gauges, was 32,800 pounds, and the velocity at 150 feet was 1,787 feet.

Two kinds of Du Pont's brown prismatic powder, marked P. A. and P. I., were then fired. With the normal charge of P. A. powder (round 12 of the record), the mean pressure was 35,450 pounds, the velocity at 150 feet was 1,812 feet. For P. I. powder (round 13 of the record), the pressure was 26,925 pounds, the velocity was 1,702 feet, and a considerable amount of unconsumed powder was ejected, showing that the P. I. powder is not a suitable one for this piece. The highest pressure indicated with the normal charge of P. A. powder was 36,200 pounds, exceeding by 1,200 pounds the provisional limit of pressure.

At the fifth round the breech block opened with some difficulty, and an examination showed that the resistance resulted from the diametral enlargement of the rear plate. Directions have been given to correct this defect. The star gauge records show that no material change took place in the diameter of the chamber or the bore. From 30 inches to 54 inches (measured from base of the breech), there was a diminution in diameter of from 0.001 in. to 0.002 in.; in rear of 30 inches there was no change. No enlargement in the shot chamber exceeded 0.001 in. From the bottom of the bore (the beginning of the rifling) to the muzzle the average enlargements were as follows: 0 in. to 6 in., 0.005 in.; 7 in. to 14 in., 0.003 in.; 15 in. to 29 in., 0.002 in.; 30 in. to muzzle, 0.002 to 0.001 in.

After the third round the joint between the D. and D. rings opened slightly on the top, and measured after the 13th round showed that the opening was about 0.004 in. wide. It cannot at present be stated whether or not this opening increased during firing, but the defect has been noted and will be carefully observed. Enough cocoa powder remains to allow a comparison to be made with such brown prismatic powder as may be adopted finally. No firing has been done as yet to test the best position for the bands, but it will take place as soon as enough of some standard powder is obtained to fire ten consecutive rounds.—*Army and Navy Journal*.

COMBUSTION, FIRE-BOXES, AND STEAM BOILERS.*

By JOHN A. COLEMAN.

MR. CHAIRMAN AND GENTLEMEN: I was rash enough some time ago to promise to prepare a paper for this occasion, the fulfillment of which prior engagements have absolutely prevented.

I would greatly prefer to be let off altogether, but I do not like to break down when expected to do anything; and if you have the patience to listen for a few minutes to the reflections of an "outsider," I will endeavor to put what I have to say in as concise form as I can, in such manner as will do no harm, even if it does no good.

For many years I was connected with steam engineering. I was once with the Corliss Steam Engine Company, and afterward was the agent of Mr. Joseph Harrison, of Russian fame, for the introduction of his safety boilers.

That brought me into contact with the heavy manufacturers throughout the Eastern States, and during that long experience I was particularly impressed with a peculiarity common to the mill owners, which, I believe it may be said with truth, is equally common to those interested in locomotive engineering, namely, how much we overlook common, every-day facts. For instance, we burn coal; that is, we think we do, and boilers are put into mills and upon railroads, and we suppose we are burning coal under them, when in reality we are only partially doing so. We think that because coal is consumed it necessarily is burned, but such is frequently very far from the fact.

I wish upon the present occasion to make merely a sort of general statement of what I conceive to be combustion, and what I conceive to be a boiler, and then to try to make a useful application of these ideas to the locomotive.

Treating first the subject of combustion, let us take the top of the grate-bars as our starting point. When we shovel coal upon the grate bars and ignite it, what happens first? We separate the two constituents of coal, the carbon from the hydrogen. We make a gas works. Carbon by itself will burn no more than a stone; neither will hydrogen. It requires a given number of equivalents of oxygen to mix with so many equivalents of carbon, and a given number of equivalents of oxygen to mix with so many of hydrogen to form that union which is necessary to produce heat. This requires time, space, and air, and one thing more, viz., heat.

I presume that most of you have read Charles Williams' treatise upon "Combustion," which was published many years ago, and which until recently was often quoted as an absolute authority upon the art of burning fuel under boilers. Mr. Williams in his treatise accurately describes the chemistry of combustion, but he has misled the world for fifty years by an error in reasoning and the failure to discuss a certain mechanical fact connected with the combination of gases in the process of combustion. He said: "What is the use of heating the air put into a furnace? If you take a cubic foot of air, it contains just so many atoms of oxygen, neither more nor less. If the air be heated, you cause it to assume double its volume, but you have not added a single atom of oxygen, and you will require twice the space for its passage between the grate bars, and twice the space in the furnace, which is a nuisance; but if the air could be frozen, it would be condensed, and more atoms of oxygen could be crowded into the cubic foot, and the fire would receive a corresponding advantage." Mr. Williams proceeded upon this theory, and died without solving the perplexing mystery of as frequent failure as success which attended his experiments with steamship boilers. The only successes which he obtained were misleading, because they were made with boilers so badly proportioned for their work that almost any change would produce benefit.

Successful combustion requires something more than the necessary chemical elements of carbon, hydrogen, and oxygen, for it requires something to cook the elements, so to speak, and that is heat, and for this reason: When the coal is volatilized in the furnace, what would

be a cubic foot of gas, if cold, is itself heated and its volume increased to double its normal proportion. It is thin and attenuated. The cold air which is introduced to the furnace is denser than the gas. With dampers wide open in the chimney, and the gases and air passing into the flues with a velocity of 40 feet per second, they strike the colder surface of the tubes, and are cooled below the point of combustion before they have had time to become assimilated; and although an opponent in a debate upon steam boiler tests once stated that his thermometer in the chimney showed only 250 degrees, and indicated that all the value that was practical had been obtained from the coal, I took the liberty to maintain that a chemist might have analyzed the gases and shown there were dollars in them; and that if the thermometer had been removed from the chimney and placed in the pile of coal outside the boiler, it would have gone still lower; but it would not have proved the value to have been extracted from the coal, for it was not the complete test to apply.

The condition of things in the furnace may be illustrated thus: If we should mingle a quart of molasses and a gallon of water, it would require considerable manipulation and some time to cause them to unite. Why? Because one element is so much denser than the other; but if we should mix a quart of the gallon of water with the quart of molasses, and render their densities somewhere near the density of the remaining water, and then pour the masses together, there would be a more speedy commingling of the two. And so with the furnace. I have always maintained that every furnace should be lined with fire-brick, in order that it shall be so intensely hot when the air enters that the air shall instantly be heated to the same degree of tenuity as the hot gases themselves, and the two will then unite like a flash—and that is heat. And here is the solution of the Wye Williams mystery of failure when cold air was introduced upon the top of a fire to aid combustion. The proof of the necessity for heat to aid the chemical assimilation of the volatilized coal elements is seen in starting a fire in a common stove. At first there is only a blue flame, in which the hand may be held; but wait until the lining becomes white hot, and then throw on a little coal, and you will find a totally different result. It is also seen in the Siemens gas furnace, with which you are doubtless familiar. There is the introduction of gas with its necessary complement of air. Until the furnace and retorts become heated, the air and gas flutter through only partially united, and do little good; but as soon as the retorts and furnace become thoroughly hot, the same gas and air will melt a fire-brick.

These are common phenomena, which are familiar, but apt to be unnoticed; but they logically point to the truth that no furnaces should present a cooling medium in contact with fuel which is undergoing this process of digestion, so to speak. It will be very evident, I think, from these facts that water-legs in direct contact with a fire are a mistake. They tend to check a fire as far as their influence extends, as a thin sheet of ice upon the stomach after dinner would check digestion, and for the same reason, namely, the abstraction of heat from a chemical process. If fire-brick could be laid around a locomotive furnace, and the grate, of course, kept of the same area as before, it is my belief that a very important advantage would be at once apparent. An old-fashioned cast iron heater always produced a treacherous fire. It would grow dead around the outside next the cold iron; but put a fire-clay lining into it, and it was as good as any other stove.

If I have now made clear what I mean by making heat, we will next consider the steam boiler. What is a steam boiler? It is a thing to absorb heat. The bottom line of this science is the bottom of a pot over a fire, which is the best boiler surface in the world; there is water upon one side of a piece of iron and heat against the other. One square foot of the iron will transmit through it a given number of units of heat into the water at a given temperature in a given time; two square feet twice as many, and three, three times as many, and so on. Put a cover upon the pot, and seal it tight, leave an orifice for the steam, and that is a steam boiler with all its mysteries.

The old-fashioned, plain cylinder boiler is a plain cylindrical pot over the fire. If enough plain cylinder boilers presenting the requisite number of square feet of absorbing surface are put into a cotton mill, experience has shown that they will make a yard of cotton cloth about as cheaply as tubular boilers. If this is so, why do not all put them in? Because it is the crudest and most expensive form of boiler when its enormous area of ground, brickwork, and its fittings are considered. Not all have the money or the room for them. To produce space, the area is drawn in sidewise and lengthwise, but we must have the necessary amount of square feet of absorbing surface, consequently the boiler is doubled up, so to speak, and we have a "flue boiler." We draw in sidewise and lengthwise once more and double up the surface again, and that is a "tubular boiler." That includes all the "mystery" on that subject.

Now, we find among the mills, just as I imagine we should upon the railroads, that the almost universal tendency is to put in too small boilers and furnaces. To skimp at boilers is to spend at the coal yard. Small boilers mean heavy and over-deep fires, and rapid destruction of apparatus. In sugar houses you will see this frequently illustrated, and will find 16 inch fires upon their grates.

We have found that, as we could persuade mill owners to put in more boilers and extend their furnaces, so that coal could be burned moderately and time for combustion afforded, we often saved as high as 1,000 tons in a yearly consumption of 4,000.

Now, when the ordinary locomotive sends particles of coal into the cars in which I am riding, I do not think it would be unfair criticism to say that the process of combustion was not properly carried out. When we see dense volumes of gas emitted from the stack, it is evident that a portion of the hard dollars which were paid for the coal are being uselessly thrown into the air; and it will be well to remember that only a little of the unburnt gas is visible to the eye.

One point I wish to make is this: We find, as I have said, that as we spread out with boilers and furnaces in the mills, so that we can take matters deliberately, we save money.

Now, coming again to locomotives. I think, if we examine the subject carefully, the fact will strike us a little curiously. The first locomotive built in Philadelphia weighed about 14 tons. Judging from the cut I have seen, I should think her furnace might have been 30 inches square. We have gone from that little 14 ton engine to machines of 50 and 60 tons—perhaps more. The engines have been increased over four times, but I will ask you if the furnace areas have been increased (applause) in proportion? Some of the furnaces of the engines are six feet by three, but that is an increase of less than 3 to 1 of furnace, as against 4 to 1 of weight of engine.

When my attention was first called to this matter, I had supposed, as most people do who are outside of the railway profession, that there was something subtle and mysterious about railway engineering that none but those brought up to the business could understand. Possibly it is so, and I am merely making suggestions for what they are worth, but I think the position I have taken in this matter was established by some experiments of three weeks' duration, which I conducted between Milan and Como, in Italy, for the Italian government, in pulling freight trains up grades of 100 feet to the mile. The experiments were made with an engine built by the Reading Railroad.

We competed with English, French, Belgian, and Austrian engines. These machines required the best of fuel to perform the mountain service, and could use coal dust only when it was pressed into brick. We used in the Reading Railroad machine different fuels upon different days, making the road trip of 120 miles each day with one kind of fuel. We used coal dust scraped up in the yards, also the best Cardiff coal, anthracite, and five kinds of Italian lignite, the best of which possesses about half the combustible value of coal.

The results in drawing heavy freight trains were equally good with each fuel, the engine having at all times an abundance of steam on heavy grades, no smoke nor cinders, and no collection of cinders in the forward part of the engine.

The fireman arranged his fires at a station, and did little or nothing except to smoke his pipe and enjoy the scenery until he reached the next station. An incident occurred to prove that we were not playing with the machine. They told me one morning that we should be given a load of 25 per cent. less than the maximum load of an engine of her class (30 tons). We started up the 100 foot grade, and found we could barely crawl, and our engineer got furious over it. He thought they were repeating a trick already attempted by screwing down a brake in ascending a grade. We detected it, however, and found a pair of wheels nearly red hot. Upon this occasion we found nothing amiss, except full cars where they had reported only a light load. We pulled to the top of the hill, the steam blowing off furiously all the time.

This was a new experience to the Italians, and might surprise some Americans. When we arrived at the station, the inspector-general and his corps of engineers were evidently amazed, and it was evident we had captured them. He said to me, "I can congratulate you, signor, on possession of a superb machine."

Afterward one of the engineers said to me: "Do not let it be known that I told you what you have hauled or I shall lose my place, but you have drawn 50 per cent. more than the maximum load of one of our 40 ton engines." I said: "You attempted to 'stall' us, and when you try it again, be fair enough to give me a flat of pig iron, and as you pack cars on one end I will pack pig iron upon the engine until she will stick to the track, but rest assured that you will not be able to get that steam down." The experience with that engine proves conclusively to my mind that the general principles of steam making are the same for both stationary and locomotive practice. The grand secret of the success of that Wootten engine was the enormous area of the grate surface, being, if I remember correctly, 7 by 9 feet, permitting thin fires to be carried and complete combustion to be obtained before the gases reached the boiler tubes. An enormous crown sheet was presented, and that is where the bulk of the work of any boiler is done.

Thin fires accomplish this. As already stated, a given amount of coal generates a given amount of gas, and this gas requires a given amount of air or oxygen. This air must be supplied through the grate bars and then pass through the interstices of the mass of heated coal. It requires about 10 cubic feet of air to consume one cubic foot of gas. In stationary boilers we find that if we use "pea" and "dust" coal, an extremely thin layer must be used, or the 10 feet of air per foot of gas cannot pass through it; if "chestnut" coal be used, the thickness may be increased somewhat; "stove size" allows a thickness of six inches, and "lump" much thicker, if any wise man could be found who would use that coarse, uneconomical size. Of course, I am speaking of anthracite coal. Opinions differ about "soft coal," but the same general principle applies as regards an unobstructed passage of air through the hot bed of coal.

Now, it will be agreed that the locomotive of the future must be improved to keep up with the times. Fierce competition requires increased efficiency and reduced expenses. I am told by you railroad gentlemen that the freight business of the country doubles every ten years. Trains follow close upon each other. What are you going to do? Are you to double, treble, or quadruple your tracks?

It seems to me much remains yet to be done with the locomotive. We must burn a great deal less coal for the steam we make, and after we have made steam we must use that steam up more thoroughly. In the short cylinder required by locomotive service, the steam entering at the initial pressure pushes the piston to the opposite end, and it then rushes out of the exhaust strong enough to drive another piston. Of every four dollars' worth of coal consumed, at least two dollars' worth is absolutely thrown away. Or, of every ten thousand dollars spent for fuel, five thousand dollars are absolutely wasted. How can we save this? It would seem obvious that if steam rushes from the exhaust of an engine strong enough to drive another engine, the common sense of the thing would be to put another engine alongside and let the steam drive it, and we should get just so much more out of our four dollars' worth of coal. It seems evident that we must follow the lead of the steamship men, and compound

*Address before the June Convention of the Master Mechanics' Association.

the locomotive engine, as they have done with the marine engine.

Next we must attack the extravagant furnace, and increase its area and reduce the depth of the bed of coal. The difficulty of making this change seemed to me to be removed, on examining an engine on the Providence & Bristol Railroad, the other day. The machine was made at the Mason Works, of Taunton. It was an engine and tender combined, the truck being at the rear end of the tender, and the driver placed well in advance of the fire-box, so that the maximum weight of both engine and tender rested upon the drivers. In thus removing the drivers from the proximity of the fire-box, abundant facility is afforded for widening the fire-box, so as to obtain a grate area as large as that of the Wootten engine or of a stationary boiler. It seems to me the increase of grate area can be obtained only by widening; for a length of more than six or seven feet is very hard upon the fireman. You certainly cannot get more power by deepening present fire-boxes, except by an enormously increased waste of fuel, which all will concede is already sufficiently extravagant.

In arriving at the conclusion of these hasty and I fear somewhat incoherent remarks, I would say that the object aimed at for the improvement of the locomotive would be reached, first, by making steam economically, by employing such increased grate area as will permit running thin fires and moderate or comparatively slow draught; and, secondly, in economically using the steam which has been economically made by compounding the engine.

I have given you merely the views of an "outsider," who has had a somewhat extensive experience in stationary engineering, and who has observed locomotive practice in many parts of the world. These views are offered for what they are worth, as suggestions for future thought in designing engines, and as a sort of refresher upon rudimentary points which long familiarity with every-day phenomena causes us at times to overlook. I trust that your deliberations may aid in the speedy reduction of the expenses of transporting freight and passengers, for the benefit of the railroad companies and, in their turn, the advantage of the people at large.

ATLANTIC STEAMERS.*

By W. JOHN.

THE author said that he hoped to bring before the meeting impartially certain facts which might be of interest, and which, when recorded in the pages of the "Transactions," might be found of some use as data for future reference. In dealing with passenger steamers, he would do so principally from a shipbuilder's point of view; but the moment he commenced to think over Atlantic passenger ships as a shipbuilder, he was met by the question whether the present tendency toward divorcing the passenger and cargo trade from each other is likely to continue or not. If the answer is yes, then it seems to become an important question, for the present at least, how to build, on moderately small dimensions, the fastest, safest, and most economical passenger steamer, using all the most modern improvements to make her commodious and luxurious, and an easy sea boat into the bargain. If cargo is still to be carried in the passenger ships of the future, a moderate speed only will be aimed at in the immediate future, and every effort will be devoted to economy of fuel, comfort, and safety, with a fair carrying capacity. This latter policy is one which may possibly prevail at least for a time, as it has powerful supporters in Liverpool; but he could not help thinking that very high speeds—higher than we have yet attained—must eventually gain the day. He also thought that they were on the eve of important movements, which will indicate what the next step in the passenger trade is to be; for it must be remembered, among other things, that none of our present English transatlantic liners, even the latest, have yet been fitted with the latest modern improvements for econo-

Fig. 1.—CITY OF ROME.

my of fuel or quick combustion, such as triple expansion engines or forced draught. They must, therefore, be at some disadvantage, other things being equal, compared with the ships of the future possessing them. The Great Eastern steaming up Milford Haven about twenty-five years ago between two lines of the channel fleet of old—two and three decked wooden line-of-battle ships—the whole fleet saluting with yards manned, was a sight to be remembered. More than this, that ship, with all her mournful career, has been a useful lesson and a useful warning to all naval architects who seriously study their profession—a lesson of what can be done in the safe construction of huge floating structures, and a warning that the highest flights of constructive genius may prove abor-

tive if not strictly subordinated to the practical conditions and commercial requirements of the times. The Sirius and Great Western crossed the Atlantic in 1838, and in 1840 the first ship of the since celebrated Cunard Company made her first voyage. This was the Britannia, which, with her sister ships, the Arcadia, Caledonia, and Columbia, kept up the mail service regularly at a speed of about 8½ knots an hour. The Britannia was 207 ft. in length between perpendiculars, and 34 ft. 4 in. extreme breadth, 22 ft. 6 in. depth of hold, 423 horse power—nominal—and 1,153 tons burden, built of wood, and propelled by paddles. In 1860 the Collins Line started in opposition to the Cunard, and, after a series of disasters, collapsed in 1858. This was three years after the Persia, the first

Fig. 2.—SERVIA.

Cunarder built of iron, had been completed. In 1850, also, the Inman Line was started with the City of Glasgow, of 1,600 tons builders' measurement, and 350 horse power. She was built of iron, and was the first screw steamer sent across the Atlantic from Liverpool with passengers, and was the pioneer of the great emigrant trade which Mr. Inman, above all others, did so much to develop and make cheap and comfortable for the emigrants themselves, as well as profitable to his company. That the builders of the celebrated old Great Britain, in 1843, and Mr. Inman, in 1850, should have pronounced so decisively in favor of the screw propeller in preference to the paddle for ocean steaming is a proof of their true practical judgment, which time and practical experience have made abundantly clear. While the Cunard Company went on developing its fleet from the early wood paddle steamer Britannia of 1,130 tons in 1840 to the iron paddle steamers Persia, etc., in 1838, the iron screw steamer China of 1862, to the still more important screw steamers Bothnia and Scythia, vessels of 4,335 tons, in 1874, the Inman and other lines were as rapidly developing in speed and size, if not in numbers. The year 1874 is memorable, for it saw the White Star steamers Britannic and Germanic put into the water, as well as the Inman steamer City of Berlin and the two before mentioned Cunard steamers, Bothnia and Scythia. By the addition of these two ships to their fleet the White Star Line, although started only in 1870, reached a front rank position in the New York passenger trade. The author gave in separate tables the logs of several of these ships, some from published documents and some kindly furnished by the owners. The Great Western had crossed the Atlantic from Bristol to New York in 15 days as early as 1838. The first Cunard steamer, the Britannia, was about the same speed, from 8¼ to 8½ knots an hour. The average duration of the Cunard voyages in the year 1856 was 12·67 days from Liverpool to New York, and 11·03 days from New York to Liverpool. The Bothnia, in 1874, reduced the passage to about nine days. The White Star Britannic, in 1876, averaged 7 days 18 hours 26 minutes outward from Queenstown to New York, and 9 days 6 hours 44 minutes homeward, and has averaged for the last ten years 8 days 9 hours 36 minutes outward, and 8 days 1 hour 48 minutes homeward. The City of Berlin, of the Inman Line, also built in 1874, 8 days 10 hours 56 minutes, and homeward 8 days 2 hours 37 minutes; and for the nine years from 1875 to 1883 inclusive, averaged outward 8 days 19 hours 56 seconds, and inward 8 days 8 hours 34 seconds; or, putting it into rounder figures, the Britannic had reduced the average passage between the two points to 8¼ days, and the City of Berlin to 8½ days. From the year 1874 on to 1879 no further advance was made in Atlantic steaming, but in that year the Arizona was added to the Guion Line, and it soon became evident that another important stride had been made in the Atlantic passenger trade, which would lead to most important results. The results, as we all know, have been sufficiently startling. The Guion Line, which had started in 1866 with the Manhattan, had now the fastest passenger ship on the Atlantic. In spite of burning some fifty per cent. more coal than the Britannic, the ship was an obvious commercial success. The spirited policy which brought her into existence was appreciated by the public, and the other lines had to move forward. Then followed a period of rivalry, the Cunard Company building the Gallia and Servia, the Inman Company the City of Rome, and the Guion Line the Alaska, all of which were completed in 1881, and afterward the Oregon for the Guion Line—1883—the Aurania the same year for the Cunard Company, and, later still, the America for the National Line, and the Umbria and Etruria for the Cunard Company in 1885.

Since the completion of the Etruria, for various reasons there has been a pause in the tremendous strides made since 1879, and we may briefly review the results. Taking the Britannia as a standard with her ten years' average of 8¼ days across, and her quickest passage of 7 days 10 hours 53 seconds, we have now the

following steamers of higher speeds. Taking them in the order of their absolutely fastest passage out or home, they stand thus:

TABLE I.

		Days.	Hours.	Mins.
1	Etruria.....	6	5	31
2	Umbria (sister ship).....	sligh	tly longer.	
3	Oregon.....	6	10	35
4	America.....	6	13	44
5	City of Rome.....	6	18	0
6	Alaska.....	6	18	37
7	Servia.....	6	23	55
8	Aurania.....	7	1	1

It will thus be seen that from the 15 days' passage or thereabout, of the earliest Atlantic steamers, we had got down in the days of the Scotia to about 9 days; in the Britannic to 8¼ days, and, at the present time, we have got to 6¼ days, with seven ships afloat that have done the passage under seven days, and capable of making their average passages range between 6½ and 7¼ days.

Ranged in order of gross tonnage, these eight vessels stand as follows:

TABLE II.

1.	City of Rome.....	8,144
2.	Oregon.....	7,375
3.	Aurania.....	7,269
4.	Servia.....	7,212
5.	Umbria.....	7,129
6.	Etruria.....	7,100
7.	Alaska.....	6,586
8.	America.....	5,528

Here the America shows to advantage, for while being eighth in size she is fourth in point of speed, and from what the author can learn, although he had no authenticated details on the subject, he believed she is economical in coal consumption. He might perhaps be permitted to say that one of the most difficult subjects in connection with the propulsion of ships on which to get absolutely accurate data is that of coal consumption. The records of six to eight hours' trials for the purpose of ascertaining the coal consumption are absolutely worthless, as all shipbuilders and engineers know, and so far as English ships are concerned they are never attempted. Foreign owners frequently stipulate for such trials in their contracts with English shipbuilders, and get wonderfully economical results on paper, but the fact that the trials only extend over a few hours renders them valueless, however carefully the coal may be weighed during that period. An authentic record of the absolute quantity of coal consumed, say by each of the eight fastest Atlantic liners, together with their average indicated horse power on the voyage, for a series of voyages, would be extremely valuable.

He gave, in Table III., the consumption per indicated horse power per hour for a number of ships. This table affords valuable data, for it gives, in addition to the dimensions, the moulded draught of water, the midship area, the displacement, the indicated horse power, the speed on trial, the coefficients for the lines both from the block or parallelipedon, and also from the midship section prism, together with the length and angle of entrance obtained by Kirk's rule, the Admiralty displacement coefficient, together with the coal consumption per day and per indicated horse power per hour.

This table, as will be seen, contains some of the most important of the Atlantic liners, and also a number of other typical ships, which will add a variety to its in-

Fig. 3.—OREGON.

terest and a value to it. The coefficient, which is contained in the thirteenth column of the table, viz.:

$$\frac{\text{Dis}^{\frac{2}{3}} \times \text{speed}^3}{\text{I.H.P.} \times \sqrt{\text{entrance}}} = \frac{10}{10}$$

generally comes out for ships of similar type more nearly a constant in the true sense of the word than the corresponding Admiralty constant. As an example, we have the curves of resistance and horse power for the City of Rome and the Normandie, a large vessel of 6,000 tons, which the Barrow Company built for the Compagnie Generale Transatlantique, in which the coefficient of fineness and the form of the lines pretty closely resemble each other below water and if we

* A paper recently read before the Institution of Naval Architects.