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THE TORPEDO GUNBOAT RATTLESNAKE.

THE Rattlesnake, torpedo gunboat, built and engined by Messrs. Laird Brothers, at Birkenhead, has just made a contractors' three hours' full power trial of her machinery at Portsmouth, previous to being received by the Admiralty. She is of 450 tons displacement, and is the first of her class. Hence the interest which attaches to her performances under way. These gunboats are both faster and more formidable than anything of the gunboat class yet designed, and are expected to prove an effective check to the operations of torpedo boats in war.

The Rattlesnake is 200 ft. between perpendiculars, with a beam of 23 ft. and a depth of hold of 13 ft. She is built entirely of steel, and is fitted with a half-poop and forecastle, and a conning tower, with a conning bridge erected over it. In speed she equals the first class torpedo boats; while, as she stands well out of the water, and has good accommodation between decks, she is vastly superior in seaworthiness, ability to keep the sea, and comfort for the crew. Her offensive power is also greater. In addition to one torpedo tube through the bow and another through the stern, in a fore and aft line, and one on each broadside forward capable of training through 90 degrees, she will mount a 4 inch 25 cwt. central pivot breechloader, capable of penetrating 8 in. of armor.

This makes her a formidable antagonist to all but heavily protected ships of war. The gun is surrounded by a steel screen attached to the carriage, for the defense of the gunner against machine guns and rifle fire. She carries six three pounder Hotchkiss quick firing guns. Above the bridge an electric search light is fitted. The final trials for speed were made recently, Mr. H. H. Laird being present as a representative of the contractors' firm, and Mr. R. R. Bevis, Jr., in charge of the engines.

Several runs were made over the measured mile in Stokes Bay, when a mean speed of 19½ knots was obtained. The maximum horse power developed was 3,100, the result of the complete run giving a mean collective power of 2,860 horses, or 160 in excess of the contract, with an average of 322 revolutions.

During one of the trials the steam steering gear was tested, when it was found that the helm could be put hard over from hard over in twenty seconds. The craft behaved very well in spite of the weather, though the sea broke over her in clouds of spray. With her bunker capacity the Rattlesnake is capable of steaming, at eleven knots, 2,800 miles, or a little more than the distance between Liverpool and New York. The Rattlesnake will now be brought forward for early commissioning.—*Illustrated London News.*

THE RATTLESNAKE.

THE Rattlesnake, torpedo gunboat, built and engined by Messrs. Laird Brothers, at Birkenhead, has just made a contractors' three hours' full power trial of her machinery at Portsmouth previous to being received by the Admiralty. She is 450 tons displacement, and is the first of her class. Hence the interest which attaches to her performances under way.

The other vessels of the class are the Spider, Grasshopper, and Sandfly, the whole of which are being constructed at the Royal Dockyards, the Grasshopper at Sheerness and the others at Devonport, while the machinery is being made by Messrs. Maudslay, Sons & Field.

The Rattlesnake is 200 ft. between perpendiculars, with a beam of 23 ft. and a depth of hold of 13 ft. She is built entirely of steel, and is fitted with a half poop and forecastle, and a conning tower, with a conning bridge erected over it. In speed she equals the first class torpedo boats; while as she stands well out of the water and has good accommodation between decks, in seaworthiness, ability to keep the sea, and comfort for the crew, she is vastly superior. Her offensive power is also greater.

In addition to one torpedo tube through the bow and another through the stern in a fore and aft line, and one on each broadside forward capable of training through 90 degrees, she will mount a 4 in. 25 cwt. central pivot breechloader, capable of penetrating 8 in of armor. This will make her a formidable antagonist to all but heavily protected ships of war. The gun will be surrounded by a steel screen attached to the carriage for the defense of the gunner against machine guns and rifle fire. She will also carry six three pounder Hotchkiss quick firing guns. Above the bridge an electric search light will be fitted.

In engining the Rattlesnake, the paramount object with the contractors has been to reduce all weights to a minimum consistent with efficiency. The contract power of the engines is 2,700 C.H.P.; and when it is considered that this enormous force is contained in a snake-like craft of only 450 tons, while the engines of the corvettes of the "C" class, of 2,380 tons displacement, develop only 2,430 H. P., the character of the problem which the marine engineer has had to grapple will be readily recognized.

The boilers are protected at the forward end and at the sides by coal bunkers capable of stowing 90 tons of fuel, while the engines, which are not divided by bulkheads, are protected by extra thick plating on the sides of the vessel. In the design of the machinery advantage has been taken of the experience derived from the performances of the torpedo fleet, and consequently there are various improvements.

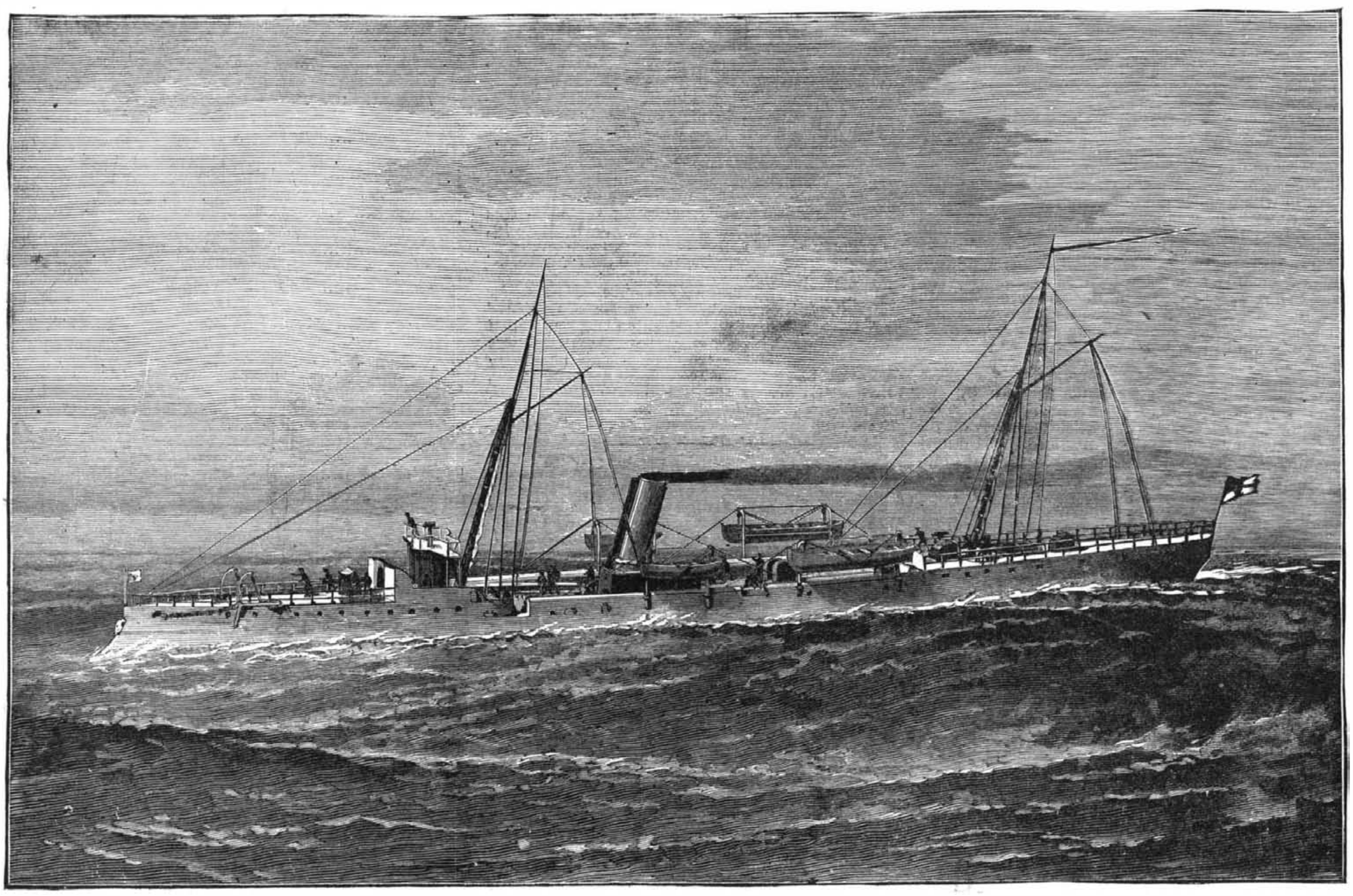
The propelling machinery consists of two sets of vertical triple expansion three crank engines, having cylinders of 18½, 27, and 42 in. diameter respectively, with a stroke of 18 in., and capable of exerting 2,700 H. P. at about 310 revolutions. The total condensing surface of the condensers amounts to 4,000 square ft.

The framing of the engines is entirely composed of steel, and this material has also been largely employed in the construction of the machinery throughout. The crank and other shafting has been manufactured of Whitworth special steel, and is hollow throughout. The propellers are made of solid manganese bronze. They are three bladed, and have a diameter of 6 ft. 6 in. and a pitch of 7 ft. 6 in.

The boilers, four in number, are fitted in two stokeholds, which are wholly separate, so that, in consequence of the duplication adopted, there would be a chance of the Rattlesnake making good her escape though partly disabled in her machinery. They are of the locomotive type, but a new principle has been introduced of constructing them with wet bottoms, and with large conical shaped tubes placed between the furnaces. In addition to increasing the heating surface, this plan affords an efficient means of circulating the water in the boilers.

The working pressure is 140 lb. to the square inch, while the heating surface is about 5,000 ft., and the area of fire grate 122 ft. The stokeholds are fitted with four fans for providing the forced draught with which the vessel will be exclusively driven. Besides supplying the propelling machinery, Messrs. Laird have fitted on board a dynamo engine for the search light, an air-compressing machine for the torpedo service, and a steering engine (made by Forrester & Co.) which works a very powerful gear in the after part of the vessel below the water line. This gear is capable of being readily converted into hand gear.

The same contractors have also fitted the torpedo tubes and gear, the gun mountings, and other work in compliance with an extra contract intrusted to them by the Admiralty. In addition to the 90 tons of coal already mentioned, the Rattlesnake will carry engine room stores for six months.



H. M. TORPEDO GUNBOAT RATTLESNAKE.

Two light spars will be carried for signaling purposes. These torpedo boat catchers or gunboats are both faster and more formidable than anything of the gunboat class yet designed, and are expected to prove an effective check to the operations of torpedo boats in war.

Considerably greater difficulty attaches to the trials of these small craft, in consequence of the lightness of the reciprocations, the want of space, and the comparative fewness of the men in charge, than to the trial of a full sized battle ship. This will serve to explain the cause of the many failures through which they pass before a thoroughly satisfactory success can be recorded.

It will consequently create no surprise to learn that the Rattlesnake did not achieve the results notified below until various weaknesses had been rectified, and sundry readjustments of the slides and other moving parts had been made. The trial was watched by Mr. Alton and Mr. Maystow on behalf of the steam reserve and the dockyard, and by Messrs. Shapcott and Smith of the controller's department, the engines being under the charge of Mr. Bevis, Jr., as representing the contractors.

The vessel was brought down to her load draught by means of iron ballast—namely, 6 ft. 9 in. forward and 9 ft. 11 in. aft. After a short preliminary run the Rattlesnake proceeded on a three hours' official full power trial, at the end of which the following mean results were obtained: Steam in boilers, 136 lb., which was less than the engines could have utilized; vacuum, 25 in.; revolutions, 311 (starboard) and 308 (port); mean pressures—starboard, 59 lb. high, 28 lb. intermediate, and 13 lb. low; port, 58 lb. high, 28 lb. intermediate, and 11 lb. low; I. H. P., 1,424·10 starboard and 1,294·17 port; thus giving a collective I. H. P. of 2,718·27, which is slightly beyond the contract. The mean of six runs upon the measured mile gave a speed of 18·779 knots.

It remains, however, to be stated that the weather was somewhat boisterous for so small a craft, the wind blowing from the southwest with a force of over three, the result being a probable loss of ten revolutions per minute. On the conclusion of the steam trial the steam steering gear was tested, when it was found that the helm could be put hard over from hard over in 20 seconds.

The craft behaved very well in spite of the weather. Though the sea broke over her in clouds of spray, and she proved at times somewhat lively, the vibration was confined to the extreme ends, and there can be no doubt that she will provide a fairly steady platform for the gun which she is intended to carry.

On February 9 she went out of Portsmouth Harbor for a final trial of her machinery, under more favorable conditions of wind and weather, in charge of Mr. Bevis, Jr., Mr. H. H. Laird being also present as a representative of the contractors' firm.

Several runs were made upon the measured mile in Stokes Bay, when a mean speed of 19½ knots (about 23 miles per hour) was obtained, being a gain of three-quarters of a knot upon what was realized at the three hours' trial. The *maximum* horse power developed was 3,100, the result of the complete run giving a mean collective power of 2,860 horses, or 160 in excess of the contract, with an average of 322 revolutions.

On the previous Monday the vessel was driven for six consecutive hours at a uniform speed of 11 knots for the purpose of testing her coal and water consumption, the latter being a somewhat novel ordeal which is reserved for craft of the kind. The speed was maintained by a mean collective expenditure of power equal to 373 horses, which was secured by an average of 166 revolutions per minute.

The consumption of fuel amounted to 2 lb. per unit of horse power developed per hour, the result proving that with her bunker capacity the Rattlesnake is capable of steaming, at 11 knots, 2,800 miles, or a little more than the distance between Liverpool and New York. The consumption, or, more properly speaking, the waste, of water amounted to 5 cwt. for the six hours, the comparatively small loss being due to the fact that the waste of water is compensated by the double distilling apparatus which has been fitted on board. The Rattlesnake will now be brought forward for early commissioning.—*Marine Engineer.*

FIFTY YEARS' PROGRESS IN NAVAL ARCHITECTURE.

THE annual lecture arranged by the Greenock Philosophical Society in honor of the birth of Greenock's great celebrity, James Watt, was delivered this year by Mr. Robert Duncan, shipbuilder, of Port Glasgow, who chose for his subject "Evolution in Naval Architecture during the Reign of Queen Victoria." Mr. Duncan has taken a prominent part in the progress made in the construction of merchant vessels during a considerable part of the present reign, and, as might be expected, his lecture contained much valuable matter.

Treating first of evolution in propulsion, Mr. Duncan remarked upon the fact that though tugs and river passenger steamers had been in use from the appearance of the Comet on the Clyde in 1812, yet up till the year of Her Majesty's accession no systematic attempt had been made at ocean steam navigation, and the screw propeller had no existence save in an experimental form.

In 1838, the first Atlantic steam communication began. In that year the Sirius and Great Western made the voyage to and from New York, at the same time, in fourteen and seventeen days respectively, under steam all the way. Thus, in the second year of the reign, the difficulty of ocean steam navigation was solved, and its further expansion has only been since then a question of time and adequate means. In 1840 the screw propeller made its first experimental trial in the Archimedes, round the coast of Great Britain.

Simultaneously with the changes in methods of propulsion an evolution was taking place in size, depending upon new material of construction. In 1837, there were only 230 merchant vessels over 500 tons belonging to Great Britain, and only one iron vessel over 50 tons register. That one vessel, which Mr. Duncan as a boy remembers looking at with contempt, was sent from Glasgow to Greenock for his father to put wooden beams and decks on it. The iron shipbuilder on the Clyde, at that period, could make the iron shell as like as possible to a long open boiler or tank, but putting a deck on it, with hatches and fittings, was a mystery he did not understand. It did not occur to him, nor to any one else for many years after that, that an iron deck would do as well as a wooden one; in many respects better. It was the same thing with iron masts and yards, and with wire rope.

The new departure did not affect the design and proportions of ships for some time; but a great revolution came about in this respect also, when the naval architect began to discover that proportions which were dangerously weak in wood were perfectly safe in iron. Full advantage of this has been taken in the design of river steamers. Development in length in proportion to breadth and depth reached its limit about thirty years ago, when a length over ten times the breadth was reached, with the result that iron, too, was found to have a limit of strength with manageable weight, beyond which it was not profitable in the owner's interest to go. During the last ten years a reaction has set in, consequent upon the researches of the late Mr. Froude on the effect of form on resistance and speed. This has affected the lower types to such a degree that the length of an ordinary cargo steamer in proportion to breadth is very little over the proportion common to the largest iron sailing ships at this time.

In his review of the history of ship building during the last fifty years, Mr. Duncan finds that all is not progress, but that, as in nature, there are instances of reversion to a primitive type. The earliest influence on the change of form was the new tonnage law in 1835, which was immediately followed by a style of ship as remarkable as it was peculiar. The square boxes of the olden time gave place to long, raking, sharp bows and sterns, broad decks and narrow bottoms. This was not development, but after a further change for the better of the tonnage laws in 1854, the extremes of the previous types gradually disappeared, and naval architecture, now free in all directions, prepared to assert itself in improved forms adapted to all the varied requirements of trade.

This freedom was, however, but short lived as regards construction, for in 1855 Lloyd's Register Committee issued their first rules for iron ships, and shipbuilders were then placed in leading strings. At first, however, Lloyd's wisely adopted the new tonnage law as the basis for scantlings, thus leaving the shipbuilder free as regards dimensions and form. In 1862, the Liverpool Underwriters' Registry started with their rules for the building of iron ships, taking dimensions solely as their basis for scantlings, and giving a distribution of materials less in weight and considerably different from Lloyd's. An early effect of this change of base for construction was a gradual reversion of the box shape for all vessels classed exclusively in that registry. Matters became so serious for Lloyd's Registry that, in 1870, they were obliged to revise their rules; but instead of reducing their scantlings in tonnage and rearranging their distribution on the same basis, as in Mr. Duncan's opinion they should have done, they adopted, with some slight modifications, the rules of the Liverpool Registry, and thereby accelerated the reaction in the forms of ships which had already begun. The recent amalgamation of the two societies has placed the construction of British shipping under the control of Lloyd's, and were it not for the conservative tendencies of all monopolies, one might be disposed to hope that a more scientific basis for construction would receive their early consideration.

A great evolution in size has also come about since 1837. The first steamer which made the voyage to India, the Enterprise, was only 122 feet long, and the first Atlantic steamer from Liverpool in 1839, the Royal William, 175 ft. long. With the building of the Great Britain, at Bristol (1840 to 1845), a large stride was made, she being 300 ft. long, but it was not till 1870 that the largest Atlantic steamer came up to 400 ft. In this comparison Mr. Duncan has of course left the Great Eastern out of the question. In her case evolution, unfortunately, did not have play, and the gigantic experiment became a gigantic failure.

Steam pressures also have risen from 10 lb. in 1837 to 180 lb. in some boilers recently built for quadruple engines, while there is scarcely a triple expansion engine of less than 150 lb. pressure. It was not till 1870, however, that pressures exceeded 30 lb. Speeds have been accomplished in torpedo boats under very forced conditions, which, until accomplished, were believed impossible. It accords with all our past experience that what has been the miraculous speed of one generation has become the very ordinary pace of the next, and it is quite within the bounds of possibility that Her Majesty's reign may yet see exclusively passenger steamers of 800 ft. long making an Atlantic passage at 25 to 30 miles per hour. Such speeds, however, must be attained under conditions which will make them a commercial success.

Mr. Duncan's experience in this connection teaches him that there is a minimum length in relation to speed which must be maintained, otherwise the economical relationship will be vitiated and power wasted. The rule for that minimum length is that "the length of every steamer should not be less in feet than the square of the speed in knots per hour for which she is designed." It follows from this, that for a steamer to successfully run 30 knots per hour, her length should be 900 feet.

In regard to evolution in the Royal Navy Mr. Duncan contrasted the wooden sailing liners of 1837 with the modern ironclads and protected cruisers of the present day. He also briefly noticed the development of schools of naval architecture in connection with the royal navy, leading up to the Glasgow professorship and to the institutions of naval architects, and the Scottish Institution of Engineers and Shipbuilders. After naming the chief contributions to the literature of naval architecture during the fifty years, Mr. Duncan concluded his most interesting review by expressing the hope that our successors may prove themselves worthy of their great inheritance.—*Nautical Magazine.*

NEW NAVAL VESSELS AUTHORIZED.

WE find that there is a great lack of exact information as to what has been done by Congress for the increase of the navy. To make this clear, we give here a table showing what vessels have been authorized, their size, proposed armament, cost, speed, and present status. This will give a clear idea of the number and character of the vessels constituting our new navy, the last of which should be in commission by 1890.

The total sum thus far allowed by Congress for the new navy is, it will be observed, nearly thirty-one millions of dollars. Of this a little over three millions is provided for guns, and a little over four millions for armor. This is over seven millions in all; a sum quite sufficient to make a beginning, and to stimulate our manufacturers to exert themselves to meet the requirements of modern warfare. It should be remembered that this is but a beginning, and that no provision has thus far been made to meet the demands of the army for heavy ordnance or coast defenses. The new navy thus far authorized includes 22 vessels, of different sorts, having a total tonnage of 65,609, and armed with two 12-in. guns, twenty-six 10-in., twelve 8-in., eighty-one 6-in; the armament of two large cruisers not yet being determined. Besides this, we shall have the dynamite vessel, torpedoes, and Hotchkiss and Gatling guns. The appropriations for armament of the new naval vessels amount, altogether, to $3,075,762, as follows:

Act of July 2, 1884	$500,000	
" March 3, 1885	84,000	
" July 26, 1886	343,000	
" August 3, 1886	1,000,000	
" March 3, 1887	1,128,362	
" March 3, 1887 (for three steel cast guns)	20,400	
		$3,075,762

The appropriations for armor are as follows:

Act of March 3, 1885	$25,000	
" March 3, 1887 (armor and gun steel)	4,000,000	
		$4,025,000
Appropriations for new vessels		21,522,350
Batteries, torpedoes, etc		2,150,000
Total appropriation for increase of navy		$3,773,112

Name or Type.	Displacement.	Battery.	Status.	Limit of Cost.	Act.	Speed, Knots.
Chicago	4500	4 8-in. and 8 6-in.	Fitting for sea at N. Y. yard.	$1,576,854	Aug. 5, 1882.	15
Boston	3000	2 8-in. and 6 6-in.	Not yet commissioned.	1,031,225	Aug. 5, 1882.	13
Atlanta	3000	2 8-in. and 6 6-in.	In commission.	1,031,225	Aug. 5, 1882.	13
Dolphin	150	1 6-in.	In commission.	460,000	Aug. 5, 1882.	15
Charleston	3730	2 10-in. and 6 6-in.	Under contract.	1,100,000	Mar. 3, 1885.	18
Baltimore	4413	4 8-in. and 8 6-in.	Under contract.	1,500,000	Mar. 3, 1885.	19
Newark	4083	12 6-in.	To be readvert'd.	1,300,000	Aug. 3, 1886.	18
Gunboat 1	1700	6 6-in.	Under contract.	520,000	Mar. 3, 1885.	16
Gunboat 2	870	4 6-in.	Under contract.	275,000	Mar. 3, 1885.	13
Double bottomed armored vessels, cruiser No. 1	6000	4 10-in. and 6 6-in.	Plans not decided on.	2,500,000	Aug. 3, 1886.	17
Double bottomed armored vessels, battleship No. 2.	6000	2 12-in. and 6 6-in.	Plans not decided on.	2,500,000	Aug. 3, 1886.	7
First-class torpedo boat	108	5 torpedoes & 2 mach. guns.	Plans not decided on.	100,000	Aug. 3, 1886.	23
Puritan	6000	4 10-in.	Plans for completion ready, but not advertised.	$3,178,046 for all five double turreted monitors.	August 3, 1886.	14
Amphitrite	3815	4 10-in.	"	"	Aug. 3, 1886.	12
Monadnock	3815	4 10-in.	"	"	Aug. 3, 1886.	12
Terror	3815	4 10-in.	"	"	Aug. 3, 1886.	12
Miantonomoh	3815	4 10-in.	Nearly completed.	"	Aug. 3, 1886.	12
Dynamite gun cruiser (230 ft. x 26 ft.)	500	3 10½-in. dynamite guns.	Under contract.	350,000	Aug. 3, 1886.	20
Steel cruiser No. 1	5000	To be determined.	Authorized.	1,500,000	Mar. 3, 1887.	19
Steel cruiser No. 2	5000	To be determined.	Authorized.	1,500,000	Mar. 3, 1887.	19
Steel gunboat No. 1	1700	6 6-in.	Authorized.	550,000	Mar. 3, 1887.	16
Steel gunboat No. 2	1700	6 6-in.	Authorized.	550,000	Mar. 3, 1887.	16

"Floating batteries, or rams and other naval structures to be used for coast and harbor defense," authorized by Act of March 3, 1887	$2,000,000
"Stiletto," purchase authorized for experiment	25,000
Torpedoes, authorized by Act of Aug. 3, 1886	75,000
" " " " March 3, 1887	50,000

—*Army and Navy Journal.*

[ARMY AND NAVY JOURNAL.]

STEEL GUNS, GUN METAL, GUNPOWDER, ETC.

By G. W. SUMNER, Commander, U. S. N.

1. WHAT is the *beau ideal* of a perfect gun? or, What does the honest and competent gun maker seek to produce? Says Tennent:

"The *beau ideal* of a perfect gun is one which will give the gunner the positive mastery over gunpowder. In other words, *a gun which cannot be burst.* To realize this requires the combined action of two distinct sciences, those of the metallurgist and the engineer, and the latter, it is clear, can always work up to the utmost achievements of the former, and furnish artillery whose performance and power is only limited by the endurance of the metal out of which it is made. And although perfection is dependent on other conditions besides the tenacity of the metal, such as the form of the bore, the configuration of the projectile, and the peculiarities of loading, still these

latter will render but inefficient service, unless combined with a material so strong and tenacious as to withstand the utmost violence of explosion."

Says Longridge:

"The first point in the science of gunnery, and that which limits its future, is the construction of guns of sufficient strength to curb and govern the utmost force of the explosive which may be used in them. So long as gunpowder can burst guns, so long is it unmanageable, and wanting in that perfect obedience which is the first principle of effective service."

Says Col. C. B. Brackenbury, R.A.:

"There is not a single gun actually adopted for service in any country which is not, by its weakness, a hinderance to the full action of the 'spirit of artillery.'"

2. Has the *beau ideal* of a perfect gun, or any approach to it, ever been produced either in a single gun or in any regularly established system of artillery?

We think so, and we think that when Col. Brackenbury said that "there is not a single gun actually adopted for service in any country which is not, by its weakness, a hinderance to the full action of the 'spirit of artillery,'" he might well have made at least a partial exception to that statement in favor of a gun, and a system of artillery, concerning which we shall now proceed to quote much favorable mention, from quite a number of eminent authorities. We allude to the artillery system of Sir Joseph Whitworth, lately deceased, a celebrated English engineer, mechanic, and metallurgist, of whom circumstances made a gun manufacturer of world-wide reputation.

Quoting from Sir Thomas Brassey, we have the following, going to demonstrate the immense strength of a Whitworth gun, the superiority of the metal from which it was made, the fine character of the workmanship employed in the construction of the gun, and the superior quality of the projectile:

"Assuming the truth of the remarkable hypothesis of double loading (referring to the bursting of the Thunderer's 38-ton gun), it so happened that a Whitworth 12-inch muzzle loading 35-ton gun was nearly, three years ago, exposed to an accidental test involving a similar strain to that on the Thunderer's gun, a strain to which it did not yield. The Whitworth gun was one of four made for the Brazilian government, constructed entirely of fluid-pressed steel. They are shorter than the regular length, in order to suit the diameter of the turrets in which they are to be placed. . . . Forty-nine rounds were fired from the gun with projectiles of various weights, forty-seven rounds being fired for range and velocity, and two rounds for penetration. . . . The first round fired for penetration was with a flat headed steel shell, empty, weighing 808 pounds. The shell penetrated the two sets of 8-inch plates forming the front of the target, punching out two disks of its own diameter, which it forced into the backing, composed of oak and wrought iron plates, to a depth of about 36 inches from the face of the target. The shell remained entire, but was shortened 0·6 of an inch, otherwise remaining perfectly sound.

"The second round for penetration was fired with a flat headed steel shell of 808 pounds weight, with a bursting charge of 20 pounds of powder. This projectile passed through the first 8 inch plate, and then exploded, blowing one entire plate off the target. The second set of plates was also deeply indented and broken in several places. Owing to the bursting charge in the shell not having a sufficient thickness of flannel at the front, the explosion took place before the shell had time to penetrate the second plate.

"A third round for penetration, with an empty steel shell of 1,180 pounds weight, with which there was an unfortunate accident. [This accident is described to show that the fault was in the shell, the rear plug of which had not been screwed home up to the collar, and the threads of the screw-plug had thus to bear the whole force of the 120 pounds of powder, and were consequently stripped off. The account continues]: It is attributable to the great strength of the metal of which these shells are made that the results described took place, as had the shell been of the usual comparatively weak material, it would have broken up at once under the strain to which it was subjected, and the gun would not have suffered. As it was, the injury was confined entirely to the muzzle end of the inner tube. No other part of the gun, except the copper vent, was in any way affected. Since the return of the gun from Gavre, the injured tube has been replaced at the request of the Brazilian officers. The gun has also been revented, and is now as good as before the accident. During the process of boring out the tube a piece was cut from the muzzle end, and a test piece made from it, which gave a strength of 46·7 tons per square inch, with an elongation of 20 per cent. This test proves that the firing of the gun might have been continued with the injured tube.

"Previous to the tube being bored out, Messrs. Whitworth were anxious that the gun should be fired again, but the Brazilian government declined to have further experiments. Notwithstanding the enormous strain the gun had been subject to, there was not the slightest appearance of powder gas on the breech screw when it was removed from the gun. The threads were as bright as when first put into the gun, affording ample evidence that the plan of closing the breech is effectual, not only under ordinary circumstances, but was also sufficient with the enormous pressure there must have been when the accident occurred. The pressure of gas in the gun was in effect exploding 120 pounds of powder in a closed cylinder, for the copper vent was entirely closed up, and the sides of the shell were wedged against the bore of the gun, which checked its passage along the bore until the shell broke up. The amount of this pressure may be imagined from the fact that three inches of the copper vent above the platinum were actually melted away."

We will give another example illustrating the power of a Whitworth rifle and the quality of a Whitworth projectile, and we would say that we think that the account of the performance of this gun merits the closest attention, because, so far as we are informed, it describes a feat in artillery practice which is without any parallel. The gun was a 9-inch Whitworth breech-loading rifle, laid at a distance of 90 feet from a target composed in the following manner:

"(*a*) A wrought iron plate, 18 inches thick, made by the firm of Sir John Brown & Co., Limited. (*b*) A steel cylinder, 37 inches long, placed horizontally, filled with sand rammed hard. (*c*) A backing consisting of a steel plate 1⅛ inches thick, furnished with T-pieces supporting a series of oak balks 7 inches thick. (*d*) Cast iron support, 19½ feet long, 14 inches deep, 5 feet wide, intended to keep the backing in a vertical position. (*e*) Balks to strengthen the foot of the cast iron supports. These balks were bedded on the ground and covered with wet sand, their ends resting against wooden piles set in the ground vertically."

The gun was fired with a charge of 197 pounds, one hole block prismatic powder, and a pointed steel shell, empty, weighing 403 pounds, and 4 calibers in length. The projectile cleanly penetrated the 18 inch armor plate, the cylinder filled with sand, which burst, the backing of oak and steel, and, leaving the cast iron support, penetrated the sand at a distance of 17 feet from the front face of the armor and 4 feet from the lower edge of the cast iron support. The projectile which had produced such great mechanical work, up to that time never arrived at by any other system, was even found capable of reproducing the same effect, showing merely a slight shortening of its curved point. At the distance of 28 meters from the muzzle of the gun, the projectile passed through 18 inches of wrought iron armor, 1·4 inches of wrought iron, corresponding to a lining of steel 1⅛ inches thick, which formed the backing, 7 inches wood of the backing, 37 inches sand wet and rammed, 112 inches cast iron support, 80 inches wet sand. All which, taken together, are equivalent to a resistance of 23 inches of wrought iron.

PECULIARITIES OF THE WHITWORTH SYSTEM OF ARTILLERY.

It becomes interesting now to inquire somewhat into the particulars of this Whitworth system of artillery, the method of its manufacture, the material from which made, etc. Very briefly it may be described as follows:

"The Whitworth construction belongs to the all steel 'type,' and differs in almost every particular from the other types. The guns are both muzzle and breech loaders. The body of the gun consists of a steel tube re-enforced by steel hoops. The tube is cast solid, and submitted to a heavy hydraulic pressure while in a molten state, giving the metal as it solidifies a perfectly homogeneous crystallization throughout. This tube is bored completely through, and in the muzzle loaders the breech end is closed by a steel screw plug. The hoops are hollow cast and forged on a mandrel, the lengths in the different layers being accurately turned and screwed together. The layers are then put on the gun, and, though originally forced home cold from the muzzle end, are now understood to be shrunk on hot. The Whitworth groove is of a peculiar nature, the bore being almost a perfect hexagon, and having an extremely sharp twist of from one turn in two feet in the 2 pounders to one turn in thirteen feet in the 9 inch. The projectiles are cut to fit the grooves, the armor-punching ones being of compressed steel."

It is a well known fact that the Whitworth is the established system of artillery for Brazil and has been so for many years, and it is well to note how and why they came to adopt it. The Brazilian Committee on Artillery Studies, after nearly two years of consideration of the various systems of cannon, pronounced definitely in favor of the Whitworth rifle cannon as that which from its material, the process of manufacture, and the system, most nearly approached perfection. The committee emphatically condemned the system of cast iron strengthened by wrought iron bands as unscientific and practically proved inefficient. The Krupp gun, of Krupp cast steel, strengthened with bands, they considered unreliable, notwithstanding its fine material. This superiority of the Whitworth cannon the committee ascribed to the quality of the homogeneous steel used, the care in its selection, to the oil tempering which it received, to the use of the hydraulic press instead of the hammer, and to the mode of constructing and connecting the cylinders and other parts of the gun. In relation to the quality of endurance, the committee mentioned that, while the Krupp cannon had an average life of 600 to 800 shots, the Whitworth cannon employed by the Brazilian forces during the Paraguayan war had averaged 3,500 to 4,000 shots each, without a single case of bursting or serious damage having occurred among them. Sir Thomas Brassey says:

"Before the present conflict between Chili and Peru, the Whitworth guns had perhaps been used in actual war to a greater extent than any of the existing naval heavy rifled guns, many of these steel pieces having been on board the Brazilian ships in the Paraguayan war. If they were ordered as late as the date of the equipment of the Independencia, it is clear that Brazilian officers were satisfied with their experience of them."

SOME OPINIONS AS TO THE WHITWORTH SYSTEM.

Admiral Porter, in 1870, commended the Whitworth ordnance to the Hon. Secretary of the Navy in strong terms, as follows:

"In the Armstrong gun there is a combination of steel and iron, and the union of any two metals is always objectionable. The gun is, moreover, 'built up,' and the numerous welds are so many weak points. Finally, the gun is extremely expensive. In the Whitworth system all these objections disappear, as but a single method is employed in the manufacture; yet the British government adheres to the Admiralty gun, and upon the latter depends the supremacy claimed for the royal navy. That the claims of the British are not altogether well founded may be inferred from the fact that serious injuries have already been discovered in their 18 ton gun, and they have reduced the charge in their 25 ton gun, throwing a shot of 600 pounds." It has been found at the Whitworth works that from the metal there in use can be made guns bearing a tensile strain of 84,000 pounds to the square inch. This is not on the Bessemer or the forged steel principle, which is not so strong as the Whitworth, because the metal is never free from porosity, but is simply molten decarbonized metal, which is poured into moulds, and subjected to great compression while cooling, by means of a very powerful hydraulic press. The immense pressure closes all the pores in the metal, and, bringing its particles into close proximity, the result is the production of a casting having all the tenacity of forged steel combined with the special convenience and economy of cast steel. The press at present in use has a power of 2,500 tons, and another which the Whitworth company are now building will exert a pressure of 8,000 tons, and will be used to exert a pressure upon castings of 20 tons to the square inch. With this pressure no moulds will stand except those made of the Whitworth metal itself. In the above extracts from the report of First Assistant Engineer R. H. Thurston, you have the principle on which the Whitworth gun will be made in the future, and here we find the means by which we can obtain a cheap and effective gun that will at once, as respects ordnance, place us on an equality with any other naval power. Unless blind to our own interests, we cannot permit such a principle as this to go unnoticed, and means should be at once adopted to secure its introduction in our service, if it is correct.

"To sum up the advantages of guns made by the Whitworth process: 'The metal can be relied on to bear a tensile strength of 45 tons per square inch, and to elongate 24 per cent. before breaking.' Here then is a metal that will enable us to cast the toughest and lightest smooth bore gun, and is yet sufficiently hard to stand the friction of any steel projectile that may be fired from rifled ordnance—a desideratum long sought for in the fabrication of our guns, but never before attained. For shells intended to penetrate armor, we have here also the metal that will not crumble to pieces against the hardest plates, and that made into a chilled or flat headed shot will cut through the toughest iron."

We will now make a few extracts from "Reports U. S. Commissioners Vienna International Exhibition, 1873":

"The Whitworth ordnance has a power of penetration and a range exceeding other guns by probably 30 per cent. The fact that the British government has persistently refused to adopt, or even countenance, this system is one of those singular instances of willful disregard of proven facts, or of official indifference to public interests, which it is difficult to account for, except on the supposition that private prejudice or private interests have been permitted to control the action of the departments. The result is unfortunate for Great Britain, but it may prove fortunate for her enemies. . . . These guns are manufactured very readily by modern methods, and there is no objection to their adoption on the score of economy. Their ammunition is cheaply made, and can be produced in large quantities, when demanded by the exigencies of war, promptly and at a comparatively small expense. Whitworth estimates the time of fitting the rough casting to gauge, and turning it out ready for use, at twelve minutes, and the expense at less than three pence. . . . In proving his guns the maker has sometimes adopted the novel expedient of securing the projectile in the gun and firing a diminished powder charge behind it, permitting the gases to escape only by the vent. . . . In putting the gun together, Sir Joseph Whitworth dispensed entirely with the rude and usually awkward and hazardous process of shrinking the cylindrical 'rings' upon the core, and adopts the more mechanical and satisfactory plan of turning and boring the parts to an exact fit, and forcing them into place by means of the hydraulic press. The hydraulic press is also used by Whitworth in forging the parts of the gun as Haswell uses that machine in forging the details of locomotive work. . . . In making shot and shell, Whitworth uses a moulding machine, and has succeeded in making such smooth and accurate castings that they can be used without loss of time or money in tool-dressing. They are, when of iron, cast of Pontypool (Welsh) white iron, which chills well and makes remarkably smooth and solid castings. . . . In the year 1870 the writer (Thurston) examined the principles, the design, and the methods of manufacture of the Whitworth ordnance, and made a report (Report of the Secretary of the Navy, 1870, p. 172 *et seq.*) on the rival systems of Great Britain, at the request of the Admiral of the Navy, exhibiting its superiority to the other systems of ordnance then known, and urging its thorough and immediate experimental examination and provisional adoption. There seems to be no reason to doubt the correctness of the conclusions then arrived at. The system is philosophical, mechanical, effective, and economical. . . ."

"*Institution of Mechanical Engineers.—On Fluid-compressed Steel and Guns. By Sir Joseph Whitworth, Bart., D.C.L., F.R.S.*

"The difficulty he experienced in obtaining sound ductile steel led the writer to institute experiments in compressing steel in a fluid state. For melting steel there are in operation at his works in Charlton Street, the crucible, the Bessemer, and the Siemens-Martin processes; and pressure is applied to the fluid metal, in each case, as quickly as possible after it leaves the furnace. . . . The power of elongation, represented by the word ductility, is of the first importance for some purposes, as in guns, torpedoes, boilers, etc., and whenever severe strains might be suddenly applied; while in some cases, as in cutting tools, the strength of the metal is of the first importance. Cylinders of steel, to resist with safety the strains produced by gunpowder, should have a ductility of 30 per cent. More than this is unnecessary, for cylinders of such metal do not fly into pieces when burst, but simply open out or tear like paper, and a metal of greater ductility would not therefore be required for any structural purposes. It is now possible to produce with certainty, by the compression of fluid metal, steel that will bear a strain of 40 tons per square inch, which elongates 30 per cent. of its length before breaking—the length of the test recommended by the author being two inches and its sectional area one-half a square inch. Such a metal would not harden sufficiently to cut other metals. . . .

"*Forging.*—The steel castings are forged by either the steam hammer, the rolls, or the hydraulic press, or a combination of these; but for large forgings generally there is a great superiority in the work produced by the hydraulic forging press. For the stroke of a press is that of a continuous pressure, and it is effective right through the mass of metal; whereas the blow of the steam hammer is largely expended within a short distance of the surface, while the center of the work is for a certain period comparatively unacted upon, and therefore the different parts of the metal of the forgings produced under the hammer exist in very different molecular conditions. This is not the case, as before stated, when the forging press is employed."

Cavalier de Cuverville, Capitaine de Vaisseau, in his "Progress in Naval Artillery from 1855 to 1880," says:

"Steel in general, but above all cast steel such as is

employed by Whitworth, that is to say, compressed in the liquid state, forged under powerful hydraulic presses, which knead it, so to speak, and form it over mandrels without the injurious action of the hammer—this steel tempered in oil *is, without exception, the metal for guns*, because with a relatively high elastic limit, which insures it against disfigurement as the result of firing, it possesses a high tenacity, and a total elongation before rupture, which increases its strength and guarantees the gun against the chances of bursting. It is capable of assuming a variety of attributes, which permit the choice of the particular quality of metal demanded by the object in view. It allows, finally, the construction of ordnance which for equal power weighs much less than that of cast iron fretted and tubed. . . . While works were being pursued in France which completely changed the iron industry and led two of our principal establishments to erect 80 ton steam hammers—Le Creusot and St. Chamond—important results had been also obtained abroad. In view of the present extended use of steel, it can be but regretted that these magnificent establishments should not have preferred the Whitworth system of forging by hydraulic pressure to that of forging under the hammer, in order to secure homogeneous steel, which both simultaneously adopted."

"*Extract from a paper read before the British Association by Mr. B. Baker, M.I.C.E., on the Forth Bridge.*

"It is hardly necessary to state that the whole of the superstructure will be of steel. . . . The steady pressure of hydraulic presses is to be substituted for hammering wherever practicable, and annealing will be required if the steel has been distressed in any way."

In the House of Lords, on Feb. 10, 1882, the Duke of Somerset, in making some inquiries of the First Lord of the Admiralty, said he had long since come to the opinion that we must adopt breech-loading guns, and if we had them we could do with guns of fifty or sixty tons instead of one hundred tons, if we had compressed steel, and if that were not possible at present, it would be soon.

It is unnecessary here to go over the recommendations of our own "Gun Foundry Board;" they are quite recent and, as is well known, they were strongly in favor of the Whitworth metal and methods of treating the same.

IS SLOW-BURNING POWDER A GOOD THING OR A TRICK OF THE TRADE?

3. Slow-burning powder—Why has it come into use? Is it a good thing, a necessary and economical innovation, or is it a mere "trick of the trade," introduced to nurse along incompetent, unmechanical, and unscientific gun construction?

Let us hear first from Longridge, an eminent physicist, engineer, and mathematician, and for a great many years past a profound student of ordnance matters. He has a great deal to say upon the subject, but we shall make only a few extracts:

"Slow-burning powder is not *per se* an improvement as regards developing propulsive force. It is a retrograde step toward the practice of the Chinese. If we have a strong enough gun, the quicker the powder the greater will be the effect of it, *weight for weight.* Col. Maitland says that the great desideratum in a powder is 'to obtain a low maximum pressure, long sustained.' Let us consider this. Take the case of the 8 inch gun fired with 35 lb. pebble powder and 180 lb. shot, length of barrel 112 inches, initial velocity 1,374 feet per second. In this case the maximum pressure was found to be 15 tons per square inch at 29½ inches from the breech end of the gun, and this was reduced by expansion to about one ton per square inch at the muzzle. The mean of all the pressure on the shot during its passage to the muzzle was about six tons per square inch. Now, if Col. Maitland's desideratum were attained, we should have a powder burning slowly and developing this pressure of six tons all the time. When this shot left the muzzle, there would be in the gun 327 cubic feet of gases at a pressure of six tons per square inch, all of which would be dead loss, and the work thus lost would be equal to the whole work expended on the shot in the first case during its passage through the last 50 inches of the chase. This is on the assumption that the weight of powder used was the same in both cases. Now suppose that the whole of this powder were ignited and converted into gas before the shot moved; we should then have an initial pressure of at least 25 tons per square inch, and a mean pressure of about 10 tons per square inch, and the shot would leave the gun with a velocity of something like 1,780 instead of 1,370 feet per second. Neither can I agree with Col. Maitland in his views of the relative effect of quick and slow burning powder in straining the gun. No doubt the slow burning powder strains the gun much less, and with a weak gun this is a great point gained; but Col. Maitland's reasoning about this is altogether fallacious. He says:

"'When quick burning powder was used, the metal in immediate proximity to the charge was called upon to undergo severe strains which had scarcely time to reach the more distant portions of the gun at all. The exterior was not nearly so much strained as the interior.' . . . The velocity of the transmission of a strain through any material is, in fact, the velocity of the transmission of sound through the same. In iron this is 15,500 feet per second, in steel from 17,000 to 18,000 feet per second. . . . As the size of guns increased, it was found that the powder was too strong for the guns, and efforts were directed to the production of a slow burning powder *to reduce the strain on the gun.* Thus the weakness of the gun was the real cause of the production of slow burning powder. . . . The real *cause* of the alteration in the powder *was the weakness of the gun*, and its legitimate consequence is not the adoption of breech-loading, but the lengthening of the gun. . . . It is, moreover, rather curious that one of the advantages claimed for this expanding band of soft metal (on the base of the rifle projectile) neutralizes *pro tanto* the advantage of the slow burning powder. The object of the slow burning powder was stated to be that it decreased the initial pressure.

"The shot moved gradually away under a gradually increasing pressure. We are now told that the function of this band of soft metal is to prevent the shot running away until, by the more complete combustion of the charge, the pressure has accumulated behind it. Surely this is equivalent to getting back toward a quick burning powder. . . . But when it is said, as it often is, that a slow burning powder gives a greater muzzle velocity, an assertion is made which is not true, *if the weight of the powder remains the same.* When slow burning powder is used, a larger charge of it must be used to obtain the same muzzle velocity. . . . There appears also to be an opinion that in the explosion of powder in close vessels or guns there is a 'liquid residue,' which continues to give out heat while the projectile is moving along the bore. . . . But beyond this there is a fundamental objection against such an action (of 'liquid residue') as regards its useful effect, which is fatal to this theory, as it also is to all the presumed ballistic advantages of slow burning powder. This objection rests on the thermodynamic law which is expressed as follows: 'Any thermal machine which works between given limits of temperatures gives the maximum useful effect when all the heat is received at the highest temperature and rejected at the lowest.' In conformity with this law, the highest useful effect that can be obtained from gunpowder is when the whole of the heat is developed in the powder chamber before the shot begins to move, and this indisputable fact at once disposes of all the asserted advantages of a prolonged development of heat, whether derived from a liquid residue or a slow burning powder. . . . A great deal has been said about the effect of what is called 'dissociation.' It is asserted that at the very high temperature existing in a gun in the vicinity of the charge, the chemical reactions which give rise to the gases do not take place, but that as the shot proceeds toward the muzzle the fall of temperature allows those reactions to take place, and by the evolution of gases keeps up the pressure. But this is at direct variance with the evidence of the Crusher gauges, and rests, so far as we know, on pure hypothesis. If it were true, the pressure curve would be higher as we proceed from the breech than is given by the formula, and it would be lower near the breech. There is every reason to believe that the contrary is really the case, and it seems to us quite impossible to admit such a hypothesis as entitled to any weight in determining the pressure at different parts of the bore. . . ."

In a paper read April, 1882, at the Society of Arts. Col. Maitland discoursed at some length on the merits of slow burning powder, and he said in summing up that the great desideratum was "a low maximum pressure long sustained." Suppose, then, this desideratum perfectly realized, and that a powder is obtained not differing in chemical constituents, but which has the property of so burning as to give a uniform pressure on the base of the projectile from its first start till it leaves the muzzle. Suppose a gun with a charge of 1 lb. of powder at density=1, and of such length as to give five expansions. In this case the powder will give out 91 foot tons of work to the projectile. In the other case, with the same gun there must be a uniform pressure of 18·2 tons, and when the projectile leaves the muzzle the gun will be filled with powder gas at this pressure. The density of this gas will be 0·66, and as the volume is five times greater, the weight of the gas will be $5 \times 0{\cdot}66 = 3{\cdot}3$ lb. In other words, 3·3 lb. of the *improved* powder will just do the same work as 1 lb. of the old quick burning powder. This is beyond dispute, and no jugglery about "dissociation" or rate of combustion can alter it.

Says Sir Joseph Whitworth, in a paper read before the Institution of Mechanical Engineers:

"With weak materials, weak powder, long guns, and short protectiles must be used. Strong, ductile, sound material allows of strong, quick burning powder, short guns, long projectiles, and rapid rotation. Long projectiles give greater penetration at both long and short ranges, also a much lower trajectory, except at the lowest elevations, for very short distances."

From a Whitworth gun you may fire anything from a rifled sphere to a rifle projectile *ten* calibers in length. You may fire, from one of them, a half a dozen rifled spheres at one discharge, and this, under many circumstances which can easily be imagined, is a matter of the greatest consequence, for the rifled spheres fly well together for short ranges, and strike a tremendous blow. Imagine their effect against a torpedo boat or an unarmored cruiser, etc. We have already quoted Col. C. B. Brackenbury, R. A., late Superintendent of the Royal Gunpowder Factory, Waltham Abbey, but we must have him right here again, in connection with this slow burning powder question. In a recent paper, read at the Royal United Service Institution, he says:

"There is not a single gun actually adopted for service in any country which is not, by its weakness, a hinderance to the full action of the 'spirit of artillery.' When gun makers say, as they frequently do, that their gun will produce a certain effect provided that a suitable powder be found for it, they mean, provided that the strength of gunpowder be restrained, cribbed, cabined, and confined, to suit the weakness of the gun. We sometimes see in human life a great and strong spirit tear to pieces a feeble frame which contains it, and we do not say, 'What a pity that the spirit is so strong!' but rather, 'How sad that the body is so weak!' In the case of artillery, we are always subduing and taming the spirit, instead of strengthening the body. This may be necessary under existing circumstances, but if so, the circumstances are unfortunate, and stand in the way of getting the most value out of the 'spirit of artillery.'"

THE LINES ON WHICH WE SHOULD DEVELOP OUR ORDNANCE.

You are right, Col. Brackenbury, "the circumstances are unfortunate," they are infernally unfortunate, and we should not be overwhelmingly surprised should some clever statistician be able to figure out that thus far Krupp, Armstrong, and Woolwich guns have wounded and slain somewhere in the vicinity of as many friends as foes. We have only one account of accidents at hand, but it is extremely interesting so far as it goes. Colonel Hennebert, in a communication to the *Correspondant*, speaking of the German artillery, says of Krupp: "When we took some guns from the Chinese during the Tonquin expedition, they were made by Krupp; and more recently the heroic Gordon, shut up in Khartoum, mentioned the part played by these guns in the regions bathed by the waters of the White and the Blue Nile. And yet this *materiel* is far from being irreproachable. During the war of Bohemia, several field pieces burst. After the war, in order to allay public agitation, trials *à outrance* were made, and these cost several young officers their lives. In 1868, General De Bœuf declared that several guns firing ordinary charges had burst. Nor can it be said that the Prussian steel guns of to-day are safe. In fact, between 1867 and 1870, numerous accidents occurred in Russia, England, Germany, and Italy, on land and on board ship." Colonel Hennebert says that during the Franco-German war 200 Krupp guns burst, as mentioned by Major Haig in a report read before the Royal Artillery Institution, and by the Duke of Cambridge in a speech in the House of Lords on April 30, 1876: "Out of 70 heavy guns employed against the southwest of Paris, 36 were disabled during the first fortnight of the bombardment by the effect of their own fire. At Versailles it was thought that if the French had held out a week longer, the German siege batteries would have been reduced to silence. It is equally certain that during the campaign on the Loire, Prince Frederick Charles had 24 of his guns disabled by their own fire."

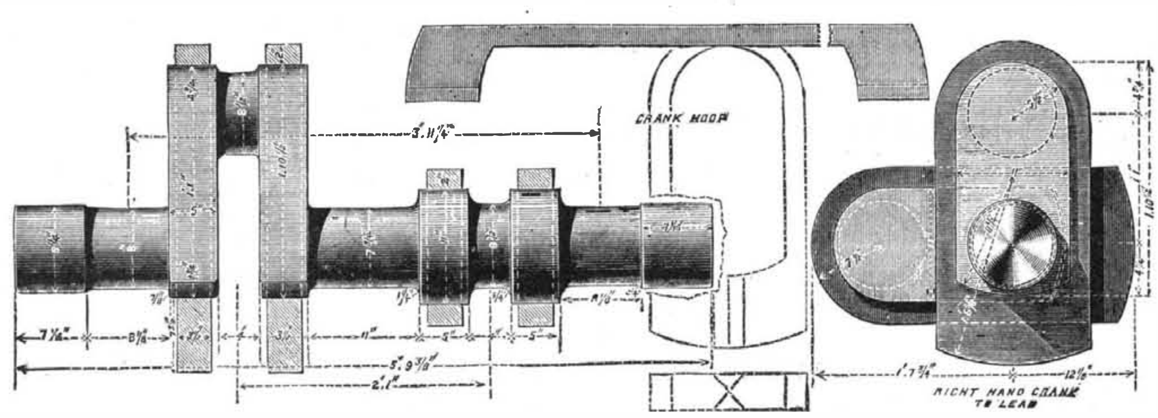
Truly, "the circumstanees are unfortunate," and in Europe they are likely to continue so, for well-known reasons. But in this country there is no reason nor excuse for going astray—the Gun Foundry Board have done their duty. Whitworth has shown how to make guns which do not burst, and which do not wear out in 200 rounds, no, nor in 5,000 rounds. Many have shown the fallacy of costly slow burning powder, with the necessary accompaniment of abnormally long, heavy, and unwieldy guns. Why, therefore, do we not here, at the outset, commence our development of our new ordnance upon proper and well marked out lines of procedure? Why go on fooling with conversions, with the multi-charge gun, with guns composed of forty different kinds of metal, etc.? With the complications already existing to the north and to the south of us, with foreign nations constantly seizing and fortifying strategic positions all around us, it is not difficult to imagine that we may very shortly be in the most urgent need of the most effective, safe, and durable artillery which can possibly be produced, and plenty of it. G. W. Sumner, Commander, U. S. N.

Washington, D. C., Feb. 10, 1887.

HOOPED CRANK AXLES, LONDON AND BRIGHTON RAILWAY.

It has been pretty clearly proved that the hooping of a crank strengthens it very materially at that part which, from the narrowness of the gauge, is made weaker than it ought to be. In addition to this, it provides, in nearly every case, for the safety of the crank should it break in the usual place through the web, as the engine runs home without causing any delay or damage. The ordinary plain heavy hoop, which Mr. Stroudley has used for the last seventeen years on some classes of engines, interfered with the balancing of other high speed engines which had not been fitted with these hoops, and he has therefore devised the present balanced hoop which we illustrate to counteract this.

The engraving shows the crank for B and C class—express passenger and goods engine—with its hoops in position, and also the manner in which the hoop itself is forged and smithed, by which it will be seen that it is an extremely easy hoop to make. The crank is turned on the outer ends of the webs to the mean center, that end nearest the axle is left in this form, but the crank pin end of the web is slotted to a circle set somewhat eccentric to the crank pin, so as to reduce the overhang as far as possible. These hoops are planed on both sides, and bored for the circular end, the other part of the inside being slotted. The hoops are made $\frac{1}{16}$ in. shorter than the crank web, and are heated up to a dull red, and are shrunk upon the crank. It makes a very nice-looking piece of work and does not disturb the original balance of the engine, at the same time it is not more costly to make than the ordinary crank hoop, except the trifling extra piece of metal, while we are absolutely sure that the weld could not possibly affect the total strength of the hoop itself.—*The Engineer.*



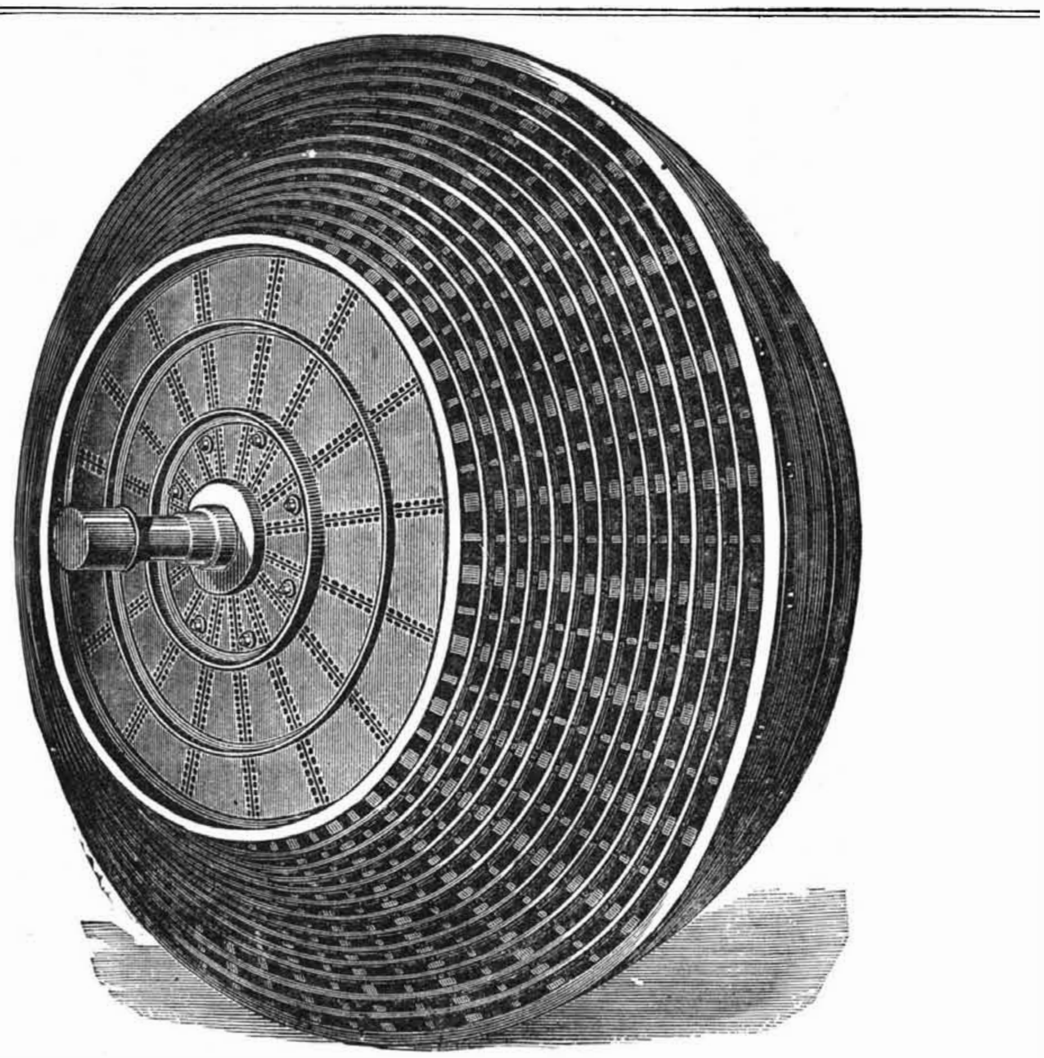
CRANK AXLES, LONDON AND BRIGHTON RAILWAY.

LARGE WINDING ENGINES AND WINDING DRUM.

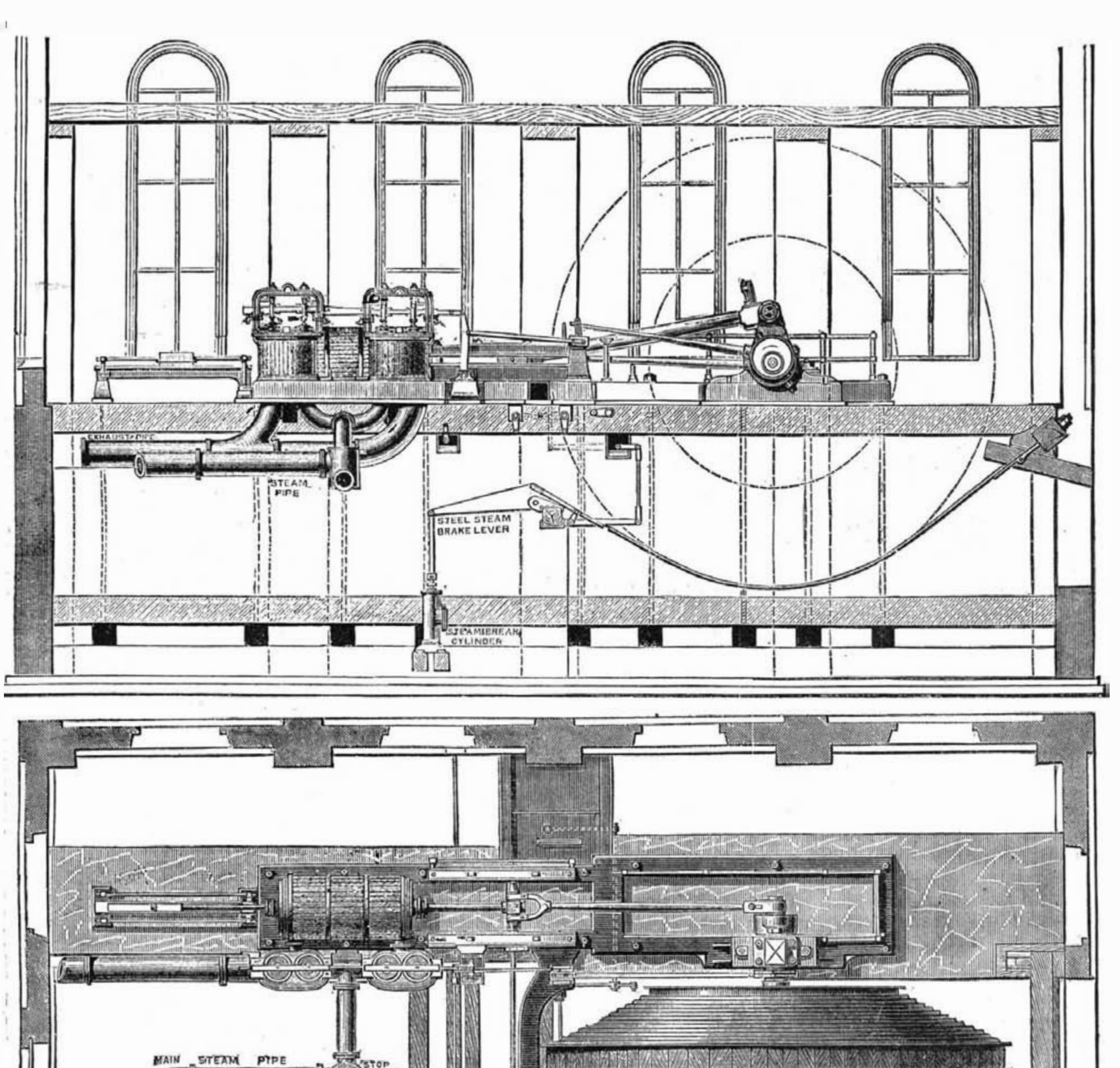
ON the 12th of October last year was started the permanent winding engine at the Lady Windsor Pit, Ynysybwl. The Lady Windsor Colliery is situate in the Clydach Valley—a mile below old Ynysybwl—in the direction of Pontypridd. Mr. Beith, M.E. (Beith Brothers) started sinking on the 16th of June, 1884. In sixteen months and four days from that time he reached the lowest seam. There are three coals which it is contemplated to work almost immediately. The No. 1 coal, at a depth of 541 yards, is 6 ft. 8 in. thick; the No. 2 coal, at a depth of 559 yards, is 7 ft. 6 in. thick; and the No. 3 coal, at a depth of 601 yards, is 9 ft. 10 in. thick. The whole series is of the finest quality smokeless steam coal. The shaft has been sunk to a total depth of 630 yards. The Schiele fan for ventilating the colliery is guaranteed by the makers to deliver 300,000 cubic feet of air. The sinking was, it is said, an unexampled feat in the history of the Welsh coal field. The down cast—the winding—pit is 19 ft. in the clear of the brickwork, and the up cast is 17 ft. The permanent winding machinery was erected during the sinking.

We illustrate the winding engines constructed by Messrs. Daglish & Co., St. Helen's. The steam cylinders of these engines are 42 in. diameter, and the piston has a stroke of 7 ft. The piston rods are of steel carried through both ends of the cylinder, and are 6½ in. diameter at the front end and 5½ in. diameter at the back end. There are two valve boxes to each cylinder, each valve box containing two gun metal equilibrium valves; the steam valve has an area of 95 in., and the exhaust valve an area of 113 in. The valve spindles are of steel, 1¾ in. diameter. These valves are worked by eccentrics on the drum shaft, with an improved arrangement of the reversing link motion. The arrangement for opening and closing the valves is the patent of Mr. Geo. Heaton Daglish, and is an adaptation of the motion of the slide valve to that of the lifting valve. The radius rod of the link motion is connected by suitable levers to a long sliding bar working in frames on the top of the valve boxes directly over the valves. On this bar is fixed a cast steel cam for each valve, working through a lifting box screwed to each valve spindle, and which has a cast steel roller under which the cam works. These cams are fixed on the bar in such a position as to lift the steam and exhaust valves of each box alternately, and being loose on the bar and secured by a bolt, are capable of the nicest adjustment, and are made of such a form as to lift the valve rapidly, and will also close the valve in its return stroke, should there be any tendency to stick.

The sliding bar is carried on anti-friction rollers, so as to make the reversing motion as easy as possible to the engineman. This arrangement of valve gear has now been at work for ten years on other engines made by the firm, and has given great satisfaction both in the speed attained by the engines, the easy handling by the engine man, and by the almost total absence of wear. The crossheads, connecting rods, and cranks are all of the best hammered scrap iron. The crank pins are steel, 9 in. diameter and 12 in. long. The foundation plates are 18 in. deep and 1½ in. thick. The slide blocks are 28 in. long and 9 in. wide, with adjustable slippers on the bottom side. The bearings of the drum shaft are 18 in. diameter and 30 in. long.



STEEL WINDING DRUM, BLACK ROCK COLLIERY.



WINDING ENGINES AND STEEL DRUM, BLACK ROCK COLLIERY.

The winding drum illustrated herewith is made entirely of Siemens-Martin steel, with the exception of the two main bosses of cast iron, which fit on the drum shaft; and is constructed under the method patented by Mr. Geo. Heaton Daglish. It is made on the spiral conical principle, and is 18 ft. diameter at the base of the cone and 33 feet diameter at the top of the cone. The spiral grooves on the face of the cone are made of a specially rolled section of steel to suit the rope. The cone is formed of strong frames of T section, without any plates, and well tied and braced together. The face of the cone is curved in such a way as to allow the grooves to be fixed at uniform pitch, and at the same time to give ample tangential clearance to each succeeding coil. Distance pieces are riveted between each coil on every frame, so as to reduce the strain of the load on the rivets of the coil. The gross load starting from the bottom of the shaft is twelve and a half tons.

At present there are six boilers placed in position, but five only are used. When the colliery is in full work, it is expected that as many as twelve boilers will be required. The fan, it should be added, is 14 ft. 6 in. diameter. It is worked by a single 26 in. cylinder engine, with a 4 ft. stroke. Arrangements have been made in the construction of the engine house for duplicating the engine power if necessary. The engine house itself is spacious and lofty, and though it seems to be lightly constructed, is yet so firm and solid that the vibrations of the immense drum are scarcely felt.

The large arches at the pit bottom, opposite four roadways, are 22 ft. 6 in. in the clear, and about 16 ft. high. Humble's detaching hooks are used for winding. They are safeguards against overwinding. The cages for carrying the coal up to the surface are spacious enough to take two trams of the size used by the Ocean Company, so that four tons of coal are raised at each lift. The main outlet for the coal will, of course, be the down cast shaft, at which the winding engine is, but coal can be worked through the up cast shaft, some little distance off.—*The Engineer.*

ROTATION INDICATOR.

CAPTAIN G. RUNG, of the Danish Royal Artillery, and sub-director of the Meteorological Institute, Copenhagen, has recently brought out an ingenious pneumatic rotation indicator. This indicator differs very materially from the strophometer, the tachometer, etc., and has the advantage over these that it enables the speed of an engine to be ascertained at a very considerable distance, while the former appliances are confined to the immediate neighborhood of the engine, or, at most, to the limits within which rotation can be transmitted by mechanical means, such as belting, etc.

If a piece of India rubber hose is swung round by the hand, the air in the swinging portion of the hose will be driven out by the centrifugal force. If the hose is open at the center of movement, other air will enter and a current will arise. If the hose is closed, the air within it will become rarefied, and this will happen in distinct proportion to the speed of the open end of the hose. This speed depends partly on the diameter of the circle formed by the end of the hose and partly on the number of revolutions within a certain time, say a minute. With a fixed diameter the difference between the pressure of air outside the hose and that inside it, at its center of rotation, will be the measure of the number of revolutions of the hose per minute. This can be read by continuing the

hose beyond the center of rotation and connecting it with a manometer of some sort, *e. g.*, a V-shaped glass tube, filled with water, the one end of which is connected with the hose, while the other is open. The difference in the height of the water in the two branches will then illustrate the difference in the pressure of air in millimeters of water pressure.

When the rotary hose is connected through a tube, which may be of great length, with a regular vacuum gauge, the hand of this will assume a fixed position as soon as the rotary speed of the hose has become uniform. If the diameter of the circle formed by the hose remains the same, the movement of the hand will increase proportionately to the square of the number of revolutions. If the number of the revolutions remain unaltered, and the length of the swinging hose is increased, the air within it will also become rarefied proportionately to the square of the diameter of the circle formed by the end of the hose.

The mathematical formula will also show—

$$H = \frac{\rho \pi D^2 O^2}{2 \cdot 60^2} K,$$

where—

H is the pressure expressed by millimeters of water.
D the diameter of the circle described by the end of the hose.
ρ the weight of a cubic centimeter of air.
O the number of revolutions per minute.
K a constant fixed by experiment.

The value of ρ varies with the density of the air, which is influenced both by the atmospheric pressure and by the temperature, but this can be compensated by special arrangements.

The pneumatic rotation indicator consists of two principal parts, the rotator, which takes the place of the hose, and the indicator or the manometer. The rotator may assume different shapes. One of the simplest constructions is shown in Fig. 1. R is a piece of gas pipe, which revolves on an axis, the one end of which is hollow, and connects the interior of the pipe with a pneumatic tube, which again acts upon the indicator. A small pulley on the other end of the axis connects the rotator with the machine the speed of which is to be ascertained. As many indicators as desired can be connected with the pneumatic tube. Experiments have proved it to be immaterial whether one or both ends of the pipe (as in the engraving) are open, nor does it make any difference if a larger number of pipes are fixed to the axle. The same speed will always produce the same rarefaction.

It has already been mentioned that the factor ρ is dependent upon the density of the air, which, of course, varies with the temperature and the atmospheric pressure. Unless this is taken into consideration, the indicator would show a greater number of rotations with a high barometer and low temperature, and a smaller speed with a low barometer and high temperature, than is actually the case. What is wanted is that H with the same number of revolutions (O) always remains the same, even if ρ should change, or, in other words, the length of the rotary pipe must be altered according to the density of the air. This can be done by the aid of the annexed table, where the figures 0—10 signify the position of a small sliding pipe placed outside the rotary pipe, and which can be pushed further from or nearer to the axis, thereby altering the length of the pipe.

—	730 mm.	740 mm.	750 mm.	760 mm.	770 mm.
degrees.					
0	6	7	8	9	10
5	5	6	7	8	9
10	4	5	6	7	8
15	3	4	5	6	7
20	2	3	4	5	6
25	1	2	3	4	5
30	0	1	2	3	4

So far the question has only been of the speed, and not of the direction of the rotation. The indicator can, however, be so constructed that it will also demonstrate this point, which is of importance under many circumstances, more especially on ships. By the aid of Captain Rung's indicator, the captain on the bridge can ascertain whether his orders "ahead," "astern," or "stop," have been immediately carried out. This end is obtained in the following manner:

Experiments have proved that it is immaterial whether the aperture is at the end or on the side of the pipe, as long as the same speed is maintained. The only exception is when the aperture is on the side, and is so placed that it, during rotation, is subject to the resistance of the air. If a slanting partition is placed in the middle of the pipe, and if both axes are made hollow (see Fig. 2), the result is two independent pipes, each with its pneumatic tube. These two pipes are closed at the ends, but have each an aperture on the same side, so that one of these holes is always turning against and the other from the direction of the rotation, and, consequently, change their position whenever the rotation is reversed. If the two pneumatic tubes are connected with each other, the revolution of the rotator will cause an air current to pass through the tube, and the direction of this air current depends upon the direction in which the rotation is revolving. It now only remains to observe the direction of the air current, and this can be done in different ways. One may, for instance, place in the tube that connects the two axles a glass tube bent downward (see Fig. 2). In this tube is placed a ball of the pith of the alder tree. When there is no rotation, this ball will, of course, remain at the bottom of the bend and indicate "stop." An air current in one or the other direction will carry the ball to either end of the glass tube (where it is stopped by a small cross of wire). The letter H or the letter S will then show whether the engine is going ahead or astern. As possible dampness on the inside of the glass tube might interfere with the movements of the ball, preference is given to the following arrangement:

Instead of the glass tube, a flat box, placed on its side, is used for connecting the two parts of the pneumatic tube. The lid and the bottom of the box are of glass, the latter of ground glass (Fig. 3). From the center of this box two fixed partitions (s, s_1) proceed, and between these a third partition (v) of some very light material (*e. g.*, aluminum) is so placed that it can swing freely. It is connected with a hand on the other side of the box. The two pneumatic tubes open out into the box close to the two fixed partitions. The position of the loose partition and its pointer will, of course, depend upon the direction of the air current through the tubes. When the engine is not working, the partition will hang straight down and the hand point straight upward, indicating "stop." As soon as the engine is started, the hand will move to left or right, according to the direction of the revolution, being ahead or astern, and the hand will keep its position as long as the revolution continues. This appliance is placed outside a lantern, the light from which illuminates the dull bottom of the box with the letters H and S.

This appliance only shows the direction of the revolution; in case the speed, also, has to be indicated, a fluid pressure gauge may be used instead. The direction can then be ascertained by the fluid rising in the one or the other of the branches, and the speed by the height to which it rises. As the movement of the ship might cause the fluid to move in a U-shaped tube, Captain Rung has constructed a gauge with three branches (see Fig. 4). These branches are all connected at the base, while the two outside ones are joined at the top, and, when united, again connected with the one pneumatic tube. The other is connected with the central branch. When the engine is not working, the fluid will have the same level in all three branches. If the vessel rolls, the fluid will fall in one and rise in the other at the outer branches, while it will keep the same level in the middle one. Here an S is marked for stop. The two outer branches are covered, all the readings taking place in the middle one. The connections with the rotator are so arranged that the fluid in the middle tube will rise or fall according as the engine is going ahead or astern, and the degree of this rise or fall will depend upon the number of revolutions made by the engine. A gauge of this kind will not render very accurate readings possible, but it will in most cases be sufficient for the officer on the bridge to ascertain whether his orders, "full speed," "half speed," etc., are promptly carried out. Fig. 5 shows a manometer like the one just described, practically applied in a shape which is particularly well adapted for merchant steamers.

The rotator shown in Fig. 2 can also be connected with a self-registering apparatus, which can furnish evidence in collision cases, etc., as the engine virtually tells its own tale as to whether and when it was stopped and reversed.

Captain Rung's indicator is already in use on several steamers, and is giving satisfaction. From the commander of the Danish warship Iylland, where the distance from the engine room to the bridge is about 100 ft., a flattering testimonial has just been received, and the new Danish ironclad Iver Hoitfeldt is being fitted out with no less than eight of these indicators in different places. They are also being successfully used for the testing of cream separators, where a very great speed is reached, and it is under contemplation to make a special size for centrifugal dairies.—*Engineering.*

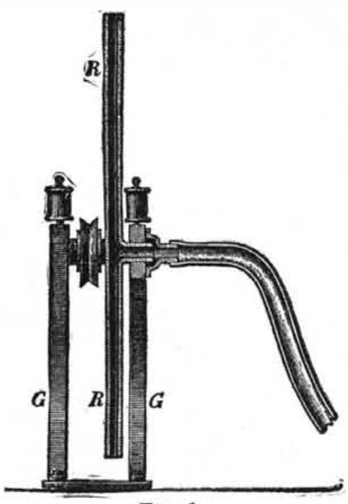


Fig. 1.

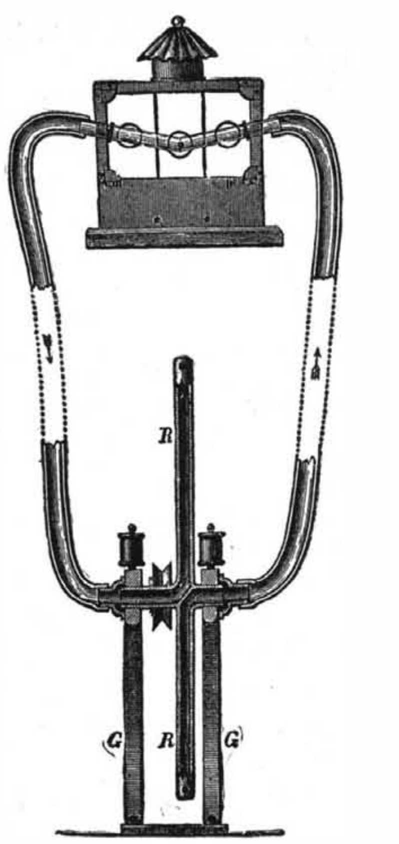


Fig. 2.

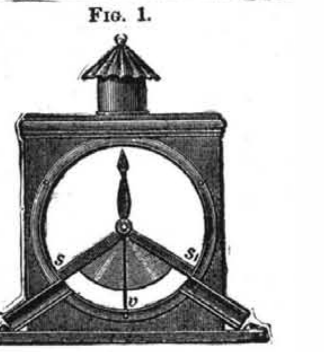


Fig. 3.

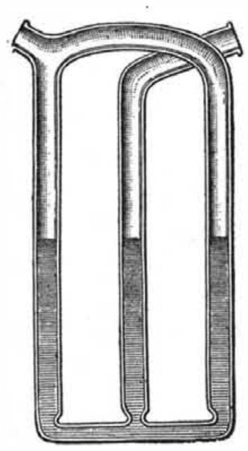


Fig. 4.

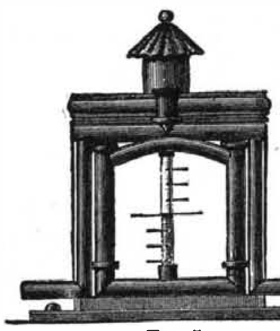
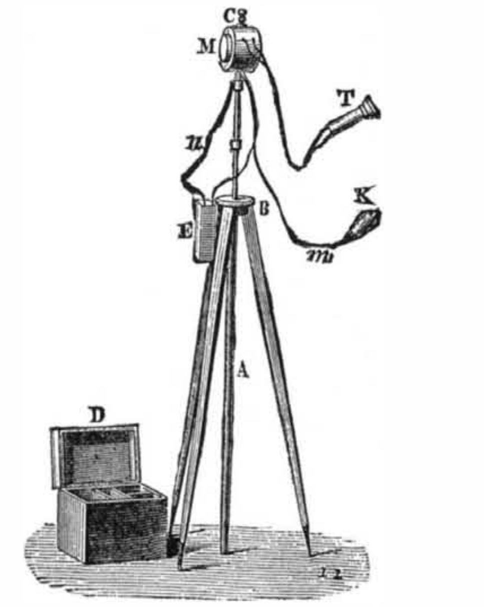


Fig. 5.

RUNG'S PNEUMATIC ROTATION INDICATOR.

THE HYDROPHONE.

MR. A. PARES, of Altona (Germany), has devised an extremely ingenious apparatus for detecting leakage in water mains, and the accompanying figure gives an illustration of it. A is a rod made of a substance that conducts sound well. This rod is held in a vertical position by a tripod, and to its upper extremity is attached a metallic box containing a microphone, M. The apparatus is completed by a regenerative dry pile, E, a telephone receiver, T, and a pear-shaped contact, K, that permits of leaving the pile circuit open, and of closing it only at the moment of observation.



PARES' HYDROPHONE.

On moving the rod, A, over the water pipe, any leak therein can be distinctly heard by the ear. It appears that the sensitiveness of the apparatus is such that the slightest leak in the pipes inside of a house can be ascertained from the street.

When the observation is made in a place where there is much noise, it is well to use two telephone receivers, or, if but one be used, to close one ear by means of a small device which Mr. Pares calls an antiphone, and which forms one of the adjuncts of the apparatus.

The microphone is so constructed that it can be fixed directly to a water conduit.—*La Lumiere Electrique.*

A WORD ON BASE-BALL-ISTICS.

By O. E. MICHAELIS, Captain of Ordnance, U. S. A.

AXIOMS.

(1.) The resistance of a medium to penetration increases with the velocity (rapidity) of penetration.

(2.) The angular velocity of a rotating body moving through a resisting medium is practically constant.

APPLICATION.

In Fig. 1, the ball is thrown in the direction A B,

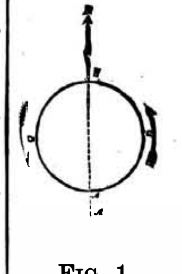


FIG. 1.

Center of Inertia coincident with Center of Figure.

FIG. 2.

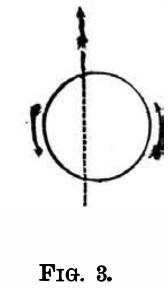


FIG. 3.

Center of Inertia not coincident with Center of Figure.

rotating to the left, as shown by the arrows. Evidently the hemisphere A C B rotates *with* the forward movement of the ball, and the hemisphere B D A *against* it. Therefore, the particles in the former are moving forward faster than those of the latter. Hence, by Ax. 1, the air opposes more resistance to the hemisphere A C B than it does to the hemisphere A D B. The ball accordingly follows the line of least resistance, and moves *inward*, as shown in Fig. 2.

When the "twisted" ball is delivered, its *initial* far exceeds its *angular* velocity. The first is rapidly reduced by the resistance of the air, the latter is not (Ax. 2). Hence there must come a time, when the angular equals, or possibly exceeds, the initial velocity; then the ball will begin to "curve" rapidly.

CONCLUSIONS.

(I.) The trajectory of the rotating ball is always a line of double curvature, but the effect of the angular velocity at the beginning may be so slight as not to be perceived by the striker, who thus receives the impression that the delivery is "straight."

(II.) With a given twist (or angular velocity), a very "swift" ball would not "curve" enough; a very "slow" one, too much. The "scientific" pitcher is he who, knowing this from practical experience, selects the most appropriate "pace."

(III.) A ball always deviates *with* the twist, unless it rotates about the axis of projection, in which case the twist will produce no deviation.

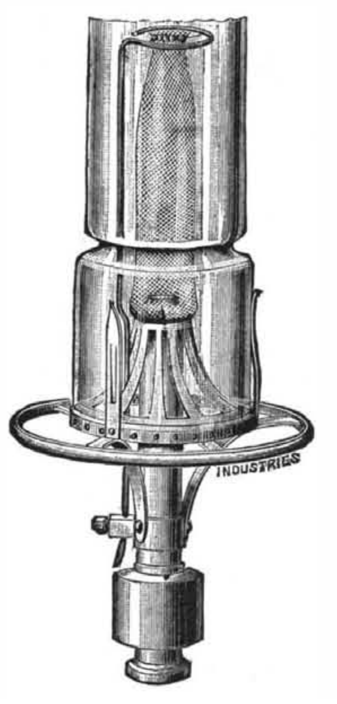
The above is a *popular* explanation.—*Jour. Fr. Inst.*

THE WELSBACH INCANDESCENT GAS LIGHT.

WE present an illustration of the burner. By the courtesy of Mr. Conrad Cooke, the consulting engineer to the Welsbach Company, we were enabled to test the performance of this burner for ourselves, and the following table gives the result obtained with two different burners:

Gas pressure in inches.	Candle power.	Cub. ft. per hour.	Efficiency. Candles per cub. ft.
0·73	13·0	1·75	7·42
0·83	15·5	1·98	7·83
1·00	16·5	2·25	7·32
1·18	16·5	2·35	7·00
1·25	16·0	2·42	6·45
1·00	15·8	2·25	7·00
1·23	14·0	2·47	5·70

If the figures given in the first five lines of the table, which refer to the more perfect of the two burners



tested by us, be plotted in a curve, it is found that the best performance is obtained with a gas pressure of 0·90 of an inch, when 7·80 candles are produced for every cubic foot of gas consumed. It is interesting to note that the efficiency of the burner, that is, the number of candles obtainable with one cubic foot of 16-candle gas, varies with the gas pressure, and this can be explained by the fact that a certain proportion of air and gas must secure the most perfect combustion, while an excess of either must render the combustion not only less perfect, but also reduce the temperature, and, therefore, the degree of incandescence of the mantle, on account of the excess of cold and unconsumed gas or air passing through. Now, the proportion of air which is drawn through the Bunsen burner depends, in a certain measure, upon the velocity of the gas; but it is not strictly proportional to it, so that an excess of pressure produces a deficiency of air, while too low a pressure admits more cold air than is absolutely necessary for perfect combustion, and, moreover, by lowering the total amount of heat generated, fails to maintain the whole of the mantle at the point of highest incandescence. From these considerations, it follows that the efficiency of the incandescent gas light must be lower if the pressure is either greater or less than that for which the Bunsen burner has been adjusted; but the falling off on either side of the maximum is not very rapid, and, in practice, an excess or deficiency of ten per cent. in the gas pressure will not be noticeable. It need hardly be mentioned that by the use of any ordinary governor, either on the main supply pipe or on the gas pipe, to every burner, the pressure can easily be kept within these limits, and thus it will be possible to realize in practice the same degree of economy as found by the laboratory experiments here recorded. The construction of the burner is so clearly shown in our illustration as to render a lengthy description superfluous. Suffice it to say that the gas is consumed with a colorless flame, in a Bunsen burner having fine internal holes for the gas supply, and somewhat larger holes at the side of the tube for the air supply. The latter are covered by a cylindrical casing near the lower end of the tube, and are, therefore, not visible in our illustration.

Upon the tube is fixed, by a screw clamp, the gallery for supporting the chimney and globe, and an internal metal cone, reaching nearly to the top of the Bunsen tube. The rim of this cone serves as a lateral support to the mantle, while its top is suspended by a platinum wire from a stout wire guard, the lower end of which is fixed in the screw clamp already mentioned. The burner, as shown in our illustration, can be screwed to any existing gas pipe, in the same way as any ordinary burner. The mantle consists of a cotton fabric, either woven on a stocking loom or sewn together from cotton netting. The top of the mantle is doubled over a thin platinum wire, with prolongations on either side, so as to serve for attachment to the wire guard. The mantle is impregnated with a solution containing oxides of zirconium, lanthanum, and other elements, the precise constitution of which is, as yet, kept secret. The excess liquid is removed by pressure, and after the mantle is dried it is ignited, so as to burn the cotton out.

The next step in the operation is to place the mantle in a Bunsen flame, preferably somewhat more powerful than that of its own burner, when the black appearance left after the ignition of the cotton quickly vanishes, leaving the whole fabric a pure white. When the mantle is examined by a spectroscope shortly after being placed in the Bunsen flame, it can be noticed that sodium, potassium, and other elements are freely given off; but after about six hours' heating, the spectroscope fails to reveal the presence of any elements in the flame, thus proving that all those matters which can be volatilized by intense incandescence have passed away, and the remainder is absolutely unaffected by heat. It further follows that the mantle does not lose weight after this stage has been reached, a conclusion which has been confirmed by Mr. Conrad Cooke, who has, by careful weighing, ascertained that there is no loss of weight after a prolonged use of the mantle. The only drawback to this system of incandescent lighting at present is the extreme delicacy of the mantle after it is formed. The least touch is sufficient to break the fabric; and although, by the combination of the glass with the suspending wire and internal cones, a reasonable amount of protection is afforded to the mantle, the latter is yet more easily broken than the glass chimney. If Dr. Auer von Welsbach can succeed in rendering the mantle more robust, the field of practical application of his burner will be enormously widened.—*Industries.*

THE MANUFACTURE OF STEEL CHAINS WITHOUT WELDING.

A NEW process for the manufacture of chains without welding was invented some little time ago by M. Oury, chief of the Maintenance Department of the Marine at Cherbourg. After various trials in the arsenal, a factory has been built at Massaeliere, near Terre-Noire. The inventor being dead, the French patent has been taken up by a company. The Oury system consists, says *The Engineer*, in cutting the chain links into a bar of metal cast and rolled in form of a cross with equal arms. The metal employed has 0·178 per cent. of carbon and 0·452 per cent. of manganese; its tensile strength is 47 kilogs. per square millimeter, and its elongation is 10 per cent. to a length of 200 mm. The metal will not temper. The bars employed are about 7 m. long, and have a transverse section the form and half size of which, for a chain of 18 mm., are

FIG.1

shown in the sketch, Fig. 1. This steel weighs about 15 kilogs. per meter run.

The company is supplied with the bars ready rolled from the forges of Terre-Noire. We have only, therefore, to consider the various transformations through which the bar passes. The first operation is performed hot, with a double cutter. The cutter is placed at the door, and operates on the bar as it is withdrawn from the furnace; it passes between two tools which act at the same time, the one descending, the other rising, and producing the notches, A, Fig. 2.

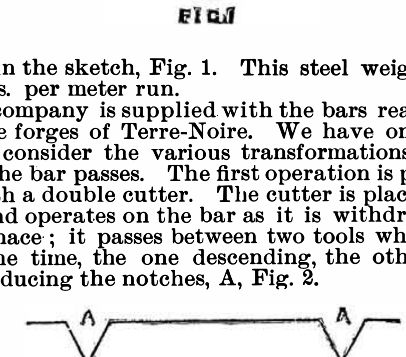


FIG.2

The notches are 90 mm. from one another from center to center, and the distance between them is regulated with exactitude by the machine. When the notches are completed over the whole length of one arm of the cross, it is reheated and passed under the cutter, which acts on the second arm, and produces the notches, B, exactly midway between the cavities, A.

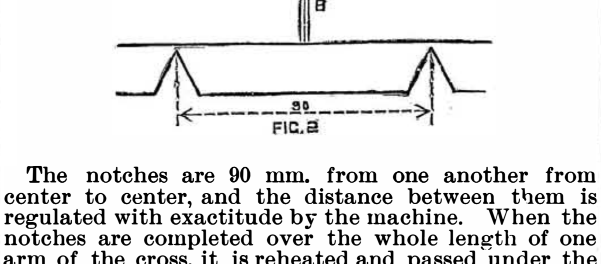


FIG.3

The second operation is performed without heat. A workman marks the place where the oblique incisions are to be pierced; these incisions are 45 mm. apart. The boring is done by means of small vertical machines and American twist drills, worked by boys. The drills are 7 mm. in diameter and 35 mm. in length. The space between the incisions being 45 mm., a bar would contain $\frac{7000}{45}$ = 155 links; the loss at the two ends, however, reduces them to 152 or 153. The third operation is done hot with a double mortise cutter, furnished with curved punches. Each branch of these curved punches has a section straight on the inside, and of a long shaped demi-ellipsis on the outside. The punches produce the shaded cavities, D, in the bars. Their length is the same as that of the spaces between the oblique incisions, C, Fig. 4. The distance between

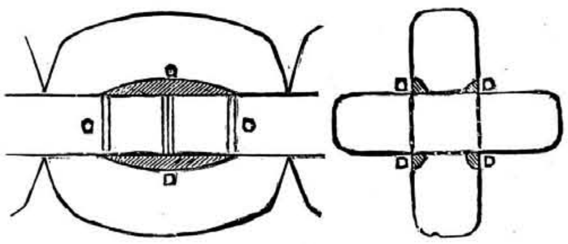


FIG. 4

the two branches of each punch is a little less than the thickness of the arms of the cross. These tools raise by the fraction of a millimeter the arm placed vertically under the instrument before hollowing out the cavities, D. Only a little less than a quarter of the depth of the bar is hollowed out by the first punching.

The fourth operation deepens and enlarges the cavities, D, and gives an oval form to the links by wedging back the metal. This operation is similar to the preceding one, the punches only being replaced by larger ones. After the second punching only a line of space remains between the two cavities, Fig. 5. The

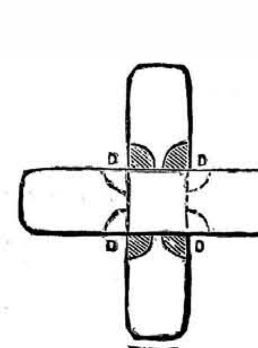


FIG.5

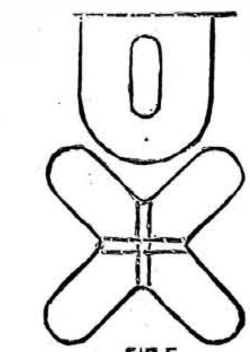


FIG.6

fifth operation is done hot with a swage or die; its object is to give, by stamping and transfer, form to the links. Every bar is heated and passed twice under the swage. The cavities, D, have now been deepened, and only a thin fin of metal remains. For the sixth operation no heat is required; it is done by two workmen, whose business it is to drive out the thin fin, D, with a hammer, to cut off the exterior and interior of the rings, then with a pointed chisel to break the adherent parts of the links by a blow. The rupture takes place at the part weakened by the nick, C. The links thus detached, the chain is in form, Fig. 7.

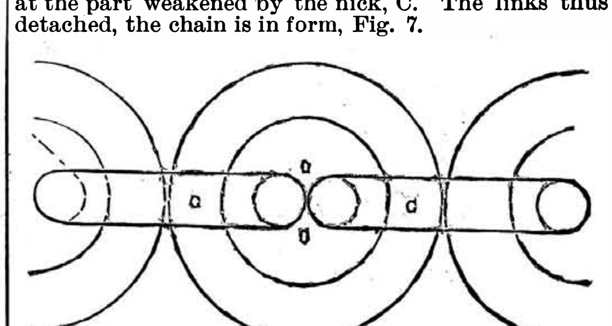


FIG.7

The seventh operation is done hot. It consists of shaping the detached links by a stamp of 550 kilogs. The four last operations all relate to finishing and perfecting the work. A link of weldable steel is used for joining the ends of the chains to each bar. This weldable steel has a tensile strength of 50 kilogs. to 55 kilogs. per square millimeter, and its elongation is 20 per cent. to 24 per cent.

The following figures will show the results of experiments: Four pieces of chain of three links of 18 mm., presenting a double section of 510 mm., have been submitted to a strain of 15,700, 22,300, 21,200, and 20,700 kilogs., being 30·8, 43·7, 41·6, and 40·5 kilogs. per square millimeter. The first two were broken, and the last two were found equal to the test.

AMATEUR SMITH'S WORK.

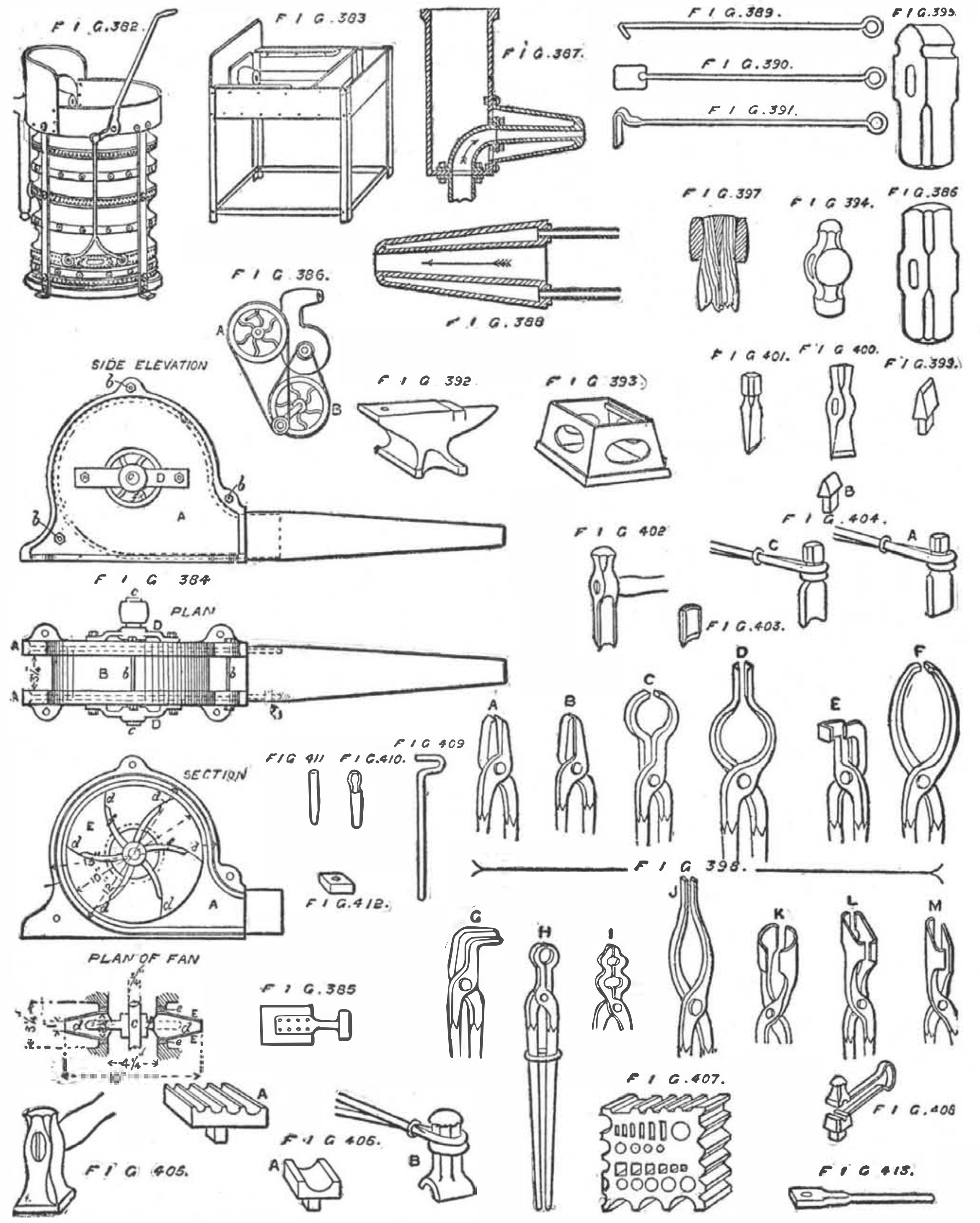
THOUGH none but a professional smith could hope to undertake elaborate works in wrought iron and steel, yet many simple jobs can be done with a very moderate amount of practice, such as the bending, drawing down, upsetting, shaping, and welding of the plainer kinds of work. I shall, therefore, devote this paper to a condensed description of the various smith's tools and their uses, together with a few practical hints on the management of iron and steel.

In a small shop an ordinary forge would be rather cumbersome. Hence one of the small portable forges would be preferable to a mass of brickwork and iron, if it were not for the difficulty of carrying off the smoke. If the forge is to be in a closed building, there must be a hood and chimney. If, on the other hand, it could be placed without the building, protected by a lean-to roof, a portable rivet or similar forge would be lighter and less expensive. The common brickwork type is so well known that I have shown two of the portable types in preference, and these are in keeping also with the amateur appliances and tools already described. The circular bellows in Fig. 382 are either of the single or the double blast type, the latter giving a continuous current of air, but being also the more expensive of the two. Forges with 16 in. bellows are the

smallest made, and either these or 18 in. would be the handiest for a small shop. A light framework of bar iron supports the circular hearth. The circular bellows are carried beneath, and are worked by the handle, levers, and rocking shaft, the blast being conveyed through the bend pipe into the back of the hearth.

The ordinary fixed forge is built of brick or stone. The hearth bricks simply inclose a hollow space which is filled with cinders, and upon which the fire is laid. The hearth back is of brick or stone, faced at its lower portion with a plate of iron through which the tuyere passes, and pierced at its upper portion with a square hole leading into the chimney. The chimney need not be long, its function not being the production of blast, but only of a sufficiency of draught to lead away the smoke. The face of the hearth for a few inches inward from the edges is usually covered with a sheet of cast or of wrought iron, for the sake of protection to the bricks. Two troughs occupy the front of the forge—a coal bunk, and a slake or water trough, the two often being made in one casting.

About the cheapest forge which can be made is that shown in Fig. 383, and one which any amateur could construct at a low cost, and with very little trouble. It can be employed out of doors, or



AMATEUR SMITH'S WORK.

placed indoors under a hood and against a wall leading into a chimney. Angle irons for the supports, flat bar iron for the horizontal stretchers, and sheets for the hearth and coal bunk are all that are required. The bearing surface of the angle iron will keep the structure from rocking; but if there is any tendency to unsteadiness when working the bellows, a diagonal brace on each framing will prevent it. The blast may be taken from long bellows placed underneath, and worked by means of a lever handle, set conveniently behind the hearth back, but keyed to a rocking shaft which moves in bearings bolted to the under side of the hearth plate. The rocking shaft passing thus underneath to the front of the forge actuates a lever and connecting rod, completing the connection with the bottom board of the bellows. Or the blast can be taken from a blower at the back, either with single or multiplying gear. A small forge of this type may measure out and out 26 in. long, 22 in. wide, and 30 in. high. The angles may measure 1½ in. × 1½ in. × ¼ in., the bar stretchers 1¼ in. × ¼ in., and the sheets about ⅛ in. thick.

The supplying of the blast is effected either by means of bellows of circular or long pear-shaped form or by fans or by blowers, and in these matters the purse and the convenience of the user would be consulted. Bellows are worked by a handle and rocking staff, and attached to the forge, or distinct therefrom, according to convenience. A fan is preferable to bellows, and is worked by hand or foot, or power, but should be driven with multiplying gear to get up the speed. In factories a single fan worked by a belt from the engine supplies blast to a range of forges; a throttle valve under the control of the smith regulating the passage of the blast to each forge. Numbers of small forges are now sold very cheaply fitted with fans, or with Roots blowers, so that the old fashioned leather bellows seem to be doomed to ultimate extinction. A small fan is shown in Fig. 384. The cheeks, A, are of cast iron grooved to a bare ⅛ in. deep, *a*, to take the strip of sheet iron or brass, B, which is cemented in with white lead and clamped together with bolts, *b*, passing between the sides. The fan spindle, *c*, is carried in bridge-like bearings, D, bolted to the sides of the cheeks, and the fan itself is composed of dished sides of sheet iron or tin, E, between which the vanes, *d*, are soldered. The dished sides are soldered to brass rings, *e*, which run against the inner faces of the cheeks. The vanes or blades are also soldered to the curved ribs, *f*, on the central boss, made of gun metal. The actual fan requires to be nicely balanced, owing to the high speed at which it rotates. The fan sides are each furnished with a central hole to admit the air. Instead of flat cheeks, two castings can be made with curved outlines, and bolted together with a central outside flange, in the manner so familiarly known in foundry and other fans; but this means the making of two rather troublesome half patterns. The form of blade used in the common old fashioned fan is shown in Fig. 385, but it is noisy. It is easy to make, the blades revolving within the outer casing, and as close to the sides without actually touching them as possible.

By multiplying gear, we mean some arrangement by which the proper speed of a fan can be imparted without excessive labor at the hand wheel. A hand wheel driving direct to the fan pulley will do, but with multiplying gear smaller wheels and less work will effect the same results. The perspective view (Fig. 386) illustrates this gear, the relative positions of the wheels varying as best adapted to the forge itself, and, of course, a treadle can be substituted for the handle. As drawn, the wheel, A, would be to one side of the forge clear of the hearth, its bearing being bolted to the hearth back, the bearings of the other wheels being bolted to the stretchers underneath the hearth. 10 in. would be a good size for the wheels, A and B. Bands are preferable to ropes running round grooved pulleys, since the latter properly require tightening gear for alterations in length due to temperature.

There is also the tuyere or tue iron to be considered, its function being the conveying of the blast to the fire. The nose of a tuyere would rapidly burn away, and does inevitably burn in time; but its destruction is retarded by the formation of a water chamber behind and around it, a current of cold water being made to circulate by convection within a conical cylinder through which the blast pipe passes, the whole being attached to a cistern or "water bosh." Fig. 387 shows this, the more modern type, in section, and Fig. 388 a section of the older tue iron, made either in cast or in wrought iron. These are illustrative, however, of the tuyeres used for large forges; but the small forges here figured are not provided with a water tuyere, because they are not subject to so fierce a heat as those of larger dimensions, and they are used intermittently. The nozzle which receives the blast pipe is, therefore, simply thickened up in these cases, and the boss piece is cast in one with a back plate, and thus bolted to the hearth back, so as to be readily renewable, as in Figs. 382, 383.

The firing tools are the poker (Fig. 389), the slice (Fig. 390), and the rake (Fig. 391). A ladle is also used for lifting water from the slake trough for the damping down of the fire.

The anvil (Fig. 392) of wrought iron, steel faced, is often supported at its proper height—about 2 ft.—on a block of wood, having spikes driven in at the corners to keep the anvil in place. A much neater and better way is to have a hollow standard of cast iron (Fig. 393) furnished with ledges for the anvil, and with holes at the sides for clearing out the scale and dust. Such a casting is easily made from a pattern by coring out, gives less recoil than wood, and looks neat. Anvils weigh from a few pounds to 4 or 5 cwt., one of 2 cwt. being of suitable size for light work. The conical end is called the "beak," or "bick," the steel top the "face," the body the "core." There is a square hole, or sometimes two square holes, in the face to receive the anvil cutter and the various bottom tools.

There are such a large quantity of tools of different shapes employed by smiths that all I can hope to do is to represent some of the commoner and more typical forms, and briefly note their uses by the way. Those which are in most constant request are the hammers and tongs. After these come the different sets, swages, fullers, and flatters. A smith who works alone is vastly more limited in the number of tools which he can employ than one who has a striker to assist him. When a man is holding his work with the one hand and the hammer with the other, he cannot be holding top swages and flatters and sets as well. But when a two-handed job is required, help can usually be obtained. Hence I shall describe the usual tools included in a fairly complete set.

Of the hammers there are two principal types, each varying in weight and shape, the hand hammer (Fig. 394) and the sledge (Figs. 395, 396). The former weighs from 1 to 4 lb., the latter from about 4 to 14 lb. A hand hammer of from 2 to 3 lb. weight is useful for general work, the lightest hammer, about 1½ lb., being chiefly used by the smith to indicate to his striker at which points to direct his blows, the heavier hammers for drawing down and forging light works. The lighter sledges are used "up-handed," that is, for lifting and striking in a circular arc simply, over the work. The heavier sledges are swung in a complete circle, or "about sledge." The handles of each of these hammers are made of ash, well spoke-shaved, and smoothed with glass paper, and are wedged with a single wood wedge, as shown in Fig. 397, wedges of wood being less likely to work loose than those of iron.

Taking the various tongs in order (Fig. 398), we have, A and B, the flat bit tongs, having flat parallel jaws, the width of opening of the jaws being greater in the "open mouth," A, than in the "close mouth," B—the former being used for thick, the latter for thin work, but each being similarly used for the purpose of grasping flat iron bars and sheets. The pincer tongs, C, are made in two forms, the first being simply concave in the jaws, the second veed as shown, the function of each being the grasping of round, square, or hexagonal bars. The hollow space behind the jaws allows of collars and similar expansions on forged work being inclosed thereby. D are tongs of similar type, but more widely useful because longer and more enlarged behind the jaws. The "crook bit tongs," E, are very common, and are made in various sizes, their peculiar shape permitting of a bar of iron passing down by the handles, while the lip on one jaw serves to retain the bar in place. The "hammer tongs," F, grasp punched work, entering into the punched holes. The "hoop tongs," G, are for holding rings of thin metal. H are "bolt tongs" for grasping bolts or rings of round bar iron. I, J, are two forms of "pliers," the latter being in constant use for general light work, picking up light rods, punches, drifts, hardening and tempering tools, etc. K are "hollow bit tongs," made in many sizes for holding rods of circular or other section. While L and M are "flat tongs," two of the commoner modifications of the last type, and also made in several sizes for grasping flat bars of different widths and thicknesses. These embrace the principal types of tongs, but like many other tools, they rapidly increase in number, and a single forge will have from twenty to fifty pairs of different sizes and in various modifications.

All tongs are made to grasp their work by means of a "coupler," embracing the handles or reins (Fig. 398, H), and just tapped over with a hammer until they tighten themselves, so that the smith has only to turn the tongs and work about, the coupler maintaining a firm hold of the jaws on the work.

For cutting off bars, rounding edges, and rough dressing of forgings to shape, the chisels, or "sets," and the gouges are employed. First there is the anvil cutter (Fig. 399), whose shank drops into the square hole in the anvil, before mentioned. The chisel edge being therefore uppermost, when a bar of cold iron is placed across it and struck with the hammer, the bar being rotated the while, the latter is nicked circularly, and may then be easily broken across the edge of the anvil, the fracture appearing of a crystalline character. The "hot" and "cold" "sets" (Figs. 400, 401) are also chisel-like tools, the difference in these consisting in the angle at which they are ground, the "hot set" being ground thin, the "cold set" relatively thick, and used as their names imply for cutting bars hot or cold. These are handled in a similar fashion to hammers, or on withy rods or rods of iron, the sketches indicating both forms, and the modes of handling applying indifferently to either. Tools like Figs. 402, 403 differ only in respect to their width and radii, their edges being curved to various sweeps for cutting corresponding outlines on red hot iron. These "gouges" or "hollow sets" are struck by the sledge, the smith holding the tool by the

withy handles, while the striker directs his blows on the head. The bevel is either inside or outside, and when cutting through a thick mass of iron, it is necessary to withdraw them occasionally and dip them momentarily in water to prevent the loss of temper and softening.

Besides these there are a large number of non-cutting tools of different forms. Chief among these is the "fuller," used, as its name implies, for "fullering" or drawing down iron in a series of grooves, both for welding, or for obtaining a flat surface, or for producing a starting point from which to bend a bar. A "top fuller" is shown in Fig. 404, A, a "bottom fuller" or "anvil fuller" at B, the latter resting by its shank over the anvil hole, the former being handled hammer-like, or by withes. The top fuller may be used while the bar rests upon the anvil face, or the bar may rest upon the bottom fuller and be struck by the hammer above, or the bar may be drawn down between the top and bottom fullers, the upper one being struck by the sledge while the bar is moved into successive positions until the iron is thinned or tapered by a series of grooves. The "nicking fullers" (Fig. 404) are made in various sweeps, and they fulfill the same purpose for circular shafts and rods that the others do for flat bars.

To finish plane surfaces, the "flatter" (Fig. 405) is employed. This is also struck by the sledge, and finishes or flattens the surface, removing the uneven ridges and indentations left by the hammers and fullering tools.

The "swages" form also a very large family in themselves. They are so termed because by their agency work is "swaged" or drawn down and made to assume definite outline corresponding with the shapes of the swages. These are, therefore, in principle dies, because the work can only assume the shapes given to the swages. Being also used in pairs, one top, one bottom, they are commonly called "top and bottom tools." Some shapes are given in Fig. 406. A A are bottom swages, that is, they fit by their square shanks into the hole in the anvil face. The shape of the corresponding top swages is seen at B. The ordinary shapes are the half-round, the veed, and the hexagonal, each being required in different sizes. Fig. 407 represents a swage block for a heavier class of work, the various sectional forms around its edges answering the purpose of bottom swages. It is conveniently laid upon a cast iron stand, similarly to the anvil, on which stand it can also be laid flat in order that the central holes shall fulfill the functions of "heading tools," that is, of the type of Fig. 413, for finishing the square shoulders of bolt heads and similar flat expansions. The top and bottom swages are frequently united in one with a bent rod of iron, which serves to keep them in line, and becomes a convenient handle. They are then termed "spring swages," or "spring tools" (Fig. 408).

There are three modes of handling tools employed by smiths. The first, just now referred to, of wedging the hammer head fast in the shaft. The second, that made use of with some of the sets, gouges, fullers, and flatters, in which the handle is simply thrust through an eye in the tool without any attempt at wedging, the reason being that their constant and almost close contact with red-hot iron would cause wedges to work slack almost directly. Hence the smith, previous to using either of these tools, usually strikes the butt end of the shaft on the anvil to tighten the head. Lastly there is the method of fixing by hazel rods. These are straight hazel sticks of about ½ in. in diameter or ⅝ in. in diameter, twisted round the necks of the tools (Figs. 404, 406), the elastic wood preventing painful jarring and blistering of the hand of the smith. Before being bent they are soaked in water and steamed over the fire, the operation being alternately repeated until they are sufficiently pliable to bear bending and twisting, but not taking more than a minute or two. The parallel rods are united permanently by a coupler, and are never taken off the tools except when they need renewal. Very often it is the practice to substitute iron rods for those of wood, as being more durable, the rods being bent in the same manner.

A hook wrench (Fig. 409) is used for giving a slight amount of torsion to flat bars while red hot, which have become twisted or winding in the process of forging. Fig. 410 may be taken as a type of the punches which are employed for piercing holes through red hot iron, and Fig. 411 of the drifts for enlarging and making them parallel, the work being laid upon a bolster (Fig. 412) the while. Fig. 413 is a heading tool, of which there are several sizes used for shouldering the heads of bolts and rivets, or any work provided with collars, though where a collar is welded or otherwise formed on the center of a bar, collar swages are often used in preference.

Having described the most important smith's tools, we conclude with a few essential hints on the practice of forging.

As a simple example, take the connecting rod (Fig. 414), one with a forked end being purposely chosen as being more complete for purposes of illustration. This could obviously be made by building up—that is, the enlargements at the ends could be welded on a bar of the diameter A; or by swaging down, in which the diameter A would be hammered down from a bar of the sizes B or C of the larger ends; or by jumping up, where the ends would be beaten up or "upset" on a bar of diameter A. Or it can be made by a combination of these processes if a bar of medium dimensions only is available.

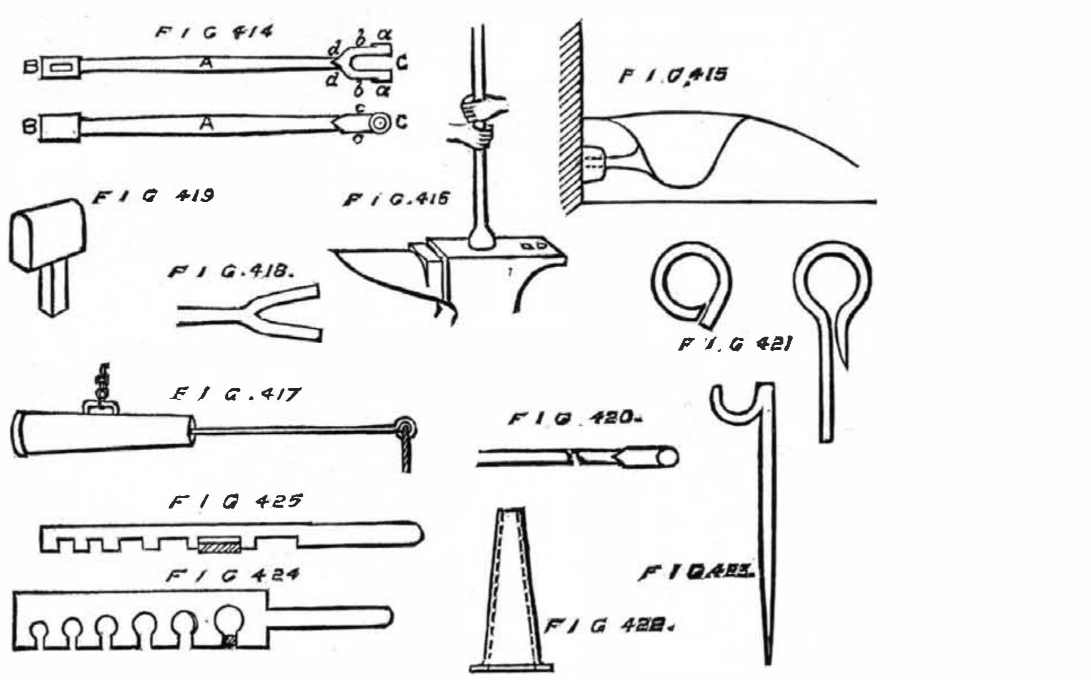
Say we have a piece of bar of the dimensions A; we can get on very well with that. We build a fire in such a way as to obtain "a solid core of heat"—that is, we have a central portion in front of, but away at a distance of a few inches from the tuyere, intensely hot, and for the time being open above, but flanked at back and front with two masses of wetted hard-caked small green coal or "slack," which partially confine the heat (Fig. 415), and form a reserve supply for the incandescent mass; and the larger the forging the larger the reserve of "stock." Putting that portion of the bar which requires to be heated—in this case the end—into the center of the fire, cover it over with a mixture of stock and new coal, so as to inclose it completely, localizing the heat where required by keeping wet coal over the portion which is not to be heated. Then the blast is put on, and the heat inclosed and intensified around the bar. The bar, especially if large, is to be turned partly round in the fire now and again to equalize the heat, the blast meanwhile hollowing the fire in the immediate vicinity of the bar; now and then, also, it will be partly withdrawn in order to be sure that it does not get burnt. The heat at which it should be taken from the fire varies with circumstances, a full, red heat being suitable for ordinary forging; while for jumping up, and welding, the iron should be white hot, and just beginning to throw off vivid sparks. Beyond this temperature it becomes burnt and spoiled. When our bar is at the white heat, it is removed from the fire by means of hollow bit tongs and transferred to the anvil, whence we will follow the process through, remembering that in smith's work the whole manipulation must be foreseen from the beginning, and the tools all be at hand, so that there shall be no hesitation and loss of time and heat. We will first suppose that the hollow of the forked end is to be slotted out of the solid, and then, for further illustration, we will assume that the hollowing out is to be done at the anvil.

While at a white heat we shall "upset" the iron in order to obtain sufficient breadth for the forked end, and to do this a short heat only will have to be taken on the end of the bar. Thus if the length of the forked portion, C, were three inches, the end of the bar would be heated only to a length of seven inches or eight inches. If more length is required, two successive heats should be taken. That portion of the bar, then, which lies beyond the part which has to be upset will not become bent or otherwise distorted during the upsetting process, but remain rigid. The upsetting is performed either by jumping the bar heavily end on to the anvil, the hot portion, of course, being downward (Fig. 416), hence also called jumping up, or it is hammered with the sledge, swung in a nearly horizontal arc, the smith holding the bar horizontally on the anvil with the tongs, or a heavy cast-iron monkey (Fig. 417), suspended by a chain, is swung heavily against the end of the bar.

When the amount of jumping up which is required is slight, the first method suffices; for heavy work the latter plans are adopted. Upsetting shortens the length and increases the breadth and thickness, and the enlargement, being very irregular in outline, must needs be made considerably larger than is actually required. At the same time, since the jumped mass will be of a rudely circular shape, being simply an expansion of the shape of the bar, a rough outline of the shape finally required must be imparted to the end by hammering, the hammering and upsetting alternating, so that the iron, still retaining its heat, is hammered approximately level and square on four sides, forming a rectangular block or lump at the end of the round bar, its extreme dimensions being slightly larger than the out and out dimensions of the bosses *a*, *a*. By this time it will probably have lost most of its heat, and will go back to the fire to be made nearly as hot as in the first place. By means of the fuller first and the flatter afterward, the hollows around the bosses, and the flats, *b*, will be set down, and similarly the flats *c*, *c*. The outside rounding of the bosses will be imparted by cutting off a portion of the corners with a hot set, then hammering with an ordinary hammer, and smoothing off with a top swage struck by a sledge. The whole of the black dimensions will remain when finished a trifle over the bright finished sizes, to give sufficient allowance for machining. The rounding off at *d*, *d* is first rudely cut with the hot set, or with a gouge tool, the heads of those tools being struck with the sledge. The angularities will be beaten down rapidly with the hammer, and a top and a nicking swage of suitable curves will be used to impart a finished outline.

The bar will now go into the fire again, and a heat will be taken over it extending from the fork to about the center. A nicking fuller may be used to shoulder down the square bar to a circular section just where it departs from the forked end, or if the bar is small it may be simply hammered at the angles with a hand hammer or sledge. When the diameter is roughly reduced down to the required size next the fork, the original size remaining at the center, it will be readily finished by swaging, the proper allowance being left for turning. This need not occupy more than one heat. The other half of the rod can be swaged down in another heat. Then there remains the stub end, B, which has to take the strap, and this will be jumped up in a short heat similarly to the forked end, finished with the flatter, and neatly fullered down around the neck.

In this illustration we have supposed the space between the fork ends to be slotted or drilled out of the solid. But if the forked ends were so wide apart that the slotting or drilling out of the interspace would be considered a heavy task, or if the end were that of a rough lever or pump rod which would not pay for



AMATEUR SMITH'S WORK.

machining, the forks would be forged as follows: If the width of the bar were less than twice the thickness of each fork, it would first require to be jumped up until its width were somewhat more than twice the thickness—that is to say, if the forks were ¾ in. thick, the width of the bar should be rather more than 1½ in., say 1¾ in. or 2 in. As before, a short heat is then taken, extending no farther than just beyond the shoulder. The flat portion is laid on the anvil, and divided through the center with a hot set, cutting first from one side, then from the other, and meeting in the center.

Sometimes a hole is first punched at the bottom of the hollow. Once divided, it is readily opened out first to the V-shape (Fig. 418), then the hollow is formed by jumping and hammering over a bottom fuller of considerable breadth and depth (Fig. 419), sometimes termed a dresser, or joint dresser, until a rough outline of the bifurcation is obtained. Then the more exact outlines and thicknesses are given in a second heat by judicious hammering, and finishing, partly over the dresser, partly on the flat overhang of the anvil, if the space between the forks is sufficient to permit of this. Finally, when the shaping is done, the forks must be tried for parallelism with the axis of the bar, and if out of truth, they will be set over with the hammer.

It is easy to see how a difference in relative proportions would modify the method of making which ought to be adopted, and since our connecting rod is selected, not as of any particular size, but illustrative only of different methods of forging, we will now make it the medium of sundry remarks in reference to the practice of welding.

Upsetting is hard work when the quantity of metal to be upset is large, and particularly so when done without the aid of a monkey, or in the absence of a massive plate which is frequently sunk in the floor for the same purpose. Welding is, therefore, much easier in certain instances. But the stub end, B (Fig. 414), is not so much larger than the original size of the bar in the center, therefore we may upset that very well. Also, when the sum of the widths of the two forks is little more than that of the original bar, and the forks are forged as in the last example, we may accept the jumping up method as being practicable. Moreover, in the first instance described we upset the bar on the supposition that, though the end was solid, it was not of great width, and this would also be applicable to the ends of many light levers. But assuming the end were both solid and wide, measuring, say, over the bosses three or four times the diameter of the bar in the center, welding then would be preferable because involving less labor.

When making a weld there are three points to be borne in mind: to have a joint of sufficient area, and in suitable direction for hammering up; to have the necessary temperature; and to be sure of perfectly clean surfaces. For the first condition, a scarf joint, that is, one running diagonally with the common axis of the pieces to be shut (Fig. 420), is to be preferred, and is, therefore, commonly employed when practicable. When a scarf joint cannot be used, a veed or cleft joint is suitable. When that cannot be employed, a spreading joint, made by fullering down a portion of the bar, is resorted to. A plain butt joint, except when the abutting surfaces are of large area, is seldom used; but flat *surface* shuts are common. The temperature for welding iron is that just now referred to, when the iron begins to sparkle, and to drop off in globules. For steel, the temperature is lower, barely approaching to a white heat. Different qualities of iron and steel require different degrees of heat, and the temperature in each case becomes a matter of experience. When the ends to be welded are taken from the fire, any scale adherent to the surface must be detached by striking the bar smartly on the anvil, joint face downward, or by sweeping away the scale with a muck brush. If any persistently adhering scale remains on the faces, the shut should not be made.

Fractures occur sometimes from this reason, the weld being perfect near the edges, but faulty in the center. The joint surfaces are usually dusted with sand, but this is not so essential as it is sometimes stated to be, provided the scale is removed in the manner stated, for numbers of ordinary iron shuts are made without it. The weld is made immediately that the faces are brought into contact, by rapid hammering, every second at the welding heat being of vital importance. When closed together with the hammer, the joint of a good weld should not be visible, the presence of a black line indicating that the shut is imperfect. If during hammering the bar becomes reduced or drawn down below its proper size, diameter, width, or thickness, as

the case may be, it must be slightly jumped up to thicken it sufficiently, and then swaged circular, or smoothed with the flatter. Iron and iron are easily welded, so are the milder varieties of steel; but some hard and brittle steels require tact and practice to weld properly, and some, if heated over a certain temperature, crumble under the hammer.

In a connecting rod, the cotter way in the stub end is usually drilled and filed out, but in many instances cotter ways and holes of other shapes are punched and drifted, either to save the labor of drilling previous to filing through, or as being suitable enough for the purpose which they have to fulfill. Before punching, the iron is brought to a welding heat, or nearly so, laid upon the anvil, and the punch, struck with the hammer, is made to pass half way through from one face. It is then knocked back, the iron turned over and punched from the opposite face, the holes meeting, therefore, in the middle or thereabout. Then a drift is inserted in the hole, and either driven half way in from each side, or right through, according to circumstances. While the drift is still in place, opportunity is taken of giving a rough kind of finish to the exterior outline. Punches and drifts become red hot, and soften and bend if they remain more than a few minutes in contact with the iron, so that it is necessary to remove them once or twice from a deep hole and quench them in water. Punches and drifts are usually picked up with the pliers, though the former are sometimes furnished with withy handles. They are circular, oval, or rectangular in section, the difference being that while a punch is tapered, a drift is parallel for a considerable portion of its length, and tapers only toward the end.

When bending work, various devices are resorted to. A turn down edge at right angles would be bent over the edge of the anvil, the flat of the bar lying horizontally across the anvil, the smith grasping the tongs, and steadying them against his leg to resist the force of the endlong blows. The bar is frequently nicked across slightly with a fuller previous to bending, and the fuller, having a circular section, does not divide the fiber as a set would do. Eyes or rings are bent around the beak of the anvil, whose tapered outline permits eyes, rings, loops, and curves of many different diameters being bent. Fig. 421 shows the method of welding a ring and an eye. Rings of large diameter are finished on the conical mandrel (Fig. 422). Small rings are finished on a parallel bar or mandrel of suitable diameter, the bar remaining in place while the outside is finished with flatters or swages. When eyes are being bent, or other work being performed on bars of considerable length, the trouble of supporting the opposite end is saved by driving a rest (Fig. 423) into the ground, and placing the bar in the hollow.

When doing forging, it is necessary to take measurements rapidly—not an easy task with hot iron. Hence, gauges notched to different sizes are made of sheet iron, say ⅛ in. thick, the size of each notch being stamped above it, Fig. 424 being a gauge for round, Fig. 425 one for flat bars.—*English Mechanic.*

[Continued from Supplement, No. 588, page 9397.]

PRINCIPLES AND PRACTICE OF ORNAMENTAL DESIGN.*

By Lewis Foreman Day.

Lecture II.

THE DISTRIBUTION OF ORNAMENTAL DESIGN.

In my last lecture, I undertook to lay down the lines upon which repeated pattern work could be constructed—to show, that is to say, the comparatively simple plan on which the manifold forms of surface ornament are built up, and the very limited range of lines on which pattern can built.

This evening I propose to discuss the lines on which ornament (not necessarily repeated) can be distributed. And I think it will not be difficult to show that, illimitable as those lines may at first sight appear to be, they, too, allow themselves to be classed pretty definitely; and, moreover, that the classes are not by any means so numerous as might be supposed.

The first thing one has to do in designing is to determine the lines on which the design shall be distributed—to plan it, that is to say. The more clearly the designer realizes to himself the lines on which it is open to him to proceed, the better. And if it can be shown (as I think it can) that these are, comparatively speaking, few and simple, so much the easier will it be for him to make up his mind promptly and determinedly which of them he will in any case adopt. The shape of the actual space to be filled will oftentimes determine for him, more or less, the distribution of his design. That is to say, it may very likely render certain schemes altogether unavailable, and, perhaps, even limit his choice to a single plan. But, at his very freest, he is limited, in the nature of things, to certain methods of procedure, which I shall proceed to define.

Obviously, it would be out of the question to discuss at length the relation of every possible plan to every possible shape. I purpose, therefore, to take the simple parallelogram (which may stand for panel, page, floor, ceiling, carpet, curtain, shawl, window, door, facade, no matter what), and to show the possibilities with regard to the distribution of ornament over its surface, and then to explain how the same principles apply, no matter what the shape to be filled.

Given a panel to be filled, then, what is to be done? There are two very obvious ways of going to work, either of which, to the sophisticated modern at all events, seems equally natural. You may start from the center or from the edge. That is to say, you may occupy the field or center as seems good to you, and work outward to the margin; or you may begin with a border, and work inward. The border once defined, the space within remains to be treated. In fact, theoretically, we have only reduced the area over which our composition is to be distributed. But, practically, that is not quite so, more especially if the border be of any importance. A border may be of such interest that nothing further is needed, and the center of the panel is best undisturbed by ornament. Especially may this be so if the material in use be in itself of interest. It is distinctly not desirable to mar the surface of beautiful wood or richly varied marble with added ornament. And pretty generally in woodwork (unless we wish for once in a while to be ultra lavish of enrichment) it resolves itself into a question of whether we shall enrich the panels or the mouldings bordering them.

If you adopt the idea of a border, the simplest and most obvious thing you can do is to keep it of one uniform width on all sides. And it makes all the difference (as I have already hinted) whether it is simple or elaborate in character. A very deep rich border has such an entirely different effect from a moderately simple one, that it looks something like a different treatment altogether. Borders may be so schemed (and should be so schemed) as to give panels of proportions suitable to them. If, for instance, a panel is to be filled with a diaper, arrangement should be made for the "repeat" of the pattern within it. If it is to contain a

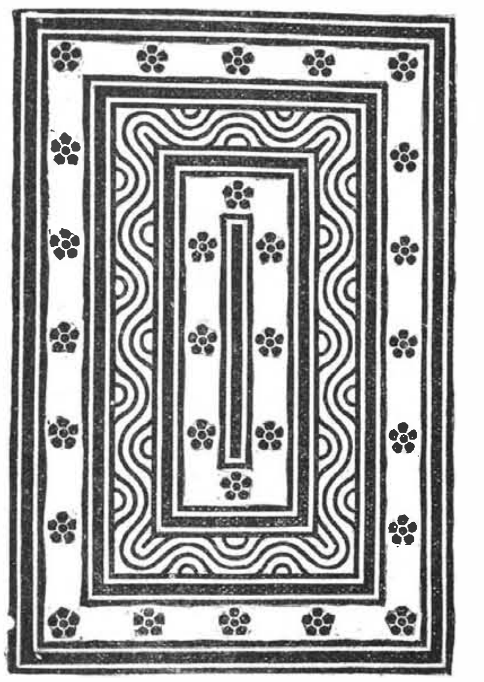


Fig. 10.

figure or a figure subject, it should be of a proportion and size not too difficult to occupy with a figure or figure subject.

In the case of an isolated panel, this is, perhaps, of less importance—the artist ought to be equal to the occasion; but in the case of a series to be treated in accord, the problem is made infinitely more difficult when the panels are of all manner of shapes and sizes.

There is a salon in the palace at Fontainebleau in which the proportions of the paneling prove to be due almost entirely to the painter, who has brought the larger panels into scale with the smaller by means of a series of borders within the actual mouldings. It is much less trouble, of course, for the joiner, when he has an awkward space to panel, to fix the width of the stiles, and let the panels come as they may. But a very little consideration on his part would save the decorator, who comes after him, an infinity of pains.

The stiles which frame a panel may be considered as a border. The mouldings again are so many borders within borders. A border which is made up of many lines really constitutes a series of borders one within the other. The use of border within border as a deliberate means of ornament is common enough. You may even add border to border until the whole field is occupied, as was the case in certain tooled bookbindings of the seventeenth century, and in Fig. 10.

Equality of width is by no means essential to a border.

Fig. 11.

der. You see in many mediæval illuminations the effect, more or less satisfactory, of emphasizing two sides of the page. Nor need the border necessarily be continued all round the space at all. Curtains have often a border on two sides only, and sometimes only on one, marking what one may call the lips of the hangings. You may look upon the architrave of a door as a border on three sides of it only. And in the same way a mantel piece partly frames the fire grate. Every frame is a border; no matter how irregular the shape of it may be, a frame's a frame "for a' that." It may take the architectural form of cornice, pilasters, and dado, or it may be arched, and, in either case, the architectural members are but unequal borders. You will see, of course, how all this applies not only to an architectural picture frame, but to architecture itself, and to things in general.

Something like a new departure occurs when the border, so to speak, *invades* the field or center of the panel, as it very often does in French Renaissance work, sometimes to such an extent that little or no further decoration of the field is necessary. In some of the interlacing strap work of the Henri II. period (the French equivalent to our Elizabethan ornament), you cannot always clearly tell where the border begins and ends, or even whether a border was intended at all. It looks sometimes as if the designer had started with the idea of a border, but had allowed it so to encroach upon the field, or the field upon it, that in the end it is not at all clearly recognizable as such. Fig. 11 illustrates the kind of thing I mean.

Nearly allied to this is another kind of border, also devised so as to be quite inseparable from the filling, in which, in fact, frame and filling are so ingeniously mixed up that, but for the emphasis of color, the effect would be confused.

It is interesting to notice the difference between this method and the practice of the Japanese, who will, in the most unhesitating manner, allow the filling pattern, whatever it may be, to break over the margin or border, just as the impulse prompts. This is a proceeding which may or may not result in confusion, according to the relative strength of the border and the pattern that cuts across it. One appreciates this kind of freak as a relief from the monotony of absolutely formal disposition, but it is not a thing to indulge in very freely. It is refreshing to see that a man is not afraid of infringing occasionally upon the margin, on sufficient grounds; but it needs always to be justified by some excuse other than the artist's impatience of order. There is no special sanctity in a margin that it should be held inviolate, but order is essential to ornament. We have to beware of a certain spirit of anarchy which appears to have taken possession of so many a modern artist. There is a class (one cannot call it properly a school) which will repudiate not only all the laws of art, but the need of all law whatsoever. Urgent need there may be of reform in our ideas of art, perhaps even of revolution; but we are justified in refusing to recognize in the artistic anarchist anything but the enemy of art.

There was a fashion in vogue in the seventeenth and eighteenth centuries—borrowed, probably, from the East—according to which the border is invaded in a somewhat formal way by the field or ground, rather than by the filling pattern—where the field, in fact, seems to eat into the border. It is usually rather a symmetrical mouthful that it takes.

A border may be lost in a sort of confusion with the panel it began by pretending to inclose. No one ever did that kind of thing more cleverly than Boulle. But a border remains a border, however undefined. The boundaries may be understood rather than expressed. Yet that makes no difference as to the lines upon which the design is constructed. You may say to yourself that you dislike formality, and that you will have none of it. You will merely sketch upon your page such and such marginal forms, natural or ornamental. But if you dispose them in anything like an orderly manner, you arrive at something which comes as clearly under the category of border treatment as though it had been inclosed by hard and fast boundary lines.

And every margin or marginal line is in its degree a border. In Indian and other Oriental work you often see the ornamental details so closely packed as to define the border shape even without actual boundary lines. And the Germans of the sixteenth century (Jost Amman, for example) sometimes did with very different details just the same thing. The looser borders of Louis XIV., XV., XVI., do the utmost they can to hide the lines of their construction; but it is a sign of weakness, I think, to be afraid of a straight line. So great is the use of the border, that even those who least like formal lines are bound to adopt it, although they are always rebelling against its formality, and doing their best to break it up, as in the case of the encroaching and interrupted borders already mentioned.

The very *naivest* way of getting over the difficulty—it is a difficulty, and a serious one—is by, so to speak, snipping a piece or two out of the panel, and carrying the border round the incisions, so as to get a more or less irregular center space instead of the four-square parallelogram. In the Certosa at Florence, there are some windows by Giovanni da Udine, in which he has deliberately snipped pieces out of the space to be filled, and left them as so many gaps in the design. One may forgive this kind of thing once in a while, but it stands very much in need of justification. Where the gap has some meaning it is different. In the case where there is a square block or patera occupying the corner, for instance, as you sometimes see in seventeenth century wood paneling, that seems to account for the break in the border. Nor is there any objection, that I see, to the doubling of the border round an imaginary line, by which means the same end of irregularity is arrived at without the brutality of Da Udine's method. The artists of the Renaissance, and of the later Renaissance in particular, were too ready to adopt any device which would enable them to depart from the simple panel form. In not a few instances, the further they went from it, the worse it fared with them.

Much might be said about the construction of the border itself. It may be continuous or broken, and broken at all manner of intervals, and in all manner of ways. It may flow or grow. It may be symmetrical or absolutely free. The outer or the inner edge may be accentuated, or both, or neither. It may spread outward from a well defined central feature or inward from the margin, diffusing itself, and giving a less definite central shape. But it is not so much the design of the border that we are considering at present as the place of the border in design.

Though you abandon all idea of bordering, and elect to place, as you well may, some arbitrary shape within the parallelogram, still the space round about that shape may be considered as an irregular border to that shape. If, for example, you plant in the center of the space a medallion, and round that medallion a cartouche, the cartouche may be called the frame or border of the medallion; and, again, the ground beyond the edge of the cartouche may be taken to be the margin or border to that. In such a case we have arbitrary shapes, one within the other, but one might just as

* A series of four lectures recently delivered before the Society of Arts, London. From the journal of the society.

well have two or more such independent shapes. Nothing is easier than to take a simple field, and to spot about upon it any shapes you please. That is one way, not a very ornamental way, but one way of occupying the space. But, if you proceed to connect those shapes in any way, you bring in another principle of design—which, however, will be more conveniently approached from the other side, when we come (as we presently shall) to the discussion of the lines inclosing various shapes and subdivisions. Abandoning all thought of border, or supposing a border already in existence, you may, as I said, plant any independent shape, medallion, shield, cartouche, tablet, what you will, within it. This form may be left, as it were, floating in space, or it may be supported by ornament, which ornament may literally seem to hold it up, or, if you will, the ornament may appear to be suspended from it, as was the case with the festoons and garlands of the later Renaissance. Finally, such ornament may be unconnected with the central shape, and comparatively independent of it, as a diaper would be.

The central feature need not be an inclosing shape. It may be an ornament, a figure, a spray of flowers, a vignette, a spot, a sprig, as free and independent as a voter who knows no party, or, just as in the case of the closely packed border, whose shape was marked without the aid of boundary lines, so the central sprig of ornament or foliage may be so densely massed within an imaginary square, circle, quatrefoil, or other imaginary form, as to assume a quite regular outline.

If you introduce a number of features, free or formal, they group themselves into a sort of diaper over the surface. And this diaper should naturally have some reference to the space it fills, or it will appear less than trivial. Whether such sprigs be all alike, or of various design, is a question independent of the lines of their distribution.

A mere series of bands or stripes across the field (vertical, horizontal, diagonal, waved, or in whatever direction) is an obviously simple way of getting over the ground, about which nothing further need be said. Any scroll, or other more important ornament filling, may be quite free, or disposed symmetrically in relation to an imaginary central line or spinal cord. Or it may radiate from the center, as it naturally would in a ceiling, pavement, carpet, or other object demanding an all-round treatment.

Such scroll work, or what not, might equally proceed from two ends of the panel, or from the sides, or from both, either symmetrically or at irregular intervals, or it might spring from the corner or corners. The treatment from the corners is again adapted to, and adopted in, ceiling decoration. In principle it is very right indeed, but in practice it is not invariably all that a decorator could desire. The "line and corner" tune, as it may be called, has been harped upon until one is heartily sick of it, even when it is played in time, which is not always the case. A cornerwise treatment is seen to advantage when it has been suggested by use, as in the metal garniture of old book bindings, and coffers such as the German smiths of the 15th and 16th centuries delighted to elaborate. These same book covers and caskets afford excellent examples of a treatment where the design is manifestly "to be continued in our next," the side unseen being necessary to its symmetrical completeness. The need of clasps, hinges, etc., no doubt gave the hint of such a manner, which, in spite of the one sided forms it gives, is eminently satisfactory in effect. We scarcely realize how readily the mind makes good what the eye does not see in design.

It is worth while to compare this symmetrical scheme (in which the symmetry is suggested rather than expressed) with the free and easy way in which the Japanese lacquer worker will overrun the limits of a box top or cabinet front, and trail his ornament over all or any of its sides indiscriminately. Here, too, the artist, in his very different fashion, chooses to consider the whole object his field, and not just the part of it he sees before him. There is a certain logic in his license, but the more restrained manner of the mediæval workman is, in proportion to its restraint, the more to be preferred.

Where the design, scroll, foliage, or whatever it may be, bears no relation at all to the shape or space it occupies it ceases to be surface design, and is merely a means of breaking the surface. It is only as a background that such haphazard forms have any meaning.

A very satisfactory and effective result is sometimes obtained where the artist starts, as it seems, with the idea of a diaper, more or less geometrical, and, as he approaches the center of the panel, gathers together the pattern, so as to speak, into points of emphasis. Designs of this kind were unmistakably first set out in geometric divisions, certain of which divisions were afterward grouped together to give point to the pattern.

The difference between this way of focusing the design and the plan adopted in Fig. 11 is that there the central shapes appear rather to have suggested the corresponding interlacements than the interlacements to have led up to them. But even in such a case it seems desirable that the artist should have in his mind from the beginning some kind of idea of geometric construction. The longer he can manage to keep that geometric notion in his mind without putting it on paper, the more freely he can go to work. That faculty of holding a design, so to speak, in solution in the mind is most invaluable to the designer. It is so much more manageable in its fluid state. Once it is allowed to crystallize into definite shape, it is no easy matter to modify a notion.

If the space to be decorated be very considerable in extent, it is often necessary to cut it up into sections otherwise than by merely marking off a border. A wall, for example, is divided into cornice, frieze, wall space, dado, and so on. Or it may be divided vertically into panels of equal or unequal width. A building in several stories is an instance of the one kind of division, a colonnade of the other. If the subdividing lines take both directions, the result is a scheme of paneling such as was commonly adopted in the domestic woodwork of the 16th century.

Further, by the introduction of cross lines at various angles, or of curved lines, we arrive, by a different road, at paneling of more complicate character, and at something like the interlaced patterns to which reference has already been made. It is clear that these various ways and means may be associated. And, under the complex conditions of the times, they usually are more or less "highly mixed."

Thus one may, as I have said, begin with a border, and then treat the space within it in any of the ways already described. One may divide a wall horizontally into two, with a diaper or frieze at the top, and paneling below. One may plant upon the field any independent feature, frame, shield, tablet, or such like, and then fill in the background without regard to it, as though a portion of the design were lost behind it. As many as three or more plans may be associated. For example, one might stretch across a title page a tablet (Fig. 12), then introduce a border disappearing behind. And the spaces inclosed between the border and the top and bottom of the tablet one might treat again as independent panels.

The idea of overlaying one ornamental feature by another was adopted pretty generally by the early Gothic glass painters, who would start with a series of important medallions (probably with figure subjects), beeind which they would scheme a series of less important medallion shapes, and behind these again a border perhaps. Such a scheme affords considerable scope in design.

The use of the border is not, of course, confined to the outer edge of the main space to be filled. Each sub-section of the design may be provided with its own border, as you see in the case of paneling, where each separate panel has its own border of mouldings. So again a central feature may have its border or borders interlacing with, or intercepted by, the borders which mark the space or panel itself. A space or panel once subdivided, as already described, it is open to the artist to accept each compartment as a separate panel, designing his ornament into it. Or, with equal reason, he may make his ornament continuous throughout, allowing it, that is to say, to run behind the dividing lines or to interlace with them. Again, the two plans may be combined, certain prominent parts being reserved for individual treatment and the subsidiary spaces being connected together by the forms of the ornament. Which of the two may be the better plan

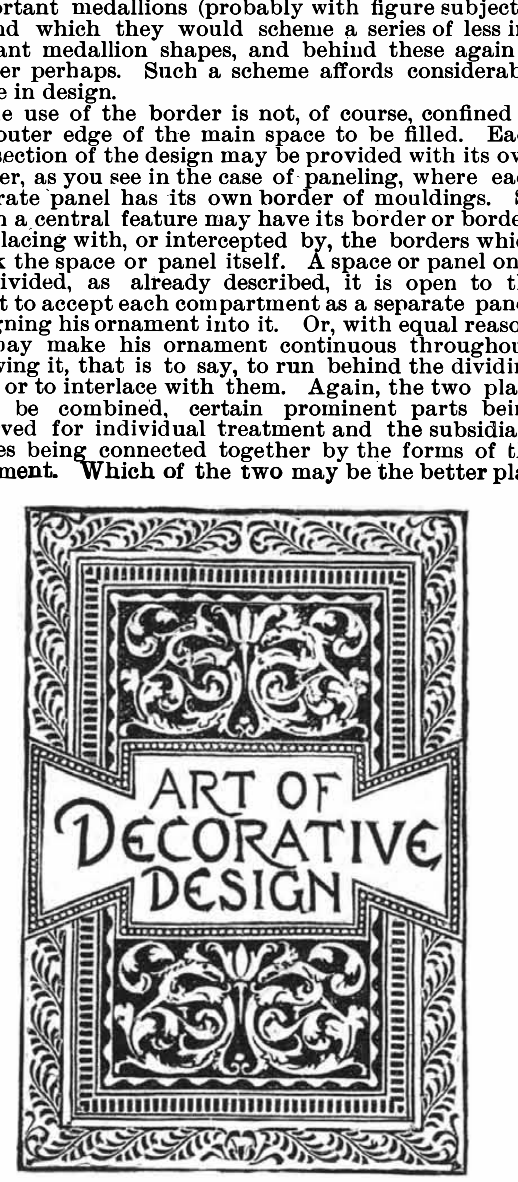


FIG. 12.

to adopt is a question of some nicety, not always easily to be decided. In proportion to the importance of the framing lines it becomes dangerous to overstep them. Who ventures nothing runs no risk of failure, but neither will he achieve any great success in art. And then there is the charm of danger. Soldiers, sportsmen, and mountaineers are not the only class of persons privileged to run a risk. It is a luxury we may all indulge in on occasion. Were it not so, art would be no congenial pursuit for any one who is really alive. Only a man should look before he leaps into danger. Count Moltke's motto puts it very pithily, "Erst wägen, dann wagen," which might be paraphrased, "Weigh before you wager."

When the artist starts from the beginning, and the design is entirely in his own hands, it is not so difficult to determine just what is fit. But in the more frequent case, in which the art of the ornamentist is only supplementary, and he has to work upon lines already laid down for him, it is only where those lines are worth preserving that he is necessarily bound to preserve them, assuming, that is, that he can obliterate them. This is heterodox, but I hold it true. If the lines existing are bad, and the artist can by his design withdraw attention from them to lines more reposeful to the eye, he is doing good work. But he should do nothing but what he can make seem right. There must be no appearance of awkwardness, no suspicion of effort about it. It is a case in which success alone justifies the attack upon the situation. To fail is to lay yourself open to the charge of the unpardonable sin, the sin of disobedience to the conditions of design.

An actually haphazard or eccentric scheme of composition, such as a Japanese will sometimes affect, is hardly in contradiction to what I have laid down. When a Japanese artist cuts a panel quaintly into two, and treats each part of it as seems good to him, he is only doing what the Greek did when he cut off a portion of his wall space, and treated as a frieze—only he does it more energetically, not to say spasmodically, and with less appreciation of grace. So, again, when the Japanese begins with disks or crests dotted about on no perceptible plan, and strews sprigs of bamboo between, he is only doing in a more eccentric manner what the Western artist does, with greater regard for symmetry, when he disposes his sprigs on a geometric basis. If only he arrive at balance, which he almost invariably does (his instinct in this respect is so little likely to err), there is no occasion to cry out against him. We, on our part, are too much disposed to design as though there were no possible distinction between weight and bulk—as though the little leaden weight did not balance the heaped up pound of fruit, or feathers, or whatever it may be

Design apparently unrestrained, such as the men of the Renaissance habitually indulged in, proves very often, upon examination, to be constructed upon one or other of the systems I have described. Sometimes, indeed, the system of construction is very frankly indicated, though not precisely defined. At all events, the confession is full enough to insure absolution for any offense there may be against strict order.

The scope of subdivision possible with regard to a space is not affected by the amount of ornament introduced or its character. No matter whether it be human or animal figure that you employ, conventional or natural foliage, scroll or growth, interlacement, arabesque, or geometric pattern, the possibilities in the way of distribution are the same.

Naturally, however, certain lines of subdivison will be found to accord with certain kinds of treatment; and so we find that, as a matter of history, the Mohammedans adopted certain lines of composition, the Greeks other lines, and the Japanese quite others again. Furthermore, the lines one would instinctively choose for different purposes would themselves be different. One would scarcely proceed to decorate a panel by merely crossing it with bands of ornament, except perhaps in the case of some long strip of a panel which it was absolutely necessary to shorten; but that is just what is suitable to the shape of certain vases; and the Greeks found it the most satisfactory way of dealing with draperies. Their pet idea of decorating a full skirt seems to have been by means of a series of parallel patterns. If you refer to the vases at the British Museum, you will see both of these uses illustrated, often in a single vase.

What one would do, then, is not the same thing as what might be done. The possibility, as distinguished from the suitability, of distribution is in all cases much the same, but there must necessarily be some correspondence between detail and its distribution. For all that, there is no cut and dried rule as to the association of this kind of detail with that kind of distribution, or *vice versa*. It does not even follow that the kind of detail usually found in connection with a certain kind of composition is the only one appropriate to it. The connection of the two is evidence only of their conformity, not at all of the incongruity of other combinations. You may fry without bread crumbs. It is chiefly laziness, if it is not a suspicion of our own incompetence, which tempts us to adopt bodily what has been found to succeed. There are so many people in the world to to whom it comes easier to take what is there than to give what is theirs.

A design is in harmony, not when it is strictly according to Greek or Gothic precedent, but when the parts all fit. Suppose, for instance, the lines lead up to some prominent feature, that feature must be of sufficient interest to justify the attention called to it. There are positions so prominent that they call almost for figure design to occupy them. So, also, if it is proposed to introduce the figure, or anything of that importance, it is only natural to provide for it in your scheme, whether in the shape of medallion, frame, niche, or what not. The gem of your design should have a setting worthy of it.

Instances of such framing occur in diagrams on the walls. I don't mean to say that a coat of arms is essentially of profoundest interest; but in the eyes of its owner it is at least worthy of all prominence.

Any feature such as a tablet, medallion, label, cartouche, shield, and so on, introduced into a composition, should bear relation not only to its surroundings, but to what it is to inclose. This is a serious consideration very often neglected. It is no uncommon thing to see a shield introduced to bear an inscription, a circular medallion to frame a picture which demands a rectangular outline, and all manner of queerly proportioned shapes, which by their very position call for decoration, while, at the same time, it is almost impossible to fill them satisfactorily.

Upon the same principle of fitness, a predetermination to adopt natural forms of foliage would, artistically speaking, necessitate the choice of a not too formal framework for it; while detail designed on a large scale would call for equal breadth and simplicity in the setting out. So also with regard to the allotment of ornament—once the lines determined, the artist must scheme his ornament accordingly. Whether he elect to ornament every portion of the surface, as the Orientals often do, or certain selected parts only, like the Greeks, whether he choose to decorate many parts or few, and which parts, and how—that is his affair. His taste must be his guide in that, and unless he have some taste, he had better not attempt to design. This may sound like discouragement; but since the beginner in design is the last person who would be disposed to admit any arbiter in the matter of taste, the warning is not likely to deter any one from trying his hand at ornament. It is so easy, you know!

So far my remarks have been confined to the discussion of the panel shape, or parallelogram; but, as I began by saying, I have no idea of making that the limit of our consideration to-night. I think I shall be able to show, without much difficulty, that the principles upon which all manner of shapes may, and indeed must, be filled, are much the same. Evidently it makes little difference at all, and in principle none whatever, whether it is four sides of a figure we have to deal with, or three, or five, or how many. In either case you proceed in the same way; you work from the center or from the sides, as best may suit; you divide the space into regular or irregular compartments, on the system already explained; you overlay one feature with another, or interweave them; you interrupt a border, or invade a center, according to the circumstances of the case; and so on, just as though it were an oblong you were dealing with.

If it is at all an awkward shape that has to be treated, you have even an opportunity of correcting it, by introducing into it some prominent regular figure which, if you insist upon it, will occupy attention, while the irregular surrounding space will go only for margin or border; just as in the case of the regular panel you had the option of discounting its severity through the agency of any irregular feature that seemed good to you.

The management of the circular shape, and of the irregular forms of vases, seems to present a more serious difficulty, which, however, is more apparent than real. A vase is easiest decorated according to

its elevation or according to its plan. Any striped Venetian glass affords a type of the one proceeding, any ringed clay vessel of the other. The glass blower arrives as naturally at the one as the thrower or turner at the other.

Another way is to cross the shape diagonally, which results in the appearance of twisting, as may be seen very often in silversmith's work. Of course these systems may be associated, and they often are, as in the German tankards of the 15th century, where the bulbous bowl is beaten out into the semblance of a melon, and the neck and foot are simply turned.

Now the decoration of a vase lengthwise, according to its elevation, corresponds to the striping of a panel with vertical lines; the decoration bandwise, according to plan, corresponds to the striping of a panel with horizontal lines; and the twisted treatment corresponds to a series of diagonal lines crossing a panel.

The way in which medallions, panels, and other shapes may be incorporated with the design of a vase is not different from that already described. There is, however, this difficulty, that any marked independent shape is likely to interfere with the form of the vase, or the form of the vase to interfere with it, as is the way with the landscape and picture medallions so persistently misapplied to Sevres and Dresden china. Not that it is at all impossible to introduce such features with good effect; only it needs to be done with judgment, which of all things is most rare. And, as it happens, the difficulty has been more often attacked with valor than with that discretion which is reputed to be its better part.

The decoration of the circular plane involves new forms rather than new principles. The circle is most naturally divided either into rays or into rings. In the one case the radiating lines answer to the division of a rectangular space by vertical lines. In the other the rings answer to the horizontal lines dividing a panel. This is easily shown in Fig. 13.

Imagine a series of upright lines, A, to represent the folding of a sheet of paper. You have only to gather the folds together at one end, after the manner of a fan, B, and you have the system of radiation. Repeat the fan shapes side by side, and you soon arrive at a circle divided into rays, C.

Again, in the case of a series of horizontal bands, D, you have only to suppose them elastic enough to be bent, and you have a series of concentric arcs, E, so many slices, so to speak, out of a circle decorated ringwise, F. The same target-like result may be arrived at by the continuation of a series of borders round the circle, one within the other. That is only another way of reaching the same point in design. The crossing of the two schemes, G, is much the same thing as a square lattice of cross lines in a rectangular panel. The subdivision of the circular space by lines of more flowing character, H, would correspond to the division of the panel by diagonal lines; and if those lines were crossed, J, it would be analogous to the division of the square by cross lines into diamonds. The spiral line, as applied to the decoration of the circle, K, is equivalent to the fret or key pattern as applied to the square, L. These analogies, I think, are plain enough.

All manner of independent shapes may be introduced into the decoration of the circle, as into that of the panel. One may plant a shield in the center, and surround it with a border. One may associate any arbitrary form with ringed or radiating lines. But should any such shape form an important feature in the design, the situation is not so free from danger. There is a limit, that is to say, to the arbitrariness with which prominent lines or forms may judiciously be introduced into a circular design. Anything which counteracts the space you have to fill needs to be accounted for. The difficulty in dealing with forms contradictory one to another is that you are apt to leave interspaces of irregular shape, which are not very manageable, as, for instance, in the inevitable spandrel which occurs so frequently in architecture. If it happens to be very large, you can insert into it a more regular shape, which will hold its own; and if it is insignificantly small, you may ignore it. You may, if it is of importance enough to be accepted as an individual panel, treat it as such, with figures, scroll, and so on. Or you may simply cover it with an unimportant pattern in the nature of a diaper. These are the extremes. But the happy mean in spandrel decoration is not easy to find; and the spandrel may be taken as the type of all awkward shapes produced by the intersection of curved lines with straight. Ornamental design would be a much easier thing if we had only to consider the lines of the ornament, without any regard to the interspaces.

From the decoration of the circle to that of the rosette is only a short step. What applies to the vase shape applies to the column, baluster, pedestal, and so on. The triangle offers no new difficulty. A branched form may be looked upon as an assemblage of familiar parts, the Greek cross, for example, as an assemblage of five squares. An altogether exceptional space will be pretty sure to indicate of itself the exceptional lines on which it can best be decorated, and a capricious one may well be left to the caprice of the artist.

Entirely apart from the question of the skeleton of your design is the consideration as to whether it shall be looked at primarily from the point of view of line or of mass. In any satisfactorily completed scheme, lines and masses must alike have been taken into account; but the artist must begin with one or the other, and the result will probably be influenced by the one or other consideration which was uppermost in his mind. Which of the two it may happen to be, is more often a matter of temperament than of choice with him.

The primary consideration, whether of line or mass, will always lead the designer, though perhaps unconsciously, to adopt a plan accordingly—that is to say, the preference for mass will lead him to attack his panel resolutely, planting shapes upon it which it will be his business afterward to connect by means of the subsidiary lines needful to the completion of the scheme. On the other hand, a greater partiality for line will induce him to have recourse to a more orderly procedure; will, perhaps, even suggest a geometric groundwork, which, however far he may depart from the first lines, will materially help him in securing the object he has most at heart.

If you start with certain arbitrary and irregular forms, so many patches, as I may say, on the panel, it is clearly not such a very easy matter to connect them by any systematic lines of ornament. If, on the contrary, you begin with some system of orderly lines, these must necessarily determine in some measure the shape and distribution of any more prominent features you may thereafter introduce into the scheme.

For my own part (while I disbelieve entirely in arriving at anything more than mediocrity by the adoption of set rules of proportion), I feel rather strongly that there should be by right a strict relation between the parts of the design, however little it may be obvious. If, for example, there is a space to fill between border and central medallion, a diaper may be enough; but the diaper should be designed into its space. And even if part of a design be permitted to disappear, as it were, behind this feature or that, it should be so schemed that no very material form is

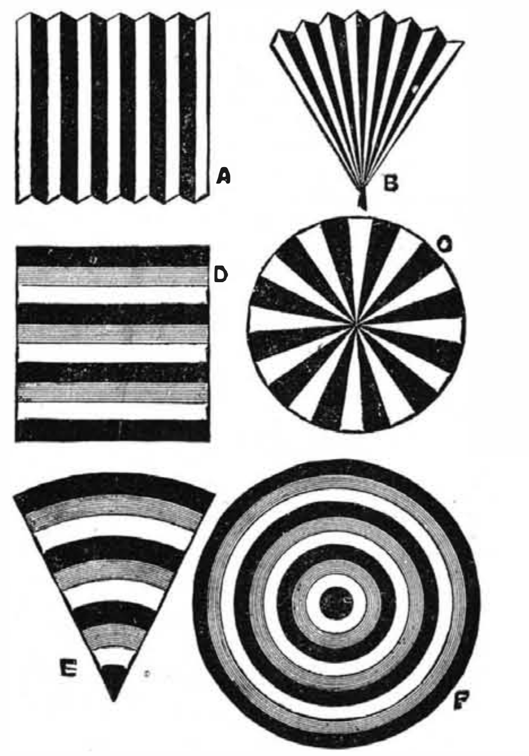


Fig. 13.

mutilated in the process. Where an interruption occurs in a border, the pattern should be planned with a view to such interruption. Even though you deliberately adopt a diaper as a background, the character of that diaper should be determined by the scroll, notwithstanding that the lines of the one are meant to contradict the lines of the other. It is not enough casually to employ any diaper. In the early English glass to which I referred a while ago, the overlapping patterns were designed to overlap. The spaces between one series of medallions suggested the shapes of the minor medallions between, which were shaped with a view to interruption. The careless overlaying of one pattern, or of one scheme, by another is the merest makeshift for design.

You will find invariably that the apparently "accidental" treatment, when it is at all successful, is not quite so much a matter of accident after all. There has been no disregard of the laws of composition, but only the omission of some accustomed ceremonial. To take what might seem a flagrant instance of the disregard of an obvious rule of art. There is a drawing on the walls of a cabinet by Boulle, in which the doors are treated as one panel, notwithstanding their actual separation by a pilaster between them. However wrong in theory this may seem, in practice it proves to be not so unsatisfactory. And for this reason—that

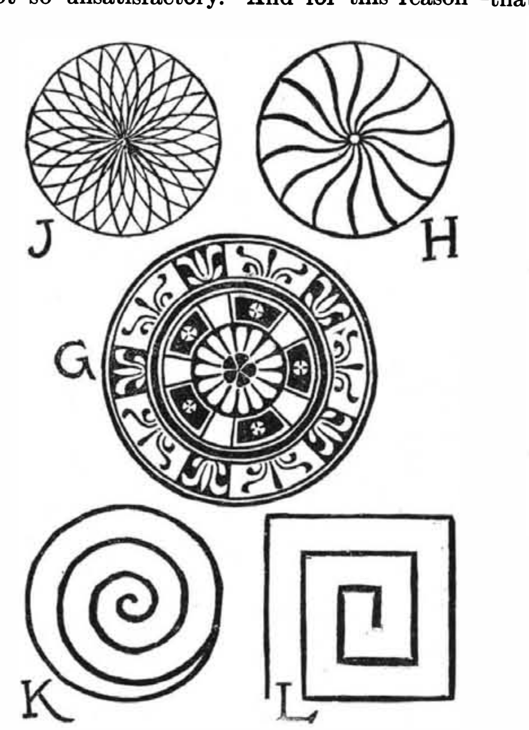


Fig. 14.

the upright intervening space was, as a matter of fact, very carefully taken into account in the design. The artist chose to make it less emphatic than its position would have suggested to most of us it should be. But he did not really ignore it. Very far from it. Had he disregarded the construction, the jar would have been very perceptible. If he succeeded at all in satisfying the eye, it is because he did with great deliberation and judgment what might easily be mistaken by the inexperienced for an inconsiderate thing.

It is when such things are undertaken by the novice, without forethought and without discrimination, that they become offensive. Wherever they are inoffensive, be sure they were designed, and designed with more than ordinary skill. It is only a master than can reconcile us to something which, until he did it, we did not think could properly be done. There is nothing careless or casual in the art of design—not even in the little art of ornament.

OXALIC ACID FOR THE SEPARATION OF VARIOUS METALS.

By C. Luckow.

If oxalic acid is added to the solutions of different common metals—neutral or faintly acid—there are produced in the majority of such solutions precipitates of insoluble or sparingly soluble oxalates. In a few cases only there takes place no separation of insoluble oxalates, and the solutions remain clear.

This latter case occurs in the solutions of the alkali metals and those of the higher compounds of some metals rich in electro-negative constituents, in which hydrated alkalies throw down hydrates corresponding to the sesqui- and peroxides, and in which such hydrates form compounds with a metallic acid. A precipitation of insoluble oxalates does not occur in the solutions of neutral salts of the alkaline metals, and in the solutions of chrome, aluminum, iron, manganese, uranium, and tin oxides, as well as of chromic, manganic, and antimonic acids, and of the acids of arsenic.

This behavior of the oxalates affords means not only of distinguishing the various stages of oxidation of the above acids, but also of separation, qualitatively and quantitatively, of the metals in question in their higher compounds from a great number of other metals. Setting aside gold and platinum, we find that among the metals of group VI. stannous oxide and antimony teroxide are separated from their solutions by oxalic acid, while no precipitation ensues in the solutions of stannic oxide, antimonic acid, and of the arsenic acids. All the metals of group V. are precipitated by oxalic acid.

The oxalates of lead, bismuth, silver, copper, and mercury, both in their maximum and minimum compounds, are almost insoluble. Cadmium oxalate is sparingly soluble. Copper, and indeed all other metals, should be thrown down only from hot liquids, preferably by a boiling solution of oxalic acid or by adding to the boiling solution a sufficiency of finely pulverized oxalic acid, as the precipitates in boiling solutions subside more rapidly. After the liquid has become clear it is filtered by decantation, so that the least possible quantity of the precipitate is brought upon the filter. The two portions of precipitate (that on the filter and that on the beaker) are then dried, placed in a porcelain crucible, and heated, very cautiously at first, and finally more strongly after the addition of a little nitric acid. Small quantities of copper oxide can be easily converted into oxide. Large quantities are inconvenient on account of the gases evolved during the decomposition of the oxalates, which may occasion loss by projection.

The silver salt enters into decomposition at 110°, and detonates if heated more strongly. The mercuric salt is decomposed at 163° somewhat violently into mercurous salt and carbonic acid. Instead of decomposing oxalic acid in its salts by heat alone, it may be destroyed by heating with strong sulphuric or phosphoric acid, with permanganic acid, chromic acid, or with chlorine in an alkaline solution.

As for the metals of group IV., oxalic acid throws down nickelous, cobaltous, manganous, ferrous, and uranous oxides, and also zinc oxide, from their neutral or moderately acid solutions as sparingly soluble oxalates. In this group, consequently, ferrous, manganous, and uranous oxides may be separated, by means of oxalic acid, from the corresponding higher oxides. The faintly rose-colored cobalt oxalate and the dull green nickel oxalate much resemble the copper salt in the fineness of the precipitates. Both are very sparingly soluble. Rather more soluble is the lemon yellow, very stable ferric oxalate, and the manganous salt, which is almost white and settles readily.

The zinc salt is most readily and completely separated by evaporating its solutions mixed with a slight excess of oxalic acid. This behavior of the zinc salt must be kept in mind in quantitative analyses. The complete separation of all the precipitates produced by oxalic acid is much promoted by the time allowed. The metals of group IV. require more time than those of group V. If to the solutions supersaturated with oxalic acid there is added a solution of ammonium chloride or nitrate, the separation of the insoluble oxalates is much promoted.

A rapid and complete separation of all these salts is effected by evaporating down the solution with a slight excess of oxalic acid, and taking up the soluble matters in a little water. A volatilization of volatile chlorides under these circumstances does not take place if oxalic acid is present in excess, even in case of arsenious compounds. Dilute sulphuric and nitric acids do not appreciably increase the solubility of oxalates which are insoluble in pure water and in dilute oxalic acid. Hydrochloric acid, even if dilute, has a decidedly solvent action. Similar is the action of strong oxalic acid upon various insoluble oxalates. Many of the insoluble oxalates combine with the alkaline oxalates to form soluble double salts. Exceptions are the strontium, barium, calcium, silver, lead, and mercurous salt. The lead and the mercuric salt dissolve in hot solutions of alkaline oxalates, but separate out again on cooling or dilution. The barium, magnesium, and mercuric salts are soluble in ammonium chloride. The non-volatility of the soluble oxalates is of importance, as evaporation is the quickest, simplest, and most certain method of separating the soluble compounds quantitatively from the insoluble. In such solutions the oxalic acid must be present in slight excess. If the evaporated residue is treated with water, the soluble oxalates are dissolved without decomposition, and may then be separated from the insoluble by filtration.

Ammonia produces no precipitates in the solutions of antimonic and antimonious acids, while precipitates of oxides or of basic salts are formed in the oxalic solutions of stannic, ferric, uranium, chromium, and aluminum oxides. Alkaline phosphates and borates, which, like ammonia, precipitate all these solutions in the absence of oxalic acid, occasion no deposits in its presence. This behavior of tin and antimony solutions with ammonia affords a simple means for the separation of

the two metals. Even in solutions containing both, the tin is thrown down free from antimony if the solution contains sufficient oxalic acid or ammonium oxalate, or if the precipitated tin oxide is dissolved in hydrochloric acid, mixed with oxalic acid, and reprecipitated with ammonia.

If we have to examine an alloy of tin, or antimony, or of both, with lead, copper, zinc, or iron, the comminuted sample is dissolved in a small excess of aqua regia, oxalic acid is added to the boiling solution so long as a precipitate is produced, the insoluble oxalates are allowed to settle on cooling, or the solution along with the precipitate is evaporated to dryness on the water-bath and taken up again in a little water. The separation of the precipitate from the liquid is best effected by decantation through a double filter, bringing upon the filter as little as possible of the precipitate. In quantitative operations the precipitate and the filter are freed from soluble portions by means of a dilute solution of oxalic acid, and both are then dried and cautiously ignited. In the solution are found the tin, iron, and antimony if its conversion into antimonic acid has been complete, and the arsenic as arsenious or arsenic acid. As various oxalates are not absolutely insoluble in water and dilute oxalic acid, traces of them may be found in the solution containing the tin, antimony, and iron, and must be considered in accurate quantitative operations.

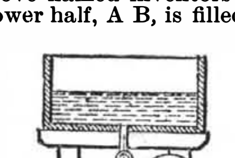
In the treatment of the ores, alloys, etc., with aqua regia, it is well, in case antimony is present in large quantity, to mix the solution, before adding the oxalic acid, with chlorine until a distinct and permanent odor of chlorine is perceptible, in order to make sure that all antimony is present as antimonic acid. In presence of zinc it is safest either to evaporate down the solution (after addition of oxalic acid) upon the water bath, or to allow the same oxalic solution, mixed with ammonium chloride or nitrate, to stand for some hours.

In order not to introduce an excess of acid, 0·1 grm. of the ore or alloy requires 1 c. c. aqua regia made up of 3 to 4 vols. hydrochloric acid, sp. gr. 1·2, and 1 vol. nitric acid of the same sp. gr., and that this 0·1 grm. requires twice the weight of crystalline oxalic acid $(COOH)_2$+aq. in order to convert all the dissolved metals into oxalates. If sparingly soluble chlorides or sulphates separate out in the solution, they may be transformed into the corresponding oxalates by boiling with a slight excess of oxalic acid.

If alloys containing tin are treated with nitric acid, the supernatant liquid evaporated to expel nitric acid, the residue or its insoluble portion moistened with a little hydrochloric acid, digested with a strong solution of oxalic acid until the hydrochloric acid is expelled, oxide is dissolved, while any metals present forming insoluble oxalates pass into the precipitate. Antimonic acid prepared with strong nitric acid does not possess this property, but the meta-antimonic acid formed by the action of water on antimony perchloride. Solutions of antimonic acid mixed with oxalic acid remain, therefore, clear on dilution with water. It is possible that this different behavior of tin oxide and antimonic acid may lead to a separation of the two metals.—*Zeitschrift Analyt. Chemie*, vol. xxvi., p. 9; *Chemical News.*

RECOVERY OF SULPHUROUS ACID.

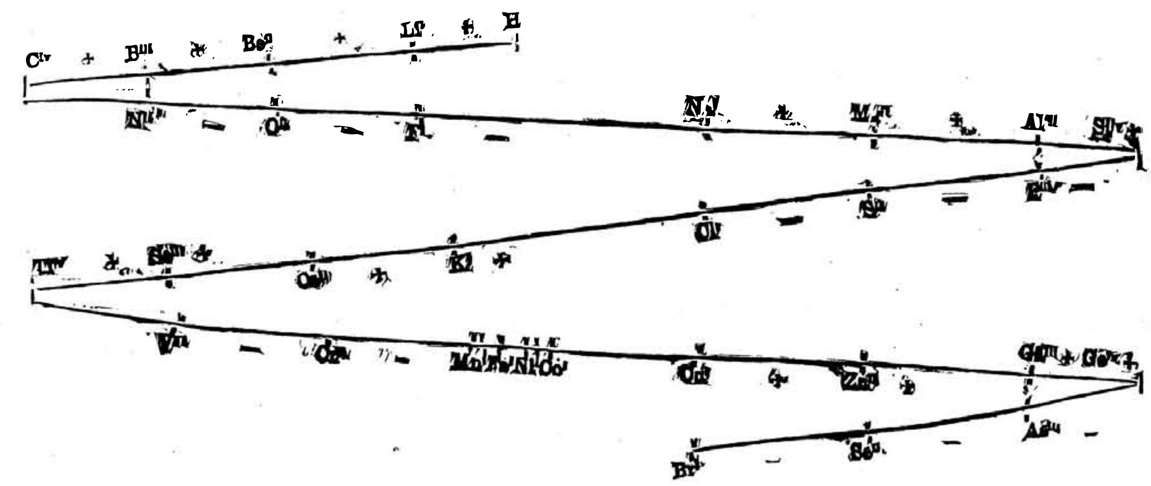
A GERMAN patent, by E. Haenisch and M. Schroeder, furnishes a means for separating steam and sulphurous acid where both are given off simultaneously. Sulphurous acid is now largely used by paper makers, and it has been found difficult to deal with the mixture of steam and sulphurous acid which is evolved in the sulphite process. This mixture, besides being a nuisance, is also a source of loss, as regards heat and sulphurous acid, and an apparatus which will enable the manufacturer to recover both should prove of value. The above named inventors use a lead tower, which, in the lower half, A B, is filled with trays made



of fire clay. The rest of the tower is filled up with coke. The mixture of sulphurous acid and steam enters at the bottom through the pipe, C, and is met in its passage upward by a stream of cold water, which is supplied from the top by means of a distributing apparatus, D. Both steam and sulphurous acid become condensed, but on running down meet again the mixture of steam and sulphurous acid. The consequence is that the condensed solution of sulphurous acid becomes gradually heated up to 212°, at which temperature all the sulphurous acid is given off. After having worked for some time, the temperature of the condensing water should rise to 212° as it arrives at the bottom of the tower. It is there discharged by a pipe, E. The temperature of the sulphurous acid, on the other hand, should decrease to the temperature of the condensing water as it approaches the top of the tower. If the quantity of the condensing water is properly regulated, it will not be sufficient to condense the quantity of sulphurous acid evolved, and a continuous current of sulphurous acid gas will, therefore, be obtained at the top of the tower, from which it is taken away by a pipe, F. We may here remark that in filling a tower with coke, great care should be observed. It is advisable to get good hard coke, and to pack the tower by hand, that is, to place the pieces of coke carefully, so that they should not be broken. The coke should be riddled, so that all the dust be removed, and the largest pieces placed at the bottom, then a layer of smaller pieces, and so on up to the top, where pieces of the size of a small apple may be put. This is the only way to avoid the stopping up of wash or condensing towers, and carelessness in this apparently paltry matter has more than once caused great trouble and expense.

GENESIS OF THE ELEMENTS.

NOTHING is so fascinating in science as an ingenious, but unproved, theory. Once proved to the dignity of a "law," it becomes a thing to be learnt, and exchanges the charm of an uncertain *denouement* for the cold severity of a lesson. The strange revelations of modern chemistry in relation to the nature of the so-called elements have kindled among all scientific students an intensely eager anticipation of the discovery of some simple scheme into which all the accumulated facts shall drop in natural connection, of the thread which links the myriad observations of patient explorers into a perfect chain. "We cannot but feel," said Mr. Crookes at the Royal Institution recently, "that unless some approach to an answer to these questions



can be found, our chemistry, after all, is something profoundly unsatisfactory. These elements perplex us in our researches, baffle us in our speculations, and haunt us in our very dreams. They stretch like an unknown sea before us, mocking, mystifying, and murmuring strange revelations and possibilities."

Mr. Crookes detailed his speculations on the genesis of the elements at the last meeting of the British Association, and we then reported his address in full. He has lately presented his ideas again in rather more popular language to the fashionable world of science assembled in Albemarle Street, and many of the keenest minds in England are pondering his theory.

A few weeks since, Sir William Thomson narrated to a similar audience his idea of the way in which the sun was formed some twenty millions of years since, by the rushing together of atoms in such quantity and with such force as to provide a source of heat for this solar system up to the present date and about ten million years longer.

Mr. Crookes takes us back a few steps farther. What was the condition before the atoms had themselves come into shape, if, indeed, they are not eternal, when creation was, in the expressive language of Scripture, "without form and void"? Mr. Crookes assumes a condition which he designates "protyle," the "proteule" of Aristotle, the formless stuff of the Book of Wisdom, the materia prima, the unknown and unknowable origin of matter, the "fire mist," as Mr. Crookes himself happily, but vaguely, terms it.

Now suppose in the midst of this protyle the introduction of external energy in some form or other, and an internal action corresponding to cooling. The energy has periods of swell and ebb, and it forces the protyle to shape itself and to develop first the lightest of atoms, say hydrogen. These atoms would then be themselves stores of energy, kinetic from their internal motions, and potential from their tendency to coalesce with other atoms by gravitation or chemically.

Each new formation would tend to the formation of others by refrigerating the surrounding protyle, and we should get sets of atoms of regular progressive weight. Now (without following Mr. Crookes in all the steps of his argument) see how these elements group themselves, and notice the regular ebb and flow of the formation.

It is not necessary to continue the diagram, which is a modification of one first drawn by Professor Emerson Reynolds. It will be found complete in this journal for September 25, 1886. What is to be noticed is this: When energy first acted on protyle, its first accomplishment was the formation of the hydrogen atom. A few thousands of years later it had got as far as lithium; next came beryllium, boron, and carbon. So far, positive elements only had been created in regular progression of atomic weight and of valency.

Now the pendulum returns, the ebb sets in, negative elements are formed until the center is reached, when a new impetus is given, and new creations result in similar order. As the pendulum reaches a corresponding stage in each swell or ebb, elements of curiously corresponding characteristics result. So we have chlorine, bromine, and iodine; calcium, strontium, and barium; arsenium, antimonium, and bismuth found at corresponding points of the pendulum's swing.

A great deal of this theory is due to the labors of other chemists—Newlands, Mills, and Mendelejef especially; but Mr. Crookes has, no doubt, most ingeniously fitted all their observations into his comprehensive scheme. His own special contribution to his theory, however, is very striking. He has worked for many years on yttrium and its spectra. By the most delicate of tests he has shown that yttrium can be differentiated or fractionated into several varieties, all showing the true yttrium spectrum, but each with some marked differences of its own in the subordinate lines.

This observation is what led Mr. Crookes to imagine that the creation of yttrium was itself a work of time, of slow evolution, leaving its effects in trifling variations of the weight of the atoms, which altogether go to make up yttrium. If that be so, is it not possible too that the whole genesis of the elements is a very slow process of evolution? The occurrence of such groups as manganese, iron, nickel, and cobalt, with their curiously similar chemical properties, all created apparently at close intervals, goes to support this idea.

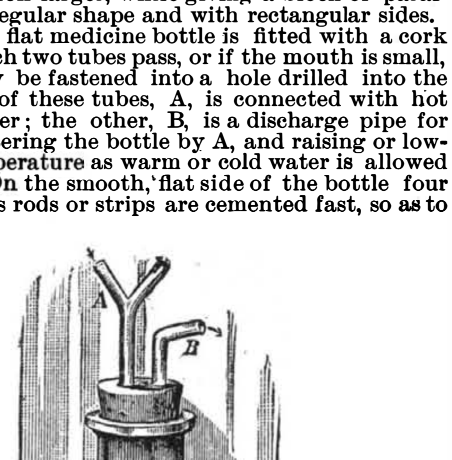
Much more will certainly be heard of this theory. We make no pretension of criticising it. Our design has been only to present its salient features in outline, leaving students who may wish to understand it more fully to refer to the emiment author's own words.—*Chemist and Druggist.*

ORIENTING OBJECTS IN PARAFFINE.

IN the *Zool. Anz.*, No. 199, Selenka has described a method of keeping paraffine melted while the contained small objects are being arranged under the microscope in any desired position, and then of rapidly cooling the paraffine without disturbing the position of the objects.

Finding it difficult to make tubes such as he describes, which should be of such shape as to admit of removing the hardened paraffine readily, and at the same time with depressions of sufficient size for any but very minute objects, I have made use of the following simple device, which, though more clumsy than the tube of Selenka, can be used for objects 1 mm. long, and much larger, while giving a block of paraffine of very regular shape and with rectangular sides.

A common flat medicine bottle is fitted with a cork through which two tubes pass, or if the mouth is small, one tube may be fastened into a hole drilled into the bottle. One of these tubes, A, is connected with hot and cold water; the other, B, is a discharge pipe for the water entering the bottle by A, and raising or lowering its temperature as warm or cold water is allowed to flow in. On the smooth, flat side of the bottle four pieces of glass rods or strips are cemented fast, so as to



inclose a rectangular space, C, which forms a receptacle for the melted paraffine. As long as the warm water circulates through the bottle the paraffine remains fluid, and objects in it may be arranged under the microscope by light from above or below, and can be oriented with reference to the sides of the paraffine receptacle or with reference to lines drawn upon the surface of the bottle.

When the cold water is allowed to enter in place of the warm, the paraffine congeals rapidly and may be easily removed as one piece. The discharge pipe should open near the upper surface of the bottle, to draw off any air which may accumulate there.—*E. A. Andrews.*

A VESSEL with a cargo of forty-four ostriches arrived recently at Galveston, Texas. This is the second cargo within twelve months. The birds are for ostrich farms in California, and came from Natal.

THE ETIOLOGY AND CURE OF ASTHMA.*

By Edwin J. Kuh, M.D.†

The work of Wilhelm Hack on the radical treatment of migraine, asthma, hay fever, and other neuroses has received very inadequate recognition in this country. By writers on hay fever he is frequently quoted in an off hand manner together with a string of other authors, so that one derives the impression that few of those who quote him have read him. And if his specialistic colleagues do not do him justice, the large class of general practitioners ignore him altogether. His work is, taken altogether, of even greater interest to the physician than to the specialist, and it is a deplorable consequence of specialistic exclusiveness that the results of his work have not yet received wider recognition among us. He teaches us that the rhinoscope must forthwith be as indispensable an instrument for all physicians as the thermometer and stethoscope.

The value of Hack's discovery, that asthma nervosum is a reflex disease with, usually, the nose as a starting point, can best be appreciated by one who himself for many years struggled against the disease and fumed at the utter impotence of medical art to stave off the attacks. If I, therefore, in the course of this paper, class myself among my own patients, I shall do so with the view of bringing the subject within closer range.

It is foreign to my subject to consider the isolated publications, from Voltolini downward, on the dependence of asthma upon polypous growths in the nose. Such cases are infrequent enough to be almost considered curiosities (Michel, for instance, reports 135 cases of polypus without asthma), and as Hack shows, polypi have rather a tendency to prevent asthma than to cause it. It will also simplify our subject if we omit hay fever from our consideration.

The form of asthma of which I wish to treat exclusively is that perennial form which is more or less independent of the seasons, namely, asthma nervosum, or "essentielles asthma" of the Germans. Some persons never get beyond a slight hint of asthma. They will from time to time make a heaving, sighing motion, or complain of præcordial fullness with or without palpitation, or of sudden drowsiness, or dream heavily at night and complain of dullness, lassitude, and headache in the morning.

This latter condition has many gradations, the culmination of which is nightmare. In the future we must, therefore, learn to distinguish between an incubus of gastric and of respiratory origin. Other half asthmatics complain only of a fleeting, leaden heaviness in the limbs amounting almost to pain, the same sensation of which so many true asthmatics complain after an asthmatic night. The typical asthma nervosum is known to us all as a neurosis occurring in paroxysm.

The patient may or may not feel an aura. He will generally, toward evening, or when he lies down, or awakes in the night, begin to wheeze. This wheezing may be associated with itching in the nose, or sneezing, or coughing. The attacks last an indefinite time, and generally end with the expectoration of a transparent glassy mucus. Such patients are often free from asthma during the day. Physical and chemical irritants, such as dust, sudden changes in temperature, the inhalation of certain gases, and a long series of idiosyncrasies, which we find enumerated in text books, can induce an attack. But the recumbent position is the most uniform exciting cause of the single paroxysms. Such patients may be free from chronic bronchitis, chronic emphysema, heart, kidney, intestinal, and uterine disease, hence the term "essentielles asthma."

When we read authors whose contributions to the study of asthma antedate the last few years, we are struck by the uniformity with which they cling to pet theories, each of which seems to give satisfaction to its upholder. It is merely an evasion to say that asthmatic paroxysms are induced by bronchial spasms, or by hyperæmia of the bronchial lining, or by the presence of Leyden's crystals, or by phrenic spasm, or by bulbar irritation, or by exudative bronchiolitis. For any one of these presumable causes would demand a first cause, in order to merit etiological dignity.

A true etiology of asthma had therefore to be discovered, and Hack did it in the following manner. He knew, of course, of the occasional *rôle* of nasal neoplasms. Schaffer and B. Frankel had also indicated that the sensibility of the nasal lining could be so heightened through chronic catarrhal conditions as to be a starting point for reflex disturbances. Then Hack found that he could experimentally produce glottis spasm by touching the turbinated bodies of a sensitive individual with a probe.

He then reasoned as follows: A nasal mucous membrane which shows merely slight affection, and which is not deadened in its sensibility by thickening and hypertrophy, is perhaps a better surface for exciting reflexes than one which shows evident signs of disease. And if this were the case, he reasoned, then perhaps the importance of nasal reflexes had been formerly overlooked just because of the significant abnormities of such a sensitive nose.

The very frequency of certain conditions may have given rise to an under-estimation of their significance. And so Hack systematically examined the nose of every patient who, for whatever ailing, came within his reach. He learned to make one distinction very rapidly, namely, that which is usually termed hypertrophic nasal catarrh is a twofold condition, which in its effects is quite opposite. In the anatomically true rhinitis hypertrophica the mucous membrane is really thickened, hypertrophied through chronic inflammation. Pressure with a probe meets with a certain unyielding resistance, and there is a purulent, crusty secretion. This form does *not* give rise to reflex disturbances.

But there is another form, a pseudo-hypertrophy, the importance of which it is Hack's merit to have pointed out. It is that transitory swelling of the cavernous tissue of the inferior and middle turbinated bodies, which has of late been so often described that I spare you a repetition. In this form the nose may either have a very dry, itchy sensation, or show copious watery secretion. Compression with a probe gives the air pillow reaction. Such individuals show fleeting alternate or synchronous obstruction of the nasal cavities.

Often, when examining the nose of patients, we notice sudden engorgements and collapse, so that Hack's term erectility is not an exaggeration. These cavernous bodies, with their frequently anæmic covering, form a link in certain morbid reflexes, and when this link is destroyed, through operative intervention, the reflexes cease. No symptom is more frequently overlooked by patients than transitory nasal obstruction. Most patients will positively deny its existence until it is demonstrated to them. Therefore the assurance of an asthmatic that his nose has always appeared healthy is of no value.

Other asthmatics, if conscious of nasal trouble, consider it simply concomitant with their asthma, and it is characteristic of them that they will often resist the inquiries of the physician who attaches so much importance to rhinoscopic examination and nasal symptoms, when all their trouble seems located in the chest. It is interesting to observe how such people become gradually convinced, and how uniformly they marvel at having forgotten or overlooked most constant symptoms. Only recently I succeeded in showing an asthmatic half a dozen rapid openings and closings within barely more than a minute or two.

The theory of Hack is a simple one, and, although it does not cover all the ground, is a very satisfactory one. He says that the turbinated bodies become engorged through various irritants, and that this vaso-dilatory disturbance is transmitted to the bronchial tubes in asthma. The turbinated bodies act as accumulators for reflexes, store them up, as it were, and then transmit them to other parts. A destruction of the nasal swelling removes the reflexes. The experiences of numerous writers since 1883 corroborate the correctness of Hack's discovery.

By way of illustration, I could not, I believe, select a better type of asthma of long standing than that of my own person. Twenty years ago, when I was eight years of age, I became subject to so-called colds in the head and on the chest. They increased in severity and frequency from year to year, so that my surroundings were often puzzled to find an explanation for each outbreak. Presently nightly dyspnœa began to set in, in the following manner: During the day my respiration was quite free, but as soon as my head touched the pillow, the first wheeze set in. The paroxysms were very severe. They ceased, after lasting throughout the night, in the morning, with the usual expectoration of glassy mucus.

During the day there was never any difficulty, except when occasioned by laughter. Laughter would infallibly cause itching under the chin and between the scapulæ. Then I would cough convulsively, and the attack was upon me. But the recumbent position was the surest exciting cause. During the first years I also suffered from that form of conjunctivitis which is now known to arise from nasal disorder.

I must give Dr. Abram Jacobi, of New York, under whose treatment I was at the time, credit for having already then, even without the use of the nasal speculum, laid stress upon a nasal trouble. But the aggravation of my troubles which followed upon the introduction of weak nitrate of silver solution into my nose, made the memory of him a less pleasant one in those years than it is at present. The greater part of 1870 to 1875 I spent in the Swiss mountains, where I was entirely well.

The attacks ceased from the day on which I reached the mountains, and infallibly returned on the very day I left them. Once during harvest season in Bavaria (1872), while I sat in a meadow, I was suddenly overtaken with convulsive sneezing, coughing, and asthma. It lasted hours before I could reach the neighboring village. During that same period I developed a peculiar idiosyncrasy toward dinner. In the midst of the meal I would invariably for weeks be seized with a convulsive cough, so severe that it threw me to the ground.

Asthma was never absent in these attacks. Then, at other times, one, or two, or three sneezes would initiate an asthmatic attack, or sometimes, especially after traveling, I would sneeze sixty or seventy times without intermission. In those days I had the sensation as if the asthma were brought on by a swelling, which seemed to begin above and behind the palate (it was associated with intense itching, which I attempted to relieve by rubbing my tongue against the hard palate), and traveled downward to the posterior pharynx, then seemed to skip the larynx, and continued from the trachea downward. This phenomenon lasted a few seconds, and then the attack began. Railroad travel would invariably cause a night of asthma. One hotel, at which I was frequently obliged to stop in Germany, adjoined a stable, and was regularly the cause of some of the severest attacks.

The few years which antedated my acquaintance with Hack's writings were comparatively easy ones, because the inhalation of Kidder's asthma pastilles—the only palliative I ever used successfully—gave me very great relief. They not only immediately terminated an attack, but also prevented their occurrence for the next hour.

As soon as I became acquainted with Hack's articles in the *Berliner klin. Wochenschrift* of 1882 and with his monograph in 1883, I commenced stricter self-observations, and found the following:

As soon as I lay down, my nose would become obstructed. The occlusion corresponded to the side on which I lay. By turning over, the occluded side would open and the other close To have any part of the nasal mucous membrane touched by a probe gave such intense pain that I could not suppress an outcry. I could bring on an attack of asthma by rubbing my ala nasi against the septum.

Never did I feel the slightest dyspnœa when nasal respiration was free, and never was nasal respiration obstructed but what I felt asthmatic distress.

Under these circumstances there could be no hesitation. Dr. Jefferson Bettman, now of New York, and Dr. Henry Gradle, performed the galvanocaustic "destruction" of both inferior turbinated swellings. When I say galvanocaustic "destruction," I should like to put the word destruction in quotation marks, for I have found the radical obliteration of the entire inferior turbinated bodies almost an impossibility. Hack demands, and my experience confirms the correctness of his view, that the radical cure of asthma demands the radical destruction of the cavernous erection. But a longer and closer observation of such patients in whom the extirpation seems complete will almost invariably show relapses, which must again be subjected to operative interference.

In my own case fourteen cauterizations, performed with both a flat and furrow electrode in the manner described by Hack, have not succeeded in permanently clearing the nose. The asthmatic attacks have, to my unspeakable relief, ceased. Sleep is now a function of which I have lost all dread. But during the daily occurring fleeting occlusions there is a feeling of heaviness on the chest and of excessive fatigue in the limbs which do not pass away until the nose is free.

What is it that causes nasal occlusion? I have observed myself so closely in this regard, and have so many corroborative observations of intelligent patients that I can make these positive statements:

First, the fullness of the turbinated bodies is regularly influenced by gravitation, and corresponds to the position of the head.

It is furthermore influenced by the temperature, and probably much more so by artificial warmth than cold. An overheated room will almost invariably cause swelling in such patients. But the most dangerous and permanent cause of nasal obstruction is the inhalation of dust.

The time is, I hope, not far distant when our views on the etiology of respiratory diseases will undergo a radical change. The superstition of catching cold has lived too long. The light which mycological research has thrown on the etiology of most infectious diseases must soon influence us toward a conviction that respiratory diseases are *inhaled*, not caught, and that suppuration in the respiratory tract is as impossible without the presence of micro organisms as it is on a wound. The superstition of "catching cold" is so pernicious because it diverts attention from the entrance way of disease generators. It is as impossible to contract an acute bronchitis through temperature influences alone as it is to contract tuberculosis through a cold.

It is, therefore, of the utmost importance to warn asthmatics that as perfect an avoidance of dust inhalation as is possible in our contaminated surroundings is necessary to prevent a recurrence of their trouble. Not only the dust in the streets, but also that in our houses, is to be avoided as much as possible. Carpets and curtains are great receptacles of dust, and a strict regulation of street sprinkling will in the course of years, when the true etiology of respiratory diseases will have been recognized, be considered as important a municipal regulation as the regulation of sewerage.

When are we to operate on asthmatics? The more recent the asthmatic trouble and the more pronounced the nasal symptoms, the better the prognosis. When complicated with chronic bronchitis and chronic emphysema, the outlook is generally bad. A most thorough examination of heart, lungs, kidneys, and intestines should precede any operative interference. In cases of cardiac and nephritic asthma with nasal complications, I have *never* cauterized. First, because it has seemed to me irrational, and secondly, because I feel so much gratitude toward Hack's discovery, that I shun any risk which might discredit it.

In some cases it is very difficult to decide whether an operation should be performed or not. For instance, in cases of long standing, say fifteen or twenty years, in which in the first years the nasal symptoms were very pronounced, but in later years have almost or entirely disappeared, in such cases cauterization is sometimes successful, but generally it is unsuccessful.

Cases in which the asthma is more or less constant and has lost its paroxysmal nature give a doubtful prognosis. It has been a matter of experience with me that those patients to whom the inhalation of Kidder's pastilles, or the application of cocaine to the nose (4 per cent. solution on cotton), gives relief, afford a much better prognosis than others.

In asthmatics in which coughing precedes the attack and on whom all nasal symptoms are missing, nasal cauterization will cure, if the cough is a so-called nasal cough.

There are a number of asthmatics, fortunately a minority, who seemingly offer a good prognosis, but with whom, for unknown reasons, the operation will fail. There can now be no doubt that there are other starting points for reflexes in the respiratory tract, besides the nose. The works of Trautmann and Tornwaldt have already added the vault of the pharynx to this list.

The bronchial tubes themselves can act as a starting point, as I can demonstrate on myself when I walk against a piercing wind, or inhale vapors of sulphurous acid with my nose plugged. So that, as Hack himself warningly says, we must not overestimate the applicability of his discovery.

We must accuse the nose *per exclusionem*. Examine every patient thoroughly in every direction, and examine the nose *last*, is what I should like to advise.

About the operation itself little is to be said. It is, as far as we know, absolutely harmless. I have performed many hundred cauterizations without any noteworthy complications. I have never had any traumatic infections. I insufflate iodoform or iodol upon the wound, introduce a pledget of cotton for a few days, and keep my instruments aseptic.

The results are, on the whole, extremely gratifying. Asthma of many years standing is sometimes broken after the very first cauterization. Almost all patients are relieved, and many cured in the strict sense of the word. Some have relapses, which additional cauterization will remove. Others again may relapse, with a new reflex sensitiveness in other parts.

But on the whole the subject, still so new, still so capable of growth, broadening, and development, is one of the most pleasing contributions to medical knowledge, and the name of Hack will be, I am sure, not soon forgotten.

* Read before the Chicago Medical Society, January 3, 1887.—*Medical Age.*

† Surgeon to the Michael Reese Hospital, Chicago.

Six miles from Mackinaw, Ill., is a bit of ground about eighty feet square that is always so warm that snow melts as soon as it falls upon it. It is said that when the earth there is disturbed it flashes like burning powder, and that a peculiar gas comes up from the ground.

HERBACEOUS AND SHRUBBY CLEMATISES.

The great improvements that have, within the last few years, taken place in our garden clematises, as well as the introduction of new kinds, have deservedly raised them to the foremost rank among hardy climbers. C. jackmanni may be seen almost everywhere, and used in all sorts of ways. In the neighborhood of London especially hardly a garden worthy of the name is without a plant of it. I have even seen it flourishing in window boxes, and it is not at all unusual to see verandas entirely covered with plants of it growing in small boxes. In the case of this clematis and its hybrids, good rich soil should be used unsparingly in the first instance, and a top-dressing of good manure should be added annually afterward, or at least when required. The general practice is to leave them unpruned until spring, when they are merely cleared of dead wood, leaving shoots on which there are fresh, healthy buds undisturbed, They are sometimes also cut down altogether, and, I am told, with good results, but I have not had sufficient experience of this practice to recommend it. Kinds possessing a woody character will only require the removal of the superfluous shoots annually. They flower on the current year's wood, and all properly placed shoots should be left so as to insure good young growth. Such sorts as C. graveolens, C. montana, C. cirrhosa, and others do well in ordinary garden soil of good depth, but we, nevertheless, find a top-dressing occasionally to be very beneficial to the majority of them.

C. GRAVEOLENS.

C. ÆTHUSÆFOLIA.

THE CLEMATIS.

C. CIRRHOSA.

C. CAMPANIFLORA.

Clematises may be used in various ways, but that in which we think they look best is creeping over old stumps or draping trees, which they do very gracefully. Many of them are also very effective overhanging large bowlders in the rockery, such as we see in Battersea Park and in the new rockery at Kew. Old ruins, walls, isolated heaps of brickwork, and old roots may all be improved and beautified by these charming climbers. Among the most useful are C. flammula, a native of Southern Europe, but as hardy and free as the wild C. vitalba. It looks well on old rockwork or tree stumps, producing dense panicles of small white hawthorn scented flowers. C. cærulea, a near ally of C. florida, introduced from Japan about 1834, has large pale violet flowers. It is the parent of many garden forms, both single and double, none of which surpasses the type in beauty. C. graveolens, here illustrated, is another species with strongly scented flowers, which are pale yellowish green ; although not so ornamental as those of some kinds, they are produced more plentifully, and the fruits with their long feathery tails remain until November.

C. graveolens is a free grower, and does well in any partly sheltered spot. The leaves, which are triternate, have a pretty glaucous sheen, not unlike that of C. songarica or angustifolia. It was introduced about 1844 by Captain Munro, when in India, but it is also found in Chinese Tartary. C. cirrhosa, the evergreen virgin's bower, is an interesting early kind. Its flowers, which are white or greenish white, are produced in bunches, as may be seen by the annexed illustration. It is comparatively hardy, and flowers freely in sheltered positions. In floral brightness, however, few equal C. montana var. grandiflora, a perfectly hardy sort, even in the most exposed situations, and one which produces such a profusion of large pure white flowers as to entirely hide the foliage. It is a native of Nepaul, and blooms during the greater part of the summer.

C. viticella is another well-known species, a native of Spain and Italy, and one which has sweetly scented flowers. Under cultivation it has become greatly improved ; its flowers, which are large, are reddish purple, and there are double forms of it. It is not such a rampant grower as C. montana, but when allowed to grow unchecked on low trees or on rustic supports, it makes a very effective plant. Others are virginiana, vitalba, ligusticifolia, lanuginosa, florida, crispa, balearica, etc. Clematises suitable for herbaceous borders or beds are also very numerous, and when run over rustic supports, such as the tops of small larches, they look truly beautiful mixed with other plants. Most of them flower all through the summer months, and many are useful in a cut state for wreaths, etc. Among these may be mentioned C. æthusæfolia, a native of Northern Asia. Its flowers, as may be seen, are thimble-shaped, and produced in great profusion all through the summer months.

Being nearly white, they are shown off to advantage by the pale green foliage. C. campaniflora bears a profusion of pale purplish flowers, which are very ornamental. It is useful for copses, covering old stumps, and it is also effective in mixed borders. It is a native of Southern Europe, and flowers in summer. C. viorna, the leather flower of the United States, is a pretty small flowered species, the sepals of which are thick and leathery and purplish in color. The variety coccinea is a native of Texas, and has only recently been brought into notice. It is one of the prettiest of the small flowered section ; its sepals, which are leathery, as in viorna, are vermilion on the outside and yellow within. They last a considerable time in perfection after opening. In many places it has proved quite hardy against a wall, and will doubtless be largely grown when more plentiful. It takes some time to become established, and it must be treated carefully during the first two or three years. A south wall, if it can be had, will be found best for it, and the soil in which it is planted should be deep and rich. C. pitcheri, davidiana, tubulosa, stans, integrifolia, angustifolia, baldwini, douglasi, fremonti, ochroleuca, etc., are all worthy of notice. The shrubby kinds are easily propagated by means of layers or cuttings made of the young wood ; the others should be increased by division and seeds, which should be sown as soon as gathered. D.

DWARFS AND GIANTS.

The history of the variations in stature in France is a most complex one. At the epoch of the Roman invasion, Gaul, according to Julius Cæsar, was peopled by three very distinct races. In the north and northwest

TRAVELER'S JOY (C. VITALBA).

lived the Belgii, or Cimbri, who were blonde and of a tall stature. An examination of their skeletons, discovered in recent times, shows that their skull was elongated, that is, that they were dolicocephalous. The west and center of France were occupied by a very numerous race, that of the Celts. These were dark skinned, not very tall, and had a round head, that is, they were brachycephalous. The mountain dwellers of Auvergne have preserved the type of the ancient Celtic race, and we find it likewise in Brittany. At the south dwelt the Iberian race, which, according to habitat, was divided into the Aquitani, Ligures, and others. Of this race, the Basques of our time seem to be the most direct descendants.

Long before the Roman invasion, in the period of polished stone, that is to say, at a period that may be dated back twenty-five or thirty centuries, Gaul already contained several races of men. Some of these not only lived side by side, but allied themselves with each other The recent discovery, by Mr. Thiullen, of a very large number of skeletons in a tumulus at Crecy-en-Brie (Seine-et-Marne) has confirmed this opinion. An examination of these skeletons shows that they belong to at least two races--one of great stature, having a dolicocephalous skull, and the other of medium height, with a brachycephalous skull. A few of the skeletons, through their stature and the shape of the skulls, show a mixture of these two races. At an epoch more recent than that of the Roman invasion, Gaul was overrun by several other peoples, such as the Teutons, the Helvetians, the Huns, and the Moors. Later on came the Normans and the English, and every invasion of short duration had its influence upon the

original inhabitants. Notwithstanding the time that has elapsed since these invasions, we still find their influence at the present day when we endeavor to determine the origin of the various groups of inhabitants of a region. In Brittany, for example, we still meet with the two principal races of Gaul, with their well marked anthropological characters. On the waste lands of the center we find the Celts. Their aspect is characteristic, and they are designated in the country as Menoz—inhabitants of the mountains of Menez. At other points, principally in the valleys, we find the Cymric type. This type has been especially well preserved in the greatest purity in certain communes whose inhabitants ally themselves only with each other. Upon the northern coast the race is very fine, and differs in every respect from the races of the center. It seems to have originated from the invasions of peoples from the north of Europe. Most of the inhabitants of the country are a product of the crossing of these three typical races.

When a region presents several types of individuals, we are almost always certain to find in the uplands of the less fertile parts the autochthonous race, either pure or more or less crossed, while the descendants of the invading race are met with in the plains and valleys, where the fertility is greater. Very frequently, in fact, the stature of the population is less on the table lands than it is on the plains, and this is explained by hereditary influences, and the influence of fertility, both of which, in this case, conspire to the same end.

The Extremes of Human Stature.—In the most diverse populations, we now and then meet with individuals whose stature varies greatly from the mean, being greater, as in giants, or less, as in dwarfs. Teratology, or the study of monsters, finds no satisfactory explanation of the causes of great variations such as these. It is interesting to compare the stature of the largest giants with that of the smallest dwarfs, as from such a comparison we can determine the extreme stature of the human species.

VARIATIONS IN HUMAN STATURE.

If we are to believe ancient writers, a large number of giants and giantesses have reached statures that are extraordinary, even for this class of persons. Pliny speaks of a giant named Gabara, who was 9¾ ft. in height, and two other giants, Posio and Secundilla, who were half a foot taller. The young female giantess cited by Garopius was, according to him, 10¼ ft. in height. According to Lecat, there was once a Scotch giant who was 12¼ ft. in height; but it seems probable that the heights attributed to these various giants are greatly exaggerated. On the contrary, we can consider statements of heights of from 8¼ to 8½ ft. as authentic.

In 1755, there was exhibited at Rouen a giant 8¾ ft. in height. A Swedish peasant mentioned by Buffon was 8½ ft. in height, and this, too, was the stature of the Finnish giant Cujanus; and the King of Prussia, Frederick William, had a guard of nearly the same height. The giant Gillé, of Trent, in the Tyrol, was over 8¼ ft. in height, and this was the stature of one of the guards of the Duke of Brunswick. We have recently given a portrait of the Greek giant Amanab,* and, previous to this, one of the Chinese giant Chang, whose height was 8¼ ft. The giant Winckelmeler,† who is now exhibiting at Paris, and who is 8½ ft. in height, may be taken, then, as an example of the highest stature reached in the human species.‡ At the opposite extremity, we find a large number of dwarfs cited as having been less than 20 inches in height. Some of these are said to have been but 16 or even 12 inches; but such dwarfs have been but monsters with atrophied legs or with a curved spine, or children whose development had been arrested and whom their showmen aged by some years. The famous General Tom Thumb was an example, as are likewise the Royal Midgets, recently exhibited at Paris, and the little Princess Paulina. But if, in the long list of dwarfs of whom a description has been preserved, we search for the smallest, even after it had reached an adult age, and one that at the same time possessed a normal conformation, we shall find one especially that merits particular attention. We refer to the celebrated dwarf Borulawsky, who was born in 1789 and died in 1837, and never was over 29 inches in height. He was perfectly well formed; his head was well proportioned; his eyes were beautiful and full of fire; his features were handsome, and his physiognomy was intellectual and portrayed the gayety, politeness, and refinement of his mind. He was straight and well formed, and his knees, legs, and feet were of the exact proportions of those of a well built and vigorous man. If we take a mean between these two extremes, the giant Winckelmeler (8½ ft.) and the dwarf Borulawsky (29 in.), it will be seen that it is 5½ ft., and the difference in the heights is $6\frac{1}{16}$ ft. It is to be remarked that this higher mean approaches that of the stature of Frenchmen. It has seemed to us of interest to figure, comparatively, the proportional height of these two extreme specimens of man's stature. The portrait of the dwarf Borulawsky was taken from a print of the period, and that of Winckelmeler from a recent photograph. Near these two are placed figures of a newly born child of a mean height of 18 inches, an infantry soldier 5 ft. in height, a man of medium height (5½ ft.), and a cuirassier 6 ft. in height. This engraving gives the different variations in human stature.—*La Nature.*

* Supplement, No. 570, p. 9104.

† Supplement, No. 582, p. 9302.

‡ John Middleton (born 1578), commonly called the Child of Hale, was 9¼ ft. in height.—*Haydn, Dictionary of Dates.*

THE CAUSE OF THE DISASTER AT CRARAE QUARRY.

A bluebook has been published containing the report of Colonel A. Ford, her Majesty's inspector of explosives, on the circumstances attending the explosion at Crarae Quarry, Loch Fyne, on September 25, last year. It will be remembered that a large party went on a steamer to see the effect of some blasting operations in the quarry, and that after the explosion they visited the spot. Many of them were seized with faintness, six were dead when rescued, one died afterward, and five were conveyed to the infirmary at Greenock, where they recovered. Colonel Ford gives, in minute detail, the gases which must have escaped after the explosion of 13,000 pounds of gunpowder, and describes the symptoms which were developed in the injured persons. Probably, Colonel Ford says, the mischief was done by the carbonic oxide, of which 468 pounds were generated by the explosion—an amount which, at the ordinary temperature and pressure, would occupy a space of 6,333 cubic feet. This would be sufficient to vitiate one hundred times as many cubic feet of air, but, in the presence of carbonic anhydride—of which 3,575 pounds were generated—it would render 1,266,600 cubic feet fatal to human life. A very small proportion of that gas in the presence of carbonic anhydride renders the air fatal. Symptoms, however, agree with those attributed to poisoning by carbonic anhydride, and the blood of one of the deceased was so liquid after death that it flowed through the coffin. It is to be regretted, Colonel Ford says, that no opportunity of examining the blood of any of the deceased was afforded, as this would have furnished clear evidence as to which of the poisonous gases which flowed out from the interspaces of the quarry and gradually vitiated the air actually caused the deaths. Colonel Ford expressly relieves any one from blame for the fatal result.

A SIMPLE FORM OF WATER BATTERY.

Prof. Rowland, in *Silliman's Journal* for February, writes: "For some time I have had in use in my laboratory a most simple, convenient, and cheap form of water battery, whose design has been in one of my note books for at least fifteen years. It has proved so useful that I give below a description for the use of other physicists. Strips of zinc and copper, each two inches wide, are soldered together along their edges so as to make a combined strip of a little less than four inches wide, allowing for the overlapping. It is then cut by shears into pieces about one-fourth of an inch wide, each composed of half zinc and half copper. A plate of glass, very thick and a foot or less square, is heated and coated with shellac about an eighth of an inch thick. The strips of copper and zinc are bent into the shape of the letter U, with the branches about one-fourth of an inch apart, and are heated and stuck to the shellac in rows, the soldered portion being fixed in the shellac, and the two branches standing up in the air, so that the zinc of one piece comes within one-sixteenth of an inch of the copper of the next one. A row of ten inches long will thus contain about thirty elements. The rows can be about one-eighth of an inch apart, and therefore in a space ten inches square nearly 800 elements can be placed. The plate is then warmed carefully so as not to crack, and a mixture of beeswax and resin, which melts more easily than shellac, is then poured on the plate to a depth of half an inch, to hold the elements in place. A frame of wood is made around the back of the plate, with a ring screwed to the center, so that the whole can be hung up with the zinc and copper elements below. When required for use, lower so as to dip the tips of the elements into a pan of water, and hang up again. The space between the elements being $\frac{1}{16}$ in. will hold a drop of water which will not evaporate for possibly an hour. Thus the battery is in operation in a minute, and is perfectly insulated by the glass and cement. This is the form I have used; but the strips might better be soldered face to face along one edge, cut up, and then opened."

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