and the ironclad's guns were not even cleared for action. Commander Fuentes, of the *Almirante Lynch*, who was senior officer, was informed by Commander Moraga, of the *Almirante Condell*, which was leading, of the presence of the battleship, and appears to have signaled to his other consorts to remain outside, and then to have ordered the *Almirante Condell* to proceed, and to have followed her. According to the official Bal-
macedist report, Don Pedro Salva, First Lieutenant of the *Almirante Lynch*, called all hands on deck, and offered to put ashore any man who might feel indis-
posed to fight, but no one took advantage of the opportunity. So bad was the watch on board the *Blanco Encalada* that she did not open fire until her
enemies, who had slowed down as they drew near,

in hexagonal prisms, this being the most convenient form for close packing. Each prism is pierced with a hole in the center, so as to give ready access to the flame and insure an equable ignition. Ten thousand of these prisms are needed to make up a full charge for this monster gun. The powder, along with the shell, comes up from the magazine below in a hoist (indicated at the rear of the model), and, having been placed on a spout tray, is rammed into the gun by a hydraulic rammer (also indicated at the rear of the model), the shell, of course, having been first driven forward into its place by the same instrument.

In nearly all naval guns the powder charge is made up into four cartridges, the object being to get each cartridge down to a weight that a man may lift. But

used. These shells are first forged, then bored, and finally tempered. While they should be tough in the body, they must be hard at the striking point. The hardness of the point increases the penetrative power of the shell, while the toughness of the body prevents its swelling as it is entering the plate and so increasing the difficulties of penetration. A good shell carries it-
self into the interior of the ship before it explodes. The shell is constructed to carry such an amount of powder as will cause it to explode and add its pieces to the destructive splinters from the broken plate. The shell used in this gun, as stated, weighs 1,800 lb. The terrible havoc which such a shell will play when fired with a full charge from this gun was most vividly illus-
trated by the course of a shell from the 110-ton gun of the *Sanspareil* at a trial Shoeburyness in March last. The shell tore its way at the rate of 2,079 ft. per second through 20 in. of compound armor specially manufac-
tured, 8 in. of iron fastened in a heavy wrought iron frame, 20 ft. of oak balks, 5 ft. of granite blocks, 11 ft. of concrete, and 6 ft. of brick; altogether, 44 ft. 4 in. of a wall unique in history, surely, for combination of width and variety and strength of material. For firing a full charge with armor-piercing shot from the 110-ton gun, the country pays for the powder, \$400; for the shell and fuses, \$600; total, \$1,000; not to mention a much more serious item if the gun were continually being fired with a full charge, the damage from the erosion caused by the powder gases, which causes it to lose its accuracy, and necessitates its being relined, at great expense and at the cost of long delay. But it is right to say the gun is seldom fired with its full charge.

Provision, in the shape of sights and range tables, is provided, with all our heaviest guns, for three charges, namely, the half charge, three-quarters charge, and full charge. It is laid down in the regulations that for peace practice the first is to be used, besides an occa-
sional round of the second to test the proper working of the mounting; the full charge being reserved for special cases during war, when the position of the ship requires extraordinary exertions to cripple her enemy. It is generally considered, says Captain Noble, in "Modern Naval Artillery," that the life of the 67-ton guns may be taken at 120 rounds, and the 110-ton gun at 75 rounds, both with full charges.

The era of these very heavy guns practically dates back twelve years. Since then thirty 100 and nine 110-ton guns have been manufactured. Most of the 100-ton guns went to Italy, two of them are at Gibraltar and Malta respectively. Of the 110-ton guns, two are in the Victoria, two in the Benbow, and two in the *Sanspareil*; and there is one spare one in each ship. The use of these huge guns can be defended; as Cap-
tain Noble asks in the work about to be issued by the Elswick firm: "What would have been said by the country, and above all by the very newspaper corre-
spondents who now fall so foul of them, had one of our ships armed with, say, 67-ton guns been destroyed in war by an enemy carrying 100-ton guns?" But, as Captain Noble acknowledges, their day is over. "For, tempting as the surprising results of power which are obtained by them may be, it is easy to see that these are expensively purchased, not only in the actual cost of the gun and its ammunition, but also in the size of ships required to carry them."

Guns of the 67-ton type are fitted on the Nile and Trafalgar and our later men-of-war. The 110-ton gun takes nearly two years to make, and costs, with mount-
ing and machinery, nearly £20,000; the 67-ton gun takes eighteen months to make, and costs about £14,000. So at least the country will save time and money by this change of policy.—*Pall Mall Budget*.

SIBLEY COLLEGE LECTURES.—1890-91.

BY THE CORNELL UNIVERSITY NON-RESIDENT LEC-
TURERS IN MECHANICAL ENGINEERING.

RIVETED JOINTS—THEIR PROPORTIONS AND STRENGTH.

By J. M. ALLEN, of Hartford, Conn.

THE many uses to which iron and steel are applied in this age of great steamships, bridges and steam boilers makes it important that the question, how to join the plates and parts together so as to secure the greatest strength, should be carefully and intelligently investi-
gated. The old rule of thumb will not be sufficient in this age of progress. Steamships that travel with almost the average speed of the steam cars are sub-
jected to enormous strains in their contest with the waves and storm. The bridges of iron and steel of long span are also subjected to sudden and heavy strains by passing trains, and steam boilers, in these days of large diameters and high pressures, are com-
pelled to carry loads that would have been impossible twenty-five years ago. In all these departments of engineering, the riveted joint has a conspicuous and important place. Upon the efficiency of these joints the safety and durability of these structures largely depend. I will not discuss this question with refer-
ence to its bearing upon steamships and bridges, but will confine myself to the importance of a proper and intelligent understanding of the various forms of riveted joints as applied in the construction of steam boilers. Up to the year 1838 there had been little or no scientific investigation of this subject. In the early part of this century, boilers were used only at low pressures. Most of the engines were of the condensing type. But the rapid introduction of steam power in the industrial world, with the improvements in boilers and engines, soon called for higher pressures and stronger boilers. In 1838, Sir William Fairbairn con-
ceived the importance of thoroughly investigating the

Armed Transport
Aconcagua.

The yards of the Blanco Encalada
showing above water.

The rebel ship
Magellanes.

The rebel ship
Huascar.

THE LAST OF THE BLANCO ENCALADA IN CALDERA HARBOR.

were within two hundred yards of her. She then began to ply them with canister, and one of her first discharges killed three men on the deck of the *Almirante Condell*, which, in the meantime, had been seriously discommoded by the giving out of a large number of her boiler tubes. The confusion thus occa-
sioned on board of her is, no doubt, responsible for the extraordinary fact that, although at this period she fired two Whiteheads, when at a distance of only a hundred yards from her prey, both weapons missed their mark. One, indeed, passed as much as fifty feet astern of the ironclad. The *Condell* had slowed down broad on the starboard beam of the *Blanco Encalada*, and the *Lynch*, after seeing the *Condell's* torpedoes discharged, appears to have passed on inside of her, within fifty feet of the *Blanco*, and to have fired two more torpedoes as she went, but they also missed, and no sooner had they been let go than a hand grenade, thrown from the *Blanco*, exploded on the *Lynch's* deck and killed six men. The *Lynch* now seems to have turned to port, and to have again passed the *Blanco*, this time so closely as to almost touch her. As she went, she fired her third torpedo, which struck the *Blanco* just abaft the citadel on the starboard side, and rent a great hole in her sixteen feet by four. The ironclad heeled over and at once began to sink. For a brief period there was a terrible scene; but within ten minutes the vessel disappeared, carrying with her 150 of her officers and men, and leaving only her top-
masts showing above water. The *Condell* was but little damaged; the *Lynch* had been struck twelve times, had lost several officers and men, and was mak-
ing water rapidly. Our sketch is from the *London Graphic*. It was made by Chas. Raxworthy, R.N., who was an eye-witness of the scene.

The Congressional navy included the following ships, of which the first three were ironclads:

Ship.	Date.	Tons.	I.H.P.	Speed in Knots.	Guns.	Men.
Almirante Cochrane	1874	3,370	2,950	12.7	6	242
Blanco Encalada	1875	3,450	2,920	12.0	6	235
Huascar	1865	2,032	1,050	11.3	4	134
Esmeralda	1883	2,810	6,500	18.2	8	
Amazonas	1874	2,000	2,400	13.2	1	145
Chacabuco	1866	1,490	1,200	10.0	7	129
O'Higgins	1866	1,490	1,200	10.0	7	129
Abtao	1864	1,370	1,100	9.0	5	179
Angamos	1876	1,200	1,485	13.5	1	110
Magellanes	1874	950	1,240	11.0	2	105
Pilcomayo	1874	800	1,080	10.0	6	128

THE FIRING OF THE 110 TON GUN.

WE will assume that this great gun is on the point of being fired with a full charge. The 110-ton gun, indeed all large guns, are fired with slow-burning cocoa powder—"cocoa" because of its brown color. As you may observe in the powder case in the gallery, it is shaped

on account of its extraordinary weight—960 lb.—the charge for the 110-ton gun is divided into eight car-
tridges. Specimens of these cartridges, to the extent of the full charge, stand as a pyramid close to the hoist. The material of the envelope, by the way, is silk cloth. At the back of each envelope, next to the primer, there stand a few prisms of black powder, because it more readily ignites than the cocoa powder. Each of these eight cartridges weighs 120 lb. To load, it is necessary to bring the gun in at extreme elevation, and then the following operations are gone through:

1. Unlock and unscrew the breech block.
2. Withdraw breech block.
3. Traverse breech block to one side.
4. Place the loading tray in the gun.
5. Wash out the gun.
6. Ram home the projectile.
7. Ram home first half charge.
8. Ram home second half charge.
9. Withdraw loading tray.
10. Traverse breech screw.
11. Insert breech screw.
12. Screw up and lock breech screw.

All these operations are performed by hydraulic ma-
chinery, and are all so provided with simple arrange-
ments to prevent mistakes, aver Messrs. Armstrong, Mitchell & Co., that accidents practically never happen. The gun having been sighted by the captain of the
turret from his conning tower, is also fired by him by electricity. The gun can be loaded and fired within two and a half minutes.

THE SHOT AND ITS TERRIBLE HAVOC—A GRAPHIC PICTURE.

The projectile fired from the gun when attacking ships or forts weighs 1,800 lb., and it goes out with a velocity of 2,105 ft. per second, and has a destructive energy equal to 55,305 foot tons. If the gun were to be used against a body of men or a flotilla of boats, shrapnel shell would be used; that is the long, drum-
like cylinder of steel standing close to the carriage would be shot from the gun, and its contents—2,300 4 oz. bullets—would scatter death among the foe. The bullets are put in in layers, though not with mathe-
matical exactness, they are merely shaken together. Melted resin is poured in among them, in order to fill up the interstices; else, when the heavy shock of the explosion came, they would be all flattened against each other.

Directly the shrapnel case bursts the bullets go flying on, while the spin of the shell, communicated by the rifling of the gun, spreads them out by centrifugal force over a large area. But the gun will most likely be used for attacking armored ships and forts. In this case the steel shell, with a strong, sharp point, will be

Ball.

11 ft. concrete.

5 ft. granite.

20 ft. oak.

8 inches iron and
20 inches compound armor.

question of proper construction of boilers, with a view to greater safety and efficiency. He made numerous practical tests of the strength of materials, particularly of iron, and also of the strength of riveted joints, the results of which are in some cases accepted to-day. It is interesting to read his account of these experiments. He was working in a new field, and the results of his careful and painstaking work have laid us all under great obligation. I quote from him the following in regard to riveted joints: "Up to the present time nothing of consequence has been done to improve or enhance the value of this process. We possess no facts nor experiments calculated to establish principles sufficient to guide our operations in effecting constructions of this kind, on which the lives of the public as well as the property of individuals depend. In fact, such has been our ignorance of the relative strength of plates and their riveted joints, that, until the commencement

square inch has been, and even to-day is, by many assumed to be 45,000 lb. per square inch, the assumption has arisen, no doubt, from the fact that the rivets rarely shear. I have examined many exploded boilers, and the fractures have almost invariably been through the solid plate or along the line of rivets. It is very rare that the rivets shear. This, no doubt, arises from the fact that the pitch of the rivets was out of proportion to the net section of plate. The old rule seemed to be, the more rivets, the stronger the joint. There was, no doubt, a desire on the part of the boiler makers to make a tight joint, and they thought that if they pitched the rivets wider it would be difficult to calk the joint so that it would be steam and water tight. One would quite naturally assume that steel plates should be riveted with steel rivets, but such is not the usual practice. Most of the boilers now constructed in this country are made of steel plates, and

as near the strength of net section of plate as possible. I will assume the elements of the problem to be as follows:

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate, 5-16 in. = decimal 0.3125.

Diameter rivet holes, 13-16 in. = decimal 0.8125.

Area of rivet hole = decimal 0.5185.

Pitch of rivets, 1 7-8 in. = decimal 1.875.

Shearing resistance of iron rivets per square inch = 38,000 lb.

Then $1.875 \times 0.3125 \times 55,000 = 32,226$ lb. = strength solid plate.

$(1.875 - 0.8125) \times 0.3125 \times 55,000 = 18,262$ lb. = strength net section of plate.

$0.5185 \times 38,000 = 19,703$ lb. = strength of one rivet in single shear.

Net section of plate is the weakest; therefore: $18,262 \div 32,226 = 56.6$ per cent. efficiency of joint.

DOUBLE RIVETED JOINT.

In double riveted joints we find an accession of strength over the single riveted joint of nearly 20 per cent. This arises from the wider lap and the better distribution of the material. The rivets are pitched wider, and there is more rivet area to be sheared together, with a larger percentage of net section of plate to be broken.

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate $\frac{3}{8}$ in. = decimal 0.375.

Diameter rivet holes $1\frac{1}{8}$ in. = decimal 0.9375.

Area rivet hole = decimal 0.69.

Pitch of rivets $3\frac{1}{8}$ in. = decimal 3.0625.

Shearing resistance of iron rivets per square inch, 38,000 lb.

Then $3.0625 \times 0.375 \times 55,000 = 63,164$ lb. = strength of solid plate.

$(3.0625 - 0.9375) \times 0.375 \times 55,000 = 43,828$ lb. = strength net section of plate.

$0.69 \times 2 \times 38,000 = 52,440$ lb. = strength of two rivets in single shear.

Net section of plate is the weakest; therefore: $43,828 \div 63,164 = 69.3$ per cent. efficiency of joint. 70 per cent. is usually assumed in practice.

TRIPLE RIVETED JOINT.

In a triple lap riveted joint, we still gain in strength for reasons similar to those above.

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate $\frac{3}{8}$ in. = decimal 0.375.

Diameter rivet holes $1\frac{1}{8}$ in. = decimal 0.9375.

Area one rivet hole = decimal 0.5185.

Pitch of rivets $3\frac{3}{4}$ in. = decimal 3.75.

Shearing resistance of iron rivets per square in., 38,000 lb.

Then $3.75 \times 0.375 \times 55,000 = 67,031$ lb. = strength of solid plate.

$(3.75 - 0.9375) \times 0.375 \times 55,000 = 50,273$ lb. strength net section of plate.

$0.5185 \times 3 \times 38,000 = 59,109$ lb. strength of three rivets in single shear.

Net section of plate is the weakest; therefore: $50,273 \div 67,031 = 75$ per cent. efficiency of joint.

DOUBLE WELT BUTT JOINT.

We now come to the double welt butt joint, triple riveted. I have selected this joint because we use it in practice where boilers of large diameters and high pressures are required. In the double welt joint a new element comes into the problem, viz., that of rivets in double shear. The inner welt is broader than the outer welt, and extends far enough beyond the former to enable us to introduce a third row of rivets, which are in single shear, but also are in double pitch. This increases the net section of plate and also adds another rivet to be sheared. All the other rivets are in double shear. The question now arises, What is the value of a rivet in double shear? We have assumed heretofore that the value of a rivet in single shear was 38,000 lb. per square inch. Now can we assume that the same rivet in double shear has twice the value that it did in single shear? It has been assumed by some writers that such is the case, and up to this time most engineers allow a double value to rivets in double shear. But the conditions are different from those of rivets in single shear. In the former the rivet is sustained by

FIG. 1.

of the present inquiry, the subject was considered of scarcely sufficient importance to merit attention. Even now it is by many assumed that a well riveted joint is stronger than the plate itself, and a number of persons, judging from appearances alone, concur in that opinion. Now, this is a great mistake; and, although the double thickness of the joint indicates increased strength, it is nevertheless much weaker than the solid plate, a circumstance of some importance, as we hope to show in the following experiments."

Without going through the details of his experiments, I will simply give his conclusions. He says, from the foregoing: "We may fairly assume the following relative strengths as the value of plates with their riveted joints:

"Taking the strength of the plate at 100, the strength of the double-riveted joint would be 70, and the strength of the single-riveted joint would be 56."

SINGLE-RIVETED JOINTS.

In calculating the strength of a single-riveted joint, we must know—*First*, what the tensile strength of the iron or steel plate is, from tensile test; *second*, the diameter and pitch of the rivets; and *third*, the resistance to shearing per square inch of the material of which the rivets are made. On this latter requirement there has been no little discussion. It was formerly assumed, when only iron plates and iron rivets were used, that the shearing resistance of a square inch of rivet was equal to the tensile strength of a square inch of the rivet itself, or of the plate. That is, if we have iron of a tensile strength of 45,000 lb. per square inch, the shearing resistance of a square inch of rivet would

they are largely riveted with iron rivets. In this country there have been comparatively few experiments on the strength of riveted joints made of steel plates and steel rivets, and as the general practice is to use iron rivets with both iron and steel plates, I confine myself here to the discussion of the iron rivet. I will say, however, that in England very careful experiments have been made, and a large percentage of strength is given to steel rivets over iron rivets. The details of these experiments can be found in *Wilson on Steam Boilers*, and particularly, and very full in detail, in *D. K. Clark's recent work on Steam Engines and Steam Boilers*. When the true value of the steel rivet is fully decided, and its use becomes general in this country, that value can be easily substituted for the value of iron rivets in the calculations of the strength of riveted joints, the other elements in the problem remaining the same. What value then shall we give to the iron rivet when used in connection with steel or iron plates? In settling this question I have not only been aided by the experiments of English engineers, but I have availed myself of the results of experiments made on the large Emery testing machine at the U. S. Arsenal at Watertown, Mass. These experiments have been made with American iron and steel, and hence will be valuable to us all in our practical work in this country. In a series of five experiments with steel plates and iron rivets, holes punched, the shearing resistance per square inch was as follows: 39,740 lb., 38,190 lb., 36,770 lb., 38,636 lb., and 41,100 lb. In view of these results, and other similar experiments, I assume 38,000 lb. per square inch as a safe estimate of the single shearing resistance of iron rivets in steel

FIG. 2.

FIG. 3.

be 45,000 lb. On this assumption it would be only necessary to so arrange the diameter and pitch of rivets that the area of rivet or rivets to be sheared should exactly equal the net section of plate to secure a perfect joint. Later experiments, together with improvements in the manufacture of iron, and the introduction of steel, have changed these conditions relatively. While the shearing resistance of rivets per

plates. Later experiments may change these figures slightly. In these experiments the steel plate was 55,000 lb. tensile strength per square inch. Assuming then 38,000 lb. as the safe estimate, we must decide upon the thickness of plate, diameter of rivet hole and pitch of rivets. In deciding upon these elements in the problem we must so adjust the size and pitch of rivets as to make the shearing resistance of the rivets

the plates above and below, while in single shear the resistance is confined to one point. An examination of the sheared sections of rivets in single shear usually discloses a slight elongation in the direction of the force applied. The experiments on rivets in single shear, and from which we get our data, have almost always been made on single riveted joints, with narrow strips of iron, as shown in the following Fig. 4.

PASSAGES OF PRINCIPAL ATLANTIC PASSENGER STEAMERS (QUEENSTOWN AND NEW YORK), SEASON 1890.
[Specially Compiled from Official Logs.]—From Engineering.

NAME..	"CITY OF PARIS."	"CITY OF NEW YORK."	"MAJESTIC."	"TEUTONIC."	"ETRURIA."	"UMBRIA."	"CITY OF ROME."
OWNERS ..	INMAN AND INTERNATIONAL LINE.	INMAN AND INTERNATIONAL LINE.	WHITE STAR LINE.	WHITE STAR LINE.	CUNARD LINE.	CUNARD LINE.	ANCHOR LINE.
Builders ..	Messrs. Thomson, Clydebank.	Messrs. Thomson, Clydebank.	Messrs. Harland & Wolff, Belfast.	Messrs. Harland & Wolff, Belfast.	Fairfield Company, Govan.	Fairfield Company, Govan.	Barrow Company.
Dimensions ..	560 ft. by 63 ft. by 43 ft.	560 ft. by 63 ft. by 43 ft.	582 ft. by 57½ ft. by 59½ ft.	582 ft. by 57½ ft. by 59½ ft.	501½ ft. by 57.2 ft. by 38.2 ft.	501½ ft. by 57.2 ft. by 38.2 ft.	546 ft. by 52 ft. by 58½ ft.
Tonnage ..	10,499	10,499	9,661	9,661	8,120	8,120	8,141
Displacement ..	13,000	13,000	12,000	12,000	10,500	10,500	11,280
Cylinders ..	Two 45 in., two 71 in., two 113 in.	Two 45 in., two 71 in., two 113 in.	Two 43 in., two 68 in., two 110 in.	Two 43 in., two 68 in., two 110 in.	One 71 in., two 105 in.	One 71 in., two 105 in.	Three 46 in., three 86 in.
Piston stroke ..	5 ft.	5 ft.	5 ft.	5 ft.	6 ft.	6 ft.	6 ft.
Boiler heating surf.	50,265 sq. ft.	50,040 sq. ft.	40,972 sq. ft.	40,972 sq. ft.	38,817 sq. ft.	38,817 sq. ft.	29,286 sq. ft.
Grate area ..	11,293 "	11,080 "	11,554 "	11,554 "	1608 "	1608 "	1,598 "
Steam pressure ..	150 lb.	150 lb.	180 lb.	180 lb.	110 lb.	110 lb.	90 lb.
I.H.P. ..	18,360	18,100	18,000	18,000	14,300	14,300	11,890

Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.
1889.*	d. h. m.	knots	knots	1890.	d. h. m.	knots	knots	May 1 ..	6 5 20	2848	19.07	May 15 ..	6 14 9	2878	18.2	May 10 ..	6 17 10	2874	17.8	May 24 ..	6 12 58	2862	18.3	April ..	7 15 0	2852	15.58
May 1 ..	6 5 23	2855	19.05	May 8 ..	6 5 8	2899	19.44	May 22 ..	6 4 46	2848	19.12	June 12 ..	6 7 45	2867	18.89	June 7 ..	6 12 10	2822	18.0	June 21 ..	6 9 28	2872	18.7	May ..	7 7 36	2811	16.00
June 30 ..	6 5 17	2844	19.05	June 5 ..	6 8 21	2893	18.09	June 25 ..	6 4 40	2845	19.14	July 10 ..	6 5 21	2838	19.0	July 5 ..	6 6 57	2845	18.5	July 19 ..	6 19 40	2836	17.3	June ..	7 7 37	2839	16.11
July 27 ..	6 5 23	2876	19.38	August 7 ..	6 5 2	2791	19.64	July 24 ..	6 5 22	2842	19.88	August 7 ..	6 5 19	2806	20.18	August 2 ..	6 10 32	2842	18.4	August 16 ..	6 3 21	2835	19.2	July ..	7 7 37	2839	16.11
August 21 ..	6 5 18	2788	20.01	Sept. 4 ..	6 0 21	2779	19.25	August 21 ..	6 5 21	2784	19.56	Sept. 4 ..	6 5 20	2774	19.69	Sept. 30 ..	6 8 33	2797	18.3	Sept. 13 ..	6 9 27	2786	18.1	August ..	6 23 40	2776	16.55
Sept. 18 ..	6 0 16	2785	19.31	October 2 ..	5 21 19	2776	19.63	Sept. 18 ..	5 21 20	2780	19.64	October 2 ..	5 22 19	2779	19.53	Sept. 27 ..	6 12 18	2793	17.8	October 11 ..	6 15 41	2792	17.5	Sept. ..	7 6 11	2779	16.52
Oct. 16 ..	6 6 22	2777	18.47	Nov. 30 ..	6 7 3	2773	18.39	Oct. 16 ..	6 1 12	2782	19.17	Nov. 30 ..	6 13 21	2775	17.64	Oct. 11 ..	6 10 36	2826	18.2	November ..	6 23 58	2791	16.6	October ..	7 3 14	2770	16.21
Nov. 13 ..	6 5 12	2783	18.66	Nov. 27 ..	6 21 45	2795	16.86	Nov. 13 ..	6 6 16	2788	17.37	Nov. 27 ..	7 6 25	2781	15.95	November ..	6 8 16	2794	18.3	December ..	6 18 57	2790	17.1	Nov. ..	7 3 14	2770	16.21
Dec. 11 ..	7 4 3	2818	16.38	Average ..	6 5 44	—	18.91	Average ..	6 2 57	—	19.12	Average ..	6 6 44	—	18.76	Average ..	6 10 47	—	18.2	Average ..	6 14 12	—	17.85	Average ..	7 5 33	—	16.16
Fastest day's run, 516 knots in voyage of May 30.				Best day's run, 502.				Best day's run, 512 knots.				Best day's run, 512 knots.				Best day's run, 481 knots in June.				Best day's run, 498 knots in August.				Best day's run, 424 knots in August.			

Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.	Month.	Time.	Distance.	Average Speed per Hour.
1889.*	d. h. m.	knots	knots	1890.	d. h. m.	knots	knots	May 14 ..	6 30 10	2896	18.79	May 28 ..	6 14 30	2926	18.46	April 29 ..	6 12 19	2913	18.6	May 10 ..	6 10 52	2919	18.8	May ..	7 4 15	2853	16.56
May 15 ..	6 0 28	2894	20.03	May 21 ..	6 8 25	2920	19.16	June 11 ..	6 9 7	2890	18.85	June 25 ..	6 12 55	2890	18.42	May 24 ..	6 20 6	2890	17.6	June 7 ..	6 15 4	2942	18.5	June ..	7 11 58	2837	15.76
June 12 ..	6 2 40	2884	19.66	June 18 ..	6 6 58	2932	19.17	July 9 ..	6 11 2	2882	18.48	July 23 ..	6 8 0	2879	18.94	June 21 ..	6 10 30	2882	17.6	July 5 ..	6 14 30	2923	18.4	July-Aug.	7 5 52	2893	16.23
July 10 ..	6 19 14	2928	17.94	July 16 ..	6 10 22	2913	18.88	August 6 ..	6 5 43	2815	18.80	August 20 ..	6 2 45	2795	19.05	July 19 ..	6 10 13	2873	18.6	August 2 ..	6 12 16	2901	18.6	Aug.-Sept.	6 22 30	2787	16.73
August 7 ..	5 23 38	2792	19.44	August 20 ..	6 0 40	2785	19.25	Sept. 3 ..	5 23 16	2810	19.62	Sept. 17 ..	5 23 34	2794	19.46	August 16 ..	6 9 22	2872	18.7	August 2 ..	6 13 48	2820	17.8	Sept. ..	7 0 59	2782	16.46
Sept. 4 ..	6 3 58	2788	18.84	Sept. 17 ..	5 23 14	2773	19.36	October 1 ..	6 4 30	2809	18.92	October 15 ..	5 23 54	2783	19.34	Sept. 27 ..	6 8 4	2825	18.6	Sept. 27 ..	6 8 4	2825	18.6	October ..	7 11 11	2777	15.49
October 2 ..	6 23 54	2788	19.37	October 15 ..	6 2 27	2776	18.94	Nov. 12 ..	6 1 13	2780	19.14	Nov. 26 ..	6 4 0	2811	19.00	October 11 ..	6 10 28	2813	18.2	October ..	6 9 39	2823	18.4	Nov. ..	7 11 11	2777	15.49
Oct. 30 ..	6 22 57	2777	19.42	Nov. 12 ..	6 1 13	2780	19.14	Dec. 10 ..	6 1 25	2792	19.2	Average ..	6 5 27	—	18.93	December ..	6 10 41	2818	18.2	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38
Nov. 27 ..	6 0 54	2759	19.25	Dec. 10 ..	6 1 25	2792	19.2	Average ..	6 6 21	—	18.88	Average ..	6 5 27	—	18.93	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38
Dec. 26 ..	5 22 50	2794	19.49	Average ..	6 4 5	—	19.18	Average ..	6 6 21	—	18.88	Average ..	6 5 27	—	18.93	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38
Average ..	6 2 33	—	19.27	Average ..	6 4 5	—	19.18	Average ..	6 6 21	—	18.88	Average ..	6 5 27	—	18.93	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38	Average ..	6 11 36	—	18.38
Mean speed of all passages, 18.92 knots.				Mean speed of all passages, 19.02 knots.				Mean speed of all passages, 19.00 knots.				Mean speed of all passages, 18.84 knots.				Mean speed of all passages, 18.29 knots.				Mean speed of all passages, 18.15 knots.				Average speed of all passages, 16.18 knots.			

* As the City of Paris was not running in 1890, we have, for the sake of comparison, taken the figures for 1889. The June-July passages were lengthened owing to the stokers' strike requiring inexperienced men to be employed, and in the outward voyage of December very stormy weather was experienced, as indicated by the log given elsewhere. If the June and December passages were deducted the average outwards would be 6 days 1 hour 32 minutes, 16.20 knots per hour, while homewards with the July passage deducted, the average passage is 6 days 0 hours 40 minutes, 18.45 knots an hour. The average speed of all the ordinary passages was, therefore, 19.31 knots an hour.

† The City of New York was fitted in July, 1889, with a movable and self-cleaning grate, the patent of Mr. Thos. Henderson, Liverpool, and the grate area reduced to 1080 square feet, at which it remained till end of 1890. By renewals it has been increased to 1096 square feet.

‡ The introduction of Howden's system of forced draught has resulted in the shortening of the firebars by 13 in., bringing the grate area to 1026 square feet.

§ The indicated horse-power of City of Paris and City of New York as given is the best sustained, that of the Teutonic and Majestic is approximated, but we understand the vessels do not maintain the full 18,000 indicated horse-power.

|| The tonnage of each vessel is from Lloyd's Register.

And it is reasonable to assume that there is a slight tendency in the rivet to lean in the direction of the force applied, which would account for the slight elongation of the sheared section in that direction. An examination of the sheared sections of rivets in double shear shows little or no elongation. The rivets being supported by the plates above and below, the shear is direct and the section is normal in form. Experiments made by the English Admiralty with $\frac{3}{4}$ in. rivets showed that the double shear was about 90 per cent. stronger than the same diameter of rivet in single shear. Chief Engineer Shock, U. S. N., found by experiment that the resistance of bolts of iron to single shear was 40,700 lb. per square inch, and in double shear 75,300 lb. This gives an increase of strength of 85 per cent. The results of numerous experiments, both in this country and in Europe, show the resistance to double shear to be from 85 to 90 per cent. greater than the same rivets in single shear. From the foregoing I assume 85 per cent. as a fair and safe estimate of the excess of strength of rivets in double shear over those in single shear. We have already assumed that the resistance of rivets per square inch to single shear is 38,000 lb. If we add to this 85 per cent., we shall have 70,300 lb. as the safe estimate of the resistance of iron rivets per square inch to double shear. Further experiments may change these figures slightly. But I regard them as safe for use in all places where joints riveted with iron rivets are used. The use of the double welt butt joint in the construction of boilers is becoming quite common. This arises from the use of boilers of much larger diameter than those formerly used, and also the necessity

FIG. 4.

of higher pressures on account of the introduction of compound engines. With larger diameter and higher pressures, we find ourselves confronted with a very important problem. We must keep within the bounds of safety. For these huge vessels are very destructive to life and property if we disregard the importance of good material, good workmanship, and the well established factors of safety. It is not always safe to assume the highest results obtained by experimental tests. There will always be those who will insist upon higher pressures than safe rules will allow. Hence it becomes important that consulting engineer shall thoroughly understand the principles of safe construction, and not allow himself to be moved in his judgment when the question of safety is involved. We will now apply the above data to the following problem:

Steel plate, tensile strength per square inch of section 55,000 lb.
Thickness of plate $\frac{3}{8}$ " = decimal 0.375.
Diameter of rivet holes $\frac{1}{2}$ " = decimal 0.5125.
Area of rivet hole = decimal 0.5185.
Pitch of rivets in inner rows $3\frac{1}{4}$ " = decimal 3.25.
Pitch of rivets in outer rows $6\frac{1}{2}$ " = decimal 6.5.
Resistance of rivets in single shear, 38,000.
Resistance of rivets in double shear, 70,300.
 $6.5 \times 0.375 \times 55,000 = 134,062$ lb. Strength of solid plate.
 $(6.5 - 0.8125) \times 0.375 \times 55,000 = 117,304$ lb. Strength of net section of plate at A B.
 $0.5185 \times 4 \times 70,300 = 145,802$ lb. Strength of four rivets in double shear.
 $0.5185 \times 38,000 = 19,703$ strength of one rivet in single shear.

This last result must be added to the strength of four rivets in double shear—thus $145,802 + 19,703 = 165,505$, shearing strength of all the rivets. The net section of plate is the weakest—therefore, $117,304 + 134,062 = 251,366$ per cent. efficiency of joint. It will no doubt be observed that the strength of rivets in this joint is largely in excess of the strength of net section of plate, and the question will arise, Why increase the width of the inner covering strip and add two more rivets? As stated above, this was done to increase the net section of plate at A B, and thus increase the efficiency of the joint. If the inner welt or covering strip had been of the same width as the outer one, the net section of plate would have been greatly reduced and the differ-

FIG. 5.

ence of strength between net section of plate and rivets would have been greater, thus reducing the efficiency of joint. The problem would be as follows:
 $6.5 \times 0.375 \times 55,000 = 134,062$ = strength of solid plate.
 $(6.5 - 0.8125 \times 2) \times 0.375 \times 55,000 = 100,546$. Strength of net section of plate.
 $0.5185 \times 4 \times 70,300 = 145,802$. Strength of four rivets in double shear. Net section of plate is the weakest—therefore, $100,546 + 134,062 = 234,608$ = only 75 per cent. efficiency of joint.

Again, it may be suggested—why not dispense with

one row of rivets in double shear, and extend the inner welt or covering strip so that an outer row of rivets in double pitch and single shear could be used, thus increasing net section of plate as in the original problem, but reducing at the same time the shearing resistance of the rivets? The solution of this problem would be as follows:
 $6.5 \times 0.375 \times 55,000 = 134,062$. Strength of solid plate.
 $(6.5 - 0.8125) \times 0.375 \times 55,000 = 117,304$. Strength of net section of plate.
 $0.5185 \times 2 \times 70,300 = 72,901$ = strength of two rivets in double shear.
 $0.5185 \times 38,000 = 19,703$ = strength of one rivet in single shear.

This last result must be added to the result of two rivets in double shear.
 $72,901 + 19,703 = 92,604$ = strength of all the rivets.
The total strength of rivets is the weakest—therefore $92,604 + 134,062 = 226,666$ per cent. efficiency of joint.
It may be further suggested that a rivet of smaller diameter could be used. I will say that I have also considered such a problem, but have come to the conclusion that the joint, as illustrated and described, for efficiency and freedom from leaks, is the best. I will say here that a joint of this description was carefully

made and tested on the Emery machine at the United States Arsenal at Watertown, Mass. The result of the test was within two-tenths of one per cent. of the calculation made, and the line of fracture was through the net section of plate at the outer row of rivets, as we had predicted. It may be interesting to you to know that the company with which I am connected has between forty and fifty thousand boilers under its care and the risk involved is one hundred and fifty millions of dollars. Hence we cannot be too careful in our calculations of the strength of boilers. We employ one hundred and twelve men as inspectors, who are constantly at work examining this large number of boilers.

In conclusion I will say, thoroughly understand whatever you undertake to do. The technical school furnishes for you the underlying principles of your profession. The superstructure must be mainly your own work. Grave responsibilities will rest upon you when you become established in your life work. It is a glorious age to live in, and he who by honesty and industry does his part well, will not fail of his reward.

DEVELOPING WITHOUT A DARK ROOM.

At a recent meeting of the Liverpool section of the Society of Chemical Industry, Mr. Alexander Watt described an apparatus which he has devised for developing without a dark room. It consists of a metallic case, A (Fig. 1), only slightly larger than the plate for which it is intended, which can be closed light tight by means of the lid, B. It is furnished with two tubes, one, C, entering at the bottom of the bath, which can be connected by a piece of India rubber tubing, E, to the funnel, D; the other is near the top, just above the level of the plate, P. The former serves to introduce the developer into the bath, and the latter, F, allows the air to escape and also acts as an overflow.

The funnel, D, and the India rubber tube, E, are supported by means of the hooks, K K, which fit into the eye, L. The tubes are so bent that no light can enter the bath. An end view of the bath is shown in Fig. 2, in which a movable hook, I, fitting into the socket, J, serves to fix the bath to any convenient support. A section, Fig. 3, shows the plate, P, the film side of which is kept from contact with the side of the bath

by means of the metallic strips, H. When the bath is intended for the development of films or paper prints, it is furnished with a carrier (Fig. 4), into which the film or paper is inserted before being put into the bath, and when required for the development of several plates at one time, it is constructed with grooves, as in an ordinary plate box.

The bath is used as follows: The dark side containing the exposed plate and the bath are placed in a changing bag, into which it is only necessary to insert the hands. The plate is then transferred from the slide to the bath, care being taken to keep the film side toward the back of the bath. After being closed, the bath is withdrawn from the bag into daylight, and fixed vertically to any convenient support by means of the hook. A vessel is placed under the overflow tube, and the inlet tube is attached to the funnel, which, after being filled with the developing solution, is raised and lowered several times, to alternately fill and empty the bath, and so insure the removal of air bells from the surface of the plate. After standing sufficient time to complete the development, the solution is run off from the bath. The plate is washed by running water through the bath (either by means of the funnel or by attaching the India rubber tube direct to a water tap), after which it is taken out in daylight, and "fixed" in a covered tray. If it be desired to "fix" entirely in the dark, the operation may be conducted in the same bath, or in a similar one to which the plate has been transferred in the changing bag. The final washing of the plate may be done either in the bath or in the usual way.

The best developer for use with the dark bath is ferrous oxalate, on account of its property of not producing "fog," even when a plate has been left in it for an hour. It should be made just before use from the following solutions, prepared according to Thomas' formulæ—

No. 1.

Potassium oxalate..... 300 grms.
Potassium bromide..... 22 "
Water to make..... 1,000 c. c.

No. 2.

Ferrous sulphate..... 400 grms.
Sulphuric acid..... 3 c. c.
Water to make..... 1,000 c. c.

To 4 parts of No. 1, add 1 part of No. 2, and water to make 8 parts.

When the developer is used at once with Thomas'

"Extra Rapid" plates, from 12 to 15 minutes in the bath at about 15° C. is sufficient to give a satisfactory negative, if the exposure has been correct. The time required to obtain a suitable density is found by placing the exposed plate in the bath and adding the amount of developer required to fill the bath, in four equal portions, at intervals of five minutes. Four densities are thus obtained by developing for 5, 10, 15, and 20 minutes respectively, from which observations the time that gives the desired density is selected. —*The Chem. and Drug.*

SMOKE AND FUMES ANNIHILATOR.

WE paid a visit a few days ago to the works of Messrs. Manning, Wardle & Co., Leeds, for the purpose of inspecting Elliott's smoke and fumes annihilator, which this firm has in operation in connection with their boilers. The machine entirely differs from anything hitherto attempted in the direction of solving the problem of smoke abatement. The idea of

FIG. 1.

washing smoke appears at first somewhat peculiar, but that such a thing can be successfully accomplished is demonstrated beyond a doubt by the machine in question. The accompanying illustrations will greatly assist our readers to understand the nature of the invention. Fig. 1 gives a front view of the mechanism, and Fig. 2 the same view, with the addition of the flue and chimney. The apparatus consists of an exhaust fan (shown in the upper right-hand corner of Fig. 1), and a washing machine and annihilator. The smoke and fumes from the boiler are drawn from the back flues by the exhaust fan, and passed into the annihilator, and the vapor escapes into the chimney, as shown in Fig. 2. The annihilator is the tank shown to the left of Fig. 1. This tank is fitted with a hollow perforated spindle, revolving horizontally, and carrying perforated paddle blades, and several curved baffle plates are placed above the paddle blades. The tank is charged with water at the bottom to a level of one or two inches below the under side of the perforated hollow spindle. The smoke and fumes enter the tank through the perforations in the hollow revolving spindle, and a fine spray is raised in the upper part of the tank by the paddle blades dashing through the water. The smoke and fumes become beaten up in this spray and against the baffle plates, the result being that all carbon, dust, and other matters in suspension in the smoke and fumes are arrested, and the sulphur and other gases that are soluble in water are absorbed, thus leaving a pure white vapor to pass away into the air. Such is a brief description of the machine, and the question is, Does it answer its description? We have no hesitation in saying it does. We had the machine shown to us in operation under various conditions, the result being equally satisfactory in every case. First, we inspected a machine provided for the purpose of showing its mechanism; then a small one affixed to a vertical boiler and engine, with the annihilator inoperative. The smoke was allowed to ascend in the usual black volume, which was speedily changed to a white vapor upon the annihilator being set in motion. Some may remark that this may do very well in the case of a small boiler, where no great volume of smoke has to be contended with, but what is the result with the largest factory boilers? This we had demonstrated to us, and found the result the same. In a third machine, we had the opportunity of noticing the nature of the scum or refuse thrown off during

FIG. 2.

the process of washing the smoke. Each machine is inclosed and proper facilities offered for removing the scum, but, in the present case, the top of the tank was removed and quantities of the scum were allowed to escape into a trough placed in a convenient position. To those who have not studied the subject of smoke abatement, the amount of black vapor found in the former, as demonstrated in the present instance, would come as a great surprise. From this residuum, by-products are recovered of such a character as to be of commercial value, and most users of the annihilator will, at least, be able to utilize the residuum as a ferti-

lizer, although it is valuable for electrical and other purposes of a higher grade. The patentee claims for the invention that it will not only abate but entirely prevent smoke being emitted from any chimney, together with the sulphurous and noxious fumes combined with smoke. The machine only occupies a few feet, and can be placed in any position, either within or outside a building, and can be attached either to existing machinery by a belt, or worked by a separate engine of nominal power. The method of attachment to existing chimneys, shown in Fig. 2, is both simple and inexpensive, and the strong draughts created by the machine can be regulated as required. Besides this, chimneys are not necessarily needed so high as those at present in use, and the cheapest form of fuel can be used with good results, either by hand or by mechanical stoking. The cost of running an annihilator is not great, and what little expense there is can, it is considered, be counterbalanced by the value derivable from the residuum obtained in the process of washing the smoke. The favorable opinions expressed by scientific and other authorities are too numerous to quote here, but, perhaps, that to which our readers will pay most attention comes from Mr. C. W. Raymond, an inspector of factories, who says: "This machine will be of immense value to manufacturers, and I shall draw their attention to it." —*Textile Industries.*

(Continued from SUPPLEMENT, No. 810, page 12941.)

FAST AND FUGITIVE DYES.*

By Prof. J. J. HUMMEL.

THE ACTION OF MILLING ON COLORS.

NEXT, if not equal, in importance to the action of light is the consideration of the effect on dyed colors of those manufacturing operations to which the dyed materials must of necessity be submitted.

These vary considerably, according to the material, and without enumerating them, I propose first to direct your attention to that of "milling" or "fulling."

When a piece of woolen cloth leaves the loom, it has not, unfrequently, a coarse, sacklike appearance; quite intentionally, in order to obtain a certain quality of texture, the warp and weft threads have not been brought into closest contact with each other in the loom. This is only effected subsequently by the milling operation, which consists in squeezing and hammering the cloth, previously moistened with a little strong soap solution, in special forms of apparatus. During this operation, the threads and fibers are felted together, and the fabric gradually becomes more and more compact.

What, then, are the influences thus brought to bear upon the colors of the fabric, supposing these to have been previously imparted to the wool or yarn of which it is made?

First, there is the action of the slightly alkaline soap; the colors should not be dissolved off by it, nor destroyed, nor even materially impoverished or altered in hue.

Further, if the fabric is composed of variously colored yarns, as, for example, in tweeds, the colors must not "run" or "bleed," i. e., the coloring matters of one set of threads, if at all removed, must not stain those of another set: white threads particularly must maintain their pristine purity, otherwise the pattern loses sharpness and decision, or the whole fabric appears soiled, and is thereby rendered quite unsalable. This difference in effect obtained by employing colors fast or fugitive to milling is well shown in the stripe and check patterns woven in our Yorkshire textile department, by my colleague, Prof. Beaumont.

The action of milling on dyed colors may be rapidly determined in the laboratory, by vigorously rubbing together, with strong soap solution, the dyed pattern and some white flannel. It is better still to stitch soft white woolen yarn into the dyed pattern, and then to submit it to the actual milling operation of the factory along with a large piece of white cloth.

On these two diagrams are patterns which have been milled in this manner; and on close examination they show how very differently the various classes of coloring matters behave when submitted to this operation. Fast to milling, especially with respect to bleeding, are all those phenolic coloring matters which can only be applied by means of mordants, e. g., alizarin, carmalum, fustic, logwood, etc. Why do these colors not bleed? Because in the dyed fibers the coloring matters form, in combination with the mordant, an insoluble precipitate, which is largely inclosed within the substance of the fiber. That portion of the precipitate which lies on the surface is undoubtedly removed mechanically during the milling process; but even then, since the coloring matter is combined with the mordant, and is not in the free state, it cannot combine with the mordants of neighboring dyed fibers, nor can it be attracted by and stain unmordanted white fibers.

I would, however, specially draw your attention to the fact that even this class of "mordant dyes," as I have termed them, are liable to bleed in milling, if they are improperly applied.

Allow me to reiterate that, in the case before us, the development of color during the dyeing process is due to a chemical combination taking place between the coloring principle of the dyestuff and the mordant. This being so, the colored pigment, lake, or precipitate, produced has a fixed chemical composition—a definite amount of coloring matter has combined with a definite amount of mordant.

It does happen, however, that the normal pigment at first produced within the fiber is capable of taking up in the dye bath a further amount of coloring matter, if the latter is employed in excess; the normal compound is, as it were, changed into a more acid compound.

Further, the wool fiber itself absorbs a certain small amount of coloring matter, which remains uncombined with the mordant. If, therefore, a deficiency of mordant or an excess of coloring matter has been employed in dyeing, the uncombined or loosely combined coloring matter will assuredly be removed during the milling process, and give rise to "bleeding."

How necessary it is, then, with dyes of this class, that mordant and coloring matter should be duly pro-

* A paper recently read before the Society of Arts, London.