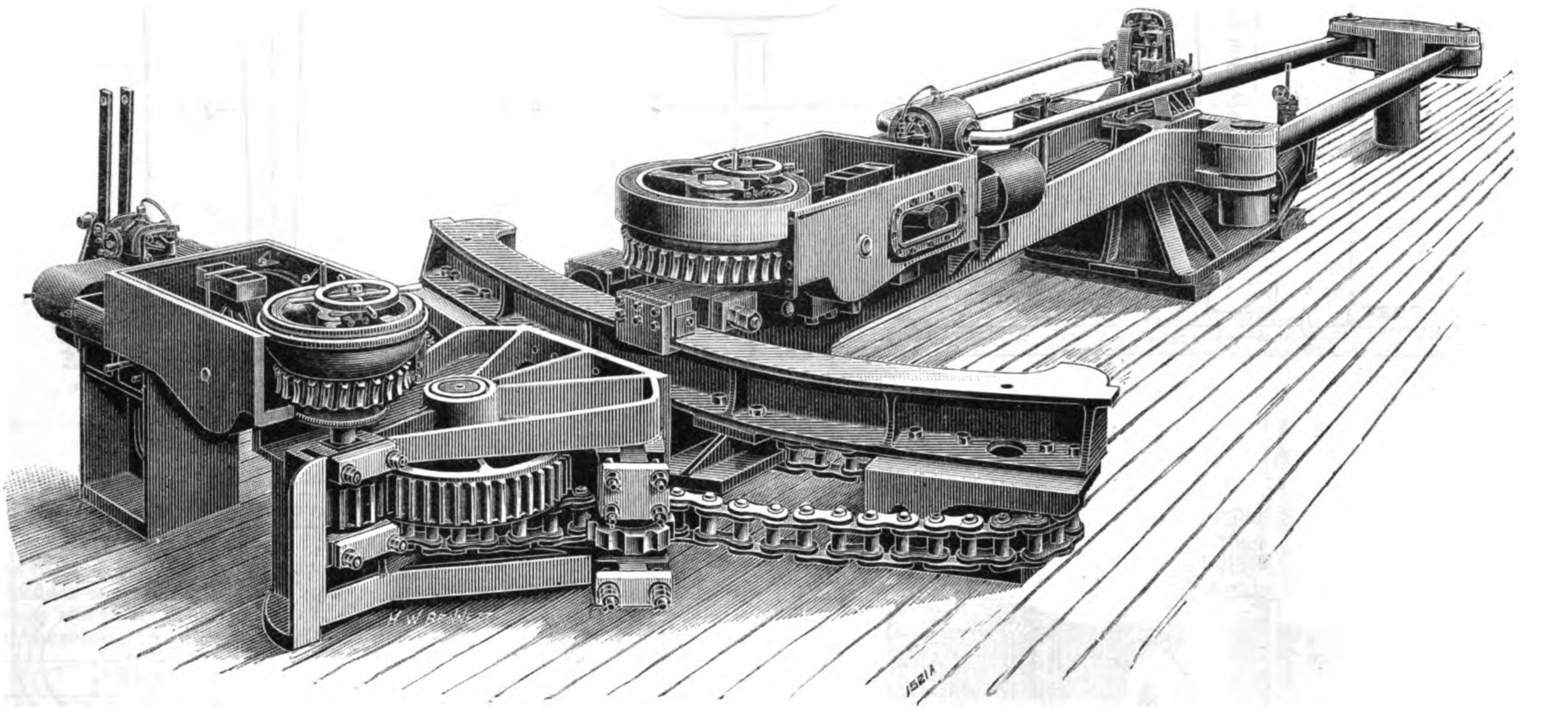


FIG. 57.

been arranged, with the engines and shafting, below deck, although means of control have also been provided on the forecastle head. A duplicate set of warping capstans has been fitted on the poop deck for working the after ropes.

SEARCH LIGHT.

A most servicable navigating appliance is the search light, which is now becoming a usual adjunct in our larger steamers. In this case a departure has been made from the ordinary practice in Atlantic vessels, where the search light is fixed. The system adopted specially for the Suez Canal has been followed in the new steamers. The search light has a projector of 16 in. diameter, having a light equal to about 2000 candle-power. The apparatus is carried in an iron cage, which also accommodates the operator, and it is made with a slot which fits on to the stem of the ship, and thus guided is lowered down to the water's edge when the ship is nearing her anchorage. In this position the cage can be fixed temporarily to the stem by bolts, and the operator can flash the light along the surface of the water, lighting the whole area for a great distance, so that it is easy in the darkest night to pick up the buoys. The light being down at the water's edge instead of on the bridge or main deck, insures that there will be no deep shadows between the rays and the water. With the buoy near the ship, and such shadows cast, under ordinary conditions the difficulties are immensely increased.

The light towers, which are strongly built of steel, are alongside the bridge, and, of course, on both port and starboard side of the ship. There are two lights in each tower. The upper one is to be illumined by electricity, while the lower light is fitted with oil in the usual way, to be a stand-by for use should the electric current fail. The masthead light is also illumined by electricity, the wire running free on the block and tackle. The lamps have been supplied by Messrs. William Harvie and Co., Glasgow.

THE PASSENGER ACCOMMODATION.

BY the date of the launch of the Campania the woodwork of the various saloon and cabin bulkheads was in an advanced state. The general scheme of the arrangements was—as will be seen from the deck plans, Figs. 69 to 73, on Plate V.—to accommodate the first-class passengers in the centre of the vessel, the finest state-rooms or suites of rooms being on the promenade and upper decks. The ordinary state-rooms are mostly on the upper and main decks, with a few on the lower deck, all the first-class accommodation being forward of the engines. The second-class passengers are located on the same decks aft of the engines, with the broad expanse of poop for promenade; whilst the third-class passengers are accommodated on the lower decks. The members of the crew have their berths in the forecastle; the navigating officers' quarters are on the shade deck close to the bridge, while the engineer officers are on the main deck close to the engines. The great size of the ships admits of

WINDLASS AND WINDLASS ENGINE.

CONSTRUCTED BY MESSRS. NAPIER BROTHERS, LIMITED, GLASGOW.

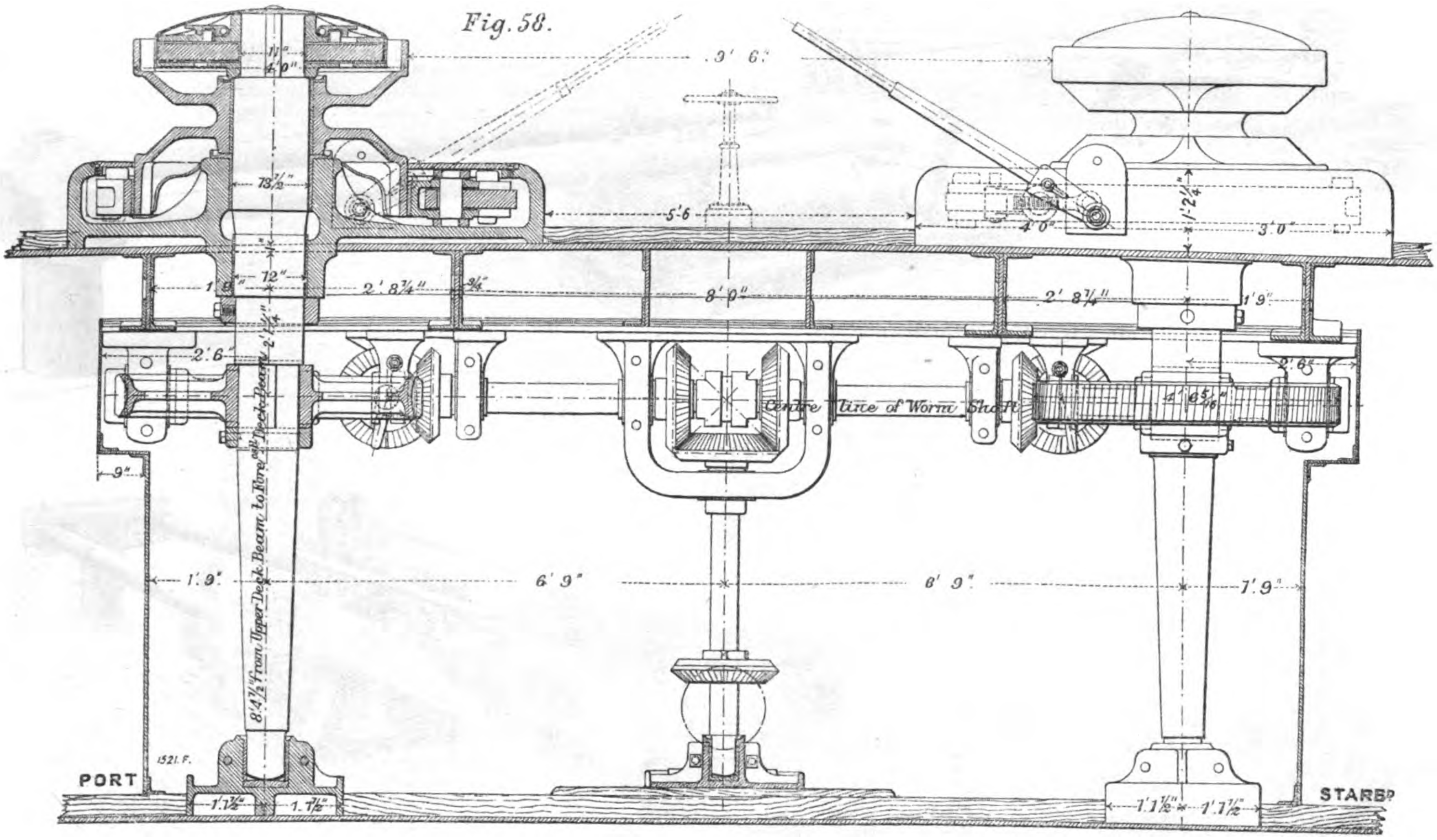


Fig. 58.

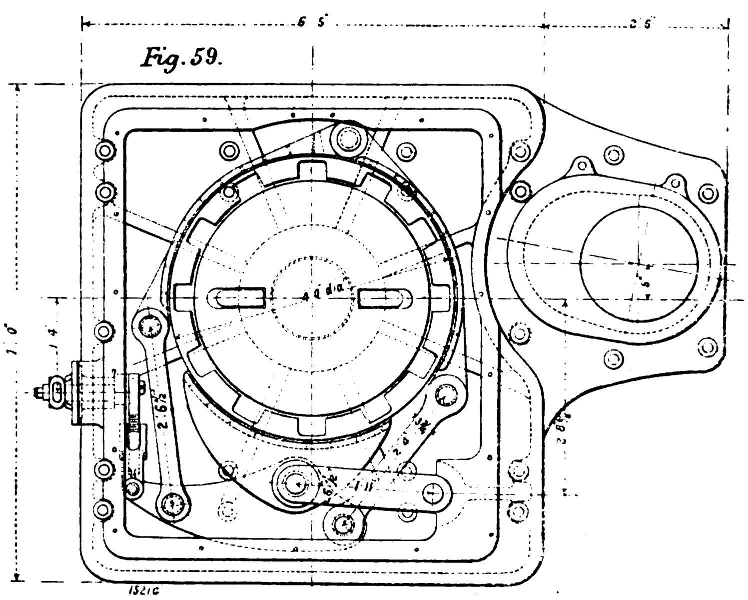


Fig. 59.

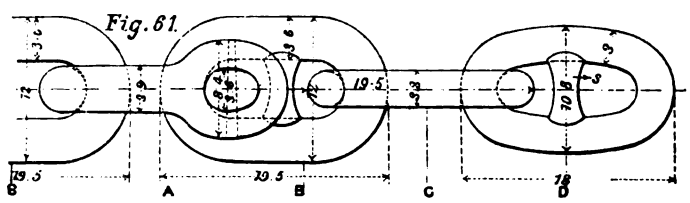


Fig. 61.

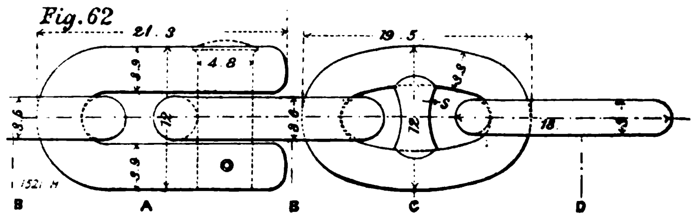


Fig. 62.

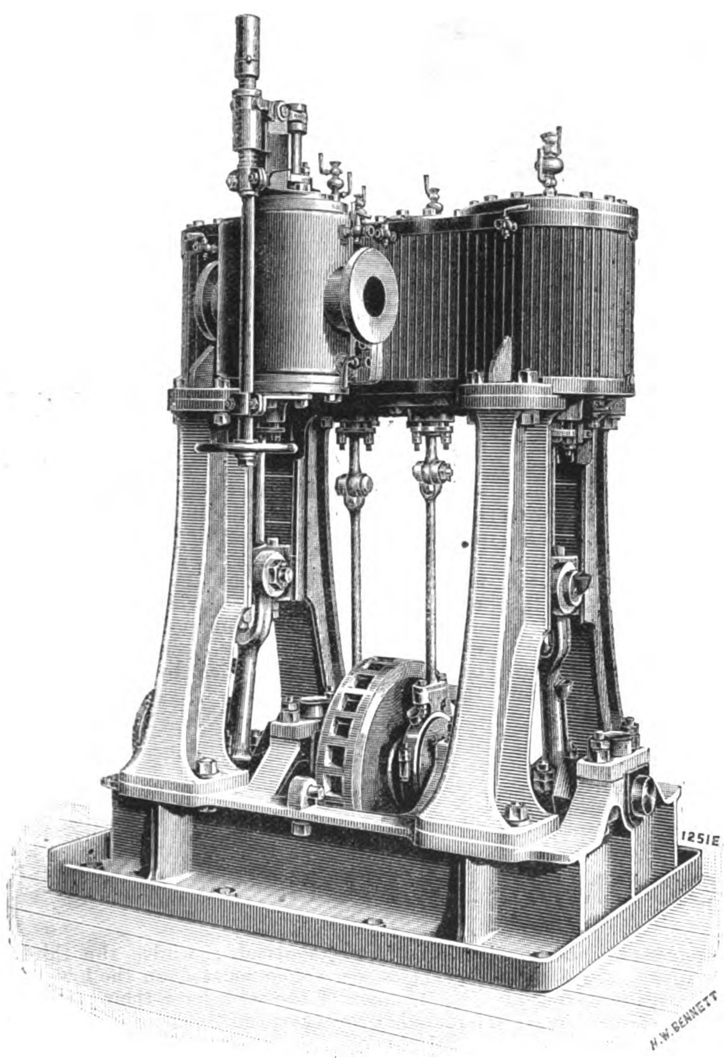


Fig. 60.

many concessions to passengers, the rooms being in many cases of unusual size, particularly as regards height of ceiling, while one-berth as well as two-berth rooms have been introduced. The promenading space, too, is ample, and in all cases is sheltered. On the promenade deck there is, as shown on the plan, Fig. 70, on the two-page Plate No. V., and by the perspective view, Fig. 88, page 494, a great stretch of clear deck, on either side of the ship, so that by a circuit of the ship four times the passenger traverses a mile, and yet scarcely appreciates the fact. The uneven line of the deckhouses, too, affords several spaces suitable for deck seats, where the passenger will be sheltered from the breeze. None of the space on the promenade deck is required for navigation, the officers having the shade deck and the bridge. They will not, therefore, be interrupted in their work.

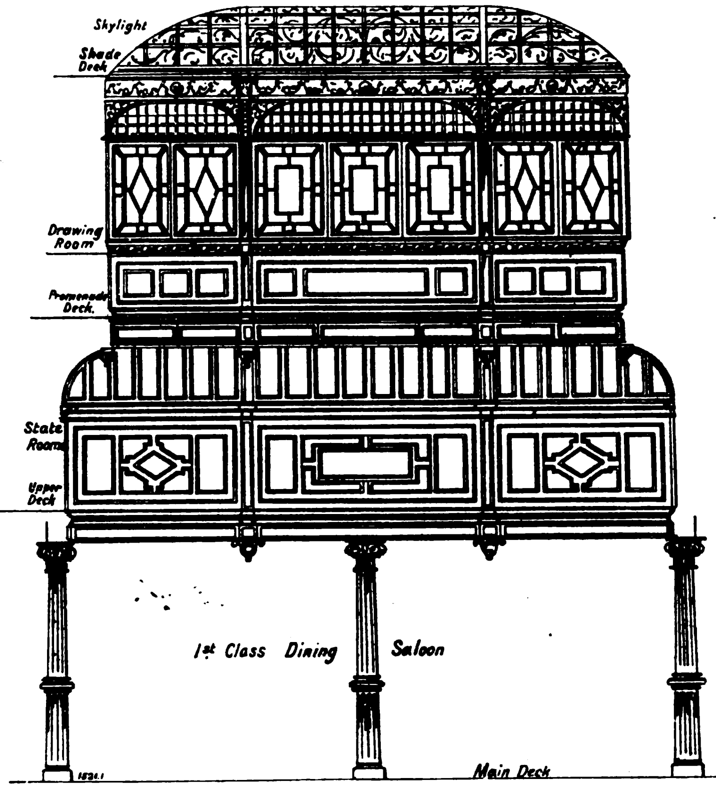


FIG. 74. SECTION THROUGH WELL.

THE GRAND STAIRWAY.

The stairway (see Fig. 81, on our two-page Plate No. VII.) leads not only to the principal public rooms in the ship, but to most of the best state-rooms. It opens from the promenade deck, and of necessity has connection with the upper deck. It has always been a difficulty, especially in a ship where room has to be profitably utilised, to so design a double flight of stairs as to give adequate light on the lower stair. This difficulty was experienced in these new steamers; but a very ingenious system of construction has resulted in a solution attended with marked success. The upper stair—that between the promenade deck and the upper deck—although amply sufficient for all possible requirements, is kept distinctly smaller than the stair immediately below leading to the main deck, and therefore into the dining saloon. The upper stair, too, is kept clear of the bulkhead, so that natural light finds its way down to the mid-landing through the space between the upper stair and the bulkhead. On the other side of the steps, too, the same principle has been adopted, of allowing light to pass down a well on to the lower flight of stairs. The roof of the stairway is curved and has a large skylight, so that the lighting area is ample, and the general result, as we have indicated, very satisfactory. The light at the foot of the double stair, indeed, is greater than is usually the case with only one flight of steps.

The staircase is panelled in solid teak, the upper portion being in gold Japanese leather paper to lighten the effect. The stairs have wide treads with a small rise, and there is a centre handrail, in addition to the usual side railings, so that when the ship suddenly lurches a passenger will have a better opportunity of readily finding a support. This is essential (although not always provided), with stairs sufficiently wide for four or six passengers to ascend or descend abreast. On the extensive landings on both promenade and upper decks lounges have been provided, suggested by the preference of these places as rendezvous.

THE DINING SALOON.

The dining saloon is placed on the main deck, and is, as reference to the plan Fig. 72 on two-page Plate No. V. shows, an apartment of immense size, the length over all being about 100 ft., and the breadth aft 62 ft. It was designed and completed by the Fairfield Company themselves. The outstanding feature of the fittings in all cases is their substantial character, and the decorations, while highly artistic, are neither garish nor offensively elaborate, as is often the case on shipboard. Interior views of the dining-room, prepared—as are our other interior views—from excellent photographs, taken by Messrs. Annan, of Glasgow, are given in Figs. 78 and 79, on Plate No. VI., and Fig. 80, on Plate No. VII.

The general style of the dining saloon suggests the Italian. The walls are in old Spanish mahogany, of a design at once chaste and effective. The upholstering is in frieze velvet, in dark rich red, with figure pattern, and the curtains are in keeping, and here it is interesting to note that there is a set of curtains suitable to the general scheme of decoration for both summer and winter for all public and several of the private saloons. An important feature is the height of the dining saloon, which is 10 ft. throughout, and even this extra foot to the usual height will be a welcome concession to comfort in insuring better ventilation. Another feature is the want of uniformity in the saloon, an advantage gained owing to the fact that various air and ventilating shafts, stairways to lower cabins, partial bulkheads, &c., break up the area. They detract from the appearance of size, which is not a disadvantage, but, by judicious planning, a large number of nooks and corners have been secured, where by arrangement small parties may dine regularly in almost complete seclusion, instead of being mixed in the general company. Indeed, sauntering through the saloon, the belief grows upon one that those seeming excrescences, with their immense bevelled mirrors or richly carved panellings, are the result of careful planning with the object of satisfying the desires of small parties.

There are four tiers of large tables running fore and aft the saloon, as is shown by the view Fig. 78 on Plate No. VI. The usual style of revolving chair is provided, with the lion rampant, the well-known insignia of the Cunard Company, carved on the back. Accommodation is provided for the whole of the first-class passengers in this saloon, while a small saloon adjoining is specially provided for the children and servants of first-class passengers. This enables all the passengers to dine at the one hour instead of in two groups, as is nearly always the case in large steamers. The sideboard, shown in Fig. 78 on Plate No. VI., instead of having the usual marble top with brass rail, is entirely of Spanish mahogany, in keeping with the general finish of the saloon, and, as it is 25 ft. long, it presents a handsome appearance, with its great expanse of bevelled mirrors.

The public rooms on the promenade deck being of unusual size, the dining-room is designed purely as a *salle à manger*, and the great necessity of perfect ventilation has been fully recognised. The system adopted is somewhat novel. Each of the sidelights in the saloon, of which there are 20 on either side, is of exceptional size and diameter; and by the use of Utley's patent ventilator, which we shall describe later, the inlet for the air can be left open, no matter how rough the sea may be. This insures a constant supply of fresh air entering for the whole length of the saloon. The outlet is provided for by oval ventilating shafts through the saloon roof, thence by passages and shafts to the shade deck, where also the ventilators may be left open under all conditions.

For lighting as well as ventilating the saloon there is a central well, which is about 24 ft. long and about 16 ft. broad, and is carried right up and through the upper and promenade decks, the covering just above the line of the shade deck being a curved dome of stained glass, with an outer casing of thick glass in teak framing, hinged to open for the purpose of ventilation. The extreme height from the dining saloon floor is about 33 ft. A section through this well is given in Fig. 74, annexed, while Fig. 79, on our two-page Plate No. VI., gives a perspective view looking upwards.

From the dining saloon floor there are a series of stanchions, as shown in Fig. 74, the sides above the upper deck being stiffened and braced with iron. The woodwork is decorated in ivory white, relieved with gold lines on the moulding. The pilasters above the line of the promenade deck are richly carved, and surmounted with a frieze all round. The outer side of the well, that forming part of the walls of the drawing-room, is of cedar stiles in the lower part, with a dado moulding, while the upper part is panelled off with heavy bevelled glass mounted in sashes, each swinging on a centre pivot, and all made to lock in position—a commendable departure from the hitherto largely adopted practice of leaving the upper part—that above a balustrade—open. This will be a relief to the passengers who are indisposed to enjoy the luxuries of the table, a condition which unfortunately does present itself to many who go down to the sea in ships, when they will prefer the solace of the cheery fireside of the drawing-room in the Campania. Thanks to the precaution taken, there cannot come to them unpleasant reminders of the penalty of their weakness in the fragrant odours which float up the well from the dining saloon below.

THE DRAWING-ROOM.

The fireside is one of the most charming features of the beautiful drawing-room, which is an unusually large apartment 60 ft. long by 30 ft. broad, and is well lighted, not only from the large square windows looking on to the promenade on either side of the ship, but from the well which pierces the promenade deck in the centre of the saloon, and from two cupolas, one in the centre of the part of the saloon forward of the well, and the other in the part aft. The general effect, too, is greatly enhanced by the roof, which has a rise in the centre. Three views of the drawing-room, giving an excellent idea of the admirable taste with which its decoration has been carried out, are shown by Figs. 75, 76, and 77, on Plate No. VI.

The "ingle neuk" is quite an unusual feature of the drawing-room, or perhaps a return to the homely condition which formerly obtained, without any of those discomforts which Dickens has narrated in his inimitable style. It is at the forward end. The mantel and overmantel are both in satinwood, richly carved, with three arched mirrors, all in keeping with the general scheme of decoration of the room, which is in the Renaissance style. The grate is of brass, and the hearth laid with Persian tiles. A feeling of cosiness is contributed by two lounges fitted on either side of the fireplace, with an ottoman in front, while the subdued light through the stained-glass cupola completes the charming effect. Comfort is suggested by the arrangement as well as by the whole apartment. The walls are in satinwood relieved with cedar mouldings, the frieze panels being of plane tree. The ceiling is in pine, decorated in light tones, old ivory prevailing, with a little gilding. The electric lamps are arranged in the alternate panels, forming the centre of a pattern, and not on the beams, as is usual.

Steel stanchions support the roof at intervals. These are covered with satinwood with carved capitals. There are two porches forward, and these connect with a passage on either side to state-rooms forward on the promenade deck. These porches are also in satinwood, with stained-glass panels, and rich brocade portière curtains hang across the entrances. At the after end of the saloon there is a recess, into which has been fitted an American organ, the casing being of satinwood, with cedar-wood panels. This portion of the room is shown by Fig. 76, Plate No. VI. There is in the same saloon a boudoir grand piano by Collard and Collard. Like all else in the apartment, it is in satinwood, the polished top and panels of which show the beautifully rich clouded figure of the wood in fine contrast to the duller surfaces of the cedar. Both instruments are specially protected against damp and moths. The stools in each case have been made receptacles for music. The settees, ottomans, &c., with the chairs for the card-tables, are upholstered in rich velvets and brocades of various colours, which, together with the rich Persian pile which covers the flooring, and the delightful variety and irregularity of the furniture, give the room a very attractive appearance. Two arched vestibules lead from this charming room into the landing of the grand stairway already described.

The Smoking-Room.

The smoking-room has powerful counter-attractions—material and otherwise. The apartment is about 40 ft. long by 32 ft. wide, and is situated on the promenade deck aft, with a bar at one end. There is the same feeling of homeliness here in the fire burning brightly in the bronze dog grate, the flames dancing on the dark blue tiles of the hearth and cheeks. The beautifully carved fireplace and overmantel are, as will be seen by the view, Fig. 82, on Plate No. VII., in excellent keeping, the woodwork being entirely of fumed oak, while the upholstering is in pigskin of the usual natural shade, which is certain to improve with wear. The decoration is in the old Scottish baronial hall style, with the old chairs and tables of the period. The whole tone is subdued, and suggestive of elegant ease and comfort. All round the smoking-room are arranged small alcoves or recesses, each with little tables and chairs around the sides, so that here, again, small parties may be formed to enjoy the comforts of the soothing pipe, or more elegant, if not more enjoyable cigar. Or even—but tell it not in Gath!—to take a friendly hand in that innocent game (not entirely unknown on the Atlantic) yclept "poker."

There are four different entrances or exits, two from the fore end leading to the quarters of the ship where the state-rooms are arranged, and one on either side leading on to the promenade deck, while a stairway leads to the deck below. In both drawing and smoking rooms, it may be noted, blowers are fitted, and these can be drawn to cover, in each case, the entire fireplace.

The Library.

The library is on the promenade deck, convenient to the grand stairway. It is 29 ft. long by 24 ft. broad, and the general effect suggests the French Renaissance; a view of it is given in Fig. 83, on Plate No. VII. In the bookcase, volumes suited to all classes of readers are arranged. The lower part of the case is inclosed with hinged doors having amboyna panels, partly carved, as are also the pilasters. The upper part has glass doors and mahogany astragals. A carved cove surmounts the whole, and is worked into the ceiling. Comfort is suggested by the two large ottomans in the centre of the room. The writing-tables and chairs are arranged close to the walls, so that visitors to the library may give the least annoyance to those engaged writing, for which purpose all the necessary materials are provided. The room is finished in richly-carved mahogany with amboyna panels. The roof, which is highly ornate, is painted in two shades of ivory; the electric lamps, which take the form of rosettes in beaten copper, being the centre of the design in each alternate panel. The floor is laid with oak parquetry, with a large Turkey carpet in the centre. As to the upholstering, the columns supporting the roof, and which form the central part of the ottomans, are covered with Mecca and blue velvet, while the chairs and ottomans are in a lighter material. The curtains on the square windows are of a rich brocade. The general design of these public rooms is very chaste, and reflects credit on the artists. The Fairfield Company themselves carried out—as we have said

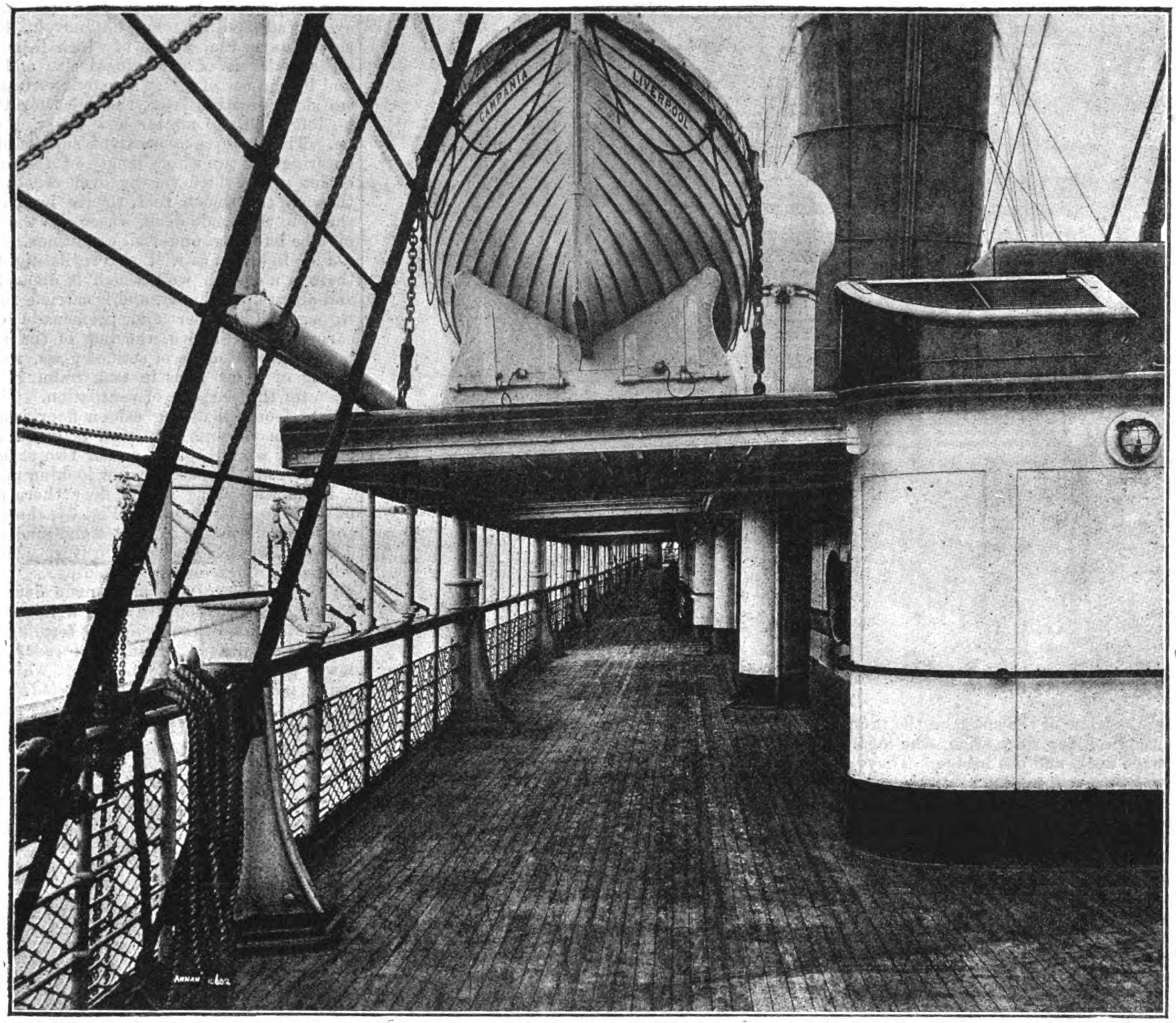


FIG. 86. PROMENADE DECK OF "CAMPANIA," LOOKING FORWARD

ARRANGEMENT AND DETAILS OF VENTILATORS.

CONSTRUCTED BY MESSRS. THOMAS UTLEY AND CO., LIVERPOOL.

Fig. 89.

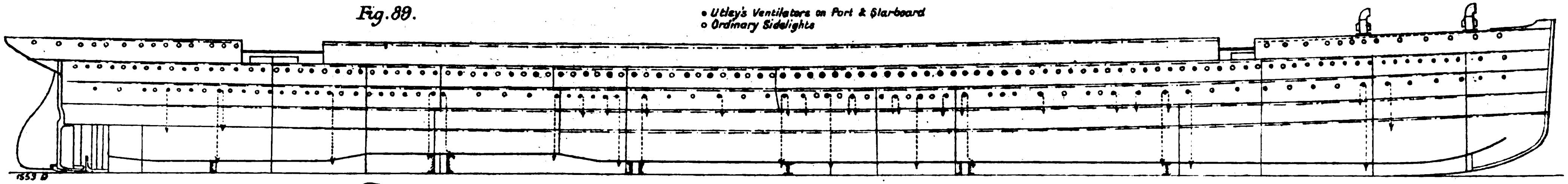


Fig. 90

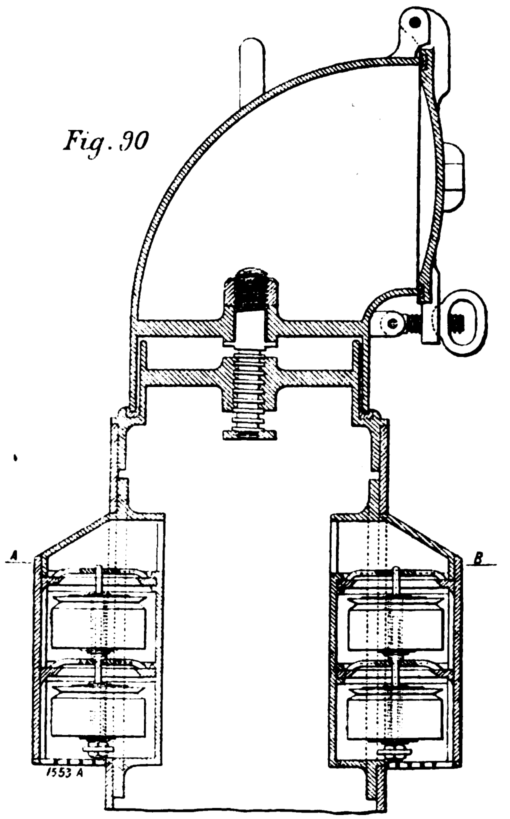


Fig. 91

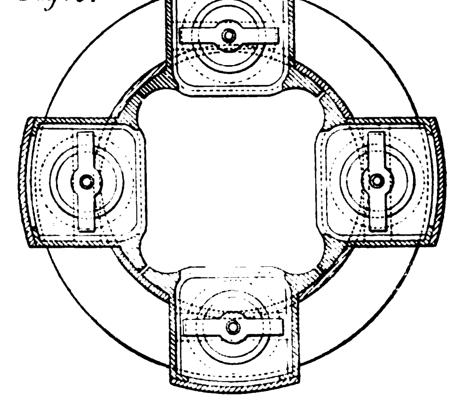


Fig. 92.

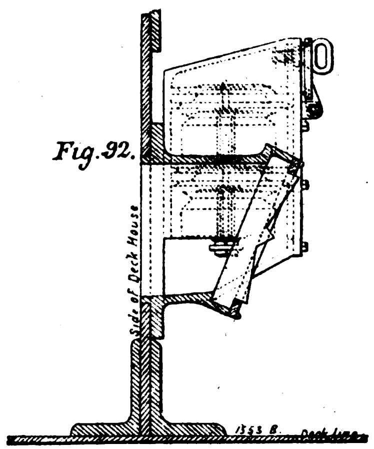


Fig. 93

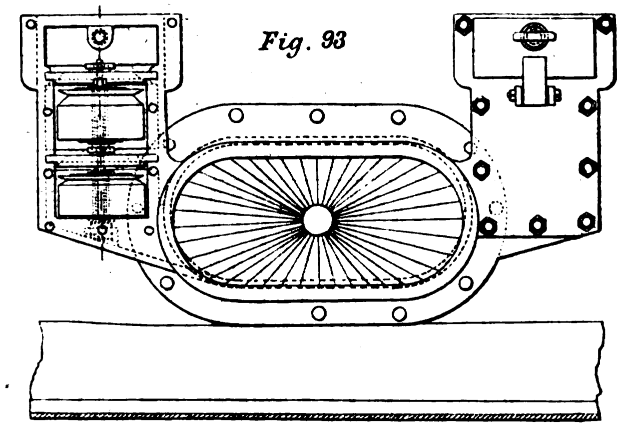
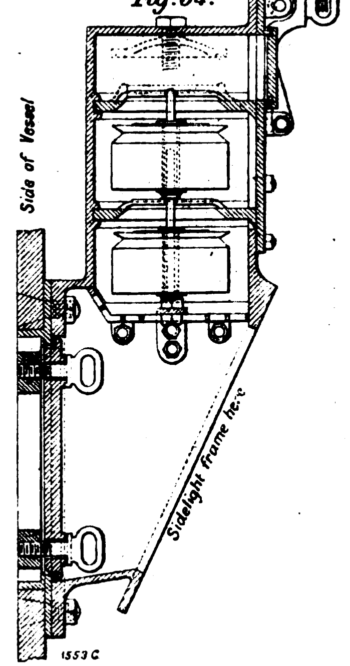


Fig. 94.



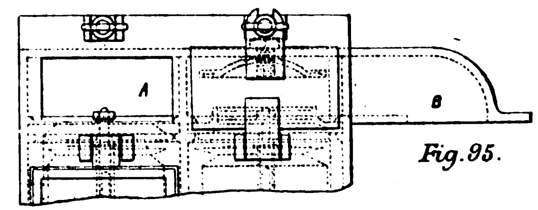


Fig. 95.

Fig. 97.

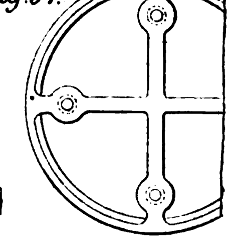
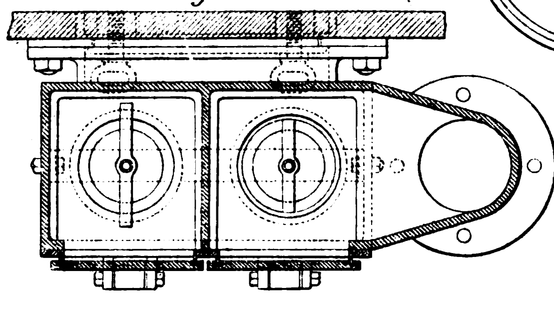


Fig. 96



—the dining-saloon, staircase, and well, while Messrs. Wylie and Lochhead, of Glasgow, decorated and furnished the drawing-room, smoking-room, and library.

State-Rooms.

The distinctive feature of the great majority of the state-rooms is their great height, which approximates to 10 ft. This, of itself, insures satisfactory ventilation, while jalousies are adopted wherever practicable, and in addition Utley's system of ventilators is adopted, as we shall describe later on, so that even in the case of those rooms which are not close to the shell of the ship the air will be changed frequently. The beds throughout the ship are entirely of iron. The old type of wooden berth, which was more in keeping with the vessels of 20 or 30 years ago, has been entirely superseded, not only for passengers, but for officers, crew, and firemen. The beds in the state-rooms are of Hoskins' "triptic" type, which combine lightness with strength. The upper bed, with all its bedding, in all cases folds up against the bulkhead, so that in the event of a smaller number of passengers being on board than is contemplated in the ordinary course of events, there will always be much more room for those who are travelling. The lee board, while framed in iron, has carved mahogany panels, and a new feature has been adopted in this respect which will add greatly to the comfort of the passenger. In the old type of wooden berth the lee board extended the whole length of the berth, and formed the front of a sort of box, in the act of getting into or out of which—especially if he occupied the upper berth—the passenger had to perform something approaching an acrobatic feat. The result was not always comfortable, nor the spectacle elegant. In the modern arrangement the lee board extends only one-half of the length of the bed, and it can be easily fixed at either end or in the centre, so that while the ship is in a sea, the passenger has all the advantage of the arrangement, and has freedom of movement either out of or into the berth. Experience has shown that this length of lee board is sufficient for protection.

The profusion of small shelves, trinket drawers, book-racks, &c., in the state-rooms certainly suggests that the designer had an intimate knowledge of the essential requirements of passengers, especially of ladies, whose love of cupboards, &c., is almost proverbial. There is a large wardrobe in each room, and, of course, the usual washstand, life-belt racks, hooks, &c. The general rooms are fitted in mahogany, and upholstered with plush or velvet, while the fittings are electro-plated. Electric light and electric call-bells add to the very complete sum of comfortable surroundings.

There are rooms to suit all tastes in the ship. A large number of single-berth cabins are, as we have said, provided, and many double cabins, together with several three or four berth rooms, while family apartments are provided, in addition to magnificently appointed suites on the upper deck. Several of these *en suite* rooms are fitted in the most beautiful satinwoods and mahogany. They are arranged as parlour and bedroom, the former being fitted with table, couches, and chairs on the model of a lady's boudoir, with suitable decorations. In the bedroom is a handsome brass-furnished bedstead, with overhangings. There are toilet arrangements in the most excellent style, with all the etceteras desirable. While these suites of rooms will form the highest attraction, there are on the same deck a large number of superior rooms, although not associated with the same luxuries. They are fitted on the lines of the better class of state-rooms, but panelled in hard wood, instead of being painted, and fitted with Watson's patent collapsible bedstead. The bedstead is capable of being extended to form a double bed, and, when a single bed, the front rail may be collapsed to form a couch or settee.

Second-Class and Steerage Accommodation.

The public rooms for the second-class passengers are all placed abaft the machinery, on the upper and promenade decks. The dining saloon is on the upper deck, and is finished in a style equal to that of the first-class saloon in ordinary ships, in solid oak, and fitted with tables, revolving chairs, sideboard, &c. This, together with a separate room for children and servants of the second class, will enable the second-class passengers to dine in two groups. The drawing-room is on the promenade deck, at the head of the stairway leading to the dining saloon and state-rooms. In the fitting of this room, as in the case of the apartment for the first-class quarters, a want of uniformity has been aimed at, the result being a very attractive apartment, which has the addition of a beautifully toned cottage piano finished in satinwood to suit the general decoration of the room. This saloon, therefore, although short of the luxuries of the first-class saloon, will be a most comfortable and pleasant resort for the ladies.

The smoking-room is on the poop, with a stair leading from the cabins below. It is finished in American walnut, and has the ever popular bar. Almost the only difference between the fittings of the first and second class cabins and state-rooms is in the use of brass mountings instead of electro-plate, and possibly there is a larger number of four-berth rooms. In all respects the accommodation and conveniences are practically the same.

The steerage passengers, of whom from 700 to 1000 may be carried, are accommodated on the lower deck, iron portable berths having been provided by Messrs. Hoskins and Sons. These passengers will be allowed to promenade on the upper deck, the circuit of which five times makes a one-mile walk, so that in this respect they are very favourably situated. Each compartment of the steerage has a pantry for the special use of the passengers located therein.

Heating.

The whole of the passenger accommodation in the ship, including the public rooms, is heated by a most complete system of steam-heating, all so arranged that the whole or any part may be heated when required. Thus the officers and crews' quarters of the ship only may be heated when the ship is in port, and there are no passengers on board. The steam pipes are all covered with polished brass casings.

The Lavatory Accommodation.

The lavatory accommodation has had special attention. The principal accommodation for gentlemen is on the upper deck aft, convenient to most parts of the ship, and particularly to the smoking-room, from which there is a special stair. There is a barber's shop, fitted, as the advertisements would have it, with all appliances for the proper treatment of hirsute appendages, and having an electric motor for driving the brushes. The general lavatory has a large number of washstands, with unlimited supply of water and tip-up basins, mirrors, and everything complete. Near this, again, are the urinals, in the ventilation of which special arrangements have been made, outcast air-shafts being conducted to the funnels, and a strong exhaust draught being thus obtained. The bathrooms and w.c.'s each extend across the full width of the ship, and the flushing arrangements are such that there is a constant supply of water always passing through the pipes. The baths throughout the ship are of marble hewn out of the solid block, and there is an unlimited supply of cold and hot water. The Fairfield Company recognise objectionable features in the method adopted in many ships of heating the cold water in the bath by means of a steam jet turned on at the will of the passenger after the cold water is in the bath. Hot water is, therefore, supplied in the Campania and Lucania, so that there cannot be any accident or annoyance. Shower, douche, spray, and plunge baths can be procured. By the utilising of a four-way cock in each case, for hot and cold water, the passenger is saved the trouble of a confusing multiplicity of handles. There is but the one handle to turn to a given point, and the position of the handle is convenient. The accommodation for ladies is on the upper deck forward, while on the promenade deck, convenient to the suites of rooms, as in other parts of the ship, there are special lavatories, &c.

Life-Saving Appliances.

We have already, in dealing with the construction of the hull, mentioned that each ship is so extensively divided into compartments by water-tight bulkheads as to insure her floating with any two of the compartments flooded, and in some cases with even three spaces filled with water, particularly forward, where the chances of a smash consequent on collision are greater than amidships or aft. Again, the provision of a double bottom, the one 4 ft. 6 in. inside of the other, will minimise the consequences of a rupture in the outer bottom, owing to grounding or running on to a hidden rock, for the inner bottom is as strong and as water-tight as the outer skin. The intermediate space will be utilised for water ballast for trimming purposes, and here it may be mentioned that the capacity for water ballast is about 2000 tons.

There is little chance of the ship foundering or sinking by collision, but withal provision has been made for such an unlikely contingency. A view of the vessel is itself reassuring, for not only does her great size and strength impress the visitor, but even the most timid will have confidence in the presence of the array of boats on the shade deck. There are 20 in all (see Fig. 69, Plate No. V.), and, viewed from the navigating bridge above, the spectacle recalls a very extensive boatyard. Sixteen of these boats are 30 ft. in length by 9 ft. beam and 4 ft. depth, and the others of slightly smaller size, so that as far as boat capacity is concerned the new ships have accommodation in excess of the Board of Trade requirements. Each boat is under its own pair of davits, and a crew will be told off for each, so that they may all be launched simultaneously, if desired. Hill's lowering gear is adopted, so that the boat, when it floats, will be automatically freed from the tackling at bow and stern, and thus obviate the chance of the boat swamping owing to one end continuing fast to the tackling while the other is free. Each boat is fitted with all appliances for keeping the sea for a long period, and as they are stowed each on its own chocks far above the water line, they will not readily be swept away or smashed by heavy seas. In addition, there are lifebelts in every cabin and state-room, more than sufficient for every passenger. Every passenger's pillow, being water-tight and air-tight, is also meant as a life-saving apparatus, and will keep the possessor afloat until a refuge is found.

VENTILATION.

The passenger rooms, and, indeed, the whole ship is ventilated on Utley's system, the distinctive feature of which is the use of a valve at the inlet—the ventilator or port hole—so that when the opening becomes submerged the valves close, forming a water-tight joint. When the water recedes the valves drop down again, leaving a free passage for the air to pass through. In this way there is a free passage for the air to enter so long as the opening into the ventilator is not submerged. This system of ventilation, as applied to the Campania and Lucania, is illustrated on page 495. Fig. 89 shows the general arrangement. The forecastle heads are supplied with a cowl and deck combination ventilators leading into the firemen's and seamen's quarters, exhausting the air which originally enters through the porthole ventilators with valves, as shown on Fig. 94. While in fine weather the cowl ventilator can be turned to suit the breeze coming in any direction, as in the case of an ordinary bell-mouthed ventilator, it is not necessary, as in the old arrangement, to unship it in bad weather, and afterwards cover up the opening, shutting up the exhaust passage. A cover is fitted to be screwed down into a water-tight joint, and even in this condition exhaust ventilation continues through one of the valve ventilators fitted on the top.

The arrangement for ventilating the rooms on the upper deck—below the promenade—is shown by Figs. 92 and 93, illustrating a ventilator at the base of the deck-house, which supersedes the ordinary hinged light, opened on the few occasions when weather and other conditions admit. Fitted inside the deck-house combing under the settees and sofas is a valve ventilator with an air space at each side of the light.

The glass is a specially designed prism light, the prisms giving good illumination. The glass is a fixture, which obviates the possibilities of leakage. Of these there are 60 on the promenade deck, affording light and ventilation to the inner state-rooms or alleyways. The arrangement is such that any one walking on deck cannot see into the state-rooms below, as is occasionally the case with the ordinary hinged light.

The saloons have been treated in a unique manner, and the result is commendable, particularly in the case of the dining saloon. There are in the dining saloon a very large number of port-hole ventilators with automatic closing valves, as shown on Fig. 94, and 18 base of deck-house ventilators, as shown on Fig. 92. Each of the 60 openings is 15⅜ in. in diameter. As an advantage of the valve, these can always be left open, even with a choppy sea, as each wave merely closes the valve, which reopens automatically, so that the air supply is intermittent under the worst conditions, and always more than sufficient. The exhaust is still more likely to be in continuous operation, as the chances of water closing the ventilators at the base of the deck-house are much less, except in a very heavy sea. It may be here stated that the decoration of the saloon has not been interfered with by the ventilating arrangements.

For ventilating the cabins on the main deck the ports have been fitted with the patent valve arrangement. The diameter of each port is 13⅜ in., or 12 in. of clear glass. The air inlets for all parts on and below the lower deck are supplied from the lower deck port-hole ventilators, all of which have the valve. They are of the combination type, for light and ventilation, one half of the air passing to state-rooms, and the other half to bunkers, &c., below. This obviates the necessity of carrying ventilating shafts from the top decks of the ship, such shafts being often obstructions, passing as they do through state-rooms or alleyways. It further obviates the necessity of cutting extra holes through watertight bulkheads, &c., to pass the shafts, increasing the chances of leakage should an adjoining compartment be filled, if not of weakening the structure. The shafts from the port-holes are inside the lining. The whole of the ballast tanks are thus supplied with ventilation, as shown by Figs. 95 and 96, page 495. There are two ventilators into each tank. The arrangements for ventilating the bunkers are similar, as are also those for the tunnel chain lockers, &c.

THE COMMISSARIAT AND KITCHEN ARRANGEMENTS.

THE immensity which characterises the whole of the new ships is very properly extended to this department; for prompt service, essential to a well-ordered establishment, is impossible without ample accommodation. Large pantries have therefore been provided, one apartment being fitted up on either side of the steamer, on the main deck, immediately aft of the dining saloon. In connection with each there is a large lobby and passage separate from the main entrance to the saloon, so that stewards will not in their work obstruct the ingress or egress of passengers. These pantries are fitted in a most complete manner, with all the details which the long experience of the Cunard Company's stewards suggested. The fittings are more or less of standard patterns for this class of ship, but the magnitude of the equipment at once impresses the visitor, and notably the number of special fittings, such as hot-plate steam tables, tea and coffee machinery, &c.

The galleys or kitchens have been arranged on the port side of the ship, and adjoining them are the bakeries and sculleries. (See Fig. 73, Plate No. V.) Access is obtained by a stair in the pantry on the port side; but for rapidly handling the food supplies two lifts are provided, one for taking to the scullery the plates to be washed and the refuse from the dining-tables, while the other is to be used solely for service from the kitchen. The advantage of this separate arrangement of hoists will be at once appreciated. The galley is not the long narrow apartment usual in ships, but is really a large, well-lighted, and carefully ventilated kitchen from 25 ft. to 30 ft. square. Along one side are tables with all kitchen utensils and chopping-boards; a second side is completely taken up with a range, which is 25 ft. long by 4 ft. wide. The great size of this range will more readily appeal to the mind of the housewife when we state that nearly 170 dinner-plates or ordinary stewpots or pans might be set on the surface, while there are many large ovens. Special boilers, which in form resemble enormous egg-shells, are utilised for various purposes, vegetable cookers, &c. This cooking is done by steam, which circulates round the outer casing of the boiler. There is also an immense grill, and here, as in the case of the range, the waste heat is utilised for heating plates, &c., in small ovens in the uptake. The floor is laid with tiles, and throughout there is a feeling of cleanliness and roominess. The butcher's shop adjoins, and next to it the scullery, where there is a plentiful supply of water, hot as well as cold. Beyond that, in the same range of apartments, is the bakery, fitted with large ovens. The arrangements we have described are those for satisfying first and second class passengers; the kitchens and sculleries for steerage passengers and crew are on a similarly large scale.

The bakers turn out at 4 A.M., or there would be no hot rolls or cakes for breakfast. The cooks begin operations at 5.30 A.M., and at 6 coffee is served in the state-rooms to any passenger requiring it, or on deck should any passenger have so far forgotten himself as to get out of bed at that hour. Breakfast is served from 8 to 10 A.M., lunch from 1 to 2 P.M., dinner from 5 to 7 p.m., and supper from 9 to 10 P.M., so that the cooks are employed until 10, while the bakers finish their day's work at 7 P.M. The stewards turn out at 6 o'clock, and do not finish their work until 11.

Extensive cold-air provision stores have been provided below the kitchen, &c. The necessity for large storage capacity will be readily appreciated when we state that each vessel when carrying her complete number of passengers will start on her voyage with something like 20,000 lb. of fresh beef, 1000 lb. of corned beef, 10,000 lb. of mutton, 1400 lb. of lamb, 500 lb. of veal, 500 lb. of pork, 3500 lb. of fresh fish, 10,000 fowls, 400 chickens, 150 ducks, 80 geese, 100 turkeys, 30 tons of potatoes, 30 hampers of vegetables, 300 quarts ice-cream, 1600 quarts milk, 18,000 eggs, &c. Again, in groceries something like 200 different articles will be carried, including 1000 lb. tea, 1500 lb. of coffee, 2800 lb. of white sugar, 4500 lb. moist sugar, 1000 lb. pulverised sugar, 2400 lb. cheese, 3000 lb. butter, 6000 lb. ham, and 1800 lb. bacon. The quantities seem large, but it would be easy, if considered desirable, to account for the consumption. Each member of the crew is allowed 2 lb. of beef per day, and therefore about 800 lb. a day will be thus disposed of, while 400 lb. will be used each day for beef-tea. Eighteen thousand eggs looks a large order, being about two per minute of the duration of the voyage, but they disappear in many forms, and one authority says, "it is not an unusual thing to see a lady or gentleman finish off a supper of grilled chicken and devilled sardines with four poached eggs on toast." Lemons are used at the rate of 1½ per head per day, oranges 3 per head per day, and apples, when in season, at the rate of 2⅔ per head per day. And the wines, spirits, and beer consumed—that is purely a case of local option, and our purpose is to note the necessity for storage capacity, not to deal altogether with consumption, and therefore it may be sufficient to state that an abundant supply of pure water is provided by three condensers on the Normandy principle.

REFRIGERATING PLANT FOR PROVISION ROOMS.

The cold air chambers are worked on the De la Vergne ammonia compression principle, the installation of machinery and fittings being by Messrs. L. Sterne and Co., Limited, Glasgow. Of the arrangement of the chambers we give views in Figs. 98 and 99, on page 498, while Fig. 100, on the same page, is a perspective view of one of the machines used. Details showing the arrangement of brine-pipes and meat-rails are given in Figs. 101, 102, and 103. The method adopted for cooling is by the circulation of cold brine. A solution of calcium chloride is reduced to a very low temperature by the direct expansion brine-cooling coils submerged therein, and is circulated by a special pump through a series of pipes fixed to the underside of the roof of the refrigerating chamber, as shown in Figs. 102 and 103. During circulation it absorbs the heat of the chamber, and returns to the brine-cooling tank in the machine-room to be again cooled to the required temperature. The circulation goes on continuously by means of the special pump referred to. The brine-circulating pipes in the chamber are divided into two sets, as shown on Fig. 101, so that any leakages or repairs can be attended to in one section, without interfering with the circulation through the other, each section being sufficient to maintain the low temperature in the room. Special means are also provided for withdrawing the brine from either section without interfering with the working of the other.

The machine shown in Fig. 100, page 498, consists of a vertical single-acting compressor 4½ in. in diameter by 9 in. stroke, actuated by a high-pressure horizontal steam engine. This is provided with a special governing arrangement which determines the steam supply, and the speed can be varied from, say, 30 to 300 revolutions if required without interfering with the running or stopping the machine. The construction of the gas compressor is such as to insure the expulsion of the entire volume of gas taken in at each stroke of the pump; it effectually seals the suction valve, the piston, the stuffing-box, the piston valve, and the discharge valve—preventing all leakage; it also obviates the necessity of packing the stuffing-box tightly, and thoroughly lubricates the piston and piston-rod at every portion of the stroke, thus reducing the friction to a minimum. It further takes up a considerable amount of the heat developed in the gas during compression, thereby economising largely the power required for compression. The practical result is that absolutely no gas is left in the clearance space above the piston, and thus there is no loss by re-expansion. The oil also serves to lubricate the compressor.

The cylindrical tank carried on the A-frame is known as the separating tank, and serves to separate the oil from the ammonia after being discharged from the compressor. The ammonia passes through a pipe leading from the top of this tank to the ammonia condenser, which consists of coils of piping submerged in the condenser tank through which sea-water is constantly circulated, and being there liquefied, passes to the expansion cock. The oil is led from the bottom of the separating tank to a separate coil in the ammonia condenser, where it is cooled to the

COLD AIR PROVISION STORE, WITH DE LA VERGNE'S REFRIGERATOR.

CONSTRUCTED BY MESSRS. L. STERNE AND CO., LIMITED, GLASGOW.

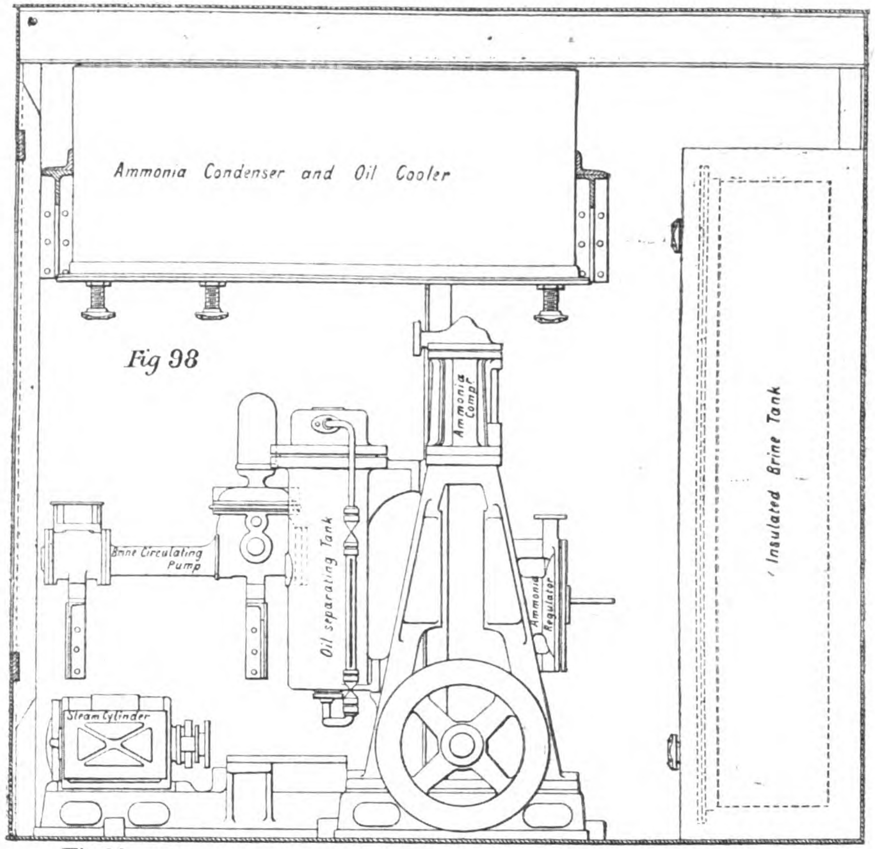


Fig 98

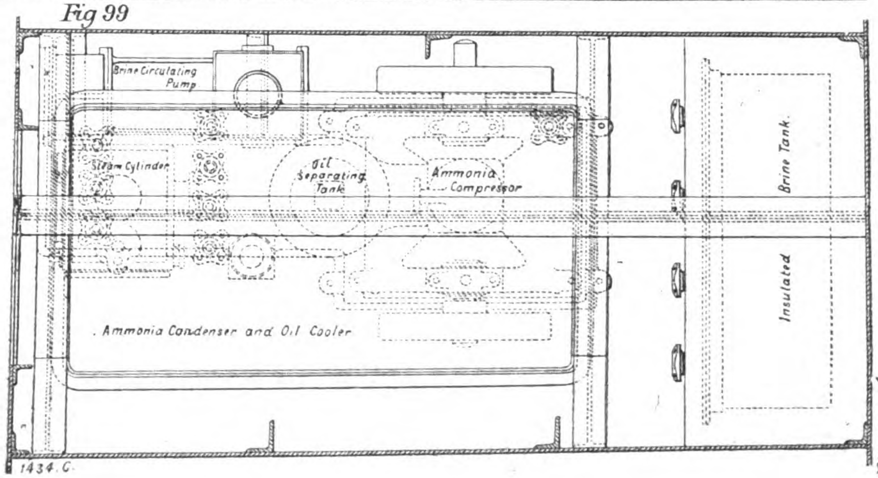


Fig 99

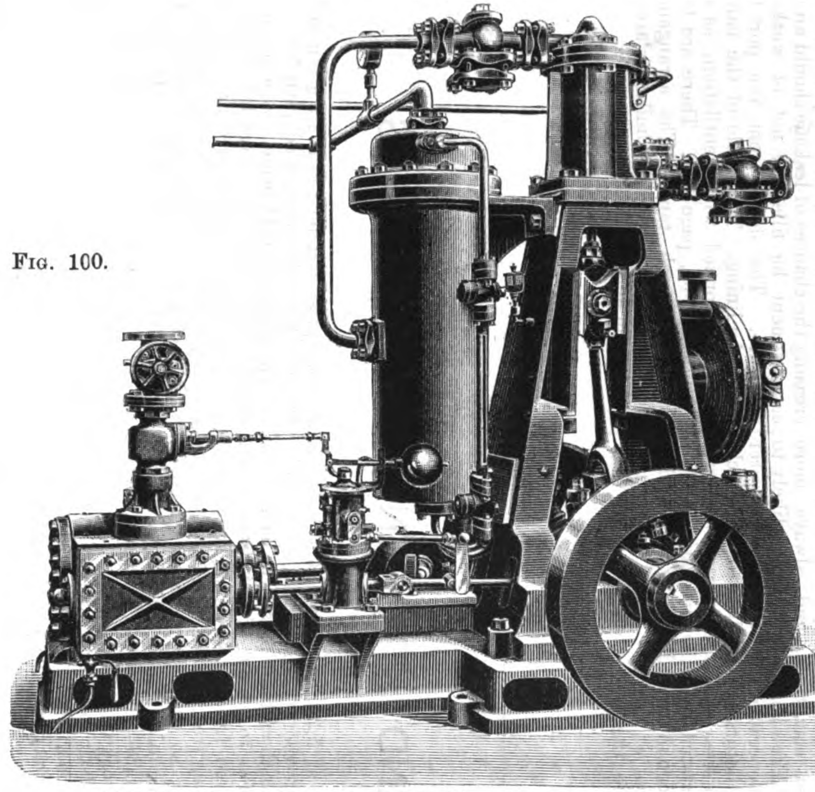


Fig. 100.

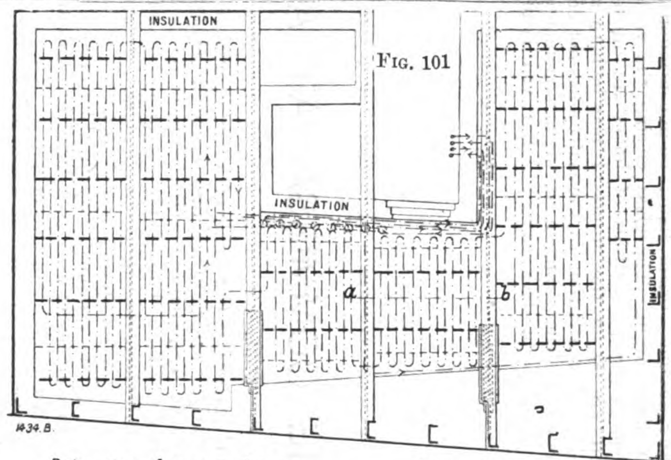


Fig. 101

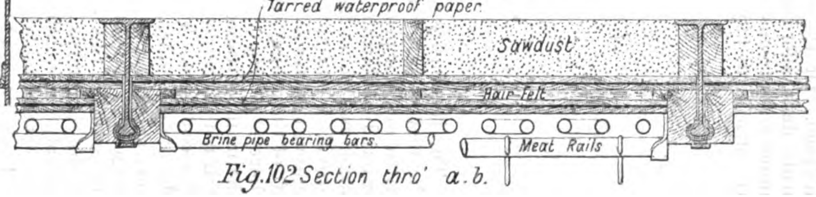
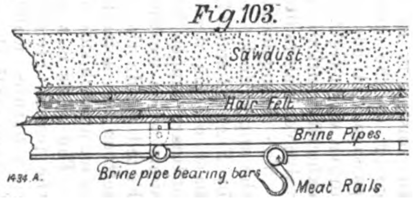


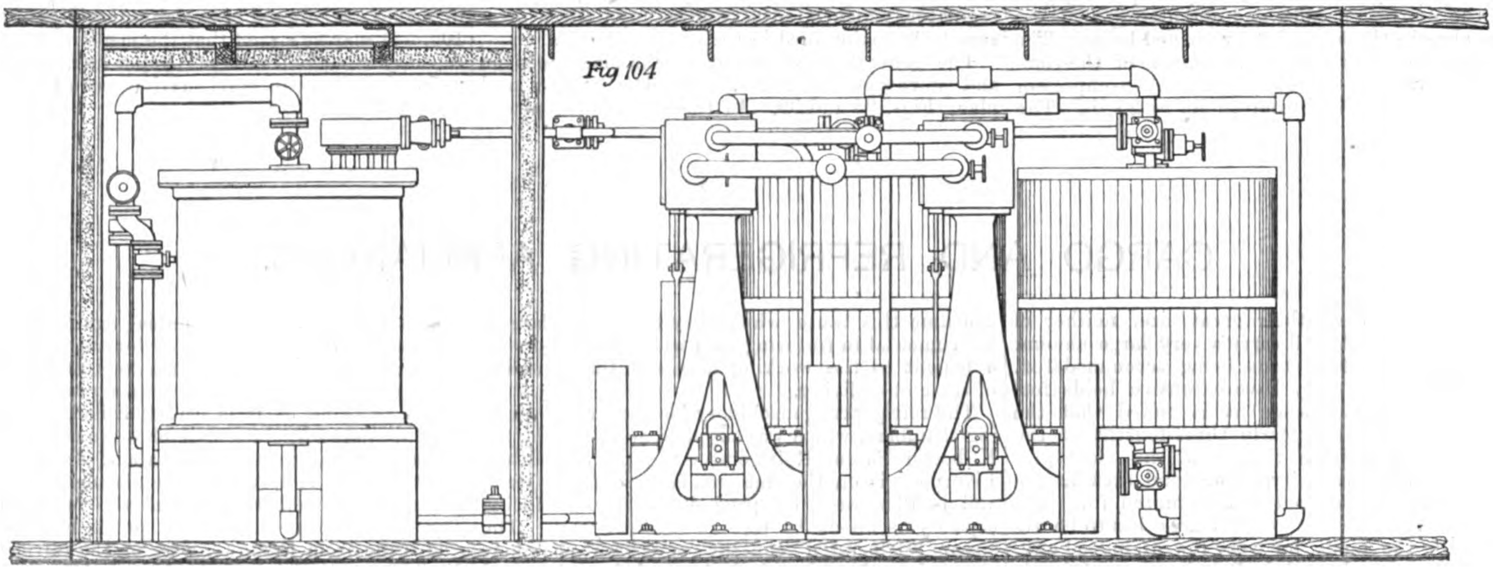
Fig. 102 Section thro' a. b.

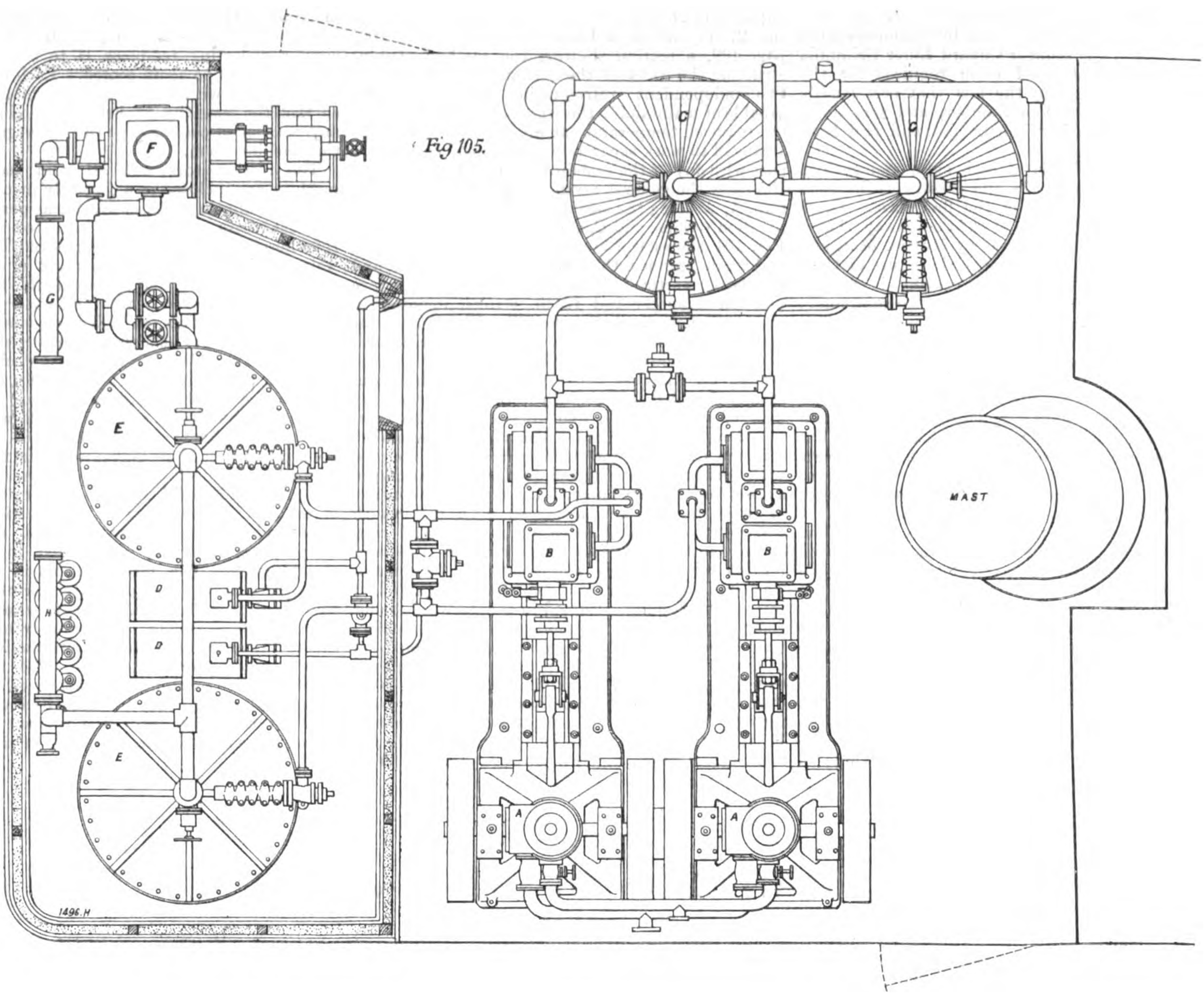
Fig. 103.

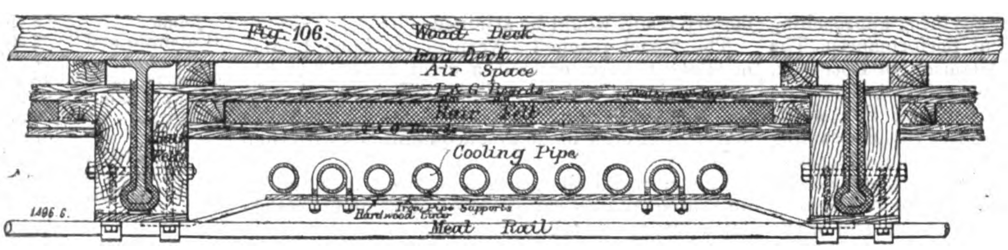


REFRIGERATING PLANT FOR CARGO HOLD.

CONSTRUCTED BY THE KILBOURN PATENT REFRIGERATOR COMPANY, LIMITED, LIVERPOOL.







temperature of the circulating water, and returns to the compressor, the same oil thus being used over and over again. The liquefied ammonia, after passing the expansion cock, which is provided with a minutely adjustable V-shaped opening, goes into the expansion coils, and, circulating in these coils, absorbs the heat of the returned brine. The coils are connected to the suction side of the compressor, the gas being conveyed to the compressor at a pressure varying from 15 lb. to 25 lb. The brine is reduced to a very low temperature, and is circulated, as already described, through the refrigerating chamber. The proper amount of ammonia allowed to pass through the expansion cock is automatically determined by means of a patent regulator, which is adjustable to any desired pressure to be maintained in the expansion coils.

The general arrangement of the machine-room and store-room is indicated in the section and plan, Figs. 98 and 99. In the former are placed the ammonia compression machine, condenser tank, and brine-cooling tank. The brine tank is effectually insulated. The brine-circulating pump is also shown, as well as the general arrangement of the brine-circulating piping, while the method of insulation adopted is explained by Figs. 102 and 103. It may be stated that the machine has ample capacity to make 5 cwt. of ice per day, in addition to performing the refrigeration required in the store-rooms.

CARGO AND REFRIGERATING APPLIANCES.

NOTWITHSTANDING their great size, neither of the two new vessels will carry a very large amount of cargo, about 1620 tons being accommodated. On the orlop deck they have extensive holds forward and aft; but when it is noted that the machinery takes up nearly three-fourths of the length of the ship on this deck, the small proportion of cargo capacity to the total area in the ship will be appreciated and accounted for. Besides, a very large part of this area has to be reserved for the mails, for very few, if indeed any, Cunard steamers have left Britain on an Atlantic voyage without mails since the Government first determined to send the latter by steamers on the maiden trip of the pioneer Cunard Liner Britannia in 1840. The extent of room required for the mails may be judged by the fact that occasionally the bags exceed 2000 in number, and sometimes require two trains between London and Holyhead to convey them.

There are five holds in each ship, and such as are not required for mails and passengers' baggage are given over for cargo of the first class. There is a powerful steam winch at each hatchway. These are of the well-known type by Messrs. Muir and Caldwell, Glasgow, and a special feature of their construction is that all the gearing is of the helical type, to reduce the noise to the minimum; but, after all, these winches are seldom used except in port, and when the passengers have left the ship.

One class of cargo specially suited to these large first-class steamers is preserved meat, and the Campania and Lucania have very large holds fitted with refrigerating machinery for this special trade. The development of this traffic during the past few years justifies this provision. In 1876 the amount of fresh meat conveyed to this country from the States was only 90,790 quarters, valued at 223,698*l*. It may be remembered that at that time some of the steamers were specially fitted with refrigerated chambers, and under these circumstances the trade quickly developed. In four years the amount of meat imported increased fivefold, although, owing to cheaper transit and other influences, the value only increased threefold. Since that time there has been a great development in the transportation of live cattle, to the detriment of the dead-meat traffic; but still over 500,000 cwt. of fresh meat are imported from the States every year, at a value of 1,138,000*l*. Under these circumstances the Cunard Company have fitted their new ships to continue this trade, which they have been largely instrumental in fostering, and which has been such a benefit to the working classes in the reduction of the cost of living.

The refrigerating machinery for these meat-carrying chambers, which was supplied and fitted by the Kilbourn Patent Refrigerator Company, Limited, Liverpool, is on the ammonia compression system, and is illustrated on page 499. The producing capacity is about 12 tons of ice per day. The space refrigerated consists of three chambers situated on the orlop deck forward, having a total capacity of 20,000 cubic feet, and capable of carrying 2700 quarters of beef. We give in Fig. 106, page 499, a section showing the method of constructing the walls of these chambers. There are two independent refrigerating machines, each capable of maintaining the whole of the chambers at the required temperature at all seasons. They are arranged to work separately or coupled, or any one part with any of the remaining parts. Figs. 104 and 105 show the general arrangement of the installation, A, A being the steam cylinders, B, B the compression pumps, and C, C the ammonia condensers. Fig. 104 shows the ammonia compression pumps and steam engines, the former being horizontal and the latter vertical. The compression pumps are 6 in. in diameter and 12 in. stroke, inclosed in water-jackets and fitted with Webb's patent arrangement of suction valves, and the Kilbourn Company's double stuffing-box and glands, with sealing oil chamber between them, which is constantly supplied with oil by a small pump on the side of the bedplate, and worked from the compression pump crosshead. The steam cylinders are 8 in. in diameter and 12 in. stroke, and coupled with forked connecting-rod to the same crankpin as the compression pump. The condenser consists of wrought-iron shells, lagged with teak, with cast-iron covers, and fitted with galvanised concentric coils of 1½-in. pipe, coupled top and bottom with suitable malleable cast tee-pieces. The circulating water for the condensers is supplied by a duplex pump situated in the forward boiler compartment. The ammonia gas, after liquefaction under the combined pressure of the pumps and cooling in condenser coils, passes by small pipes to the liquid ammonia reservoirs D, D (Fig. 105), thence through a small graduated regulating valve into the lower part of the coils of the refrigerators E, E, which are similar in every respect to the condensers. Here, under a pressure of about 30 lb. absolute, the liquid ammonia again vaporises, abstracting the heat necessary for its vaporisation from the liquid surrounding the coils, and returning to the compression pumps for re-compression. The liquid, or brine as it is usually called, referred to is composed of a solution of chloride of calcium in water, and has a density of about 48 Twaddel's hydrometer. It forms the circulating medium for cooling the chambers in which the beef is hung. The duplex brine-circulating pump F draws the cold brine from the lower part of the refrigerator, discharging it through the distributing tee-piece and valves G to the different sections of the cooling pipes in the chambers, returning through a similar collecting tee-piece H to the top of the refrigerator to be again cooled. Each return brine pipe is fitted with a valve and thermometer at H, so that the quantity of brine and temperature of any section of cooling pipe can be regulated from the machine-room.

The refrigerators and all cold parts of the machine are inclosed in a carefully insulated chamber, to minimise the losses as far as possible. The cold chambers are carefully insulated with double thicknesses of tongued and grooved boards with waterproof paper between them, 2 in. of best hair felt, 1 in. air space, and again a double thickness of tongued and grooved boards and waterproof paper, the whole being finished with two coats of varnish. On the ceiling the insulation is arranged so that the brine pipes are placed between the deck beams (as shown in the section of chambers, Fig. 106), and do not unnecessarily curtail the limited head-room. The brine pipes are of special heavy 2-in. galvanised tube, with malleable cast return bends. The meat-hook rails are of 1⅛-in. galvanised round iron firmly clipped to the deck beams, and on these are placed the galvanised steel hooks for carrying the quarters of beef. Each chamber is fitted with thermometer tubes from the upper deck, so that the temperature may be ascertained in any part at intervals. The machine-room is fitted with a complete arrangement of water-sprinkling pipes, controlled from outside, so that, should at any time a leak occur in any part, from whatever cause, the ammonia would be effectually prevented from spreading over the ship. The brine circulation of these machines is so arranged that in case of need the brine may be circulated through the coils in the ship's provision rooms, as well as through the cold chambers for the carriage of fresh beef.

THE MANNING OF THE VESSELS.

THE Campania was completed and left Glasgow Harbour on March 17. During the following week she underwent preliminary steam trials in the Firth of Clyde, running to Ailsa Craig and to the Mull of Cantyre. The engines, meanwhile, were gradually worked up to three-quarter power, but no attempt was made to get anything approaching full power, or to take record of performances. The two photographs by Messrs. Adamson, of Rothesay, which we have reproduced in our illustrations on Plate No. VIII., were taken during this week, the first (Fig. 84) representing the vessel steaming at a pace which, in her case, may be characterised as easy, but which, in an ordinary vessel, would be regarded as fast; while the other view (Fig. 85) shows the steamer lying at the Tail of the Bank. Subsequently the vessel sailed from the Clyde to the Mersey, making the circuit of Ireland, but no effort was made to get the maximum results. Enough power, however, was got from the machinery to give assurance that when the vessel was put on her official trials an eminently satisfactory result would be attained.

The vessel reached Liverpool on April 1, and, needless to say, created a great sensation. She was put into the largest dock at Birkenhead, with the view of having the hull cleaned, while the officers and crew made first acquaintance with their ship.

The crew, all told, numbers 415. It is divided into three groups—sailing, engineers', and stewards' departments—as follows:

Sailing Department.	*Engineers' Department.*	*Stewards Department.*
Commander.	1 Chief engineer.	1 chief steward.
6 officers.	21 engineers.	105 stewards.
Purser.	2 refrigerating engineers.	45 cooks, bakers, &c.
Surgeon.	1 dock engineer.	8 stewardesses.
Carpenter and joiner.	8 electricians.	
Boatswain and 2 mates.	2 storekeepers.	
	1 "donkey" man.	
6 quartermasters.	18 greasers.	
1 lamp-trimmer.	9 leading firemen.	
40 A B.s.	75 firemen.	
	57 trimmers.	

In sailing department	61
In engineers' department	195
In stewards' department	159
Total crew	415

It is scarcely necessary to add that the commander, and chief engineer, and the leading men of the staff are all men of great experience. The crew of the Lucania, which will be ready to go on her station early in the summer, will be composed exactly in the same way as that of her sister ship.

It is not expected that the Campania will show her best pace in the first trip—that is very exceptional in the history of the Atlantic; but the traditions of Fairfield and the performances of the Alaska, Oregon, Umbria, and Etruria give confidence to the many in their assumption that the new vessels will, before the season is over, thoroughly attain the results aimed at by the owners and builders. Certainly the best wishes of all interested in marine science go with the vessels, and we doubt not all marine constructors join with us in the wish so neatly expressed by the Chairman of the White Star Company—May their career sustain the good reputation of the Cunard Line.

We cannot conclude our description of these steamers without acknowledging our indebtedness to Sir John Burns, Bart., and the Directors of the Cunard Co., and to Sir W. G. Pearce, Bart., and the Directors of the Fairfield Co., for the aid they have afforded us in the preparation of our account of the new vessels and engines, and of the details of construction; while to Mr. R. Barnwell, Mr. R. S. White, and Mr. Andrew Laing, our hearty thanks are also due for the facilities and assistance given to our representative in preparing the narrative.

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ILLUSTRATIONS.

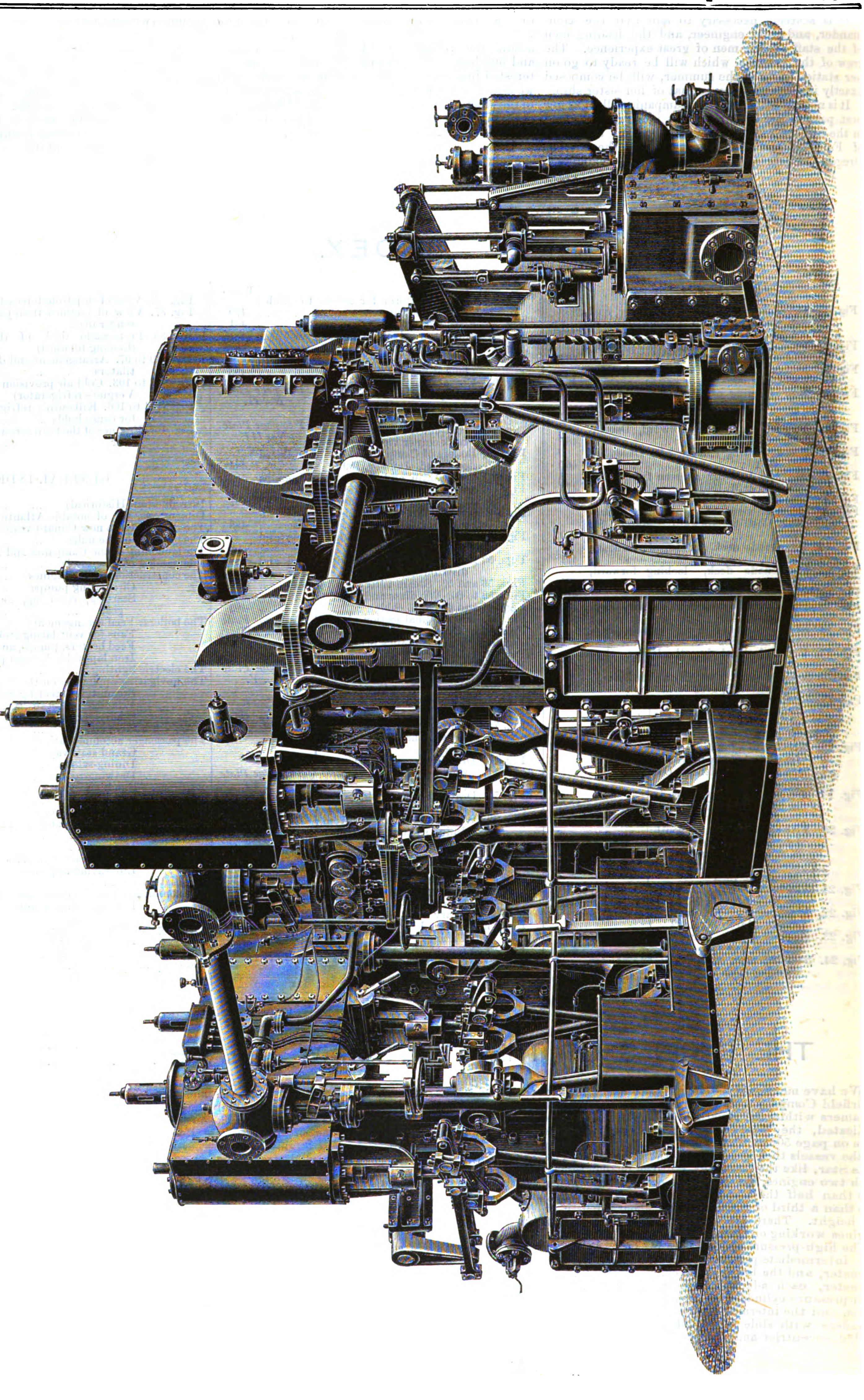
GENERAL INDEX.

THE ENGINES OF THE TWIN-SCREW STEAMER "POLE STAR."

WE have mentioned the circumstance that while the Fairfield Company were constructing the two Cunard steamers within the remarkably short space of time indicated, they were engaged on other work, and we give on page 502 an illustration of the engines of one of the vessels then constructed—the Pole Star. The Pole Star, like the Cunarders, is driven by twin screws with two engines, but the latter occupy space much less than half the breadth of those of the Campania, less than a third of the length, and about a fourth of the height. There are three cylinders in each set of engines working on three cranks.

The high-pressure cylinders are 14½ in. in diameter, the intermediate-pressure cylinders are 24 in. in diameter, and the low-pressure cylinders are 39 in. in diameter, each adapted for a stroke of 2 ft. The high-pressure cylinders are each fitted with a piston valve, and the intermediate-pressure and low-pressure cylinders with slide valves, all worked by the usual double eccentrics and link motion valve gear. The reversing engines are of the steam and hydraulic direct-acting type. The engines have the usual surface condenser, with pumps arranged at back and worked by levers from one of the crossheads. Each crankshaft is a solid forging, and all the shafting is of Siemens-Martin mild steel. The propellers are fitted with blades of manganese-bronze, and arranged to work outward. In the engine-room there are fitted the usual auxiliary feed-pumps, and an evaporator for making up the fresh water supply to the boilers. The steam is generated by two single-ended boilers, each 12 ft. 1 in. in diameter by 9 ft. 9 in. long. There are six corrugated furnaces in the two boilers. The boilers are constructed entirely of steel, and are adapted for a working pressure of 160 lb. per square inch. The speed at sea is 13 knots.

The Pole Star was built for the Commissioners of Northern Lighthouses for service in connection with the Orkney and Shetland Lights, including the Sule Skerry, which lies 40 miles to the westward of Orkney, and the Fair Isles Light, situated midway between the Orkneys and Shetland. As the vessel would thus have frequently to cross the Pentland Firth and the "Roost" between Orkney and the Fair Isle, she was constructed of great strength, sufficient to enable her practically to keep the sea in all kinds of weather. The vessel is of the following dimensions: Length, 175 ft.; breadth, 26 ft. 6 in.; depth, 14 ft. 4 in. She is built with a top-gallant forecastle, bridge, and deck-house aft, and rigged with two pole-masts having fore-and-aft sails. The foremast is fitted with strong derrick and gears for working buoys. Accommodation for the commissioners and their officials is provided in a saloon, with five state-rooms finished in polished hardwood. The chief officers and engineers are accommodated in the bridge-house, and the crew forward. Cargo holds are arranged for the conveyance of oil and stores to the various lighthouses. Every precaution has been taken to make the ship reliable at all times and under all circumstances for her important service.

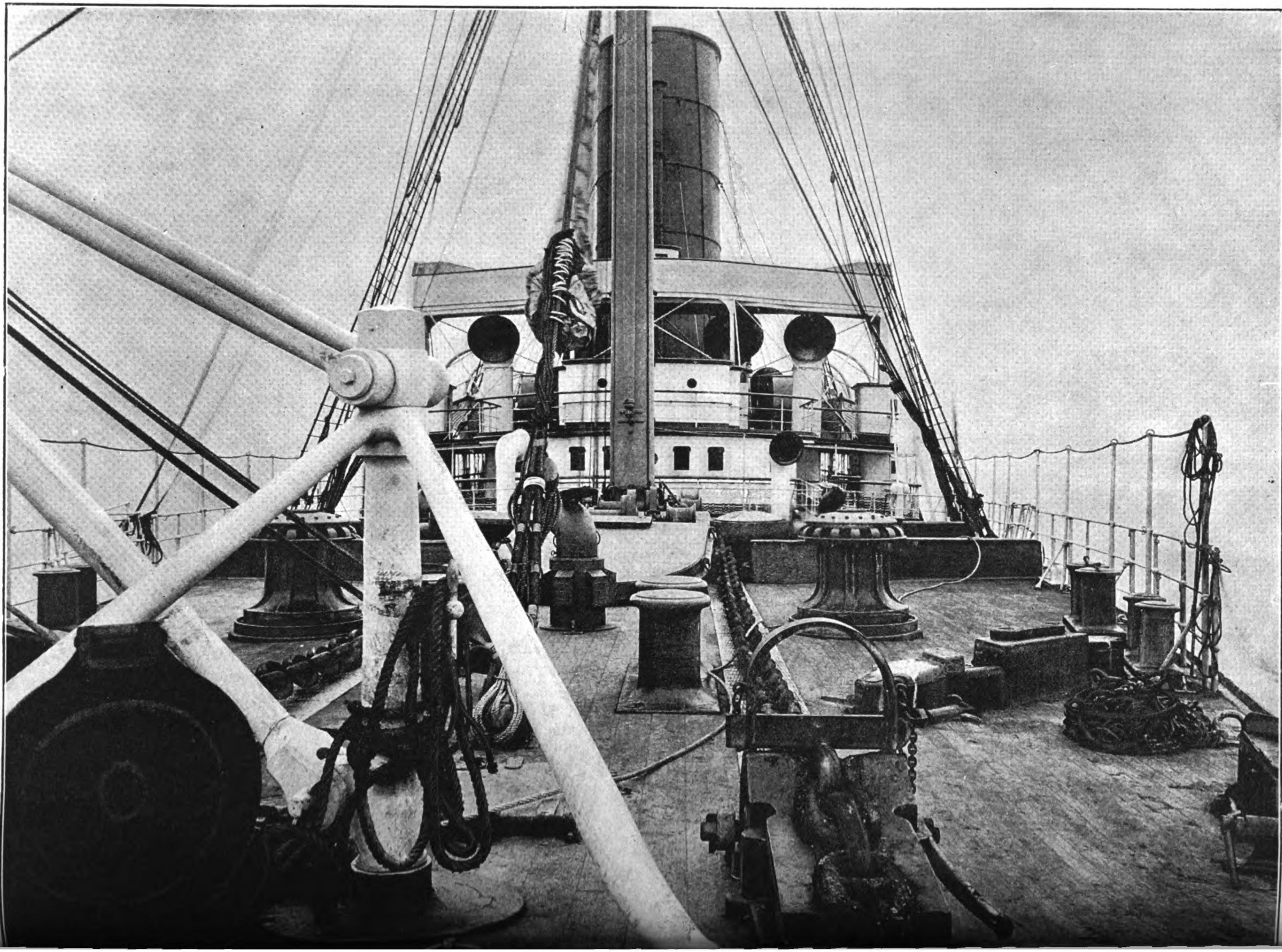


TRIPLE-EXPANSION ENGINES OF THE TWIN-SCREW STEAMER "POLE STAR."

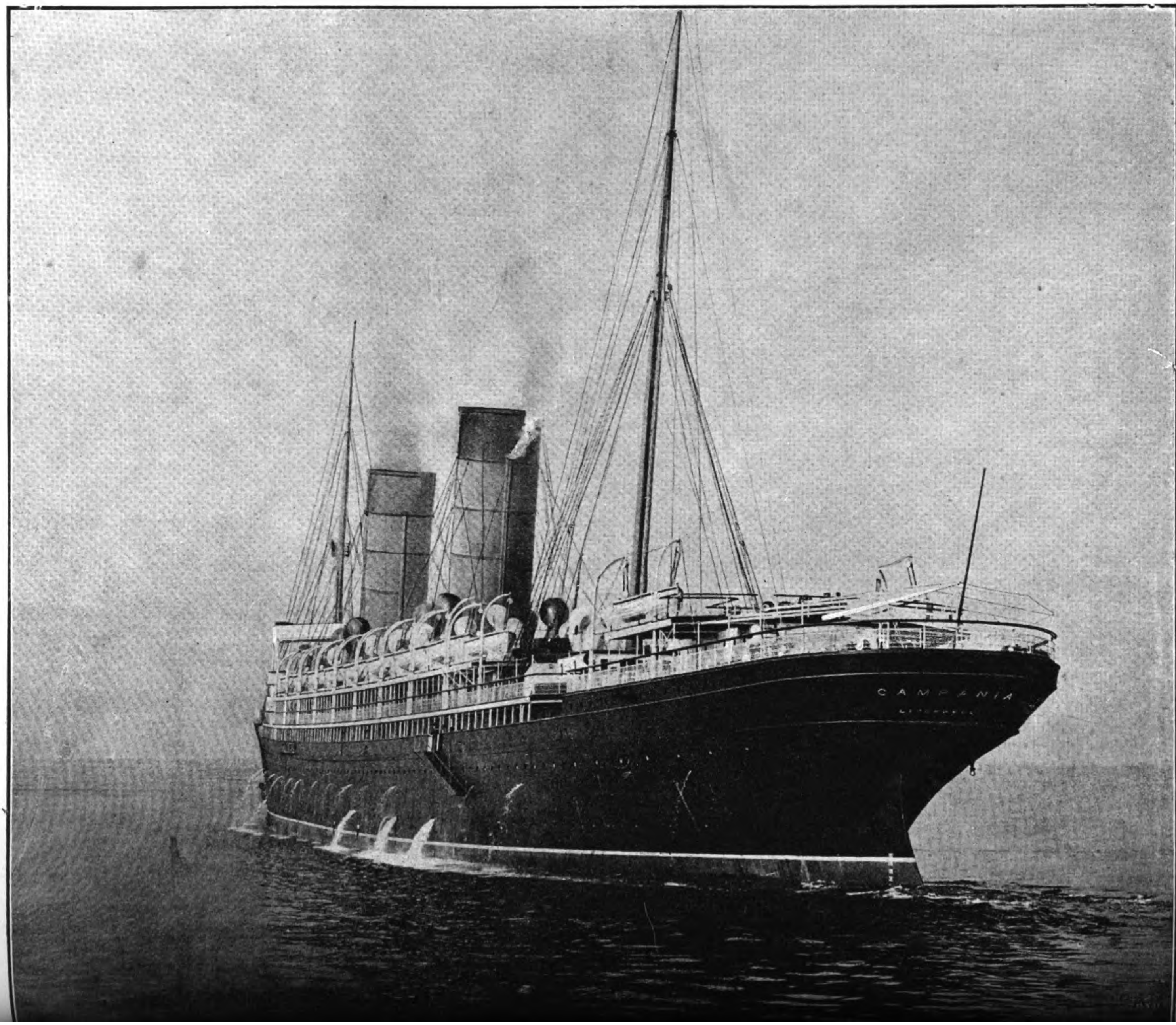
CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN.

(*For Description, see Page 501.*)

THE CUNARD TWIN-SCREW STEAMER "CAMPANIA."



THE CUNARD TWIN-SCREW STEAMER "CAMPANIA."



VIEWS OF THE FIRST-CLASS SALOONS OF THE "CAM

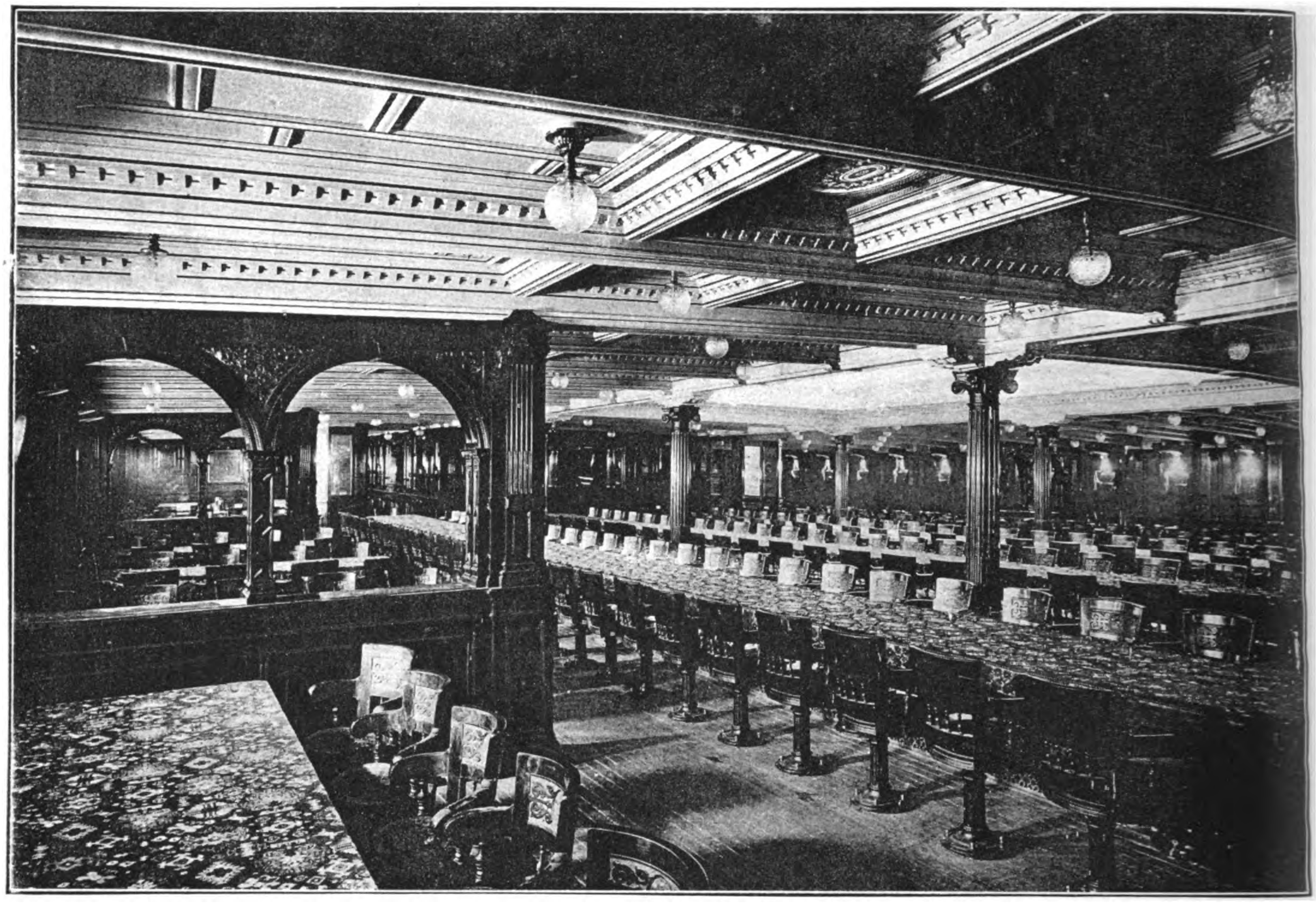


Fig. 80. Dining Saloon (looking Forward).

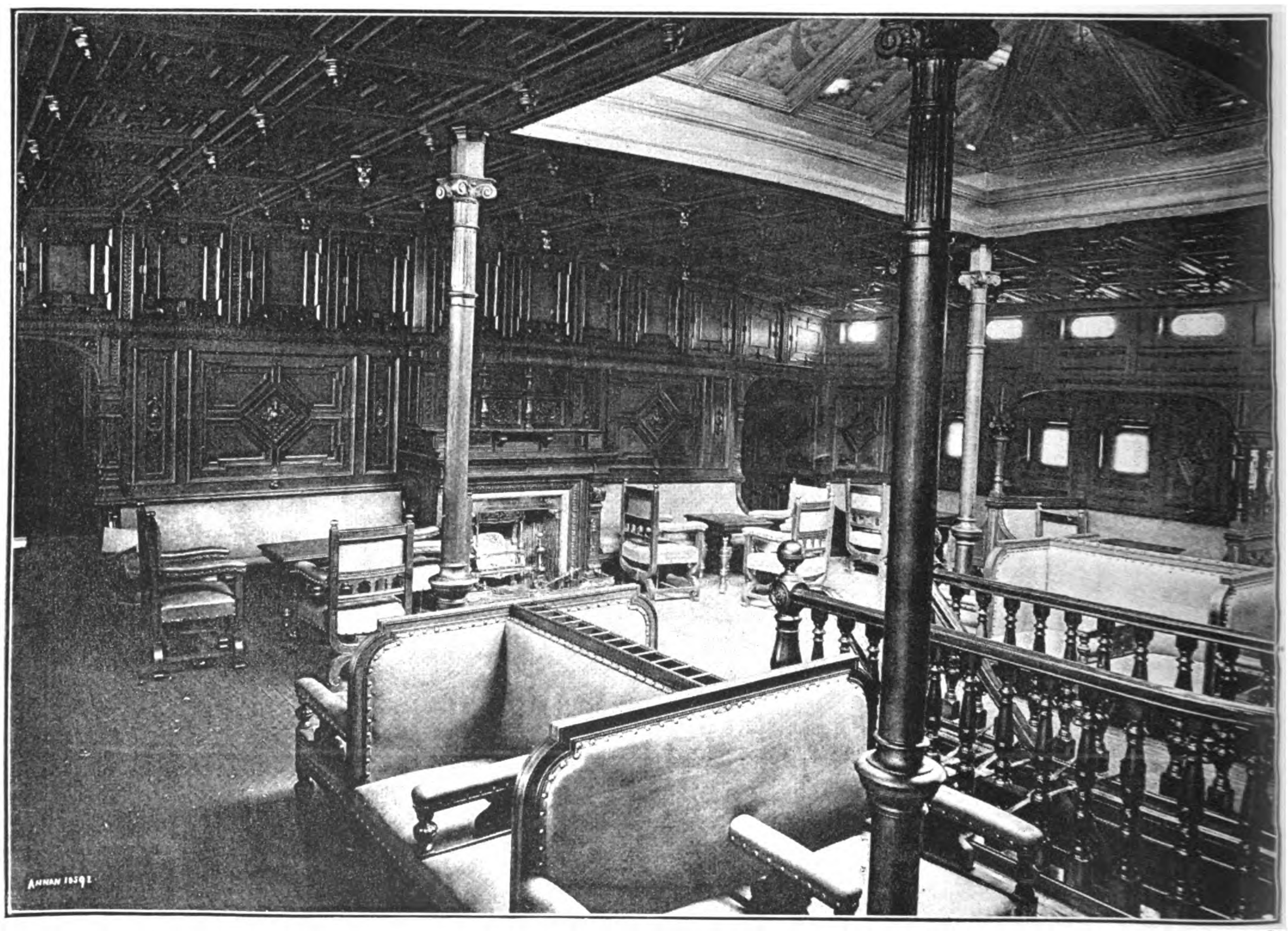


Fig. 82. Smoking Room (looking Forward).

VIEWS OF THE FIRST-CLASS SALOONS OF T

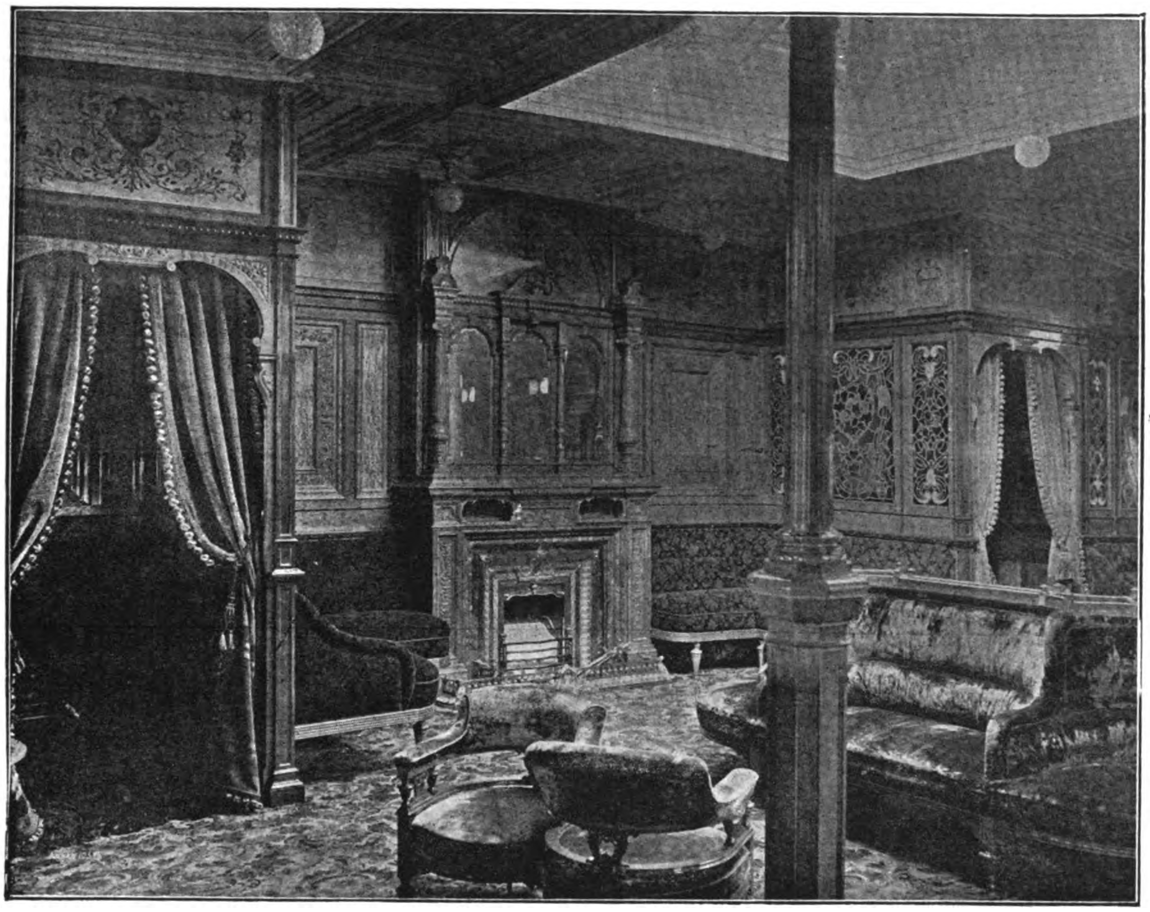


Fig. 75. Drawing Room (Forward End).

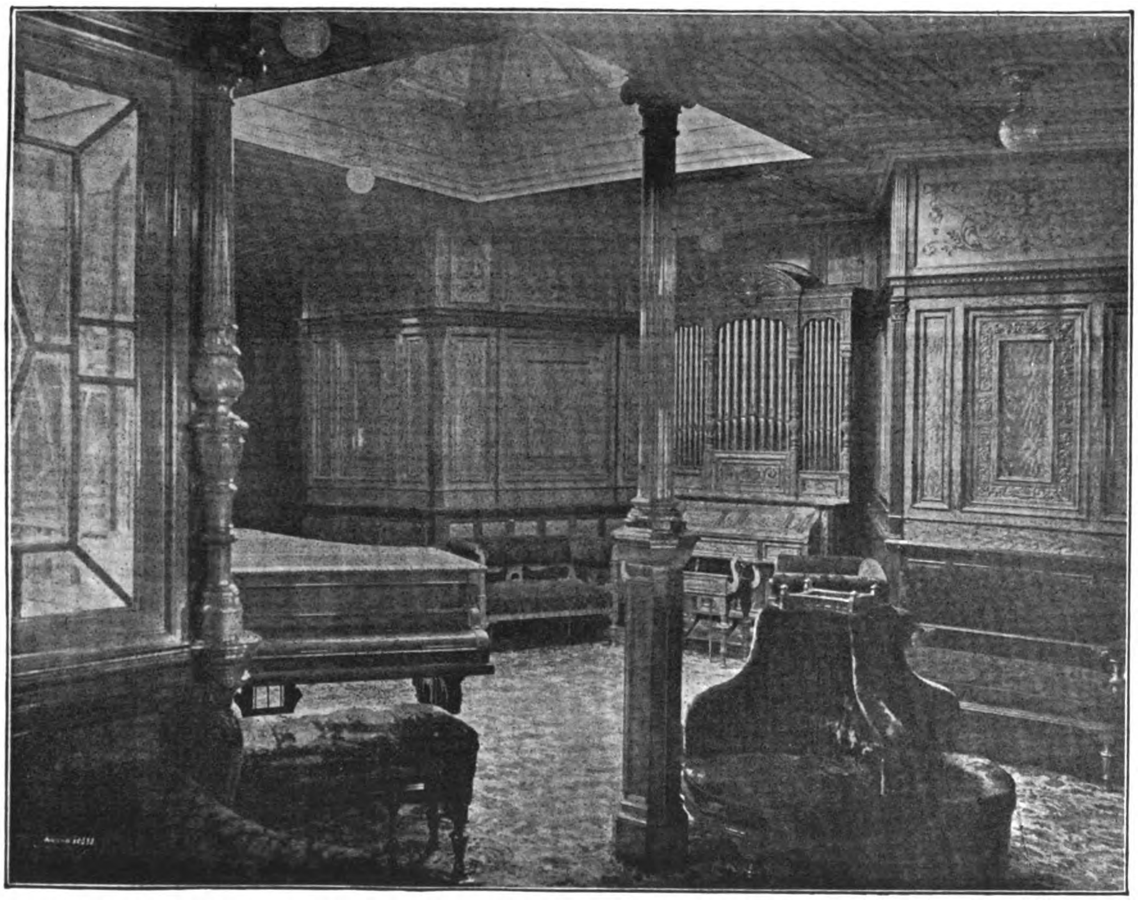


Fig. 76. Drawing Room (After End).

Fig. 79. Dining

DECK PLANS OF THE CUNARD

Fig. 69.
SHADE DECK.

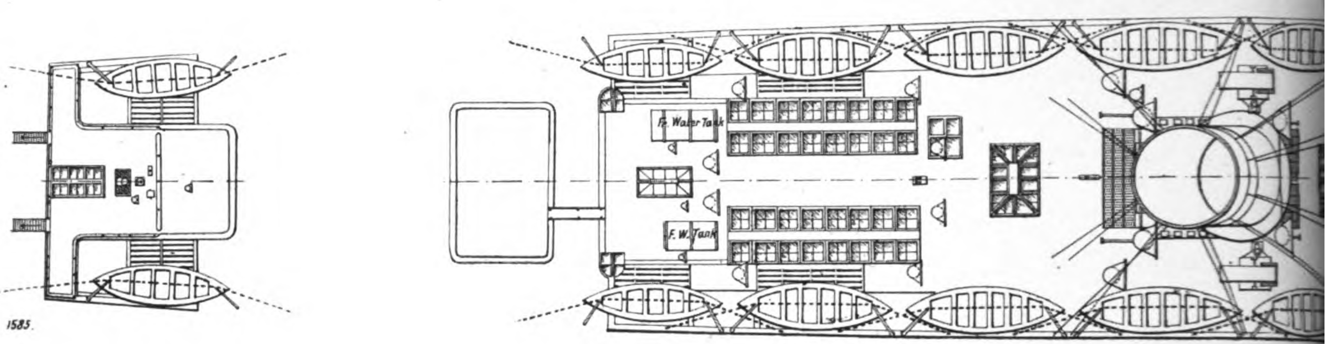


Fig. 70.
PROMENADE DECK

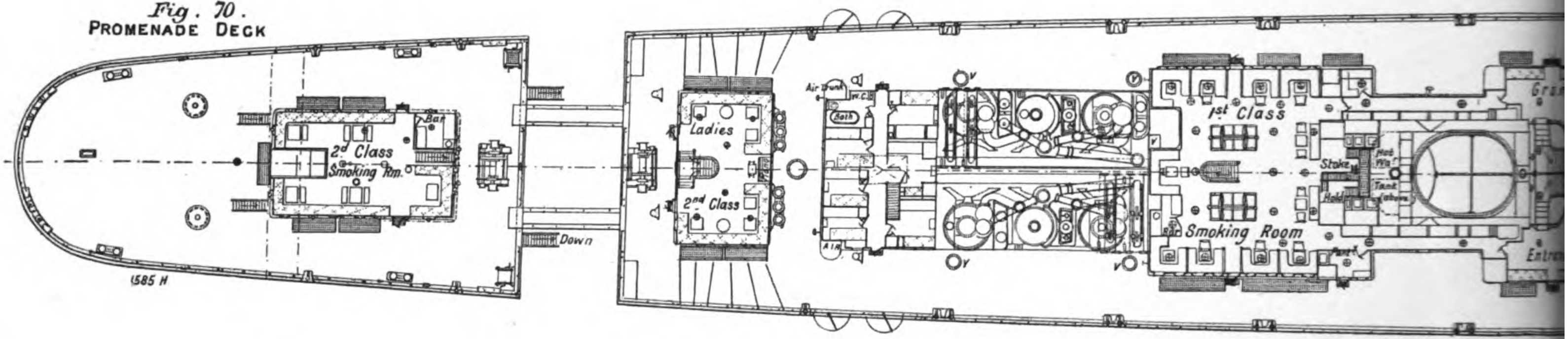


Fig. 71.
UPPER DECK

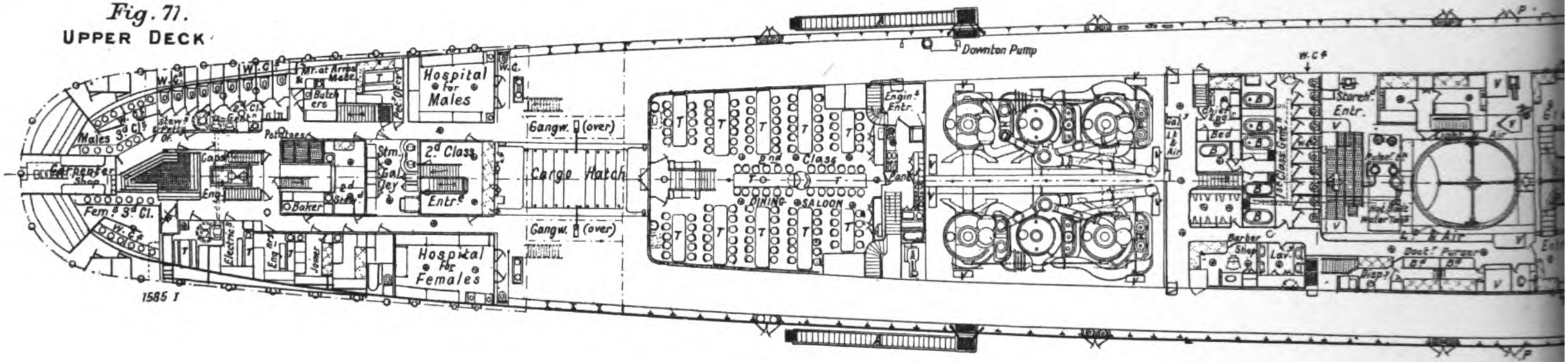


Fig. 72.
MAIN DECK

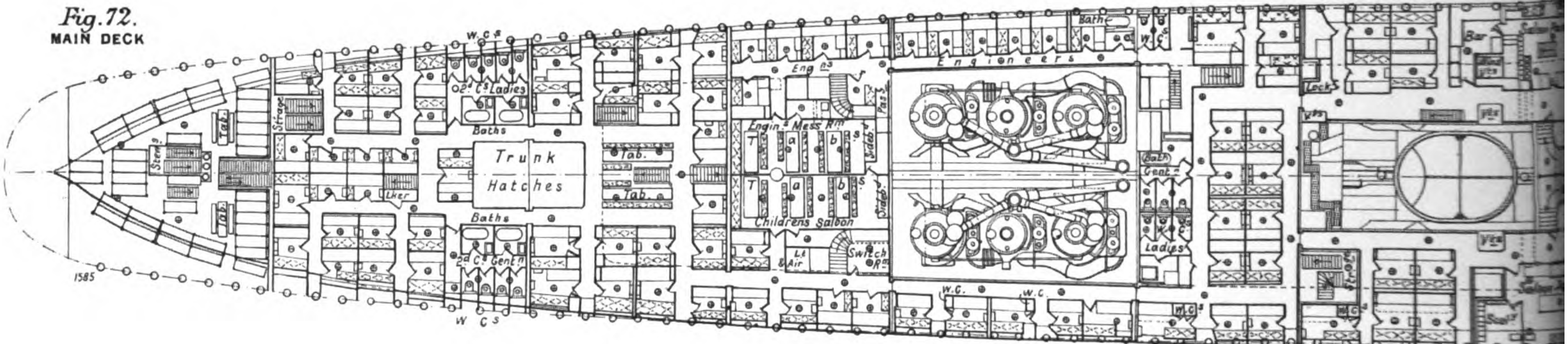
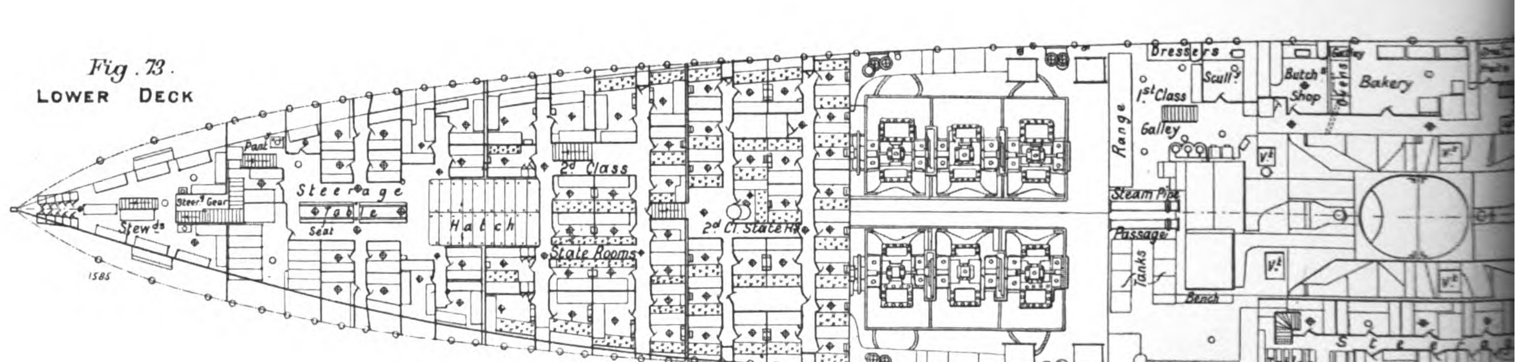
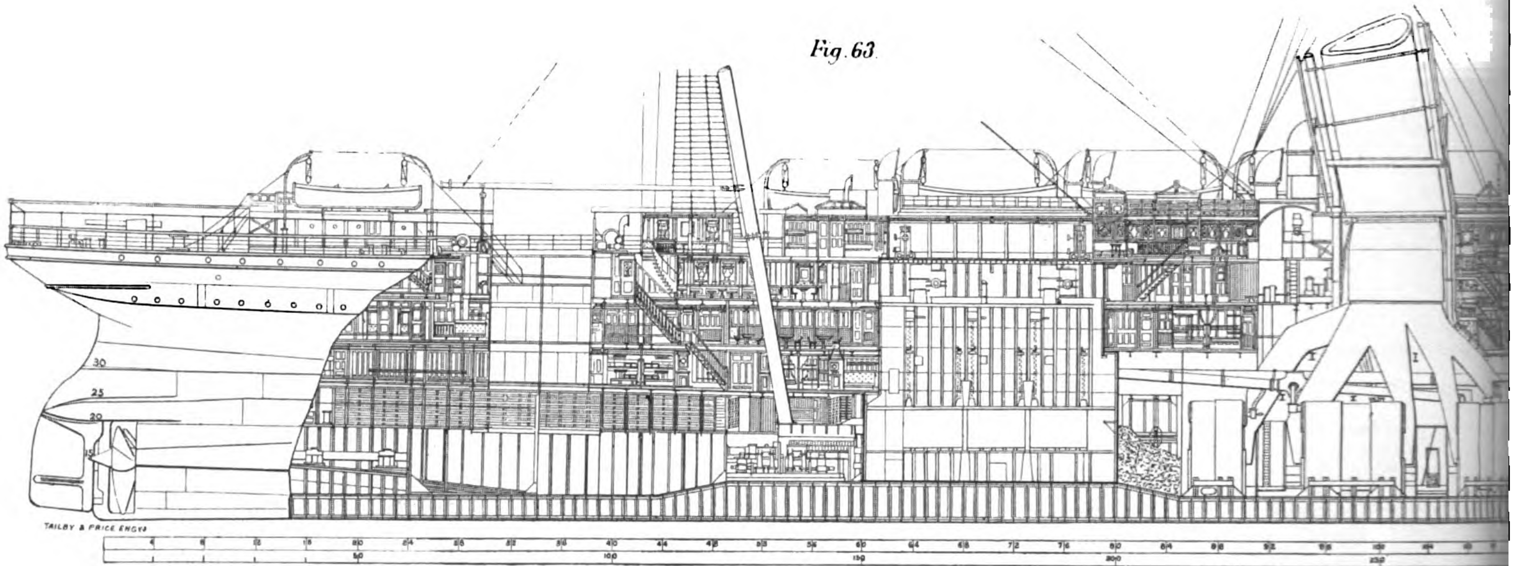


Fig. 73.
LOWER DECK



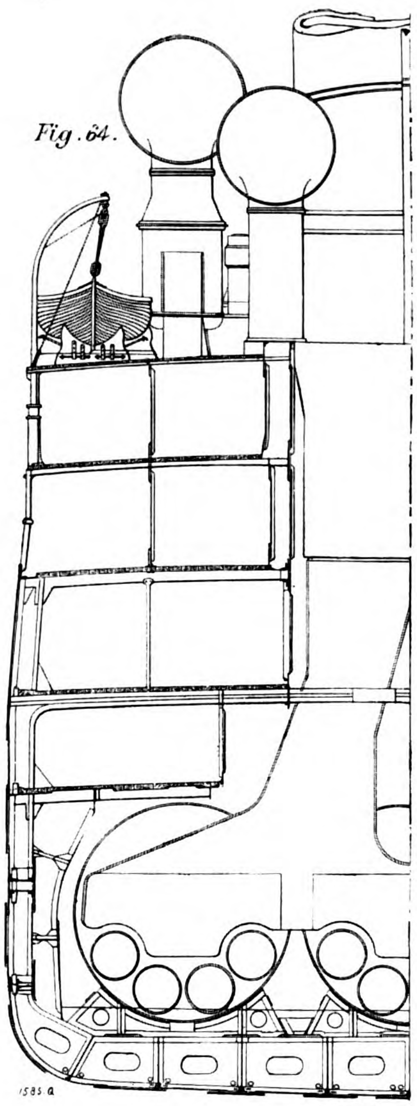
SECTIONS OF THE CUNARD TWIN-SCR

Fig. 63.



PRINCIPA

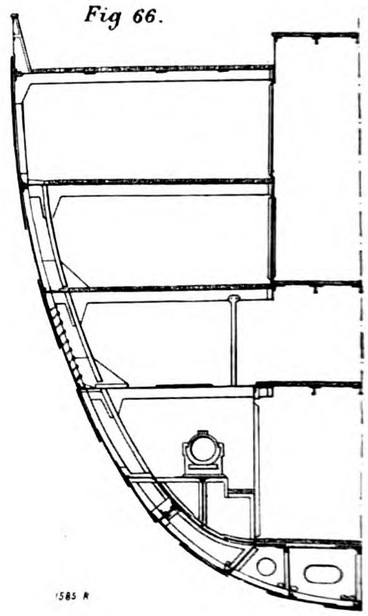
Fig. 64.



Hull:—		
Length over all	...	622 ft.
„ between perpendiculars	... ...	600 „
Breadth, extreme	...	65 ft. 3 in.
Depth from upper deck		41 „ 6 „
„ shade „		59 „ 6 „
Tonnage ...	... ...	12,950 tons

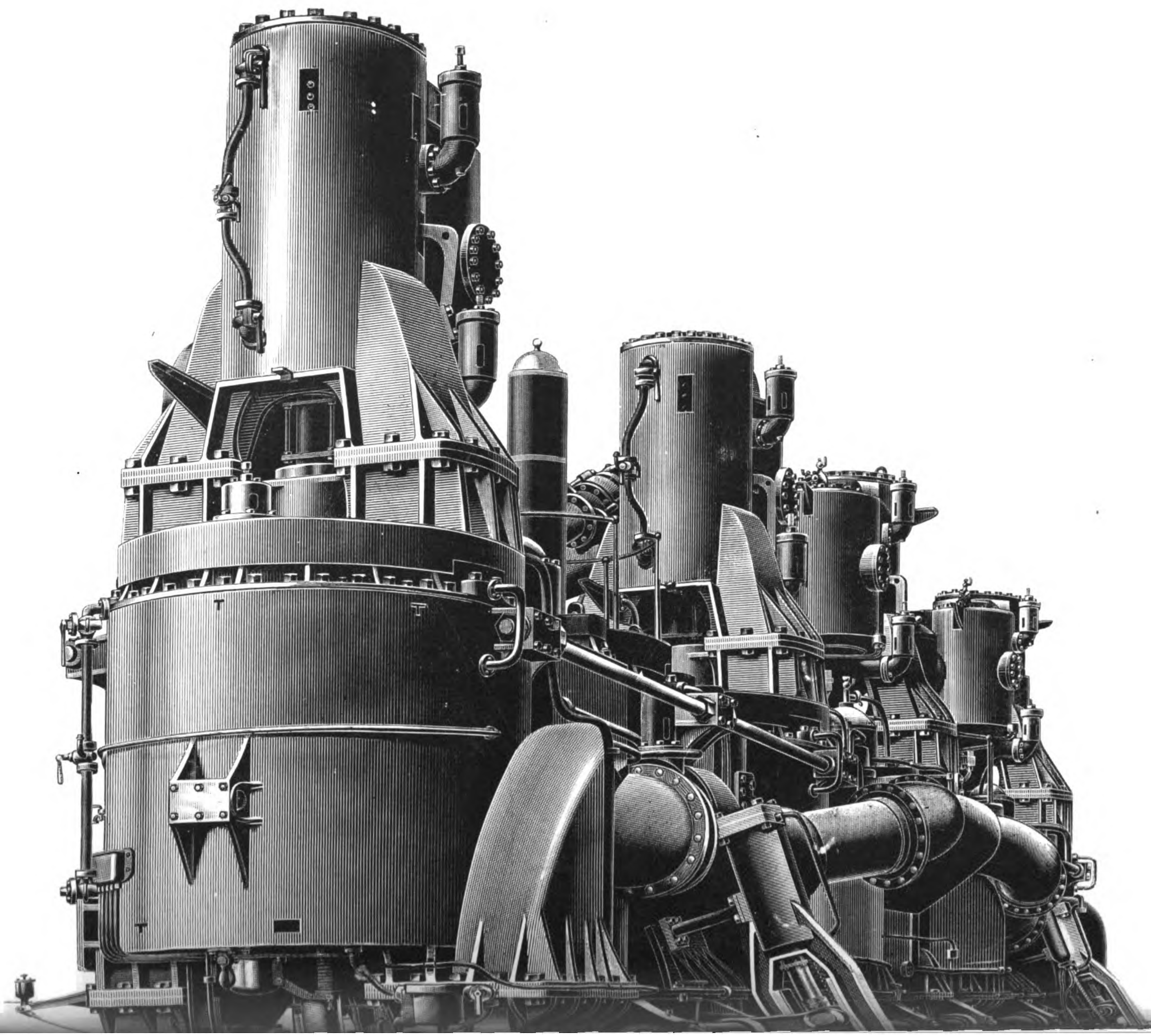
Passenger Accommodation:—	
First class	... ...
Second class	... ...
Third class	... ...
Crew	... ...
Cargo-carrying capacity...	
Engines (Twin Screw):—	
High-pressure cylinders	

Fig 66.



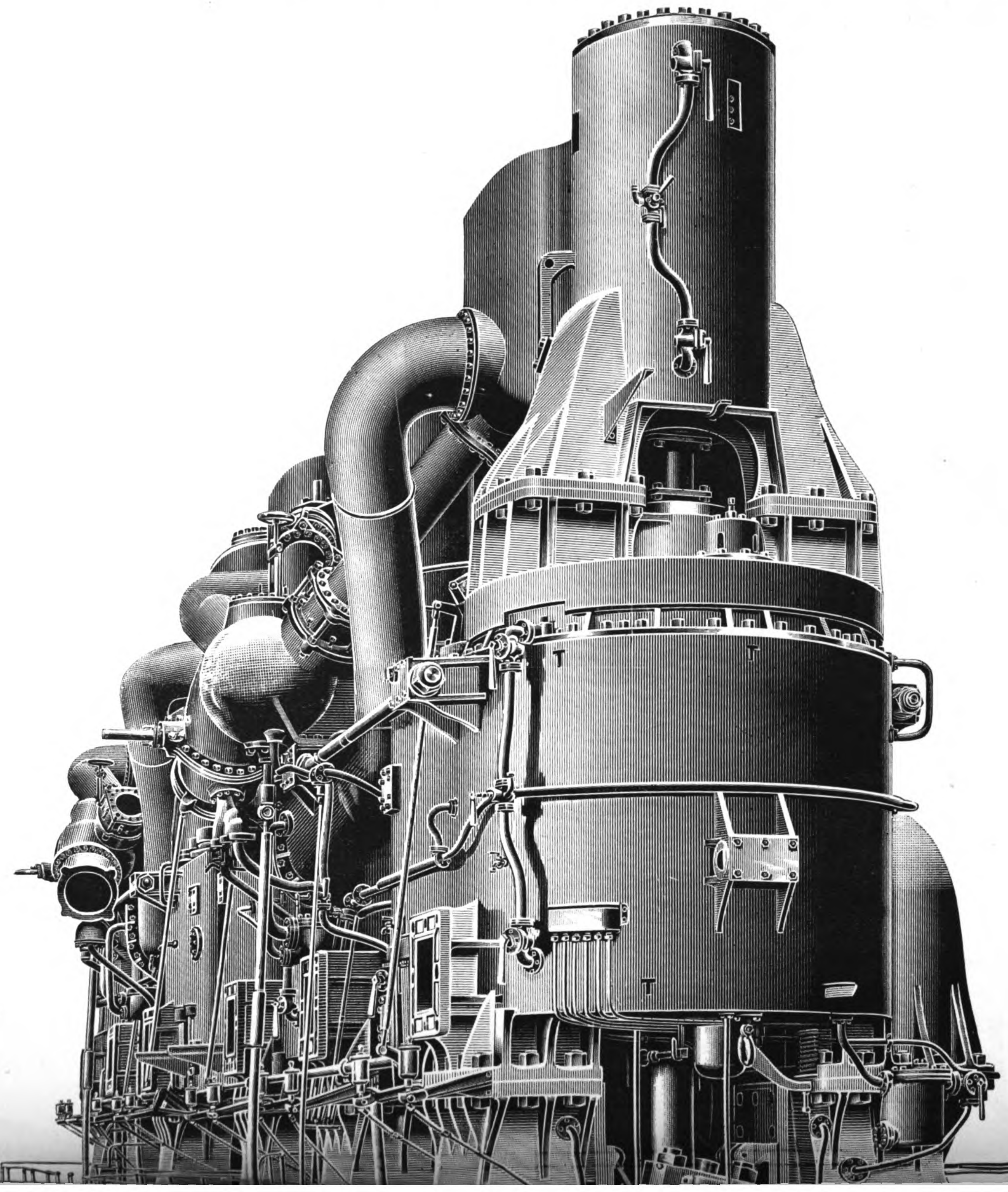
TWIN FIVE-CYLINDER TRIPLE-EXPANSION ENGINES OF THE CUNARD STEAMER "CAMPANIA."

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GLASGOW.



TWIN FIVE-CYLINDER TRIPLE-EXPANSION ENGINES OF THE CUNARD STEAMER "CAMPANIA."

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GLASGOW.



THE FITTING AND MACHINE S

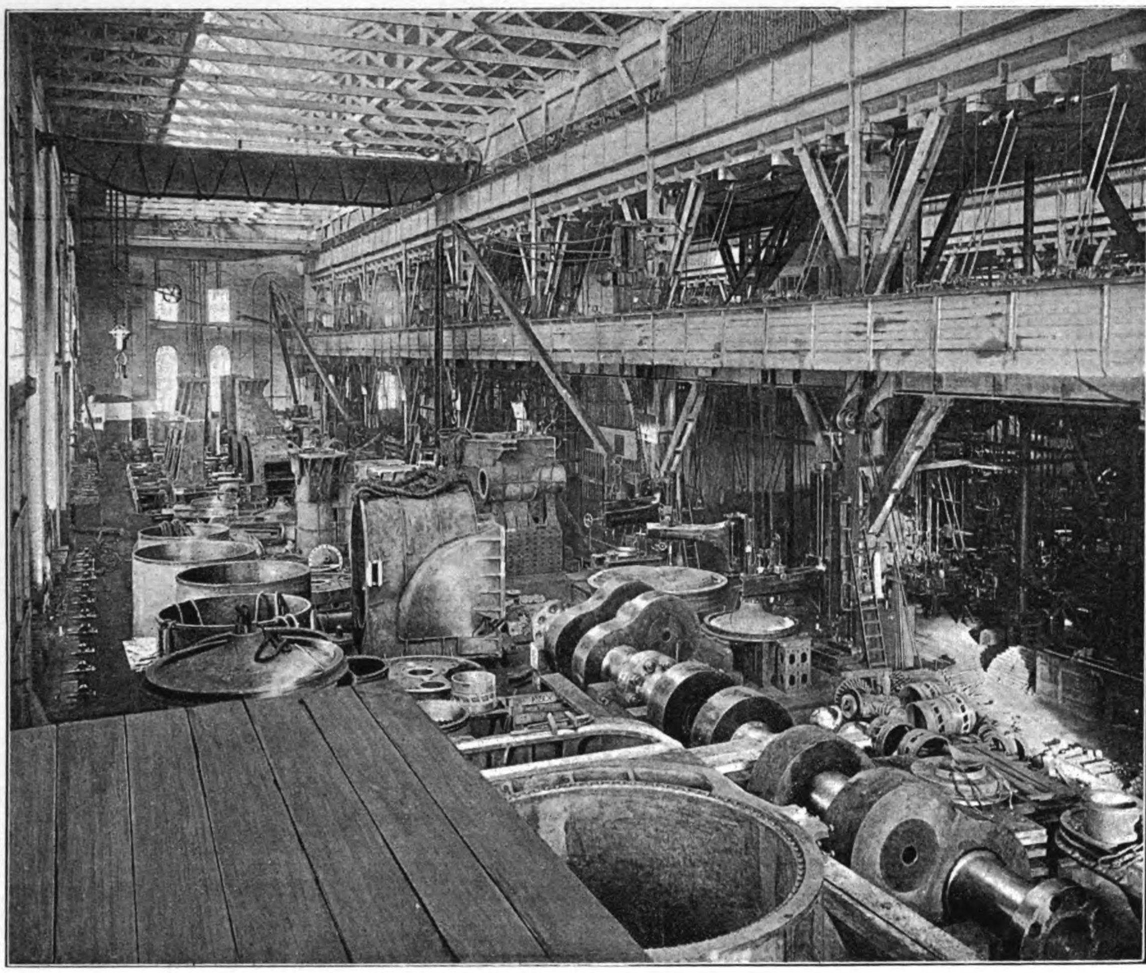


Fig. 17. Fitting Shop, looking North; Frames of one of "Campania's" Engines Erected. December 31, 1891.

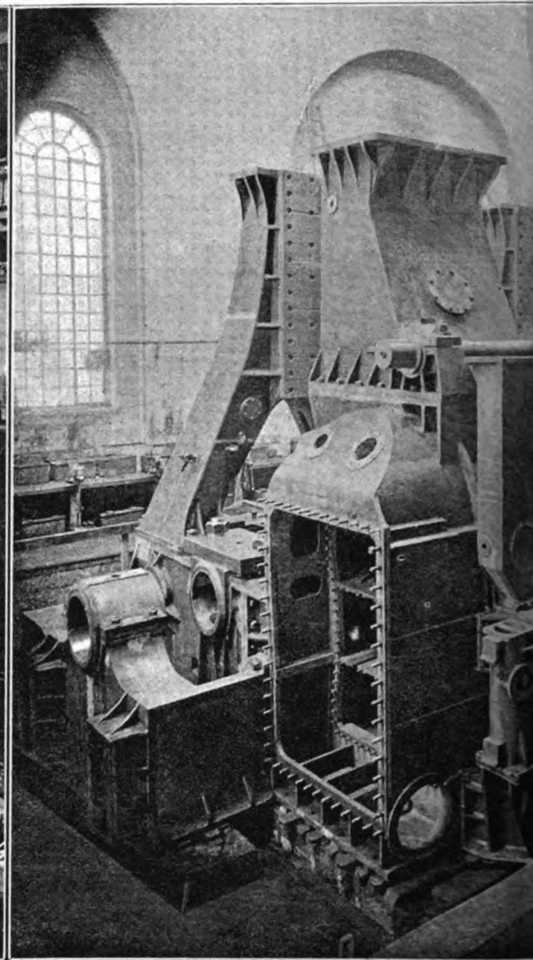


Fig. 18. North End of Fitting Shop
Dec

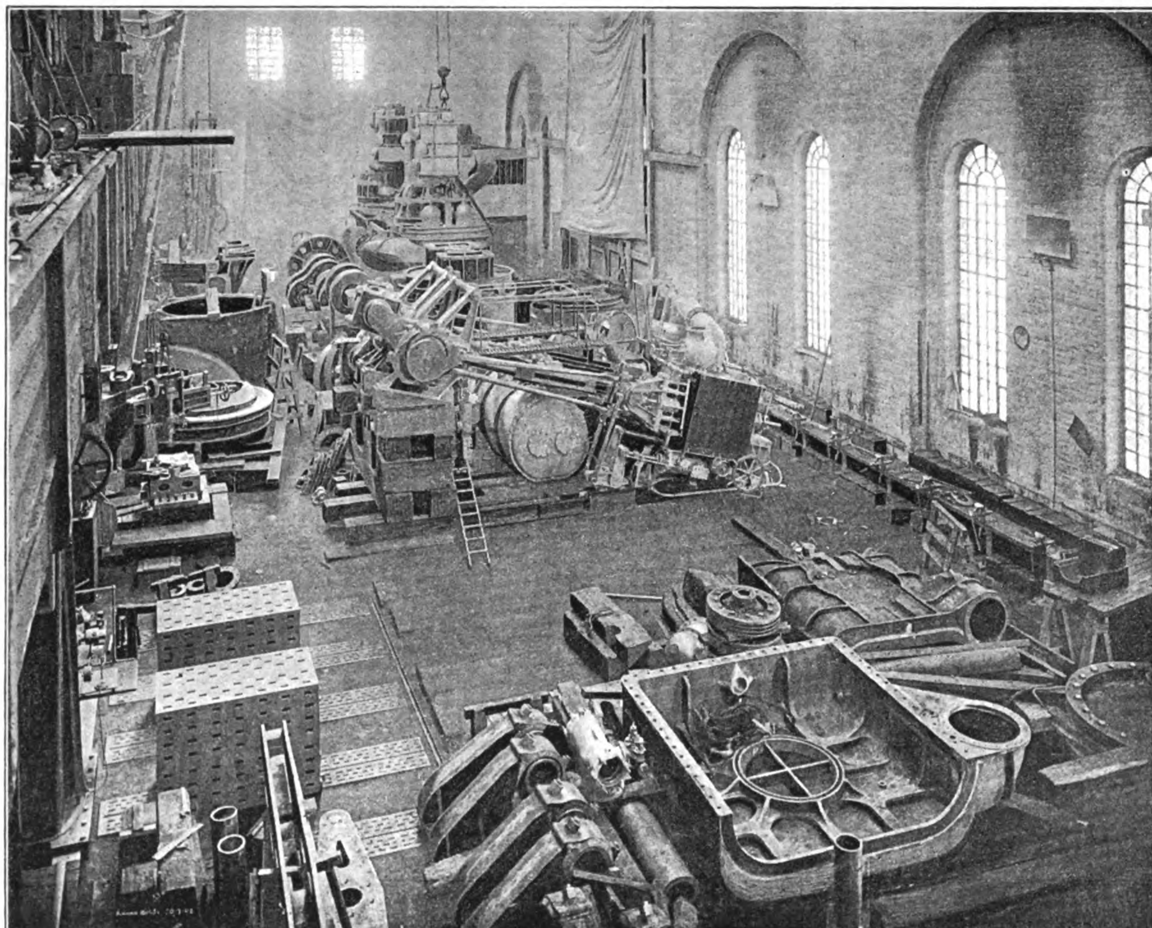


Fig. 20. Fitting Shop, looking South; Engines of Paddle Steamer "Koh-i-Noor" and Twin-Screw Steamer "Pole Star." March 30, 1892.

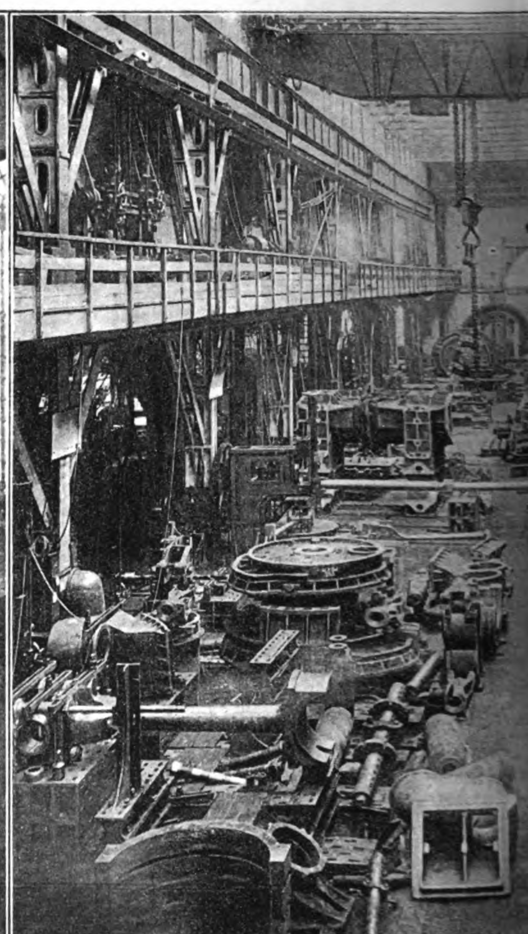
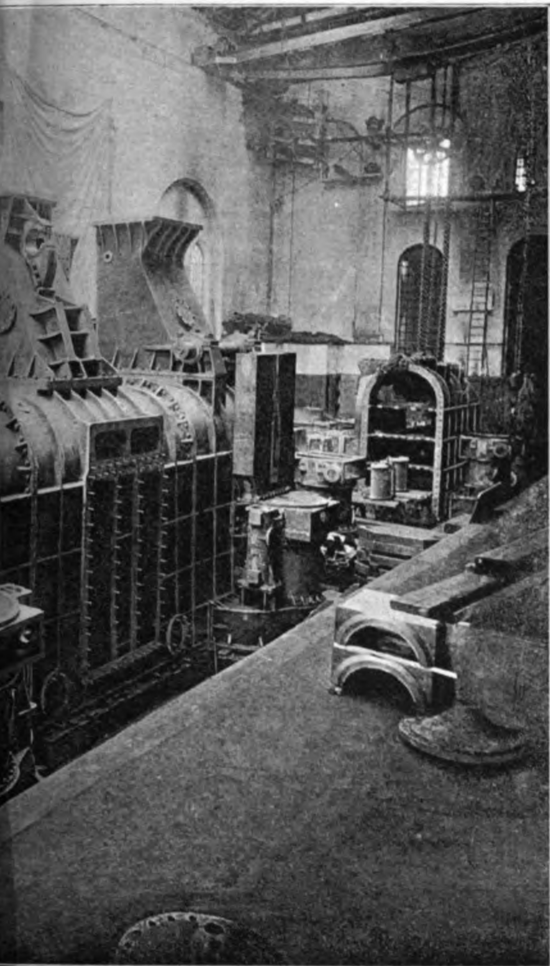


Fig. 21. Machine Sh

OPS AT THE FAIRFIELD WORKS.



RAMES OF "CAMPANIA'S" ENGINES ERECTED.
1, 1891.

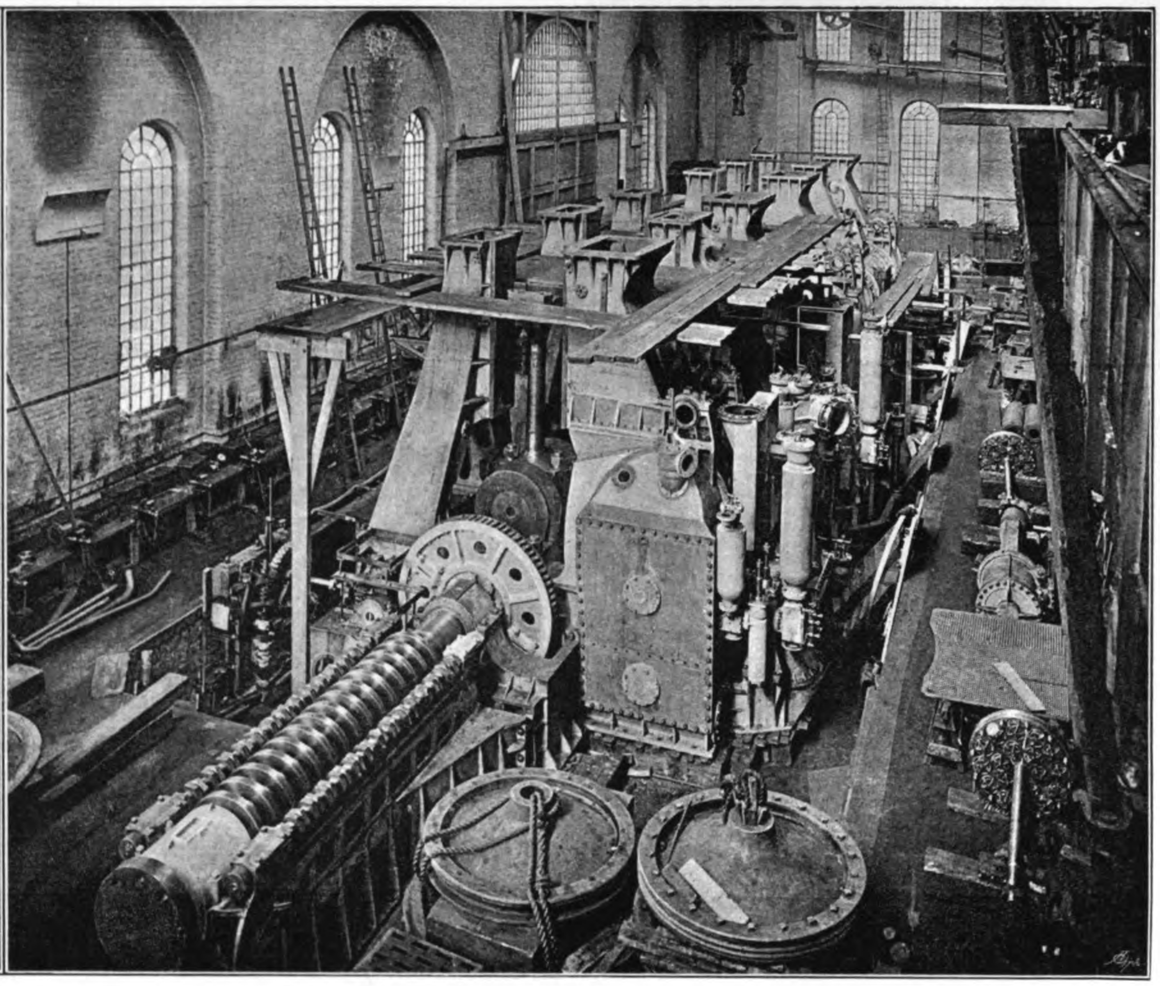
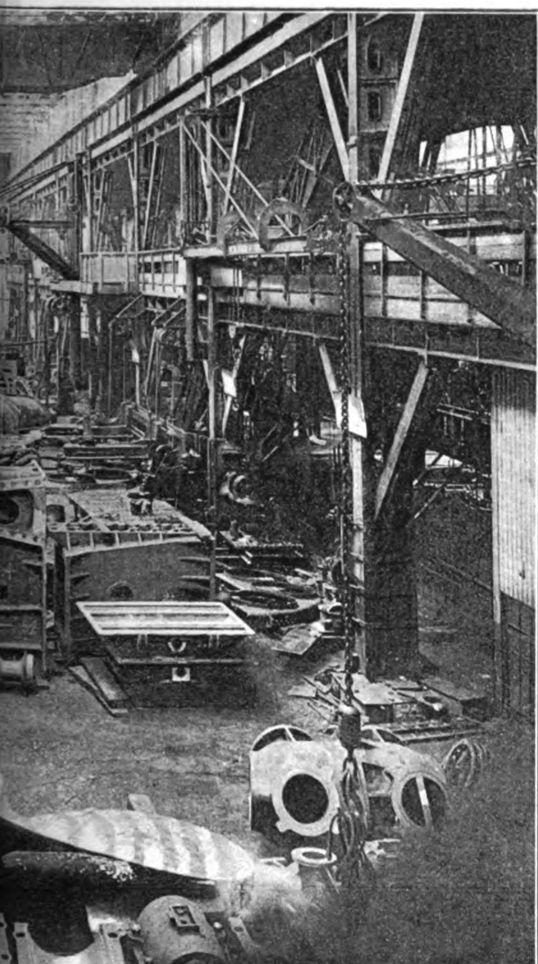


FIG. 19. TWIN ENGINES OF "CAMPANIA" IN FITTING SHOP. MARCH 30, 1892.



NORTH. MARCH 30, 1892.

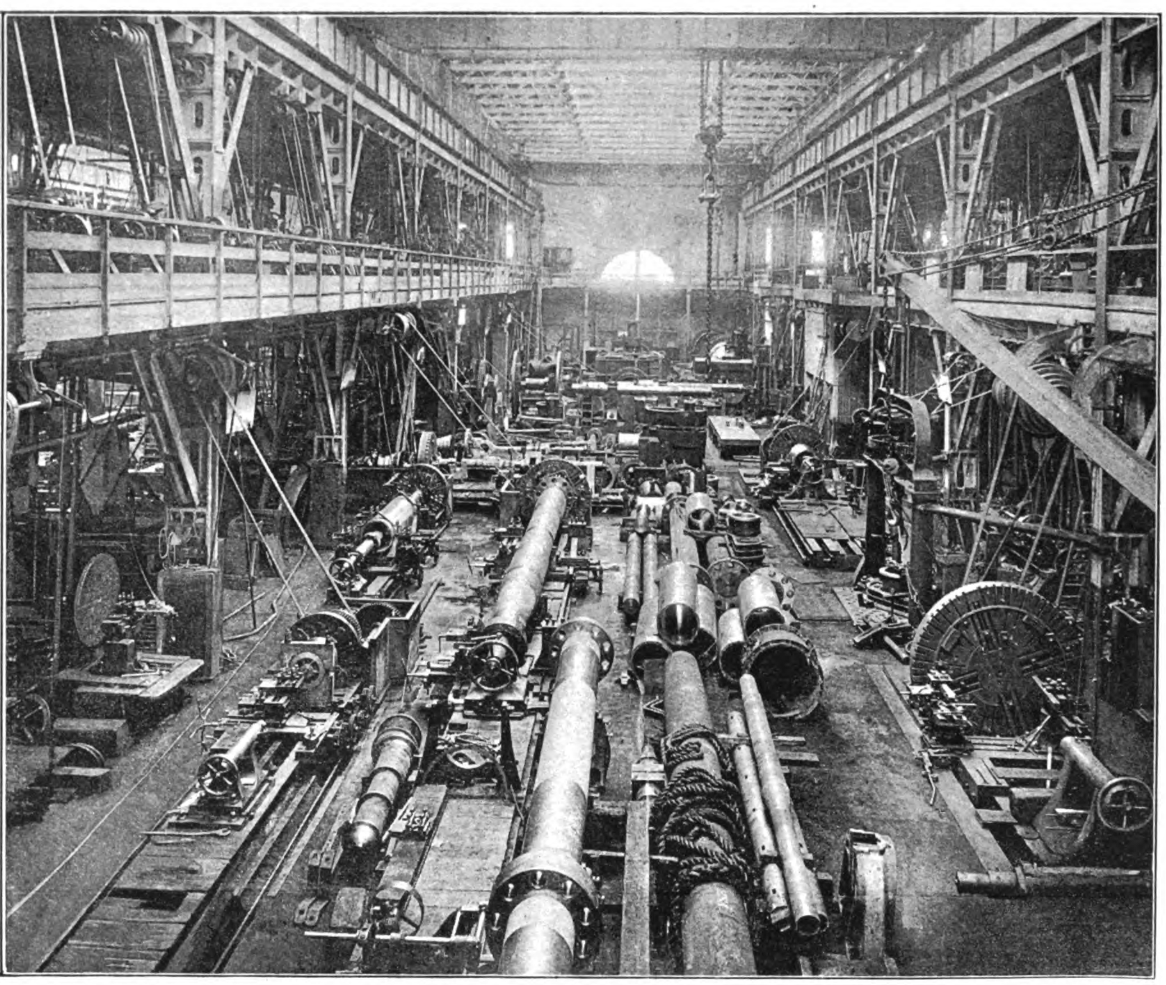


FIG. 22. MACHINE SHOP, LOOKING SOUTH. MARCH 30, 1892.

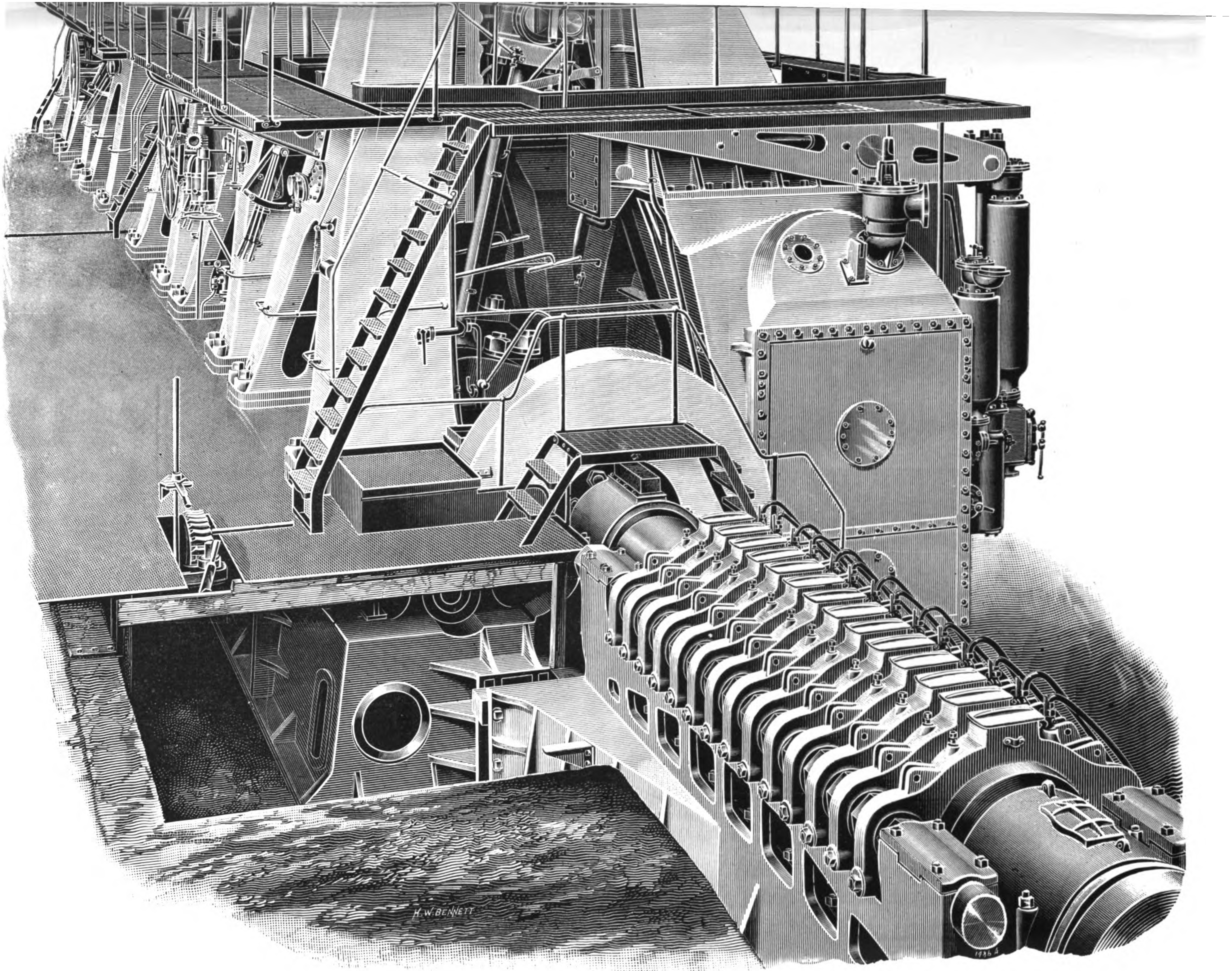


Fig. 34.

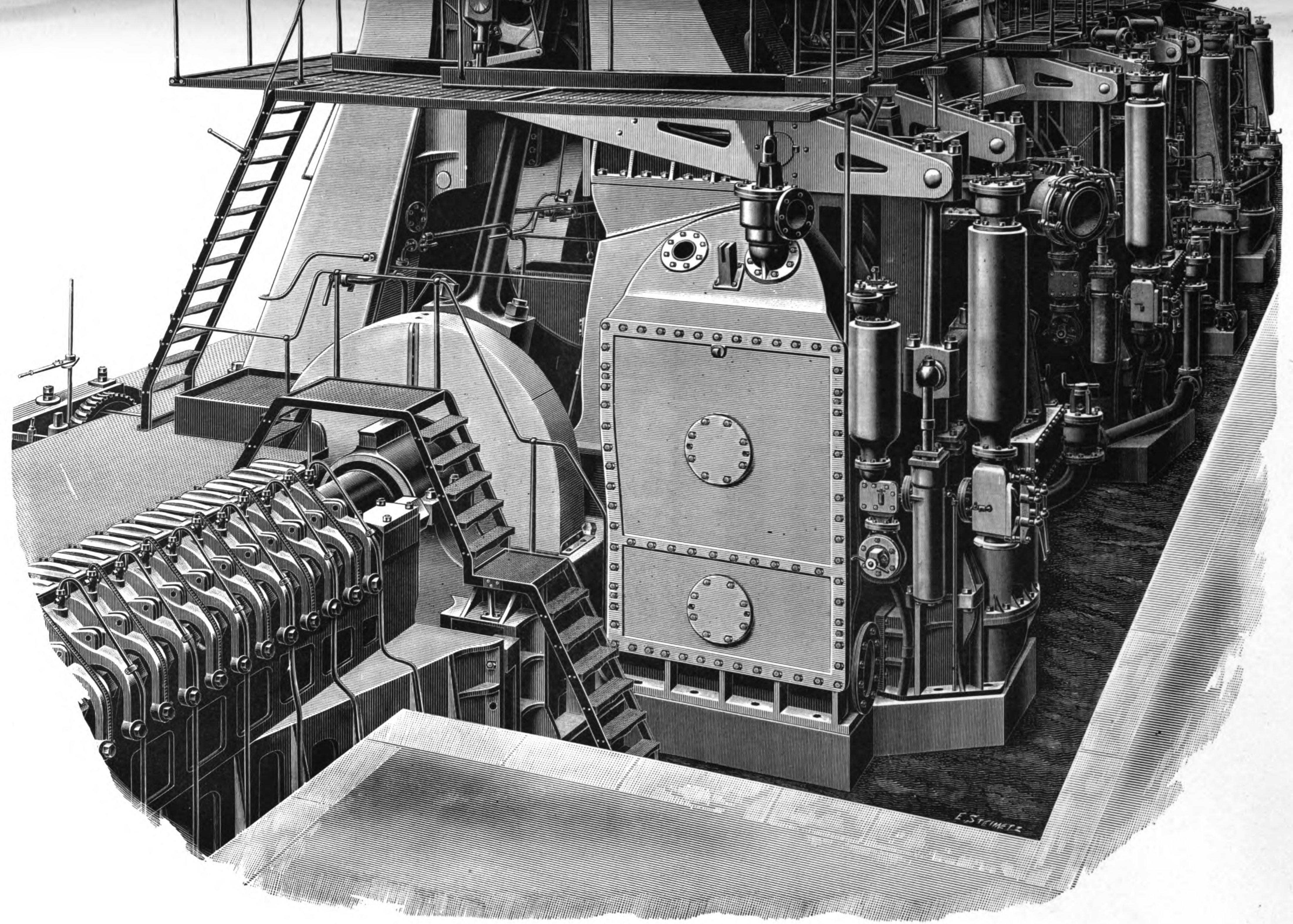
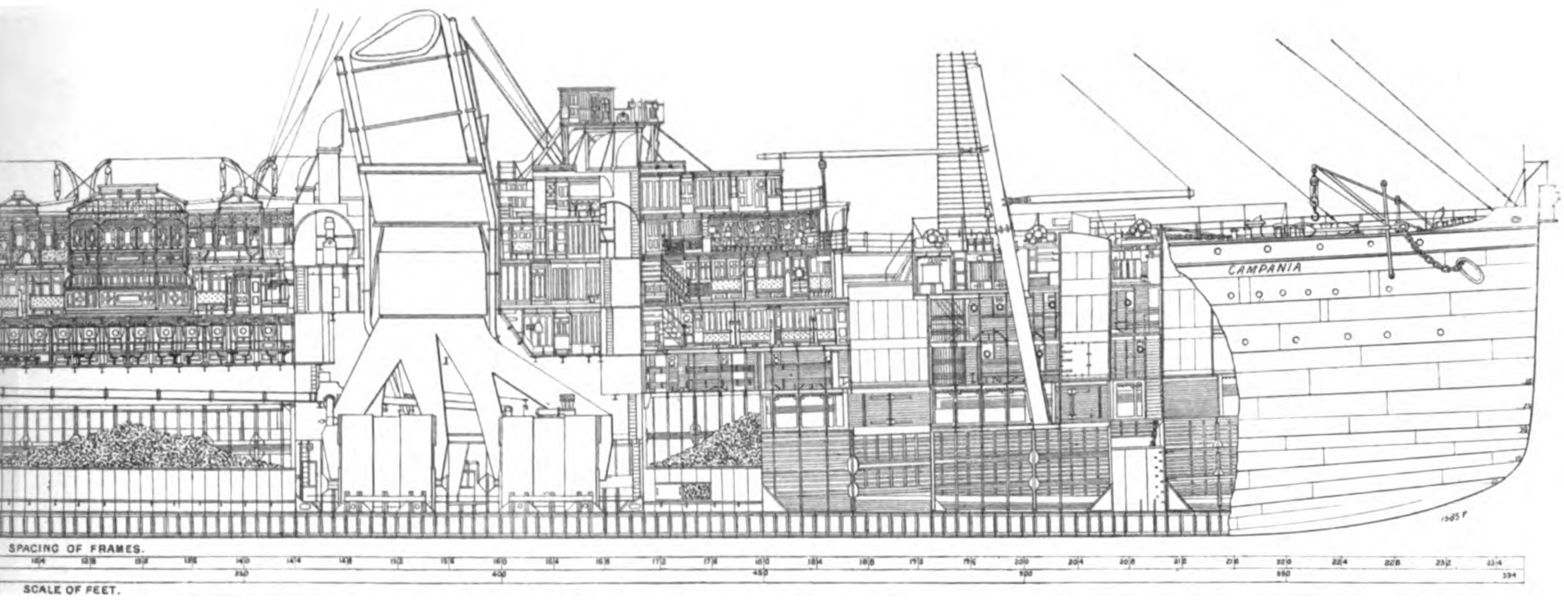


Fig. 35.

STEAMERS "CAMPANIA" AND "LUCANIA."



MENSIONS, &c.

Engines—continued :—	
Intermediate cylinders (2)	79 in.
Low-pressure " (4)	98 "
Stroke	69 "
Boilers :—	
Twelve double-ended ...	18 ft. dia. by 17 ft. long
One single-ended ...	18 ft. dia. by 11 ft. long
Boilers—continued :—	
One single-ended ...	10 ft. dia. by 10 ft. long
Total number of furnaces...	102
Working steam pressure	165 lb.
Indicated horse-power on sea trial	31,050
Speed on sea trial ...	23.18 knots

Fig. 67.

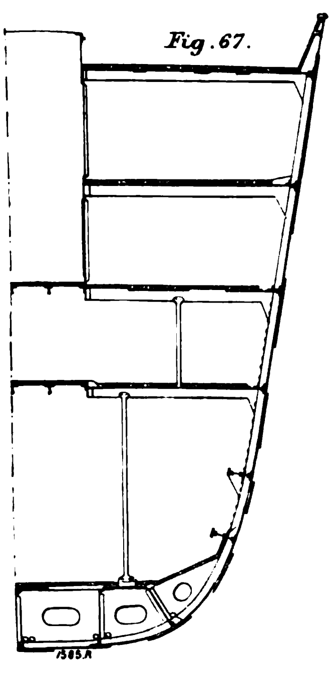
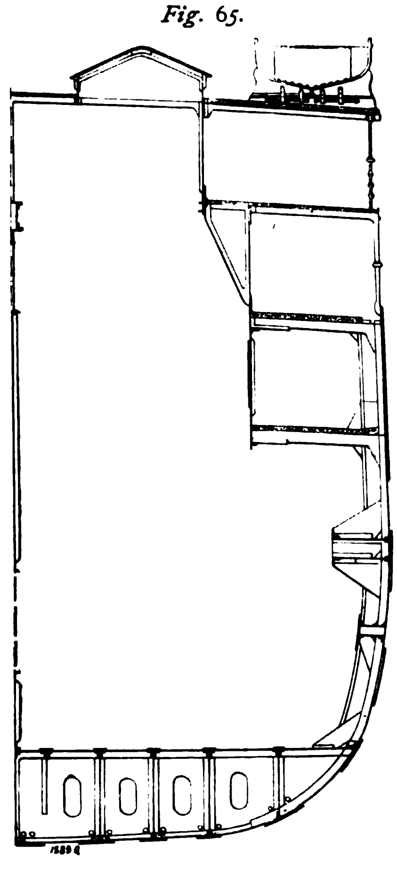


Fig. 65.



IN-SCREW STEAMER "CAMPANIA."

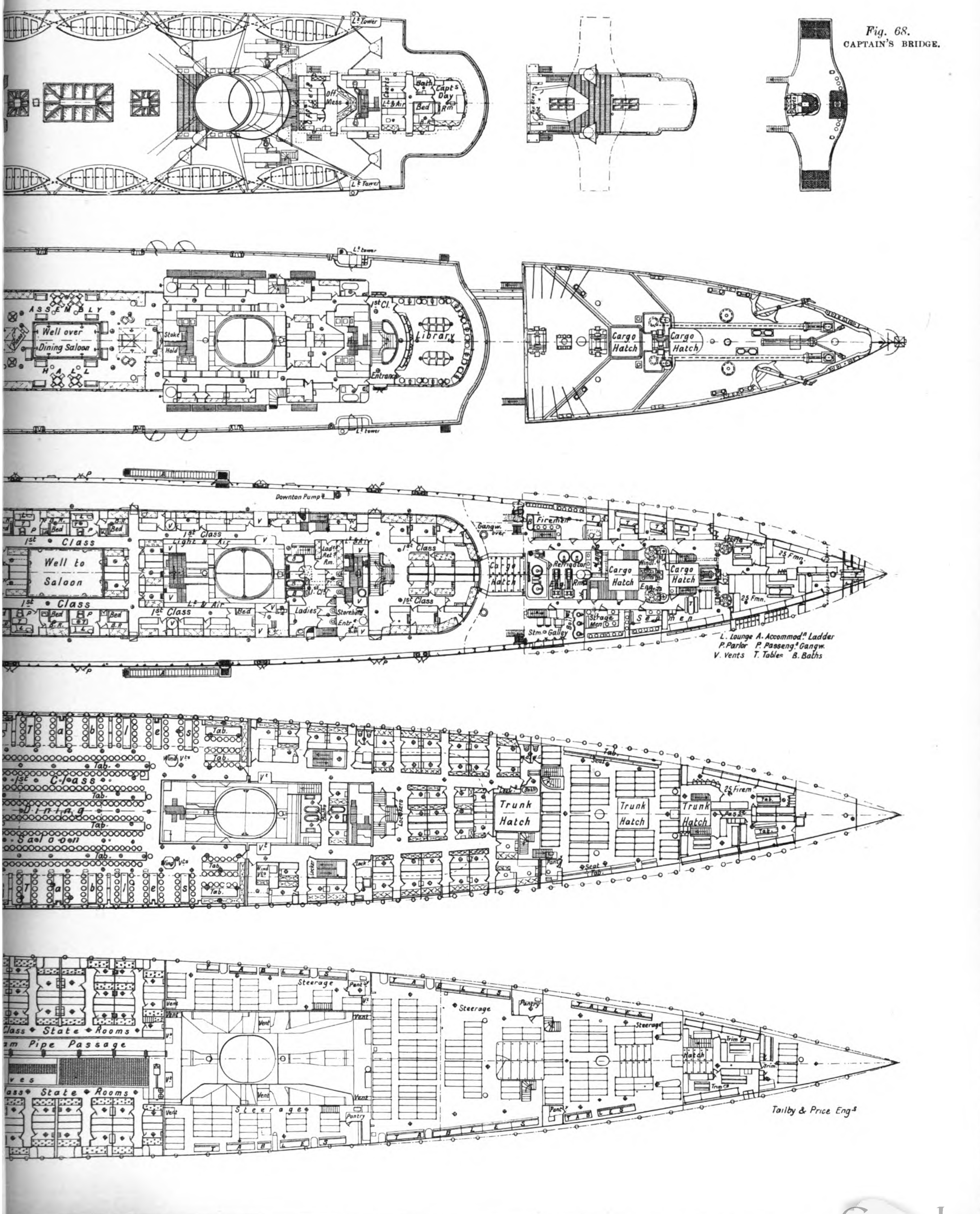


Fig. 68.
CAPTAIN'S BRIDGE.

"CAMPANIA:" DRAWING AND DINING ROOMS.

ND SKYLIGHT.

FIG. 77. DRAWING ROOM (LOOKING AFT).

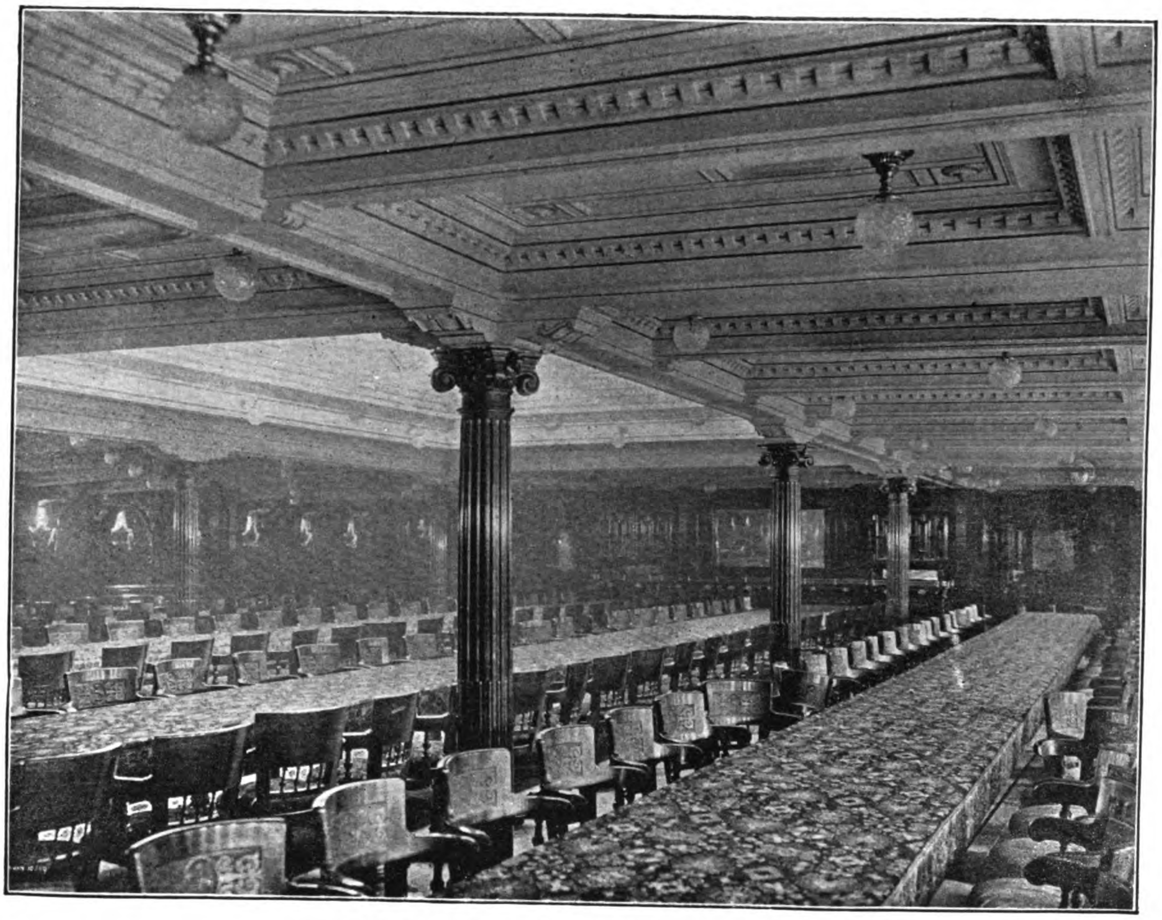


FIG. 78. DINING SALOON (LOOKING AFT).

[A:" DINING SALOON, SMOKING ROOM, AND LIBRARY.

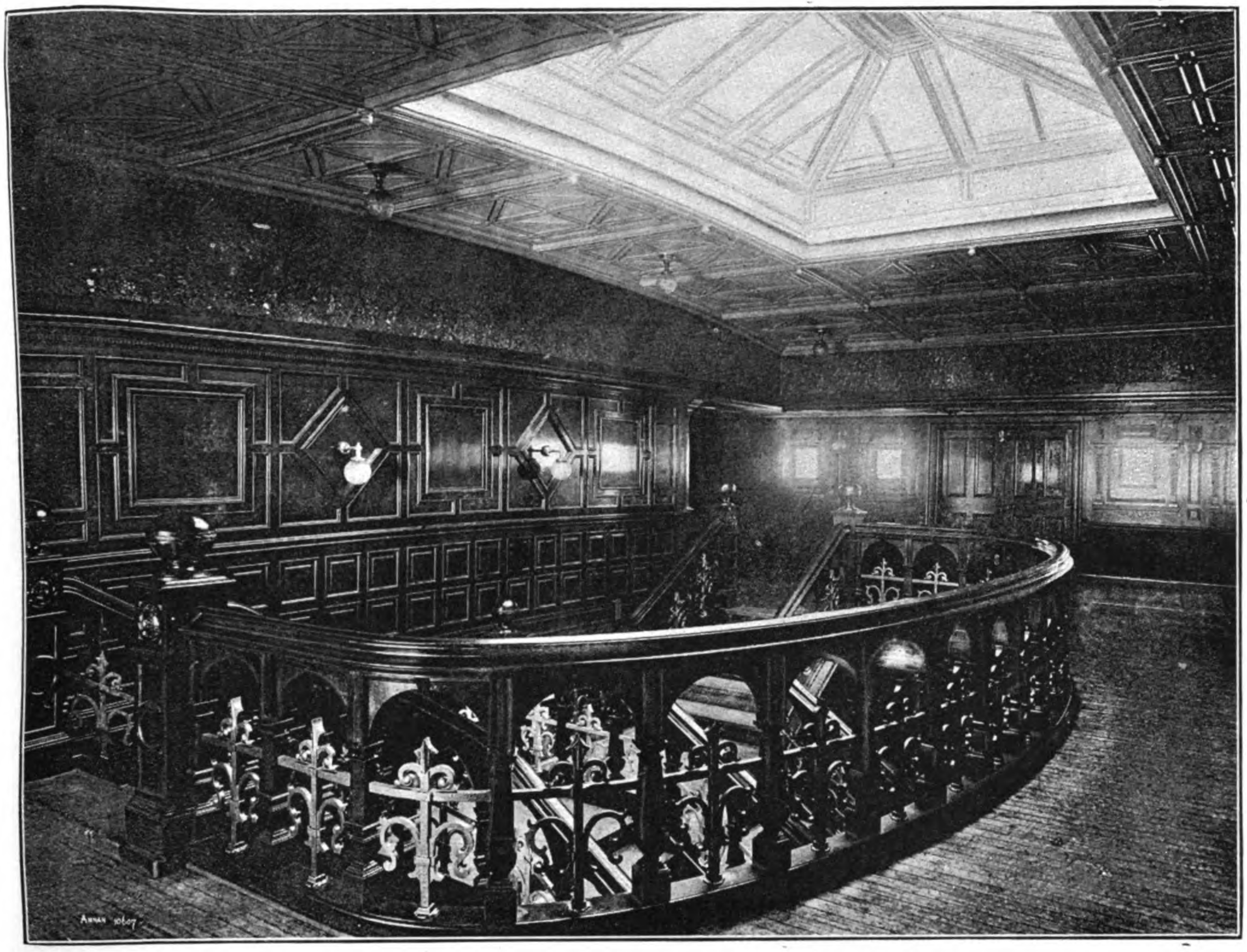


FIG. 81. GRAND STAIRCASE (PROMENADE DECK).

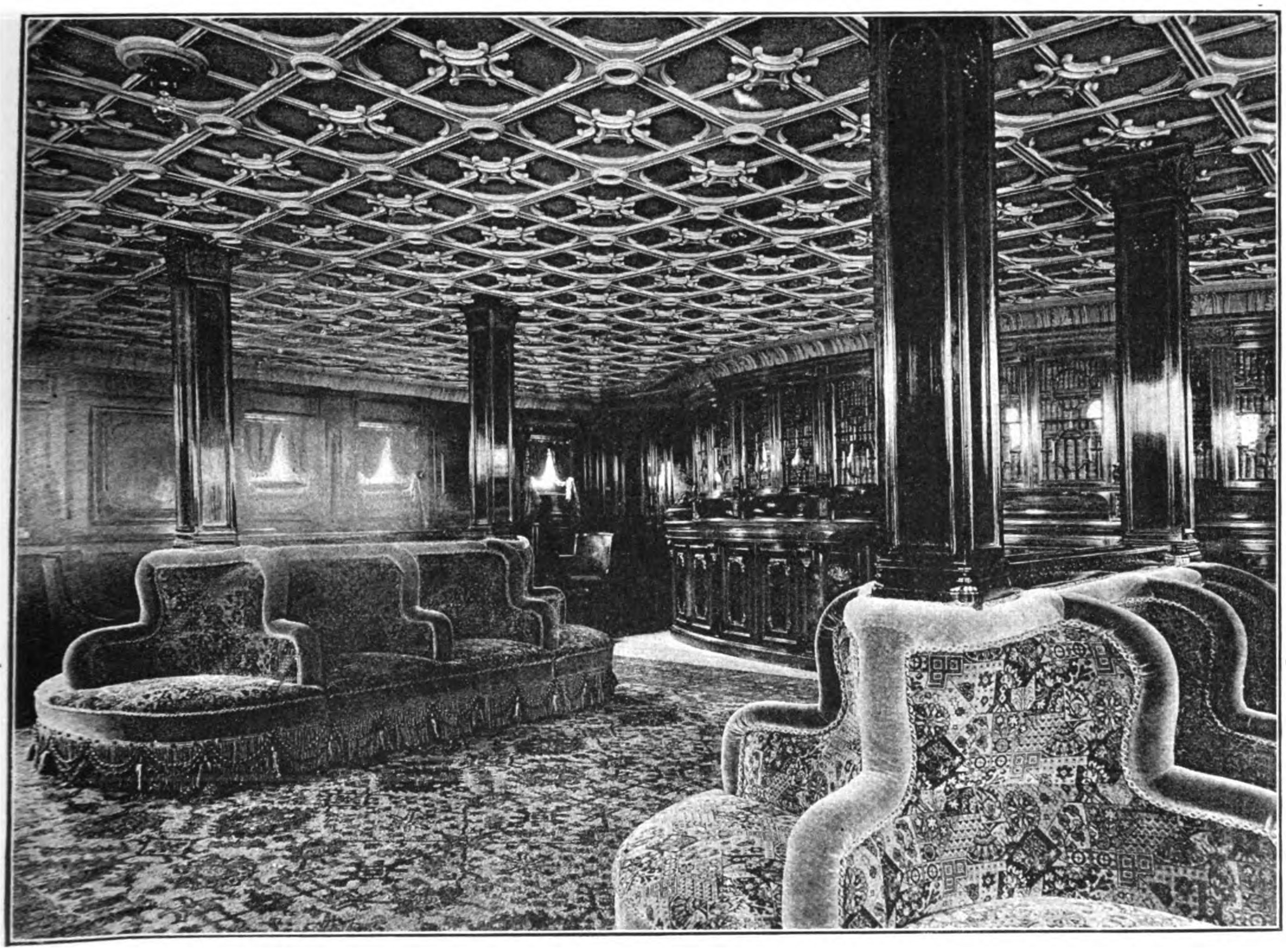


FIG. 83. LIBRARY.

Fig. 85. The "Campania" at the Tail of the Bank.

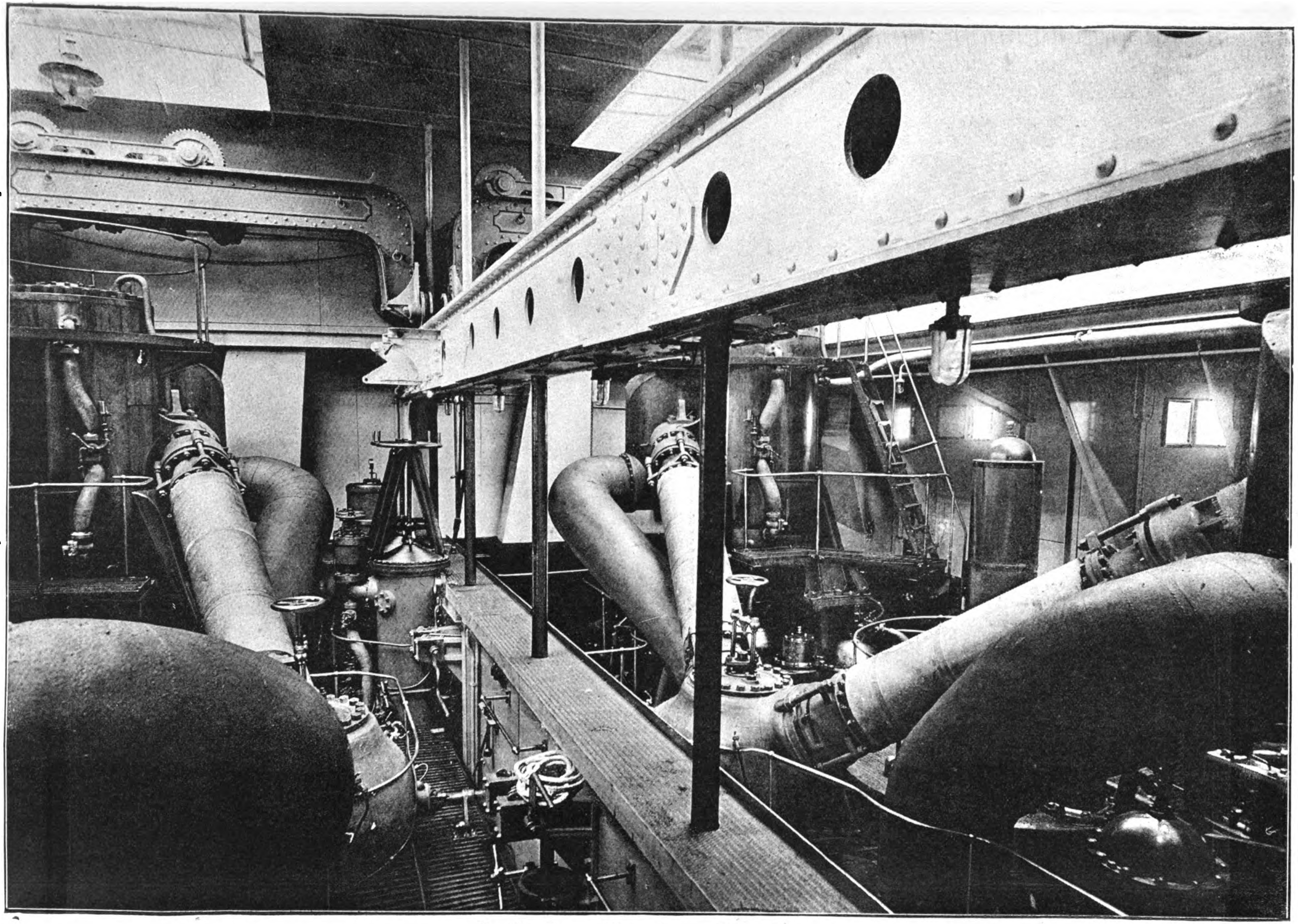


Fig. 87. View of Upper Part of Engine Room.