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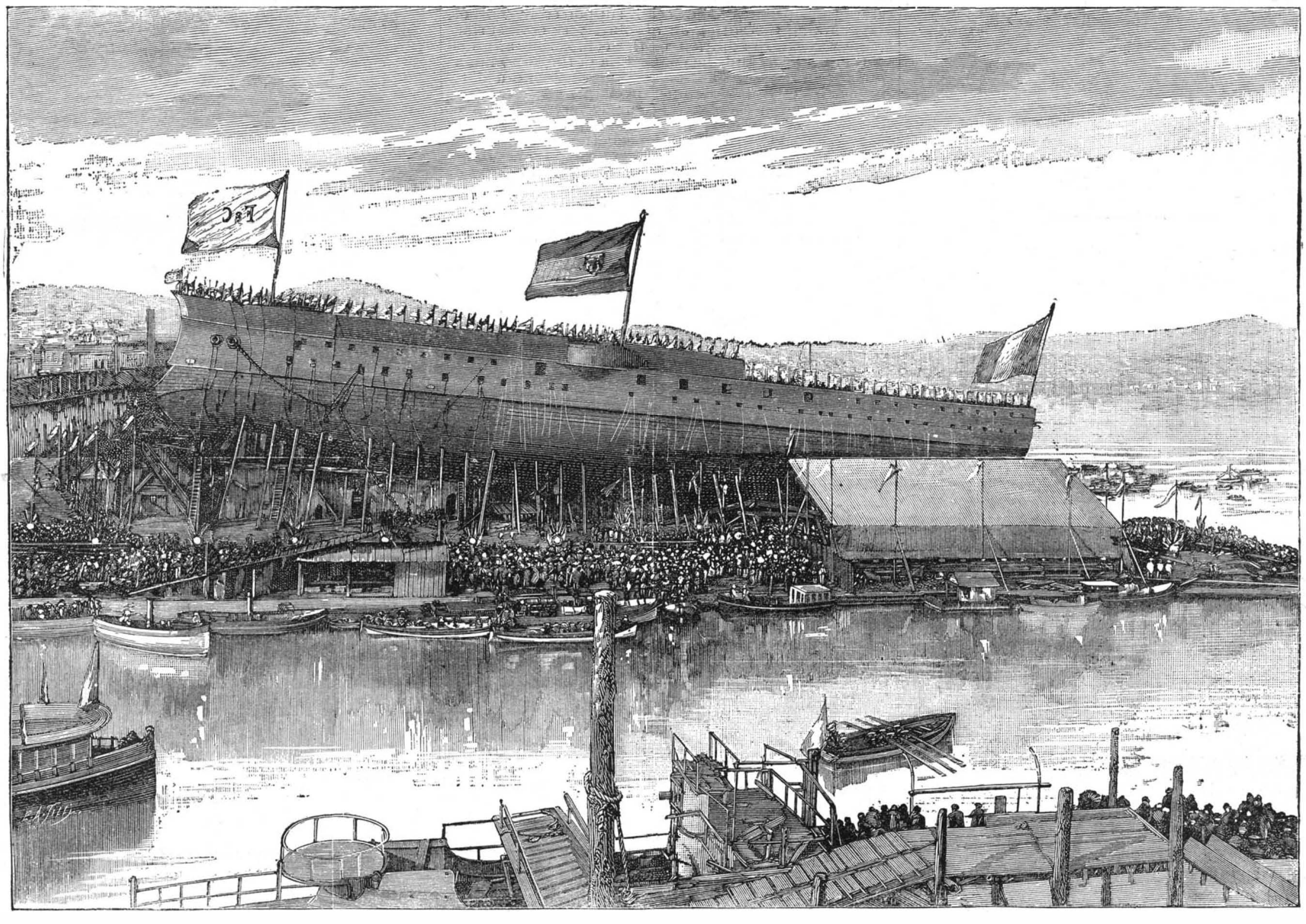
THE SPANISH SHIP OF WAR PELAYO.

THE armorclad ship of war Pelayo, built for the Spanish government by the Societe des Forges et Chantiers de la Mediterrané, has the following dimensions:

Extreme length, from stern to point of ram	346 ft.
Extreme width at the float water line	66·25 ft.
Depth of keel at the midship frame	24 ft.
Draught of water at the stern	24·75 ft.
Displacement, when loaded	9,900 tons.
Power of engines with natural draught	6,800 horses.
Presumed speed on trial	15 knots.
Power of engines with forced draught	8,000 horses.
Estimated speed	16 knots.



LAUNCH OF THE NEW SPANISH WAR SHIP PELAYO.

The two speeds of 15 and 16 knots are those that the builders have guaranteed, but which they hope to greatly exceed.

The Pelayo is entirely of steel of French manufacture. The keel is constructed according to the cellular system as far as to the main deck, which is armor clad, and is situated above the float water line. Starting from this deck, the top sides are lighter and are arranged for the reception of the cabins of the crew, officers, and staff.

A water tight double bottom extends nearly the entire length of the vessel. This consists of an interior lining of steel plate, resting upon the timbers, and placed at 29½ ft. from the external border of the keel. The double hull is thus divided into 98 cellular, water tight compartments. Above this double bottom, the ship is again divided into numerous compartments by sixteen transverse water tight partitions. Besides, in the engine and boiler rooms, as well as in the central ammunition chambers, there is a central, longitudinal, water tight partition, which extends from the interior lining as far as to the plates of the armorclad deck, thus dividing the vessel into 145 tight cells.

All these compartments, as well as those of the double bottom, can be exhausted of water by means of a collecting drain, 12 in. in diameter, which runs from stem to stern, and from which the water can be removed by two rotary pumps capable of discharging 500 tons per hour each, and by a 30 ton pump, and by the pumps that serve the engine.

The float water line is protected by an armor plate swifter that runs from end to end. This consists of a single row of Creusot steel plates. Its height in the center is 6¾ ft., 5 ft. of which is below the float water line. In the central part the thickness of these plates is 18 in., but at the extremities it is but 12.

To this protection is added that furnished by the coal bunkers, which have a capacity of about 700 tons, and which are arranged on each side of the furnace rooms.

The armor plated deck, which extends the entire length of the ship, and which protects the latter's vital parts, is 3½ in. in thickness. All the openings in it are protected by armor plate frames, 12 in. in thickness and 3 ft. in height. The top sides above the armorclad deck inclose two decks, one of which contains a battery of twelve 5 in. guns. On the one beneath are situated the quarters of the admiral, staff, officers, midshipmen, engineers, and masters. There are also two spacious and well ventilated hospitals. Between the two decks there is space also for hammocks for five or six hundred men.

The Pelayo's artillery will be arranged as follows: Upon the upper deck, four barbette turrets for the large artillery, the fore and aft ones of which will each be armed with a 12 in. gun, while the other two in the center of the ship will have 11 in. guns.

These four turrets will be provided with hydraulic gun carriages, frames, platforms, and elevators of the style patented by Mr. Couet. The arrangement adopted on the Pelayo will permit of loading the gun in any position. It is applied upon the first class ironclad Marceau, and upon our ironclad cruisers Acheron, Cocyte, Phlegeton, and Styx.

The upper tier will comprise twelve 5 in. guns, of the Hontoria system. A 6 in. Hontoria gun will be placed at the forward extremity of the upper deck, for use while in pursuit of an enemy. The rest of the armament will consist of a large number of Hotchkiss guns of 1¼ in. caliber, and of revolving guns of 1¼ and 1¾ in. caliber, placed in the tops and on the bridges and other parts of the upper deck.

Finally, seven torpedo launches of the Schwartzkopf system will be placed upon the cuirassed deck, and fourteen torpedoes will be laid near them.

The magazines for powder and projectiles are arranged in three groups, corresponding to the turrets which they are to supply. They are all provided with the most improved devices designed for maneuvering the ammunition.

The boilers, which are to be twelve in number, will be distributed through four different rooms, which are in pairs and back to back. Each room will contain four boilers, each provided with three furnaces, or thirty-six in all. The total grate surface will be about 800 square ft., and the total heating surface nearly 24,000 square ft.

In each of the four furnace rooms there will be a blower for quickening the draught, so as to permit the engines to develop a power of 8,500 horses.

The motive apparatus, which will be placed back of the generators, will consist of two independent engines, symmetrically arranged with respect to the central longitudinal partition. These motors are to be vertical ones, and each will actuate a bronze screw. Each of these main engines will consist of two compound engines connected with the same line of shafts, a condenser, and two auxiliary upright engines for actuating the two condenser pumps. Besides these, there will be two auxiliary engines, for actuating two blowers for aerating the engine rooms. The generators are to furnish the steam for all these apparatus, as well as for the following: Four compression pumps for actuating the hydraulic apparatus of the turrets; a Gramme machine for supplying two electric light projectors placed upon the upper bridge; and four small donkey engines.

Two auxiliary boilers placed on the orlop deck, and each having one furnace, will co-operate in the production of the steam necessary for these various apparatus.

The ship will be provided with two steel masts, with double tops, armed with revolving guns.

Her canvas will have a total surface of 600 square yards.

The contract was made in 1884, and the vessel was launched with great success on Feb. 5, 1887.—*Le Genie Civil.*

STEAM LIFEBOAT.

WE illustrate opposite a steam tubular lifeboat, designed by Mr. Charles H. Beloe, C.E., Hon. Secretary of the Liverpool and New Brighton branch of the Royal National Lifeboat Institution. A model of this boat was exhibited at Liverpool last year. The boat has been designed to meet a want long felt on the Mersey, namely, a lifeboat which should be able to work its way back into the main channel after taking the crew off a wreck on the banks to leeward. The present boats have great difficulty in performing this service, being propelled only by sails and oars, and it has often been suggested that mechanical power should be employed for this purpose. It is not intended to dispense with the use of tugs, which are now employed to tow the lifeboats to the wreck, but to retain their services; and while the boat is being towed out, steam would be generated in the boilers. On arriving to windward of the wreck, the lifeboat would be cast off from the tug, proceed to the wreck, and return to the main channel under her own steam. The rescued crew could then either be transferred to the tug or brought ashore in the lifeboat.

The design, Mr. Beloe states, is based upon that of Richardson's tubular lifeboat, several of which have rendered such excellent service at New Brighton and Rhyl. The largest of them measures 45 ft. long by 10 ft. beam, and consists of two circular tubes 3 ft. in diameter, the ends tapering and curving upward and inward at the bow and stern. A water-tight deck is placed between the tubes above the water level, and supported by a series of arches, which also brace the tubes together. In this design the length over all is 50 ft., the beam 15 ft. The tubes, or rather hulls, are not circular in cross section, but are 5 ft. 3 in. deep and 4 ft. 6 in. wide, and have a midship section somewhat of a ship form, but at the ends they approach an oval section.

Instead of the tubes being separate from each other at the ends, they are curved above the water and joined together, forming practically one complete structure. Each tube is divided into eleven water-tight compartments, the largest being 8 ft. long; but as this compartment would be occupied by the boiler and the non-conducting composition with which it is surrounded, there would only be a small space for water in it, supposing the hull to be injured. Great attention has been paid to the form of the hulls, and good water lines have been given to them. The beam of each hull diminishes toward the stern, instead of the parallel tubes of the Richardson lifeboat, and this facilitates the discharge of the water, which has a tendency to heap up between the hulls. The maximum draught of water is 3 ft. A deck is fixed 12 in. above the water at the lowest place, and instead of the complicated arches and frames of the existing boats, which greatly retard their progress, the deck is supported by T irons, the planking presenting an absolutely smooth surface to the water. In addition to the connection afforded by these T irons and the connection of the two hulls at the bow and stern, additional strength is afforded by three pairs of heavy channel irons placed across the boat, one pair at each end of the covered portion of the boat, or about one-third of the entire length from each end, and the other pair near the center at the bulkhead dividing the cabin from the engine room. The lower channel iron is placed between the hulls at the level of the deck, and the upper one is placed on the top of the hulls, and extends from gunwale to gunwale, thus bracing the hulls together in the strongest possible manner, without offering any resistance to the passage of water between the hulls, or interfering with the working of the boat. At the bow, for a clear space of 12 ft. inside the tubes, the boat is fitted with thwarts in the ordinary manner, and in this space the crew could work the anchors, warps, etc., with safety, being as well protected as in an ordinary lifeboat, the height from the deck to the gunwale being 2 ft. 6 in. The space between the hulls is then covered over for a length of 7 ft. by an arched iron roof, forming a cabin in which rescued persons could be placed and protected from the elements. Aft of this cabin is the engine room, 10 ft. 6 in. long, covered like the cabin, the roof being arched, but extending to the center line of the hulls to afford protection to the smoke stacks and ventilators, and also to cover the entrance to the stoke-

Fig. 1.

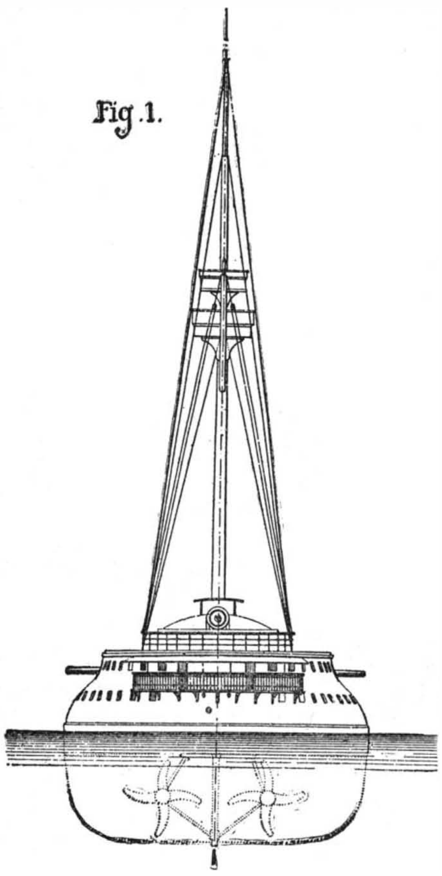


Fig. 3.

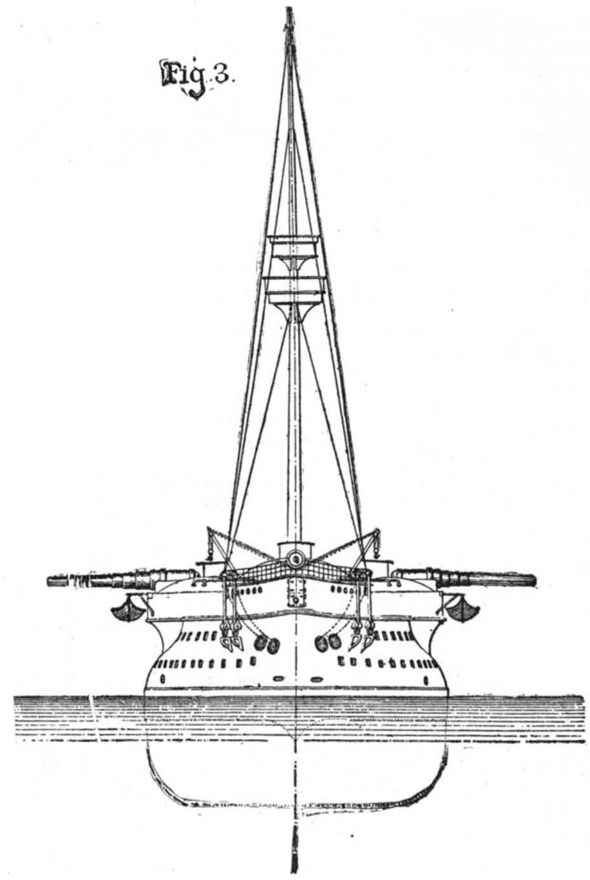


Fig. 2.

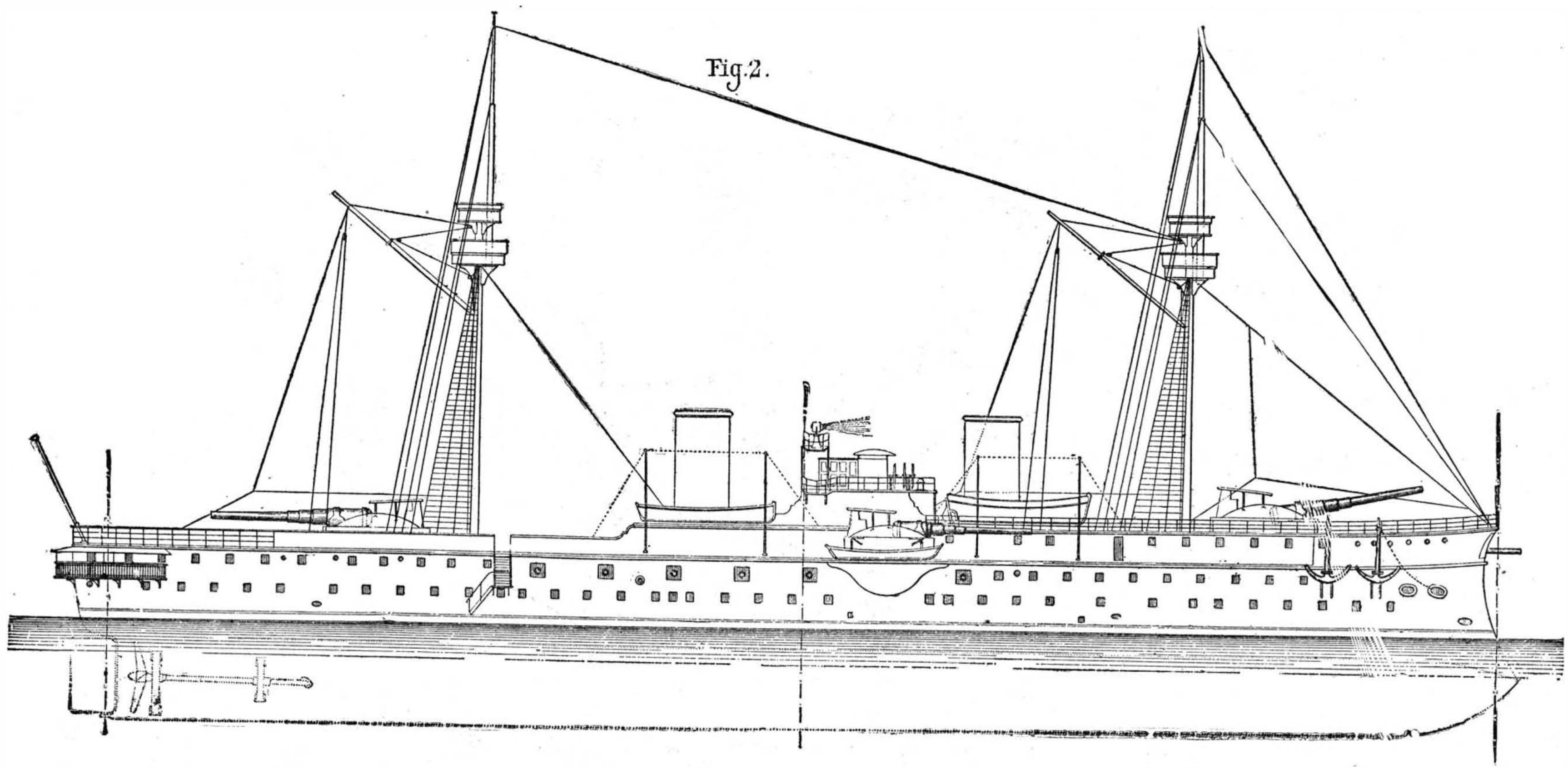
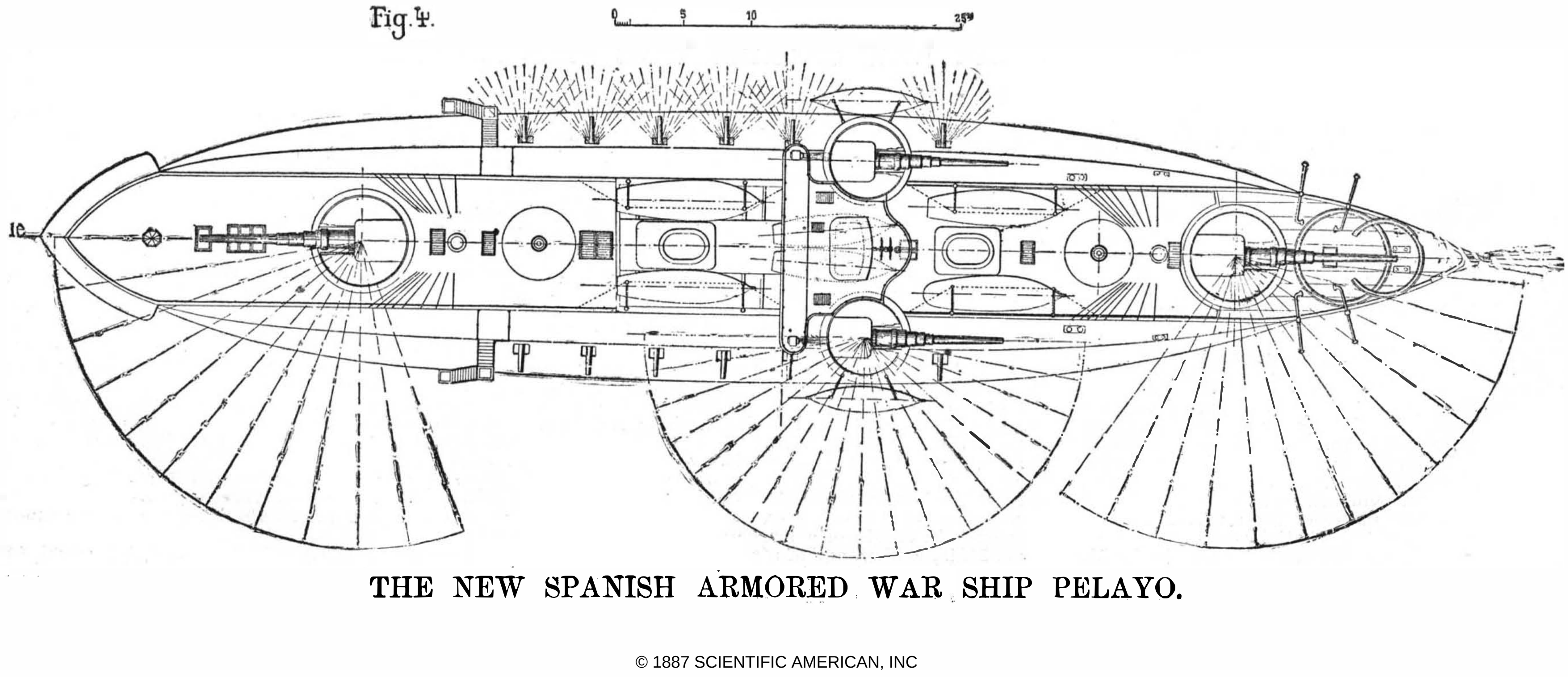


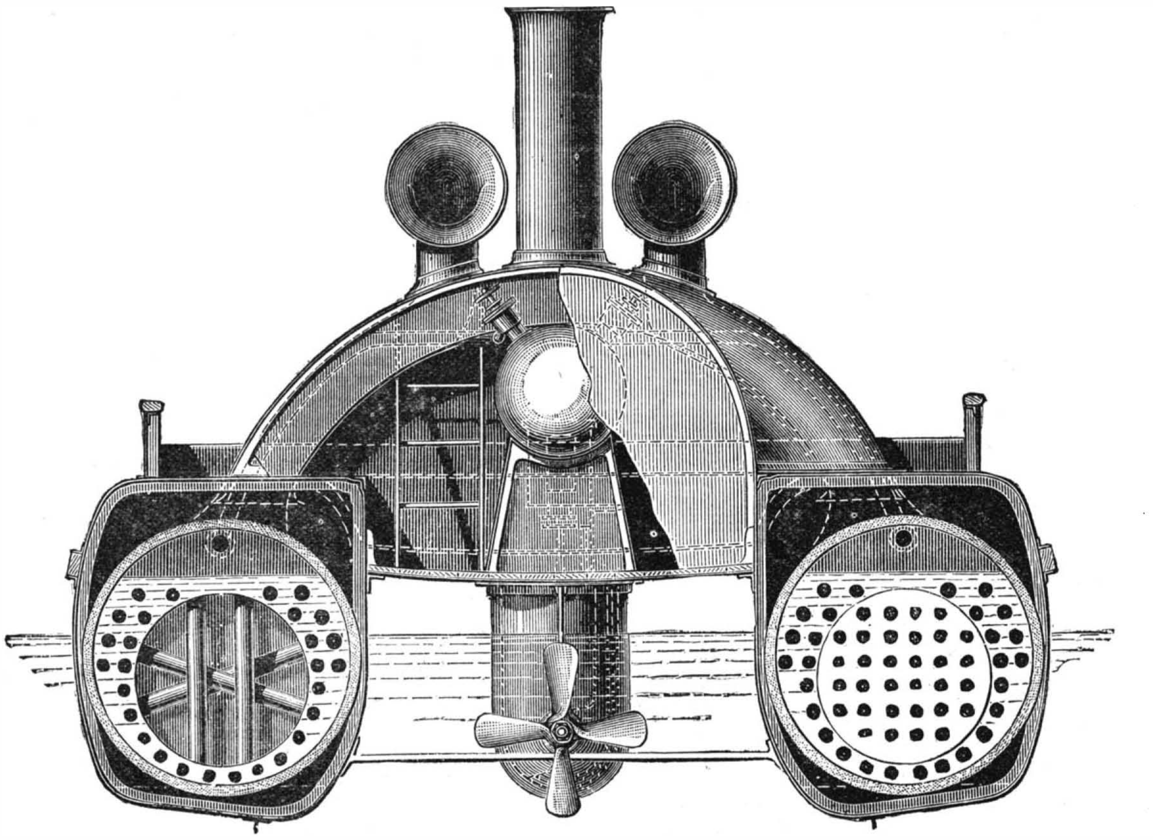
Fig. 4.



THE NEW SPANISH ARMORED WAR SHIP PELAYO.

holes. The boilers are placed one in each hull, and are 8 ft. long and 4 ft. in diameter. They are designed to burn petroleum, and are provided with internal furnaces 6 ft. long and 2 ft. 6 in. in diameter, furnished with five cross tubes, slightly inclined from the horizontal, and ten vertical tubes. From the end of the furnace twenty-six copper tubes, 3 in. in diameter, convey the products of combustion back to the front of the boiler, passing between the furnace and the shell, the total heating surface being 250 square feet. The petroleum is stored in a cylinder in another compartment, and is expelled by a piston driven by springs. The burners, fifteen in number, are placed three immediately under each cross tube, and consist of a sort of injector, by which a combined spray of steam and petroleum is introduced into the furnace.

The system is no novelty, but is in constant use on the locomotives on the Russian railways in the Caucasus, where petroleum is extensively used for fuel. The small quantity that would be required for lifeboat work would render the comparatively expensive nature of the fuel used a matter of no consequence. The steam is drawn from the boiler through a perforated pipe placed in the steam space, and then coiled round the smoke box and conveyed to the steam chest placed in the engine room, and at a considerable height above the boilers. By this means the priming, which is likely to take place from the violent motions of the boat, will be obviated as much as possible.



CROSS SECTION OF LIFEBOAT THROUGH BOILERS.

The engines are of the ordinary type, and are connected directly with the cranks on the propeller shaft, which work in a casing suspended below the deck between the two hulls. The propeller shaft is placed on brackets between the hulls, and is furnished with a screw at each end, the screw being placed about one-third of the length of the boat from the bow and stern. By this means it is almost impossible for both screws to be out of the water at the same time, which would be the case if twin screws were placed at the stern; and there is also a great advantage attached to their present position, as a hatchway is provided in the deck over each screw, so that in the event of any wreckage getting foul of the screws it can be readily removed by the crew of the lifeboat, which would not be the case if the screws were under the counter.

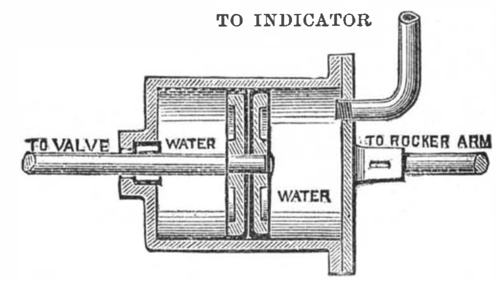
The space aft of the engine house, 15 ft. long, is open like the bow, and affords accommodation for the coxswain and the remainder of the crew. Rowlocks are provided at the bow and stern to enable oars to be used in pulling the head of the boat round; and the oars, boat hooks, masts, and sails can be conveniently stowed, when not in use, on both sides of the engine house. The sailing powers of the ordinary tubular lifeboat are not in any way interfered with, and the same masts and sails can be used.

One important feature in any steam lifeboat must be its weight. It is not expected, by this plan, to produce a boat which would supersede the ordinary small coast lifeboats, which have to be frequently conveyed long distances on their carriages and launched off the beach, but the design is only intended for places where the boat can be kept afloat or launched from a slipway into deep water; but even in these cases a very large and heavy boat is not suitable. The impact of a heavy boat either on the ground or against the side of a wreck would be so great that the boat itself would be liable to be wrecked, consequently it is of the utmost importance to reduce the displacement as much as possible. The total weight of the design, with engines and boilers, but without passengers, is twenty tons.—*The Engineer.*

THE RESISTANCE OF SLIDE VALVES.

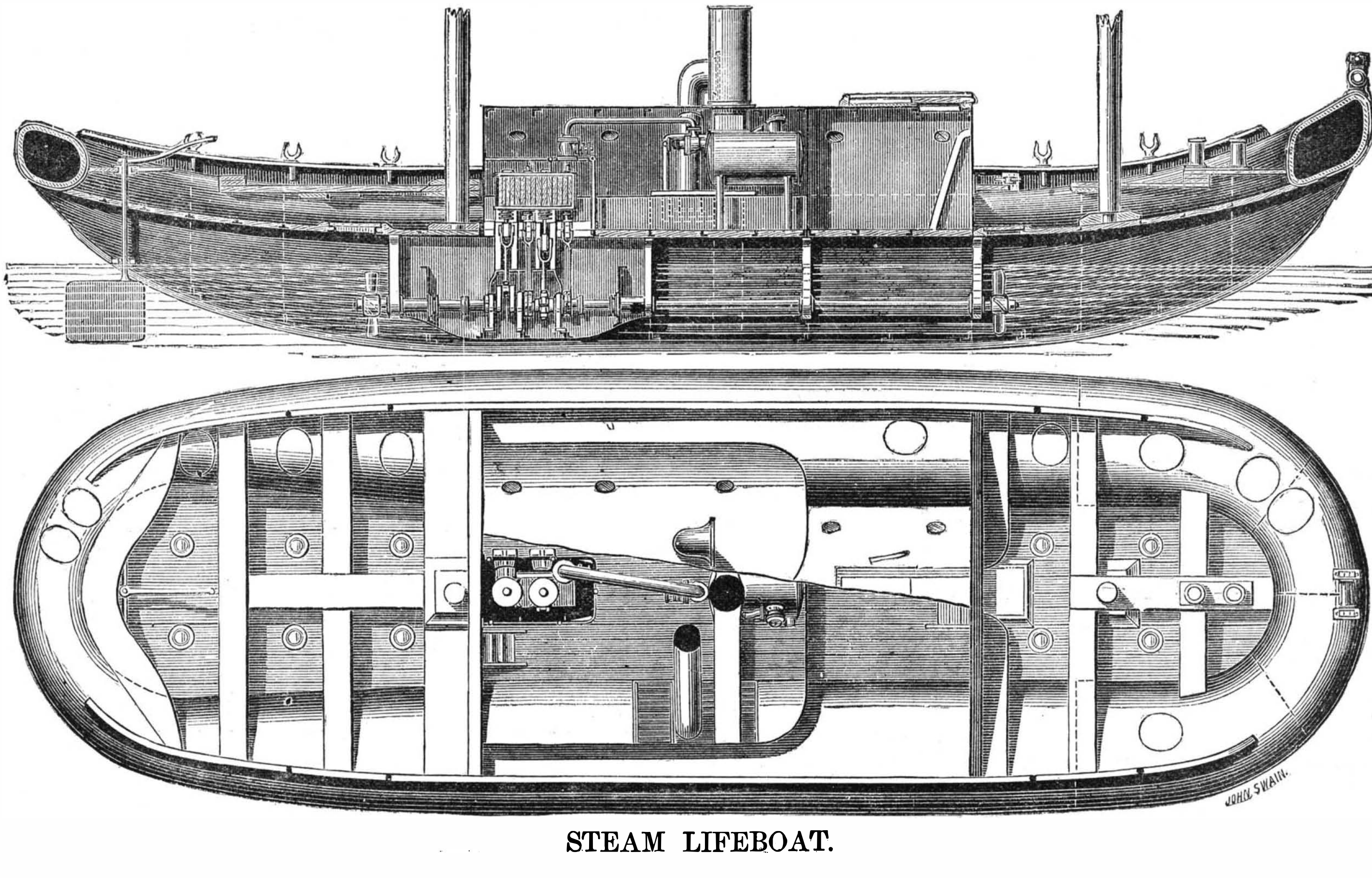
"SOME interesting experiments," says the *Railroad Gazette*, "have been made lately on the Chicago, Burlington, and Quincy road, as to the friction of locomotive slide valves. The method by which the amount of friction was ascertained was simple and ingenious, and leaves little room for error. The valve stem or rod is removed, and in its place two rods are used. One rod is coupled to the valve and the other to the rocker arm. The two rods are coupled by means of a cylinder filled with water. One rod is coupled to a piston with double cup leathers working in this cylinder, and the other rod is coupled to the cylinder itself. The accompanying diagram shows the principle of the device, but is not drawn to scale, or accurate in details. When the rocker-arm moves, movement can only be transmitted through the water, which, being closely confined and incompressible, transmits to the piston the pressure necessary to move the valve. An indicator being placed on the cylinder registers the pressure, drawing a diagram in the same manner as if applied to an ordinary steam engine. The motion of the piston of the indicator of course causes a slight amount of lost motion, but as the cubic contents of the indicator cylinder are very small in proportion to the contents of the hydraulic cylinder, the lost motion is very minute, and cannot much affect the total movement of the valve.

"It was found that the average power taken to move an ordinary slide valve was 990 lb., and that only 300 lb. was necessary to move a balanced valve of the pattern now used on the Chicago, Burlington, and Quincy. In an ordinary passenger engine, when working in a notch giving 4½ inches travel to the valves, the tractive force necessary to overcome the resistance due to the valves would be about 82 lb., or rather over 1 lb. per ton weight of engine and tender. The friction of balanced valves would be overcome by a tractive force of 25 lb., or about ⅓ lb. per ton weight of engine and tender.



"These amounts are much smaller than have been usually supposed, and show that the friction of the valves in good order is not an all important factor in the frictional resistance of a locomotive engine. D. K. Clark reckoned that the total resistance of the engine and tender was 12 lb. per gross ton of their combined weight, but there is reason to think that this figure is somewhat too high for modern well constructed passenger engines in good order. Doubtless the total amount of friction varies in different types of engines, and is probably greatest in engines with several pairs of coupled wheels of small diameter. Clark's formulæ for the resistances of engines and trains were based on experiments made between thirty and forty years ago on rolling stock and permanent, they differing widely from any now in use. The use of steel rails, better lubricants, larger wheels and journals, and more accurate turning and fitting of the moving parts, have done much to reduce friction, and it is much to be regretted that some careful experiments are not made with modern rolling stock in order to settle authoritatively the laws which govern the resistance of trains."

On this we may remark that the information is incomplete, since nothing is said concerning lubrication. Mr. Aspinall has carried out an elaborate series of experiments on the Great Southern and Western Railway, Ireland, details of which are not yet published, but we may say that the results he has obtained show that the amount of slide valve friction is enormously influenced by comparatively small variations in their lubrication. Our contemporary goes on to state that



STEAM LIFEBOAT.

some interesting experiments have been made lately on the Chicago, Burlington and Quincy, with a view to test the relative merits of eccentrics with 5 in. and 5½ in. throw :

"Some little difficulty has been experienced with slipped eccentrics, almost the only trouble caused by the valve gear. The eccentrics of course slipped because the strap heated. Were the eccentric keyed on, the whole valve gear would suffer when the strap seizes, but where it is secured by set screw, the strap can partially seize and slip the eccentric without breaking anything or doing any damage that cannot be easily repaired. It was, of course, however, considered advisable to prevent any heating that might cause even a slight delay, and it was suggested that by diminishing the throw of the eccentric, the diameter of the sheave and strap might be reduced, and consequently the velocity of the rubbing surfaces would be diminished, thereby reducing the tendency to heat. It was objected that the reduction of the throw of the eccentrics would diminish the power of the engine, and that where 5½ in. throw eccentrics had been substituted for 5 in. the engines had been able to haul heavier loads in the same notch.

"On examining this question, it was found that this last assertion was on the surface correct, as in changing the eccentrics, the notches in the quadrant had not been re-marked, and, consequently, when the lever was in the notch marked as cutting off at 14 in., the actual cut-off with the 5½ in. throw eccentric was about 15½ in. It was therefore resolved to thoroughly test the question by running an engine with a train of given weight over the same piece of road, one trip with the 5 in. and another with the 5½ in. throw eccentric. The speed was noted at frequent intervals, and it was found that practically the engine could do precisely similar work with the 5 in. as with the 5½ in throw. It will, of course, be understood that with the 5 in. throw eccentric the angular advance was increased, so that the lead was unchanged. With the shorter throw, the port openings at late points of cut-off were diminished, but in notches nearer the center the difference in the port opening and cut-off was very slight.

"As the smaller eccentric has some manifest advantages, and appeared not to diminish the power and efficiency of the engine, the advisability of setting the eccentrics with a greater angular advance appears evident. It is therefore proposed to try what effect will be produced by 5½ in. eccentrics set with a greater angular advance and used with a valve having increased lap. It is expected this arrangement will give improved results. Hitherto the 5 in. and 5½ in. throw eccentrics have given the same result, and the smaller throw appears to equal the larger in virtue of its greater angular advance. Hence it is possible that the longer throw combined with the greater angular advance will give better results than either of these features singly."

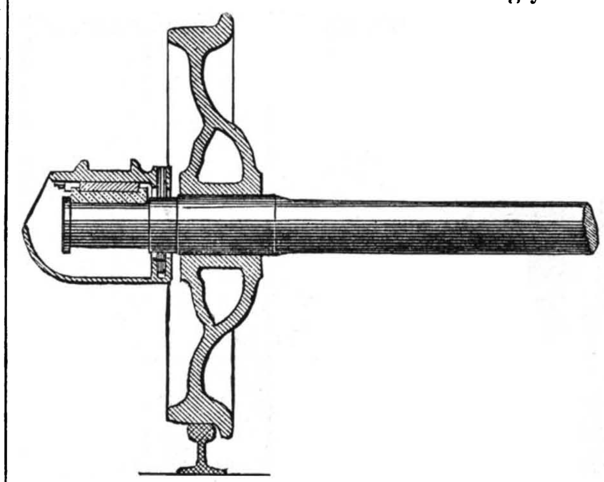


FIG. 1.—CAR AXLE AND GREASE BOX. (Scale, 11-180.)

RAILROADS IN NEW REGIONS.

THE important question of the cheap construction of railroads in new regions has recently been the subject of three interesting communications to the Institute of Civil Engineers of London by Messrs. Gordon, Mosse and Cunningham. These communications relate especially to the rules followed in the United States and Canadian practice, and possess a peculiar interest from the position of their authors, who have studied the said practice *in situ*, not only in the above-mentioned countries, but also in others. Now that the necessity of these cheap railroads for the development of the colonies that the European powers find themselves forced to take possession of in various parts of the world, in order to furnish an outlet to their industries, is being more and more felt, we believe that it will prove of interest to our readers if we give an account of what has already been done in this direction in foreign countries.

We shall begin with the work of Mr. R. Gordon "Upon the economical construction and operating of railroads in countries in which the traffic is light, according to United States practice."

In the first place, Mr. Gordon notices a communication by Mr. Dorsey to the American Society of Civil Engineers. Mr. Dorsey shows that the 18,000 miles of railway existing in the United Kingdom cost more than $250,000 per mile, while the 106,200 miles constructed in the United States at the same epoch cost, on an average, but $80,000 per mile, and that the costs of operating amount to $12,500 per mile on the English lines and to $2,750 per mile on the American ones. Upon the whole, on taking as a type of the American lines the Baltimore and Ohio Railroad, which is an extreme example of the great lines of the United States, with elevated summits, very steep gradients, and very sharp curves, Mr. Dorsey concludes that all such difficulties increase the cost of operating but eight per cent.

Even granting the accuracy of these figures, it is necessary to make some reservations before establish-

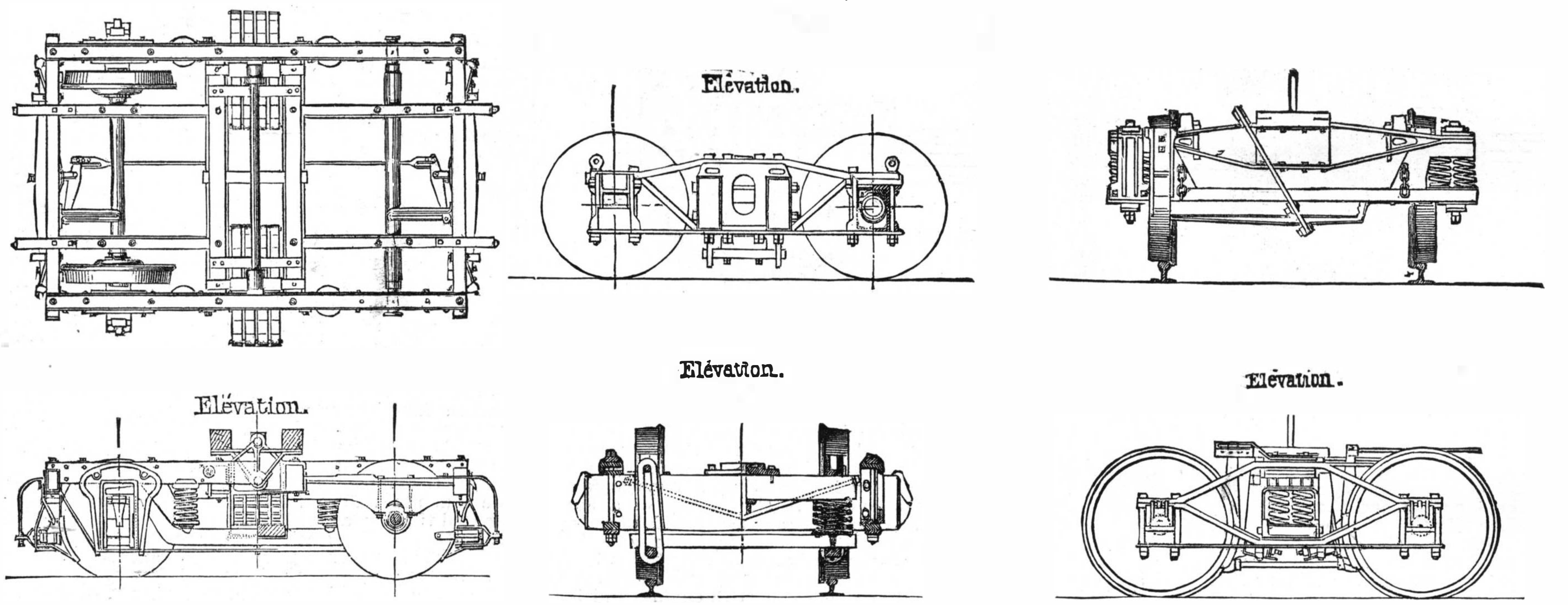


FIG. 2.—TRUCK FOR PASSENGER CAR. (Scale, 1-50.)

FIG. 3.—TRUCK FOR TWENTY TON FREIGHT CAR. (Scale, 7-240.)

FIG. 4.—TRUCK FOR THIRTY TON FREIGHT CAR. (Scale, 2-75.)

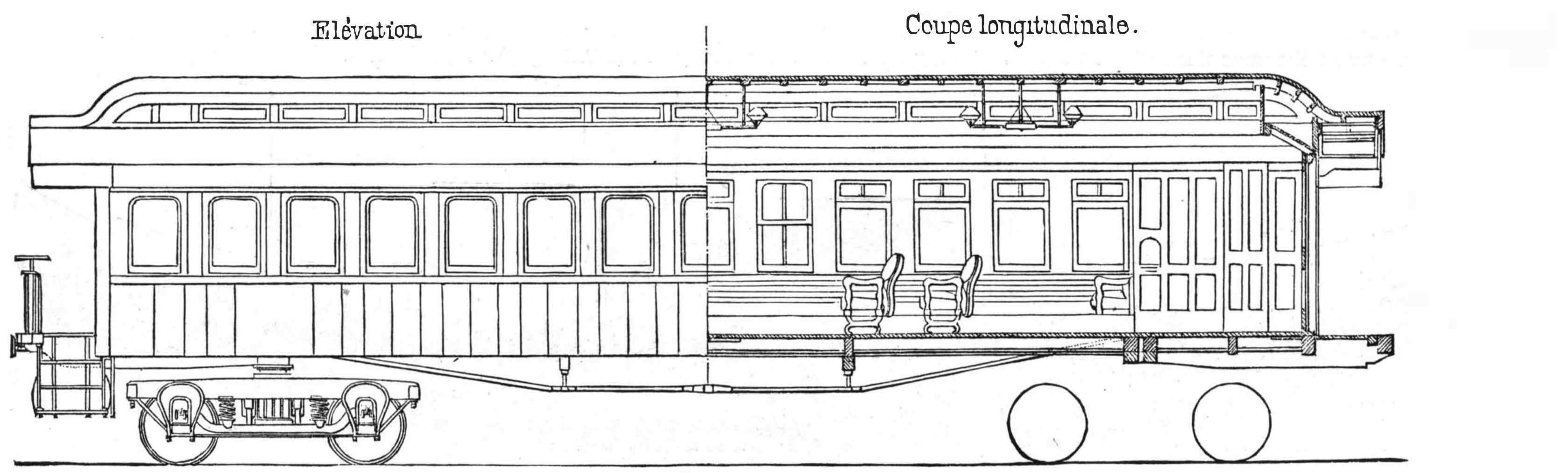


FIG. 5.—PASSENGER CAR OF PENNSYLVANIA R.R. (Scale, 1-80.)

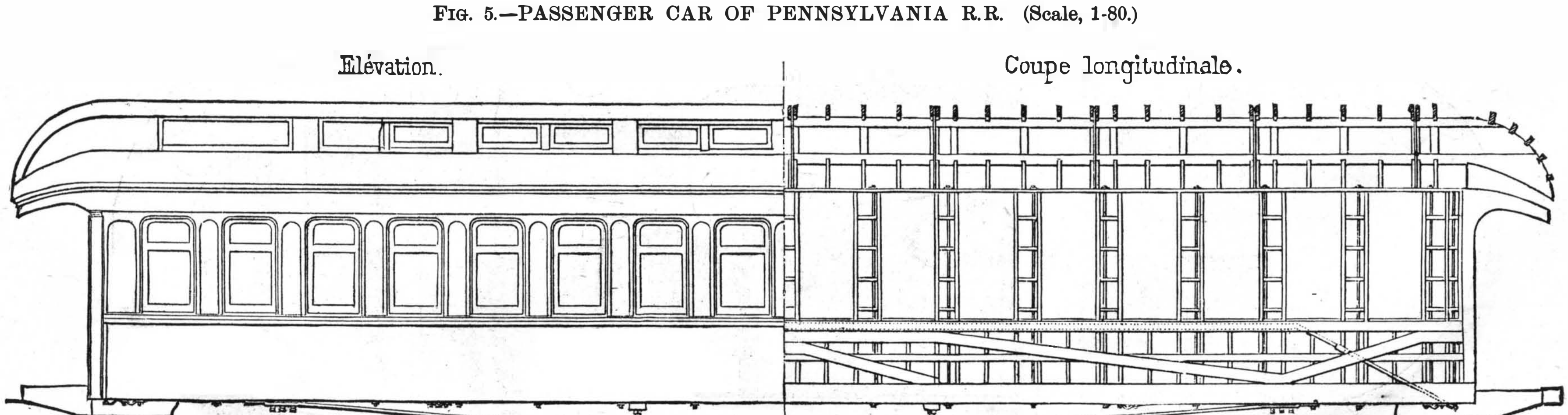


FIG. 6.—EMIGRANT CAR, CANADIAN PACIFIC R.R. (Scale, 17-1200.)

ROLLING STOCK AND BRIDGES OF AMERICAN RAILROADS.

ing a definite comparison. In the first place, most English lines have double tracks, while in America this is an exception. Then, while the land costs the American companies nothing, and even brings them in money in many cases from the sale of property that has been conceded to them, in England the high price of the land increases the cost of the lines by about $25,000 per mile.

On another hand, it is true that speculation has encumbered the United States lines by about $12,000 per mile. The cost of construction, properly so called, then, is brought to $225,000 in England and $68,000 in the United States.

Making all other reservations for the difference in the value of the property and the economic conditions, it is clear that railroads must cost less in America than in England and in Europe generally.

Mr. Dorsey concludes that a line can be constructed in the United States for half or a quarter of the sum that it would cost in England, and in half or quarter of the time. These are important statements, if bridges have had to be strengthened or rebuilt, and loads of twenty or twenty-five tons are now carried by cars which formerly carried but ten. The cars are made longer, and an endeavor is made to reduce the dead weight as much as possible.

Moreover, another and very powerful movement is now in progress. The tendency in the United States is to make the track and rolling stock as uniform as possible. At present, there are but few broad gauge lines, all the rest having been reduced to a uniform narrow gauge. Constructors all endeavor to have the same style of wheels, and before long there will be a typical car, which will be nearly the same on every line.

Fig. 1 gives the type of axle, wheel, and grease box now universally adopted. The axle weighs 440 lb., and the wheel is of cast iron.

The ever increasing weight carried by the present freight cars greatly strains these cast iron wheels, which, however, when derived from careful manufacturers, still give a mean of 60,000 miles, although the The width of the latter's base is about four and a half feet.

The number of freight cars in use in the United States is estimated to be 800,000. The repairs necessitated thereby cause considerable loss of time and complication, and it would evidently be advantageous to have a uniformity, and to make the parts in duplicate, in advance and in large numbers. This would reduce the price and facilitate the work. Figs. 7 and 8 show the most recent arrangements adopted for freight cars.

The Pennsylvania Railroad car carries thirty tons, and weighs but about ten. The housing can be removed so as to convert it into an ordinary platform car. The box car of the New York and Baltimore Railroad weighs a little more, say twelve tons for a load of twenty-five tons.

As regards the carriage of passengers, Mr. Gordon does not think that this is done any more cheaply in America than in England. Figs. 5 and 6 show an ordinary passenger car and an emigrant one.

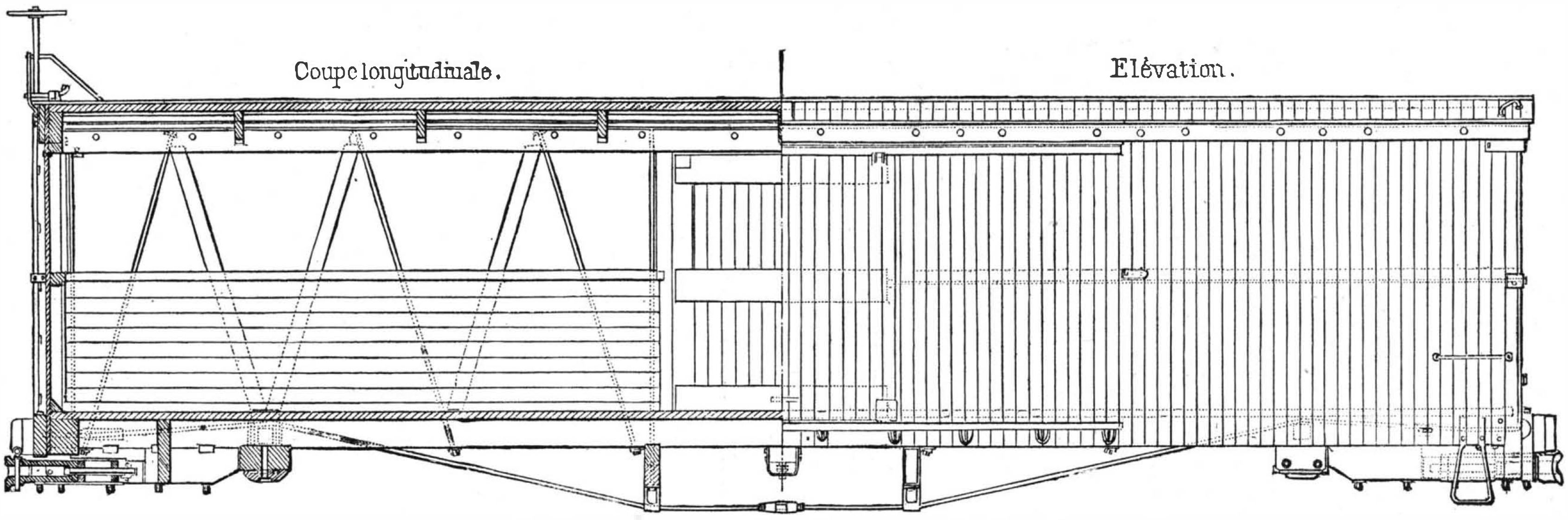
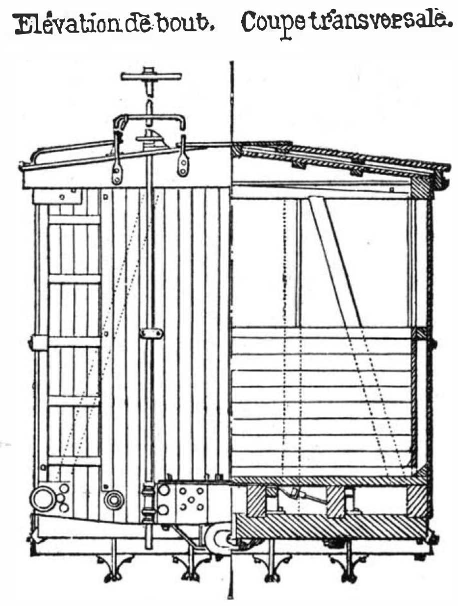


Fig. 7.—New York and Baltimore Freight Car. (Scale, 1-48.)



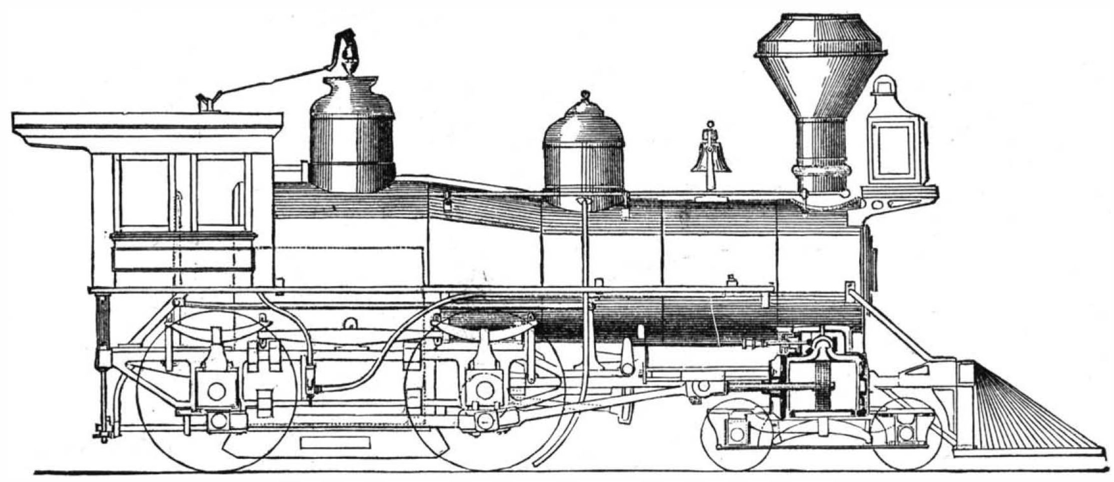


Fig. 9.—Typical Locomotive. (Scale, 1-75.)

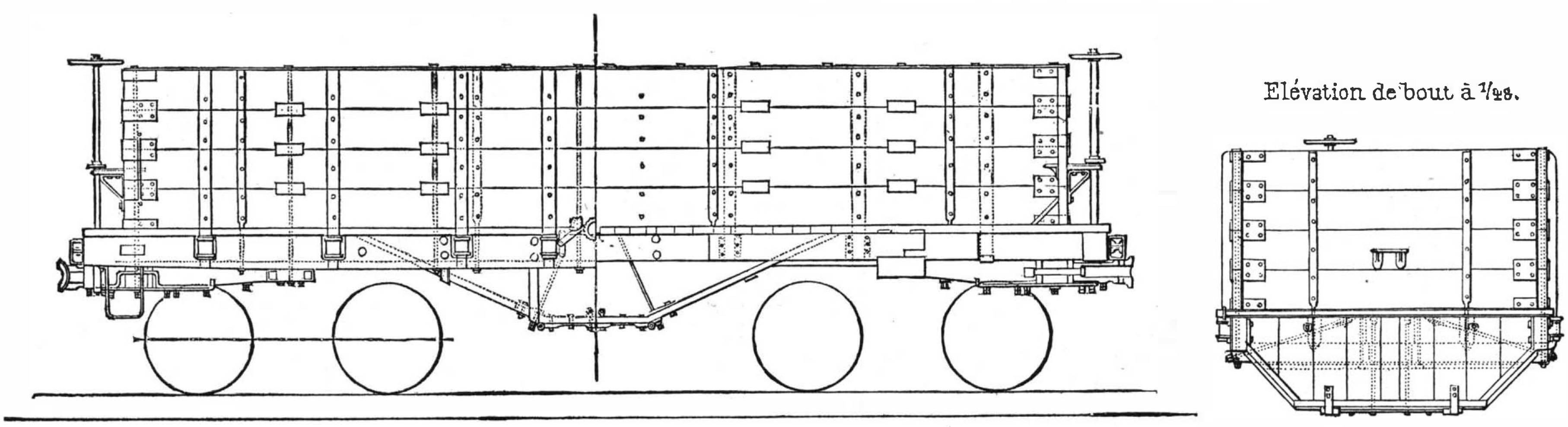


Fig. 8.—Open Freight Car, Pennsylvania R.R.

ROLLING STOCK AND BRIDGES OF AMERICAN RAILROADS.

they are well founded, and are worthy of a detailed examination in order to determine the modifications to be made in the English system, in cases in which, as in the colonies, there are new roads to be opened.

The essential difference between the American and English systems resides in the general use in the United States of the bogie truck, which has a short and flexible base, and flexible connections between the wheels and the boxes, while the English employ a system of wheels of wide base and rigid connections with the boxes. The developments that this initial difference has led to cover an immense field, and it is impossible here to follow them in all their details. We shall merely speak of those that are most important from an economic standpoint.

It must be remarked, moreover, that the system of operating in the United States has undergone a genuine revolution in recent years—first, through the introduction of steel rails and rigid fish plates, which permit of the transportation of a greater weight with less wear, and, second, through the competition that has arisen between the great lines for the traffic of the West. The general mean has dropped to 30,000. So we find that there is now a tendency to substitute wheels with steel rims, whose duration is 300,000 miles, and which, on the whole, are more economical than cast iron ones, notwithstanding the latter's good performance.

An endeavor has also been made to have a uniform type of truck for the freight cars. These trucks have four wheels, with a five foot base, and are connected with the box through a central pivot, and with or without springs for lateral motion. Springs, however, are used in the passenger cars (Fig. 2), and they are used on about half of the existing freight cars. It is to this arrangement that must be attributed the qualities of the rolling stock on certain lines having curves of short radius, upon which English cars could hardly be used.

Figs. 3 and 4 show two trucks, one of which was built by Mr. Congden for the Union Pacific Railroad (which has a gauge of three feet), and the other by Mr. Ely for the Pennsylvania Railroad. Mr. Ely's truck is designed for loads of thirty tons, and is wholly of iron, while the Union Pacific one carries twenty tons. The width of the base is seven feet in the four-wheeled trucks, but the larger cars have six-wheeled trucks with a ten foot base. The usual length of an ordinary car accommodating from fifty to seventy passengers is from fifty to sixty feet, the total load being from twenty to thirty tons; but some drawing-room cars take but twenty or thirty passengers, and have a total weight of more than forty tons. We are well acquainted, however, with the characteristic points of the American cars, with end platforms and steps, central passageway, etc. All the rolling stock is coupled centrally, and great effort has been made to make this portion of the equipment uniform. Much attention, too, has been paid to automatic car couplers, but as there are three or four thousand of these in competition, it seems to be difficult to make a choice.

Automatic brakes are being more and more applied to freight cars, and preference is given to those whose shoes work independently on each wheel. The Westinghouse brake is very much employed, but it costs at least $50 per car, without counting the apparatus on the locomotive, and this causes a hesitancy in using it

more, notwithstanding its recognized efficiency. In recent times, cheap brakes, costing $10 or $15 per car, have been much used, although perhaps wrongly.

It would require a special treatise to discuss the differences that exist between the English and American locomotive. The most essential one consists in the use of bogie trucks, instead of rigid bases, as is the custom in England and in Europe generally. As for the other points of difference, it will suffice to enumerate them. In the American locomotive shown in Fig. 9, we find the barred frame, with forged joints, fixed rigidly to the body of the boiler. The English frame, on the contrary, consists of plates, and the boiler, which is connected with it by means of a few bolts, rests upon it as upon a

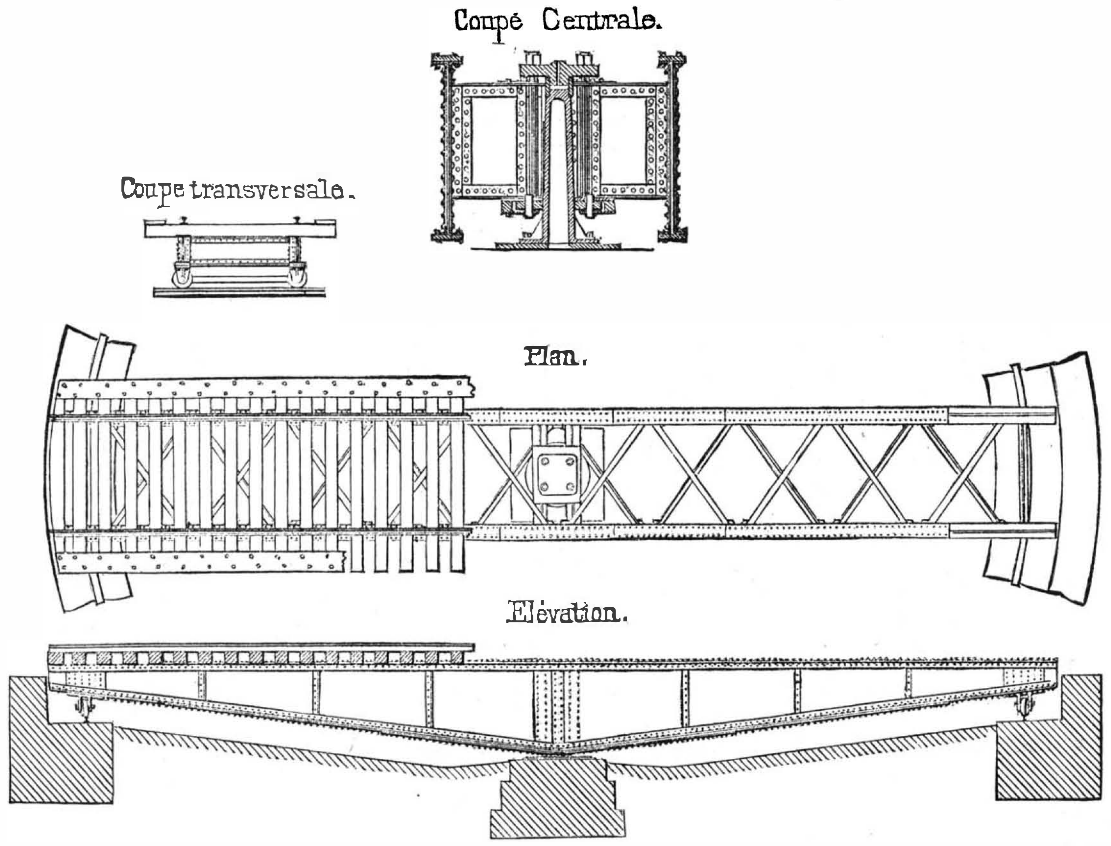


FIG. 10.—TURNTABLE, ERIE R.R. (Scale, 1-120.)

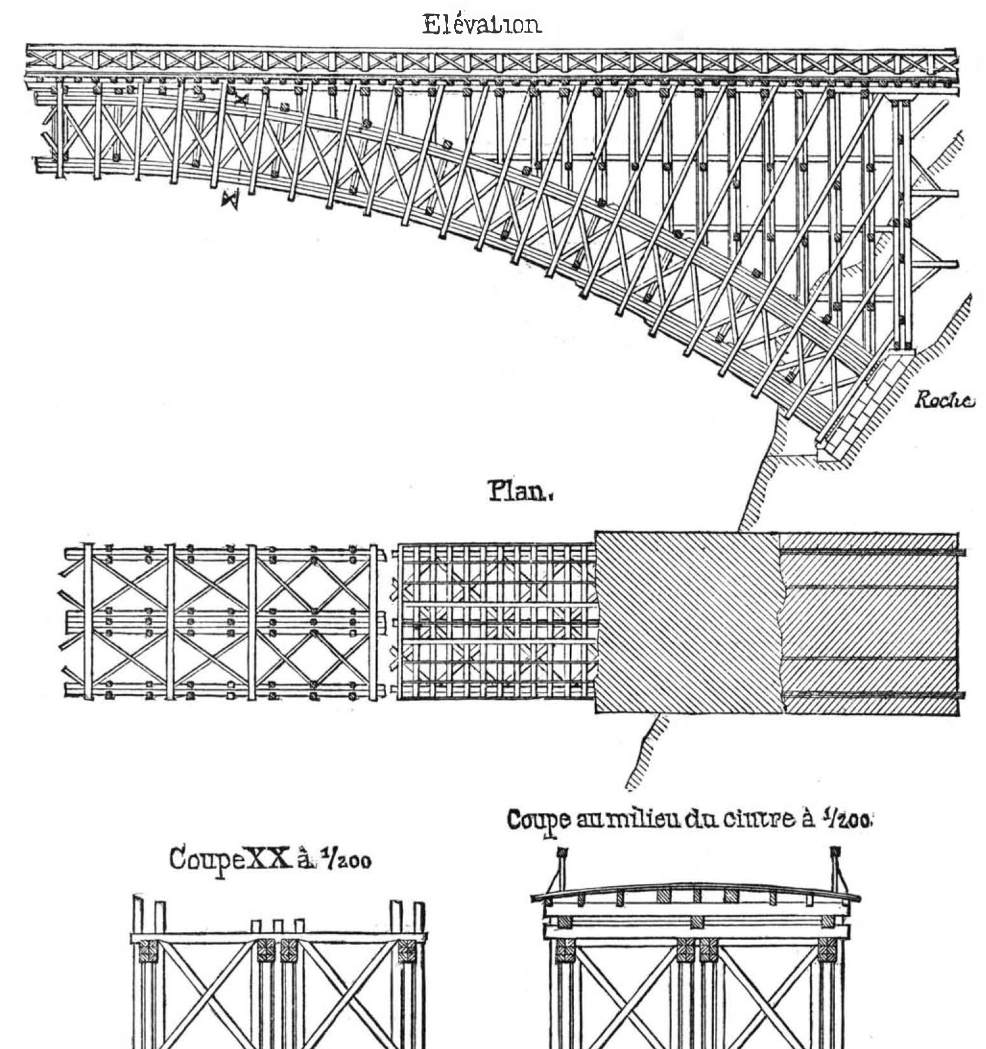


FIG. 11.—CASCADE BRIDGE, ERIE R.R. (Scale, 1-400.)

ROLLING STOCK AND BRIDGES OF AMERICAN RAILROADS.

cradle. The adversaries of this latter mode of construction claim that it does not possess sufficient lateral rigidity, and that to this should be attributed a large number of the cases of breakage of connecting rods and couplings. On another hand, there is no doubt that accidents to the frame frequently put the American locomotive out of service. In the United States, the cylinders are almost invariably placed outside of the frame; the fire boxes are of steel and the wheels are of cast iron, with levers for distributing the load over all of them.

In engines that have a wide wheelage base, the wheels, which are in pairs, have no collars. There are still a few other differences of less importance, such as the cow catcher, the flaring smoke stack, the large head light, and the cab for the engineman and fireman. In general, the American locomotive has a more ornamental appearance than the English one. The bogie has for some years past been adopted for the English locomotive, and we sometimes find the distributing levers used in it. These details are not absolutely indispensable to the English lines, but they should be adopted in all engines designed for exportation.

The most economical lines should employ the 20-ton car, as heavily loaded as the strength of the bridges will admit of. In the construction of new lines as cheaply as possible, the bridges should be so designed as to be capable of supporting a train of locomotives such as are usually employed on the line, and the cars should carry their maximum load, so as to reduce the proportion of the dead to the effective weight. On the new line in course of construction in Southern Pennsylvania, the bridges are designed to support a train composed of two coupled locomotives, each weighing, with its tender, 85 tons, or one 10-wheeled locomotive weighing, inclusive of tender, 97·5 tons. The iron bridges of the Canadian Pacific, elaborated by Mr. Shaler Smith, are designed to support 84 ton locomotives and tenders upon a base of 55 feet, and the bridges of the Atchison-Topeka line are for 80 tons upon a base of 60 feet. The Pennsylvania Railroad Company requires the same tests for its bridges.

Upon this last named line, trains of 100 loaded cars are running, and these are passed over steep gradients by two powerful locomotives, one hauling and the other pushing. These trains carry about 3,000 tons of freight per trip.

Up to the present, the strongest rails used in America have been steel ones, weighing about 26 lb. to the running foot. A large portion of the New York Central is already provided with these. The ties are usually closer together than they are in England, thus giving more solidity to the road. The rails are 30 ft. in length, with 16 ties about 8¼ ft. in length. These ties are in most cases of oak or hardwood, and do from eight to ten years' service, on an average. The foot of the rail is from four to five inches in width, thus giving much surface of support. Where wood is cheap and ballast scarce, the number of ties is still further increased

The main lines use steel rails, weighing from 20 to 24 lb. per running foot—sometimes 28 lb. The branch lines are provided with lighter rails, of from 15 to 18 lb. per running foot. American engineers, however, are strongly opposed to light rails, and assert that economy should be sought somewhere else than in the rails and ties. They are likewise opposed to narrow gauges, except for mountainous regions.

The economy in the construction of American railroads resides, then, especially in the gradients, the straight line, and the bridges, etc., and in the gradual adaptation of the line to the needs of traffic. A glance at a hypsometric map of the United States will show that engineers have met with but few natural facilities, and that there have been enormous difficulties to conquer in the construction of most of the lines.

Physically, the United States are divided into two immense and nearly equal plateaux by the 99th line of longitude. The eastern plateau rises to an altitude of 1,000 ft. above the level of the sea, while the western reaches 5,000 ft. This latter forms the base of the Cordilleras, and of such secondary chains as the Rocky Mountains, which extend as far as to Colorado, and form a plateau of from 5,000 to 10,000 feet altitude, with peaks of 13,500 ft. and passes of from 10,000 to 12,000 ft. It is in these regions that we find the narrow gauge roads of Denver and the Rio Grande and the Union Pacific. To the north and south the summits become lower, and give passage to the great transcontinental lines of the Pacific. The descent toward the east is usually a gentle slope, with here and there a few irregularities due to the lesser chains. It is in this region that we find the most economical lines, and those that best represent the American system. We shall here give a short description of a few of them, and at the same time recall their principle.

The Baltimore and Ohio line has gradients of 1 in 45 and curves of 580 feet radius. The Pennsylvania Railroad has initial gradients of 1 in 37 and 1 in 49 and curves of 325 feet radius, which have been modified by a recent straightening of the line. The Erie road has gradients of 1 in 88, and consequently cost as much as the best English lines, and earns but little.

We next come to the New York Central, with maximum gradients of 1 in 56 and very sharp curves. This line once had a formidable rival in the West Shore road, which likewise follows the Hudson River, and whose gradients and curves are very slight. But a union between the two companies has recently taken place. Finally most of the other lines of the region, including those of the Pacific, have very pronounced gradients and curves.

The Chicago, Milwaukee and St. Paul Railroad owns and operates 4,800 miles of lines, and is the largest company in the world. Its nearest rivals are the Chicago and Northwestern and Chicago, Quincy and Burlington roads, which nearly equal it as regards length of lines and receipts. In 1883, this company carried 4,591,000 passengers over a total extent of 166,000,000 miles, and its freight traffic was 1,883,200,000 tons. Its rolling stock consists of 657 locomotives, about 500 passenger cars and 19,734 freight cars. It owns coal mines from which are annually extracted 500,000 tons, and is provided with most beautiful stations in the principal cities, as well as with magnificent shops (Figs. 21 and 22) and storehouses, elevators and docks. Steel rails are now being everywhere substituted for its old iron ones. Figs. 15 to 19 show its stations, shops, bridges, etc.

The economical lines in America cost from twenty to twenty-four thousand dollars a mile prepared for operation. In order to reach such a result, it is necessary to employ steep gradients, curves of short radius, and numerous wooden bridges. The lines are in the first place studied with a view to cheap construction. To calculate the receipts, we suppose a maximum running, at first, of from four to six trains in each direction. Afterward, in measure as the region develops, and its needs make themselves felt, the road is improved, the gradients are reduced, the curves are given a greater radius, and bridges of a permanent character are substituted for the provisional ones.

Mr. Whittemore thinks that the Pennsylvania Railroad (one of the types of the good lines of the United States) might now spend $240,000 per mile over a great portion of its line, while it would have been folly to do so at its inception. The Chicago, Milwaukee & St. Paul Railroad began with 44 miles of track, which soon increased in large proportions as a consequence of the failures of the companies in the vicinity. In 1878, its capital stock and obligations amounted to $46,000 per mile of road opened. Since then, the following lengths have been annually constructed:

	Miles.
1878	216
1879	148
1880	313
1881	462
1882	210
1883	196
1884	38
Total	1,583

The cost of these lines, ready for operation, was from twenty to twenty-four thousand dollars per mile.

The present debt must be slightly less than $39,000 per mile for the existing 4,800 miles. A large proportion of this total was constructed in regions that were uninhabited, but that were settled in measure as the line advanced; yet the operation of the line generally covered expenses a year after the completion of the road. As soon as it was possible to pay the interest on

the debt with 40 per cent. of the gross receipts, the supplementary sums were devoted to improvements. All the bridges are first built of wood, and form about two per cent. of the length of the line. In Figs. 12 and 13 will be found views of a few types of pile work and fences. These last between nine and eleven years.

Figs. 20 and 23 give views of the Burlington & Milwaukee shops. The engineers of this line prefer to distribute these establishments along the route, rather than to concentrate all of them at a single point. Here are constructed and repaired all the locomotives and cars. Yet the system that predominates in the United States is generally to manufacture the various pieces in special shops for each object, thus effecting a saving in the net cost.

On three-fourths of the Chicago & Milwaukee line the stations are from three to four miles apart, and on the rest of the line seven miles, on an average. The road is a single track one, with turnouts for the meeting and passing of trains. The Chicago & Northwestern Railroad has 9 per cent. of these shunts, and twelve trains per day pass in the two directions. The Cleveland & Indianapolis line has 30 per cent., and thirty trains per day pass; the New York, Pennsylvania & Ohio has 35 per cent., and thirty trains per day pass; the Pennsylvania has 70 per cent., and fifty-one trains pass; and the Erie has 90 per cent., and forty-five trains pass.

Mr. Gordon next gives a summary of various works on the cost of operating railroads in the United States, especially the works of Messrs. Wellington, Vose, Searles, and others, and from this we extract the following table:

	Locomotives. Per cent.	Cars. Per cent.	Salaries. Per cent.	Expenses. Per cent.	Repair of Road. Per cent.	Total.
Mean of 13 lines.	30·7	14·4	17·6	62·7	37·3	100
Mean of 3 States.	28·8	14·5	17·9	61·2	38·8	100
Mean of all the U. States lines....	25·3	13·8	28·4	67·5	32·5	100

As to curves, Mr. Wellington estimates the expenses that they cause from two standpoints: (1) *The wear of the road.*—The supplementary wear of the rails is less than 10 per cent. per degree of curvature; and the expense of keeping the ballast and ties in repair varies between 4 and 5 per cent. (2) *Excess of fuel.*—About one pound more of coal per ton of train and per degree of curvature is burned at slow speeds, and half a pound at high speeds; but these figures are not absolute, and are subject to great variations.

Finally, as to the question of the most economical gradients, in the United States, as elsewhere, opinions are greatly divided, and it may be said that we are still in a period of transition.—*Annales Industrielles.*

(*To be continued.*)

THE NEW MAGAZINE GUN USED BY THE GERMAN ARMY.

THAT important element of modern warfare, the rapid firing of the infantry, has lately received an impulse by the introduction into the German army of a magazine gun. The most rapid firing can be attained by the use of these guns. But if they are to be useful in time of war, they must also be capable of being loaded from the belt, so that the shooting can be kept up after the magazine has been exhausted. The repeaters known heretofore gave little promise of fulfilling the requirements of practical use. Great strength was required for loading them, their construction was complicated, and they were not durable. The loading apparatus was liable to be rendered useless at the important moment by dust, sand, and rust. And as the operation of taking the weapon apart, cleaning it, and putting the parts together again was always a difficult one, considerable time would elapse before the gun was in working order again. Besides, it was necessary to have shorter cartridges, so that more of them could be put in the magazine at a time; whereby the loading was made more difficult, the initial velocity of the shot decreased, and the position of the center of gravity was changed after every shot, rendering the aim uncertain. The Swiss "Vetterli gun" filled the requirements best of all the magazine guns constructed heretofore, but even this one had many disadvantages in practical use, so that it was not generally adopted.

The new weapon now to be used by the German army is made on the principle of the Mauser gun, and is the result of the experiments of the military school and the gun works at Spandau. With the bayonet, it is about 6 ft. long, and weighs 12 lb. when the magazine is empty; without the bayonet, it weighs about 10 lb. It is shorter than the old gun, and consequently the center of gravity is further back, and aim is more easily taken in free hand shooting.

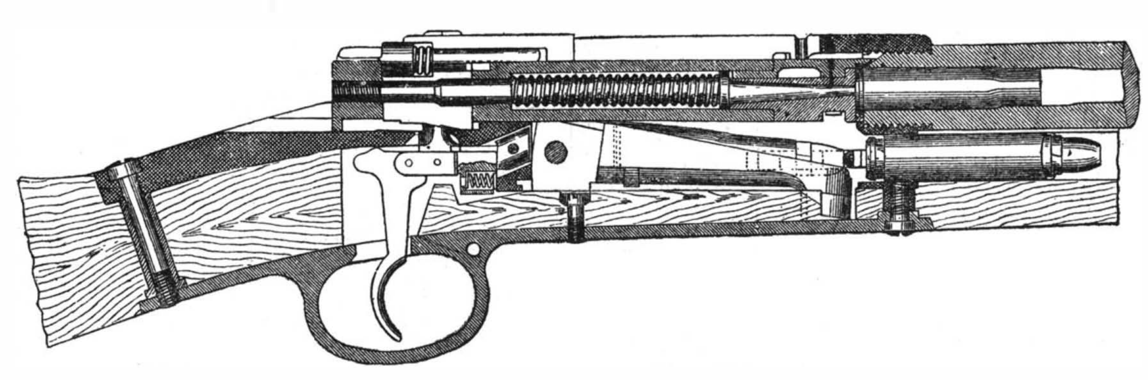
The lock presents two important improvements. Formerly the empty cartridge shell had to be removed by a movement to the right. But this is now done by an extractor which throws out the empty shell when the carrier is drawn back. At first it was thought that this discharge of the shells would injure those near the gun, but this has not proved to be the case. A further improvement is the possibility of maintaining a regular and steady fire. The magazine will hold eight cartridges, and the mechanism is so arranged as to feed the cartridges when the receiver is opened and closed. In the magazine there is a long spiral spring which fills the tube and presses the cartridges on the carrier. On the rear end of the spring there is a plunger which holds the spring in the magazine when it is empty, and prevents the spring from pressing directly on the cartridges when the magazine is full.

The gun is ordinarily used for firing from the belt, but if the magazine is to be used the operator moves a lever on the left side of the barrel backward. This can be done very quickly. The manipulation of the lock mechanism is the same for firing from the magazine as for firing from the belt. In the former case aim can be taken and a shot fired in from two to three seconds, while in the latter from five to six seconds are required for each shot, whereby the superiority of firing from the magazine over the other method is shown. If the German magazine gun is fully loaded, that is, if there are eight cartridges in the magazine, one in the carrier, and one in the barrel chamber, the operator can fire the ten cartridges in from twenty to thirty seconds.

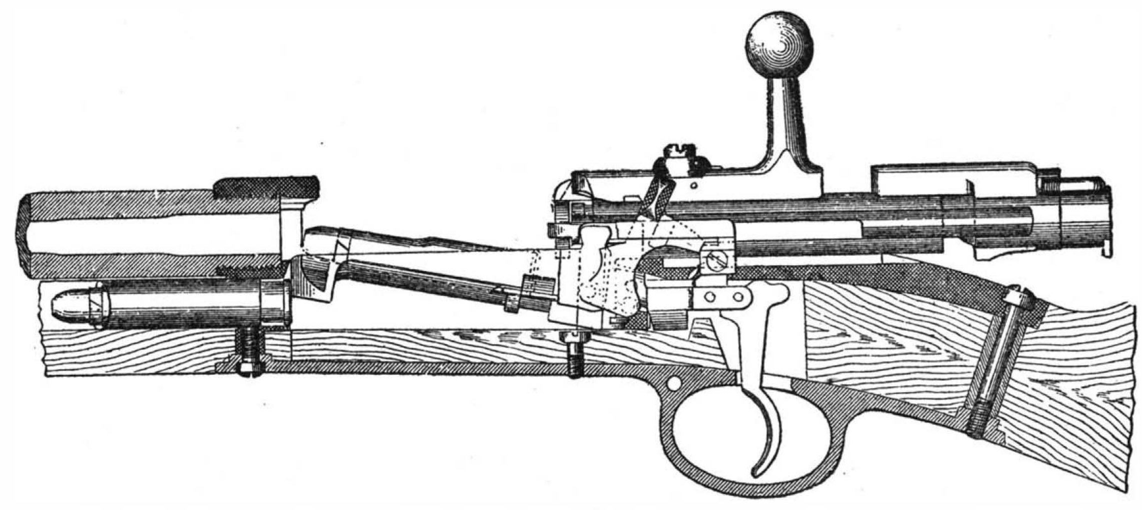
The magazine is, of course, always to be filled before a battle, but the commander should see that the cartridges in the magazine are not used until the proper moment. These moments are very few, but are always the decisive ones.

The range of this gun is the same as that of the Mauser gun; that is, for a target, about 432 yards, for a moving object like a man or a horseman, about 216 yards, and for a very large target 648 yards.

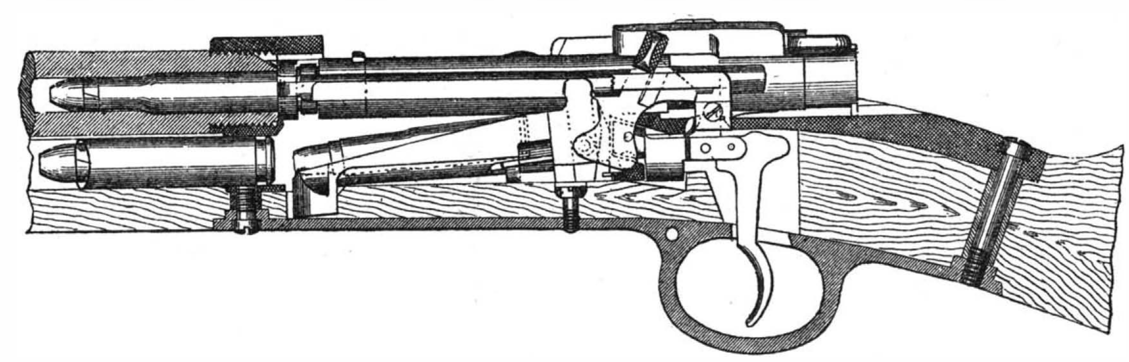
The German army was the first army supplied with breech loaders, and now it will be the first to have magazine guns.—*Illustrirte Zeitung.*



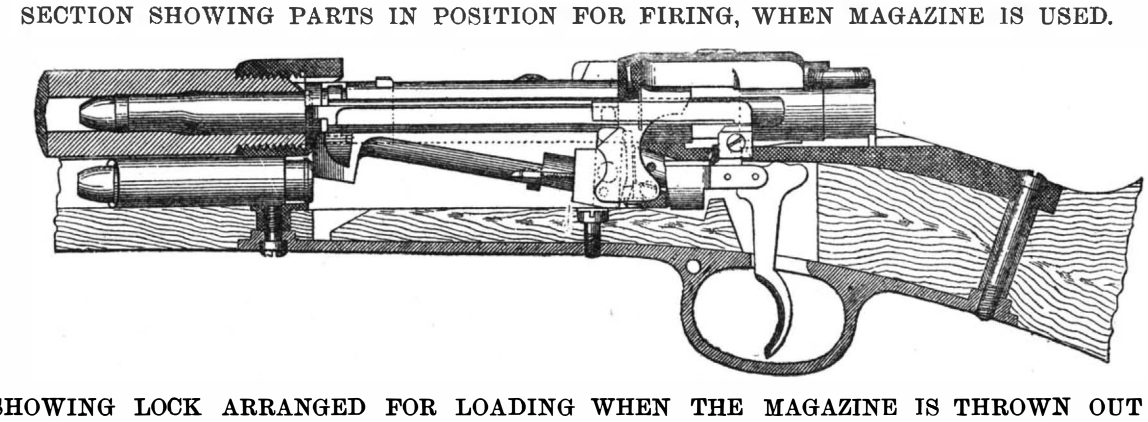
LONGITUDINAL SECTION, SHOWING POSITION OF PARTS AFTER FIRING, WHEN LOADING FROM THE MAGAZINE.



SECTION SHOWING POSITION OF PARTS WHEN LOADING FROM MAGAZINE.



SECTION SHOWING PARTS IN POSITION FOR FIRING, WHEN MAGAZINE IS USED.



SHOWING LOCK ARRANGED FOR LOADING WHEN THE MAGAZINE IS THROWN OUT OF ACTION.

THE NEW MAGAZINE GUN FOR THE GERMAN ARMY.

ZINCOGRAPHY AND ZINCO PRINTING PLATES.

THE question put by our correspondent as to zincography, which means drawing upon (in line or crayon) zinc plates, and printing therefrom, as a substitute for stone, would seem rather to refer to zincotype blocks; but as the two processes are very similar up to a certain point, we give the following description:

The zinc plates for either are sold ready polished, and differ only in thickness, the zinco block being four times as thick as those used for drawing upon. The zinc for drawing upon is not ready for graining until it has been washed with strong potash and rinsed in clear water, and the graining must be done with sand and water, in a manner similar to that adopted for the stone. If for crayon work, it must be very sharp in the grain or it will not take the crayon. If for ink, in line or stipple, an inferior grain will do. In case of drawing anything that may require erasing, the zinc must, on no account, be scraped, as it would roll up solid black. It is better to take out with a piece of clean rag dipped in benzine anything that is wrong, and let it dry, when the crayon or ink may be used without fear over the same part. For convenience of working, the white portions may be stopped out as on stone, but the gum used should have a few drops of glacial acetic acid or nitric acid mixed with it to the strength one would use for a "strong etch" on stone.

When the drawing is completed, take a solution made as follows, and etch the plate with it for ten minutes, not longer: Put two dozen nut-galls into a saucepan—preferably one glazed with earthenware—and cover them with a pint of water. Simmer over a slow fire until it is reduced to half a pint or rather less. Strain through fine muslin into a clean vessel, and let it stand until cold; or it may be kept in a stoppered bottle. Take of strong gum and the above tincture of galls equal parts, and add a drop or two of glacial acetic or nitric acid. The former is preferable, as in washing, the acetate of zinc is more soluble than the nitrate.

This solution should be rapidly passed over the plate, whether chalk or lime, just as the "etch" over a stone. After ten minutes' etching, wash off with a clean sponge and plenty of water, and roll up in the usual way, bringing it up with a roller. Some prefer to allow the plate to dry all over during the rolling up, and keep rolling until the whole plate is one black mass, when they wash out the job with "turps" and water and roll up again. Others are careful to prevent the plate drying in the white or clear parts by wiping very frequently with a very slight etch of gum and acetic acid, feeding the job with the roller all the time, in between. If a transfer is required, a few impressions should be run off before again washing out, when the job will be found strong enough to roll up in retransfer (litho) ink, and the transfers pulled may be put down upon *polished* zinc for the bath.

Zinco blocks for letterpress printing *must be polished*,

unless perhaps for coarse poster work. The grained surface would not answer in the printing. To polish the zinc, take the ordinary pumice powder, very fine, and, with a piece of soft, preferably linen, rag and a little water, rub it down till an even, polished surface appears; after which, with the same powder, *dry*, complete the polishing till the surface reflects like a mirror. Immediately put the transfer down exactly as if it were stone; then, before rolling up, dip it in a very weak bath for a minute or so, and rinse and dry without heating. It should not be washed out, but rolled up in litho ink, and may then be put in the trough and rocked in the usual way, being heated from time to time, and rolled again with the ordinary varnish.

Sufficient care is not usually exhibited in England in biting up these plates for zinco blocks. The writer has had the advantage of seeing the process as conducted in Paris, where the plates are carefully examined through a strong magnifying glass; and, if any tendency to undermine the lines is shown on arriving at a certain depth, the operator takes a varnish brush and protects the shelving sides with it, and also touches up any parts of the surface which seem feeble. If any specks of "scum," or "dirt," adhere to the sides of the lines or among the chalking, he takes a graver and cuts them away, taking care to touch each graver out with varnish, so as to prevent the subsequent bath from undermining the line. To this care is due the superiority of the French, and for that matter the American, process work.

Some houses, before subjecting the transfer on zinc to the weak bath, etch it with the tincture of galls and gum for five or six minutes, which will clear away all scum, and then rinse off with cold, clear water, and immerse in the bath.

Almost every operator has his own favorite mixture of ink for rolling up the zinco block during the biting up, which he pretends to keep a profound secret. But anything which will feed the job, and prevent the acids in the trough from impoverishing it, will answer the purpose satisfactorily. Cobbler's wax, resin, and white or yellow wax, all of which are rendered fluent by the heated plate, in various proportions of admixture, form the bases. Like the earlier receipts for transfer paper, retransfer paper, transfer and retransfer ink, and the photographic processes of earlier days, there always has been an amount of pretended secrecy that imposed upon the credulity of the many, but had no reality about it. Once the principle is understood, the rest goes without saying.—*Printing Times.*

LIQUID FUEL.

FOR two or three years past, some very interesting trials of the use of oil for fuel, instead of coal, have been conducted by the Central Pacific Railroad Company on the freight and passenger ferry steamers on San Francisco Bay. When, therefore, a short time since, the use of this liquid fuel was abandoned by the company, and the furnaces of the boilers again altered to burn coal, it was concluded that oil burning was a failure. It was thought strange, too, because it was understood that the oil was the more economical fuel, doing away as it did with the numerous firemen on the steamers, since the oil was fed to the furnaces by an automatic arrangement. A number of reasons were given by the general public for this abandonment of oil as fuel, among them that the supply was insufficient, that it cost too much, and finally that it burned the furnaces and boilers out so badly that it cost more than it came to finally.

As the matter is of considerable general as well as local importance, we have obtained some information on the subject, which, being mainly official, will be read with interest.

In the first place, as to the character of the liquid fuel itself. It is not a crude petroleum, as many suppose. It is a residue or refuse. The Pacific Coast Oil Co. before selling this material remove the lighter oils, which enables them to sell the refuse at low cost. The first product removed is a gasoline of 84 specific gravity; the second is naphtha of 74 specific gravity; the third is benzine of 63 specific gravity; the fourth is what is known as water-white illuminating oil of 48 specific gravity. Then they remove the standard white illuminating oil of 44 specific gravity. This leaves a refuse of about 26 specific gravity, which is the fuel oil used on the steamers.

The liquid fuel was used on three of the largest steamers of the company, the Thoroughfare, Piedmont, and Solano—the latter the largest ferry steamer in the world. The records of the runs and results of work on these steamers we obtain from the office of the auditor of the motive power and machinery department of the railroad company.

The first steamer to consider is the Thoroughfare, which runs from Oakland Creek to the depots at the southern end of this city, carrying freight trains across the bay.

STEAMER THOROUGHFARE, DEC., 1883, TO DEC., 1884, WITH COAL.

6,169 tons Ione coal at $3.96	$25,617.20
62 tons Carbon Hill at $5.50	506.00
	$26,123.24
Pay of firemen	3,049.61
Total cost of fuel and firemen	$29,172.85
Miles run 22,662½	
Cost per mile in cents—fuel 115.27	
Cost per mile in cents—firemen 13.46	
Total cost 128.73	

STEAMER THOROUGHFARE, JAN., 1885, TO AUG., 1886, WITH OIL.

2,135¼ barrels of oil at $1.65	$3,523.16
11,519¼ barrels of oil at $1.70	19,582.72
	$23,105.88
Pay of firemen	2,227.35
Total cost of fuel and firemen	$25,333.23
Miles run 40,800½	
Cost per mile in cents—fuel 56.63	
Cost per mile in cents—firemen 5.46	
Total cost 62.09	

The above shows 66 64-100 cents per mile in favor of oil, or 51 77-100 per cent. In this statement it is shown that 58·14 gallons of oil equaled one ton of coal.

The Piedmont, a large steamer, is in the ferry traffic between Oakland Mole and San Francisco. She was originally devised for coal, but was afterward fitted for oil (as were the other steamers).

PIEDMONT, NOV., 1884, TO AUG., 1885, WITH COAL.

4,929¼ tons Carbon Hill coal at $5.00	$24,646.25
1,285 tons Carbon Hill coal at $5.50	7,067.50
	$31,313.75
Pay of firemen	7,658.04
Total cost of fuel and firemen	$39,371.79
Miles run 43,525	
Cost per mile in cents—fuel 72.86	
Cost per mile in cents—firemen 17.59	
Total cost 90.45	

STEAMER PIEDMONT, SEPT., 1885, TO AUG., 1886, WITH OIL.

4,136 barrels oil at $1.65	$6,829.35
15,985 barrels oil at $1.75	27,174.50
	$34,003.85
Pay of firemen	4,541.76
Total cost of fuel and firemen	$38,545.61
Miles run 44,307	
Cost per mile in cents—fuel 76.74	
Cost per mile in cents—firemen 10.25	
Total cost 86.99	

The above shows 3 46-100 cents per mile in favor of oil, or 3 8-10 per cent. In this case it took 133·63 gallons of oil to equal one ton of coal.

The Solano is the immense steamer which takes the overland trains, freight and passenger, across Carquinez Straits, between Benicia and Port Costa. The run is very short.

STEAMER SOLANO, DEC., 1883, TO FEB., 1885, WITH COAL.

1,027½ tons Carbon Hill coal at $5.00	$5,137.50
2,090½ tons Carbon Hill coal at $5.50	12,047.75
5,724¼ tons Empire coal at $3.79	21,694.91
	$38,880.16
Pay of firemen	8,476.70
Total cost of fuel and firemen	$47,356.86
Miles run 7,504	
Cost per mile in cents—fuel 518.12	
Cost per mile in cents—firemen 112.96	
Total cost 631.08	

STEAMER SOLANO, MARCH, 1885, TO AUG., 1886, WITH OIL.

2,395¼ barrels oil at $1.65	$3,952.16
16,909 barrels oil at $1.70	28,745.30
	$32,667.46
Pay of firemen	8,496.84
Total cost of fuel and firemen	$41,194.30
Miles run 7,308	
Cost per mile in cents—fuel 447.42	
Cost per mile in cents—firemen 116.26	
Total cost 563.68	

The above shows 68 40-100 cents per mile in favor of oil, or 10 68-100 per cent. This gives the result of 94·16 gallons of oil equal to one ton of coal.—*Min. and Sci. Press.*

VINEGAR.

IT is one of the marvels of chemistry that the sourest substance with which we are familiar is made from the sweetest. By the action of a ferment, the sugar in some sweet liquid is turned first to alcohol and the alcohol then changes to acetic acid, which is the acid in vinegar. In Great Britain, vinegar, until recently, has been manufactured almost entirely from malt. Of late years, glucose, cane sugar, and molasses have been largely used. British proof vinegar contains 4·6 per cent. of anhydrous acid. A notion formerly prevailed that sulphuric acid acted as a preservative to vinegar, and one-tenth of one per cent. was allowed to be added. This addition is now an illegal adulteration.

In France and elsewhere in Europe, the manufacturer starts with an alcoholic liquid already partly acetified, light wines that have been turned sour being generally employed. In fact, the French name, *vinaigre*, from which the English word vinegar is derived, means sour wine. Six and one-half to seven per cent. of acid have been found in French vinegars. Sour ale and beer do not yield good vinegar.

In the United States, cider vinegar has long held the preference, and if the cider has been from sound, sweet apples, the vinegar has a very agreeable flavor and color. The old fashioned way, which is followed by farmers in making vinegar, is to set out of doors in the spring a barrel of cider, which has become too hard and sour to drink, from the sugar partly turning to alcohol and acetic acid. The bung is taken out of the barrel, and the bung hole is loosely stopped by sticking the neck of a large bottle in it. Such exposure to the air at a warm temperature effects the conversion of the cider to vinegar in three or four months. The change goes on very slowly, because the air can act only on the surface of the liquid, and the fresh portions of alcohol are brought to the surface only as the newly formed acid sinks and mingles with the liquid below. The best cider vinegar is made from new cider, and it is well to cause several fermentations to take place by adding a fresh quantity of cider every two weeks.

Vinegar is chemically a dilute solution of acetic acid, containing some minute quantities of fragrant ethers, which give it its odor, and some brownish substance, to which is due its color. Other matters, derived from the liquid from which the vinegar is made, are sometimes accidentally present, as sugar, gum, starch, cream of tartar, and other salts. Vinegar usually consists of between ninety-three and ninety-seven per cent. of water, the rest being acid, except a fraction of a per cent. of solids.

From the time of Moses down to at least 1820, the same slow process had been employed in the household for obtaining vinegar. In 1814, Berzelius had found out the chemical composition of acetic acid, and De Saussure that of alcohol; so that, after Doebereiner had discovered that a weak solution of alcohol, exposed to the air in contact with platinum black, was converted to acetic acid, he was enabled to set forth the theory on which depends the modern quick process of vinegar making. The essential feature of this process consists in bringing the alcohol solution into immediate contact with the air, by causing it to trickle through a mass of loose material, which effects the acetification in from twenty-four to forty-eight hours.

The operation is carried on in wooden tubs, six to ten or more feet high, called generators. Around the sides of the generator, a few inches above the bottom, is a ring of air holes. Just above the air holes is a perforated false bottom, and from this nearly to the top the generator is filled with beechwood shavings, which are closely curled, so they will not crush and prevent the air circulating freely through them. A few inches above the shavings is a wooden head, or sieve, perforated with small holes, which serves to distribute the alcoholic liquid, or wash, evenly over the shavings. Several air pipes are inserted in the sieve, extending a few inches above and below it. The generator has a cover with a hole in the middle through which the mash is poured in and the ascending current of air passes out. The vinegar room is kept at a temperature between 70° and 90° F. A high temperature and a large supply of air hasten the operation, but cause loss by the evaporation of the alcohol. The mash must be passed several times through the shavings in order to effect its complete acetification.

Two kinds of vinegar are sold by grocers in the United States for domestic use, cider vinegar and white wine vinegar. Both kinds are made in the factories by the process just described. Massachusetts, New York, and some other Eastern States have laws concerning vinegar. In these States the cider vinegar may be depended on as being really made from cider, for the risk of heavy penalties is hanging over any adulterations. The laws require also that all vinegar shall contain 4½ per cent. of acetic acid. Cider vinegar contains a little malic acid, and will give a precipitate with acetate of lead. The absence of the precipitate shows that the sample is not cider vinegar.

Many persons still retain a strong preference for cider vinegar. If the apples are good and the operation cleanly, and a thorough purification of the product is made, then home-made cider vinegar is an excellent article. But much of it is deficient by reason of its lack of purity. Many times as much white wine vinegar is now consumed in the United States as cider vinegar.

The white wine vinegar, however, is not made from white wine. Until recently manufacturers started with whisky, rum, or other alcoholic liquor, but they are now allowed to produce their own spirits. In the East molasses and in the West a wort from grain is first fermented in the vinegar still, and a liquor containing fifteen to twenty per cent. of alcohol is produced. The liquor is then converted to vinegar in the usual way. This vinegar is perfectly colorless, and the brownish color which the consumer expects is given it by an addition of burned sugar or an infusion of roasted barley malt. Cider vinegar has an agreeable flavor, due to the presence of acetic ether and malic acid.

A recipe is given by which it is said excellent vinegar for domestic use may be made: To each gallon of the sirup, containing 1¼ pounds of sugar to a gallon of water, is added one-fourth of a pint of good yeast. The liquid is kept at a temperature of from 75° to 80° F. for two or three days, and is then racked off from the sediment into the ripening cask, where one ounce of cream of tartar and one ounce of crushed raisins for each gallon is mixed in. When the vinegar is freed from any sweet taste, it is drawn off clear into bottles and closely corked. Vinegar should not be kept in metallic vessels except those of silver or perfectly clean copper.

The value of vinegar as a condiment depends on the fact that acetic acid dissolves gelatine, fibrine, and albumen, hence it aids in digesting young meats, fish, lobsters, and hard boiled eggs. The acid assists, also, in the conversion of cellulose into sugar, which is the first stage in the digestion of the green leaves used in salad. It is a mistake to use vinegar on beans, for it renders insoluble the legumen which is their chief nutritive constituent.

Vinegar partly supplies the want of a vegetable acid in the system, but not wholly, for it will not prevent or cure scurvy. A craving for acid is better satisfied by fruit or acid vegetables. Those young girls who indulge largely in such indigestible articles as pickled limes, cucumbers, and the like would enjoy better health if they should eat instead sour apples, tomatoes, and rhubarb and cranberry sauce. The habitual use of vinegar in excessive quantities leads to dyspepsia.

Vinegar is used in medicine for its astringent action, being employed locally to check hemorrhage. It is also a refrigerant, for sponging the skin with diluted vinegar has a cooling effect. The heat and pain of sprains and bruises are relieved by applying to the place brown paper soaked in diluted vinegar.

The tough, leathery substance called "mother," which forms in vinegar, is one of the many fungi whose spores float in the air, settle as dust on exposed objects, and fall into exposed liquids, ready to grow into a bulky plant when conditions favor. Under the microscope, the fungi of the vinegar plant exhibits two forms, the minute rounded particles and the rod-like forms. It has been known to reach the thickness of half an inch, and its presence tends to accelerate the operation, though it interferes with the flow of vinegar through the apparatus of the manufacturers. There is a popular notion that the absence of mother shows that the vinegar is made from cider and is of good quality, but the vinegar plant appears also in vinegar made from molasses, and it is really as undesirable in vinegar as mould on bread.

The little, wriggling creatures which swarm in some vinegars have been credited by uneducated persons with being the "life" of vinegar. In one sense they are, but their presence is in no way beneficial. These vinegar eels (*Anguillula aceti*), as they are called, are developed in most fruits, and hence readily

find their way into vinegar made from fruit juices. Vinegar which contains them must contain also as impurity some mucilaginous or albuminous matter, or the eels would have no food and could not exist. They need air also, and they have been observed engaged in a curious struggle with the mycodern on the surface. The plant tends to prevent their obtaining the requisite supply of air, and the eels were seen combining their efforts to submerge it. They may be killed by heating the vinegar to 128° F., or by adding boracic acid. Vinegar when long kept, especially if exposed to the air, putrefies and becomes ropy, losing its acidity, and acquiring an unpleasant smell; the presence of the vinegar plant, vinegar eels, or other foreign substances is liable to induce putrefaction, especially if the vinegar is weak.—*Popular Science Monthly.*

THE SULPHUR INDUSTRY OF THE UNITED STATES.

By HARRY C. MYERS.

THE mineral deposits of the great West have for many years attracted a great deal of attention, both in the United States and abroad. Besides the common minerals and compounds that chemists acknowledge as existing, there are beds of pure white kaolin, mineral wax or ozokerite, borax, petroleum, bituminous coal veins forty feet thick, rich sulphur deposits, etc. Sulphur, I believe, is not recognized by text-books as existing to any extent in the United States, and yet, in the Territory of Utah, there is beyond doubt the richest and largest known sulphur deposit in the world.

It would seem by the extent and purity of *this* deposit, however, that at some remote period the sulphur must have poured out in a molten mass and flowed like lava into the valley beneath. This enormous deposit was located in about 1870 by the government surveyor, and is situated two hundred miles south of Salt Lake City, between the counties of Millard and Beaver, on Cove Creek.

The deposit is about two thousand feet square, and shafts have been sunk in different places from thirty to sixty feet deep without reaching the bottom of the deposit. The depth is as yet unknown. It is easy to see by using these figures and multiplying by the weight of a cubic foot of sulphur, which is over a hundred pounds, that this deposit contains easily ten million tons of sulphur.

The poorest ore yet found in this locality contains 40 per cent. sulphur, and is almost black in color; but as the 90 per cent. ore is inexhaustible, the poorer ores are disregarded. These ores were analyzed at Case School of Applied Science by a familiar process, and found to be absolutely free from arsenic and antimony, which cannot be said of the imported Sicily sulphur.

The sulphur in this deposit is in strata, measuring from eleven to twenty-two inches in thickness, and as it is a surface deposit, it is worked much like the quarrying of stone. It is then refined by a new process, which consists of melting the sulphur, forcing and straining it through a cylinder by the heat and pressure of steam, and as the ore is only contaminated with lava sand, it is very easily separated.

In many parts of this deposit the vapors are still rising and the deposition is continuous. In sinking shafts the vapors are so intense that several workmen are required, for one man is soon overcome and another one must take his place; and often birds and small animals enter the sulphur pits for shelter and are soon overcome and suffocated.

In 1872, a party of business men endeavored to find the extent of this deposit. On camping out the first night, their tents were filled with vapors and they were nearly suffocated. Next day they started to sink a shaft. Again the vapors drove them away, and they had nothing to show for their trouble except a pair of sore eyes apiece. On their return they reported the discovery of the infernal regions in active operation.

The way in which this deposit was discovered is a rather peculiar one. It was noticed at a certain time in the year, when the foliage of the trees was just beginning to appear, that wherever a tree was growing near a sulphur deposit it was greener and more advanced than the trees about it. Knowing this fact, a single person was enabled to discover and locate fourteen deposits. This advanced growth was probably due to the warmth of the rising vapors. Soon after the discovery of these beds, some English capitalists sent over experienced men at a great expense, who, being ignorant of this fact, failed to make a single location.

A few years ago sulphur was discovered in Mount Humboldt, Nevada, which was 98 per cent. pure, but it proved to be only a "pocket," and was soon exhausted. Rich deposits were also discovered in New Mexico, as well as in California and Colorado. In fact, at the exposition at New Orleans, nearly all the Western States reported sulphur deposits and exhibited specimens of the ore, but owing to lack of railroad facility or extent of the ore these deposits have not been operated to any degree.

The high rates of freight in the West have been a great drawback to the mining industries, and have compelled us to borrow of our neighbors when we have abundance at home. This is the case with our sulphur industries.

We now import nine-tenths of our sulphur from Sicily. The ore there is taken from the bed of an extinct crater, several hundred feet below the surface, and is carried to the surface upon the backs of children. The ore does not average above 20 per cent. It is then partially refined and shipped to us as "crude sulphur." This is done to avoid the duty on the refined article, and as it is shipped *free* as ballast, it makes a cheap article with which American high priced labor and freights will hardly allow of competition.

The great demand for sulphur is, of course, for the manufacture of sulphuric acid, and it would seem at first sight that it would be necessary to ship the Western sulphur to the East and supply this demand, in order to make the enterprise a profitable one. This, plainly enough, would eat up the profits. But such is not the case; the demand for sulphur in the West is enormous, and is steadily increasing, and will continue to increase as long as the population increases and new industries are started in operation.

Sulphur is used largely in the West, especially in Colorado, New Mexico, and Texas, as a "sheep dip." This "dip" is composed of sulphur and an alkali, and is used for cleansing the sheep and destroying a kind of itch that is common in that locality. The carrying out of this cleansing is compelled by law. Little towns in the West, that are hardly noticeable on the maps and are almost unheard of, purchase annually from five to ten car loads of sulphur.

This sulphur is then sold to the various ranches in the vicinity and used as described. Sulphur, again, is largely used in restoring old vineyards, especially in California and that vicinity. It is also used in a variety of smaller ways that are well known in the East.

The imports of this article in 1878 were 48,102 tons, and in 1886 were 117,538 tons, showing an increase of over sixty-nine thousand tons in the importation in eight years, and in the next eight years the increase of course will be much greater unless we bring our Western sulphur into the market. And it will be brought into the market and will compete with the Sicily trade, just as sure as American energy and enterprise continues to be what it has been in the past.—*Amer. Jour. Pharmacy.*

IMPROVED WARPING MACHINE.

Mr. ROBERT HALL, Bury.

THE manufacture of small wares is a branch of the textile industries of no great dimensions, and it is probable that it is owing to this fact that it has to a certain extent escaped the hands of mechanical inventors and improvers. We believe that smallware looms have not been changed to any important extent for many years, though we know of one improvement, which we hope shortly to notice, that must be regarded as a considerable one. In the preparatory stages of winding and warping, matters are in a very primitive state, the latter process being still generally performed by hand. Improvements are, however, on the alert, and we have made a note of the fact, and the following description may perhaps be regarded as that of one of the first results.

This is an ingenious adaptation of the ordinary stop motion warping machine to the wants of the smallware trade. As will be seen from our illustration (Fig. 1) of the side view, it differs little in appearance from the machine just mentioned, the creel frame and stop motion being the same. The front view (Fig. 2), however, shows the nature of the changes that have been introduced. The cylinder has been elevated from its former position and divided into sections. Upon these are mounted the small warp rollers, with their ends placed in slide standards. The contents of the creel being divided according to requirement, are attached to the rollers, and the machine being started, the warping proceeds, the warp being rapidly traversed in a lateral direction to the extent of the width of the bobbin, so as to fill it uniformly, and by crossing prevent any falling down of the sides, there being no flanges to sustain these. By means of the foot lever, any particular bobbin can be raised out of action and stopped for any requirement or for doffing, without interfering with the remainder. When the bobbin is filled, it falls into the grooved tops of the standards prepared to receive it, and is doffed. The section cylinder shaft is friction driven.

As a smallware warp may contain any number of threads, from those required to form a narrow tape or fillet to the considerably greater number entering into such fabrics as ribbons, bands, belts, braces, girths, webs, etc., it will be obvious that this improvement will find a fairly wide field of usefulness, as it can be made of any dimensions in its details, according to requirement. It lends itself with facility to various purposes; as, for instance, each section may be of different counts or colors of yarns, while patterned warps of any sort and any length may easily be made.—*Textile Manufacturer.*

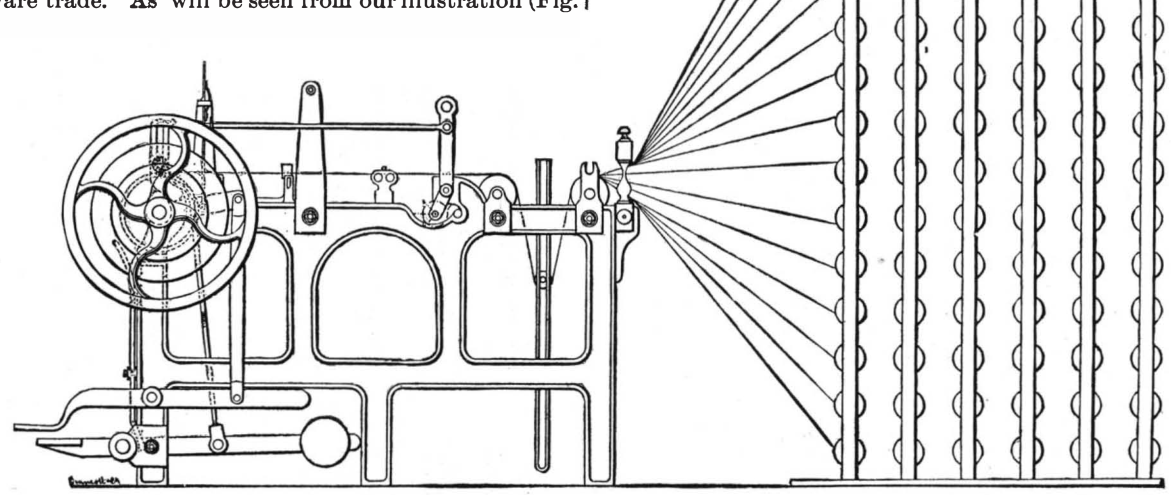


FIG. 1.—HALL'S WARPING MACHINE—SIDE VIEW.

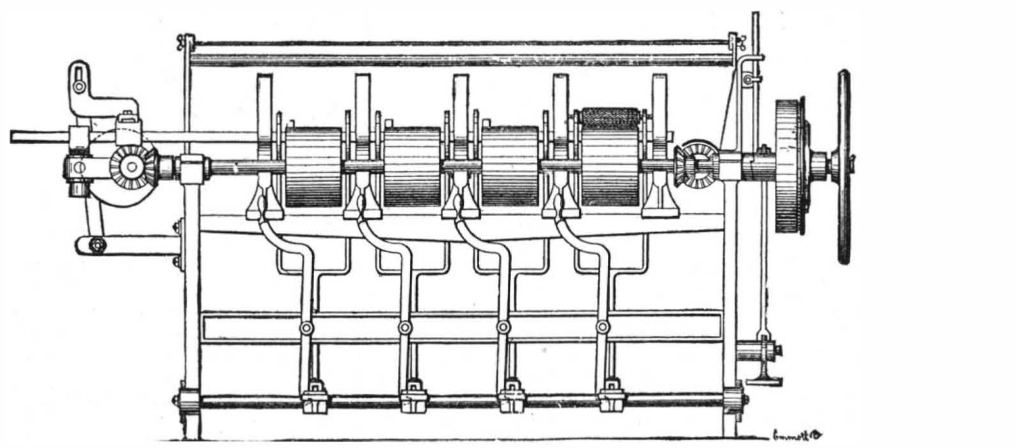


FIG. 2.—HALL'S WARPING MACHINE—FRONT VIEW.

MANUFACTURE OF OIL OF SASSAFRAS.

By THOMAS C. HARRIS.

IN some of the interior counties of North Carolina may be seen in operation many primitive establishments for the manufacture of the oil of sassafras and oil of pennyroyal. The apparatus used in this work is so exceedingly rude and primitive as to appear ridiculous to most observers; but the product is of good quality, and constitutes a profitable industry. For these oils the usual style of "still" may be briefly described as a short trench in the ground, ending in a low flue or chimney. Over this trench is placed a closed wooden box, having a sheet-iron bottom, and an auger hole on top, through which water is poured. An ordinary barrel stands endwise on top of the steam box, and has several holes bored through its bottom, and also through the top of the steam box, allowing steam to pass freely up through the barrel. A lute of clay is used to close the joint between the lower end of the barrel and the steam box, as well as the cover of the barrel. Instead of a "worm," a tin pipe immersed in a trough of cold water is used; and a steam connection with the barrel is generally made by an elbow branch of wood, bored out with an auger. The sassafras tree (*Sassafras officinale*) grows abundantly in this section (Raleigh, N.C.), especially on worn-out lands, where it is usually found in dense thickets of small shrubs. The root is dug and washed free of dirt, and, after being chopped short and bruised with a hachet, is ready for the "still."

When the barrel is filled with the roots, and the cover made tight with clay, the process of distillation goes on rapidly. The steam passes through the mass of bruised roots, and is condensed by the tin tube into a mixture of distilled water and oil, and runs into a glass vessel set to receive it. Being of different densities, the oil and water rapidly settle into two strata, and one can be decanted from the other. It is said that the operator of such a "still" can pay all running expenses and make a clear profit of three dollars per day.

The same outfit is used in the production of the oil of pennyroyal (*Hedeoma pulegiodes*), which grows abundantly in the woods in many counties.—*Pop. Sci. News.*

QUICK SETTING CEMENT.

ACCORDING to the *Journal du Ceramiste et du Chaufournier*, the maritime authorities at Boulogne have been using, since August, 1885, a quick setting Portland cement, made by the French Cement Company, of Boulogne-sur-Mer. It has the appearance of Portland cement, and is made under similar conditions, and differs entirely from the Boulogne Roman cement formerly made. Laboratory experiments have shown that this cement, mixed with sea water at 63° F., sets in about ten or twenty minutes. When used with gravel in the proportions of 1 to 1, or 1 to 2 of gravel, it sets in thirty and ninety minutes respectively. It is necessary to mix a small quantity at a time, and to

use it at once. The composition of this cement is given as follows:

	Average percentage.
Silicious sand	0·49
Combined silicon	23·62
Alumina	7·60
Peroxide of iron	1·96
Lime	62·54
Magnesia	0·88
Sulphuric acid	0·76
Loss in fire	2·07
Substances not analyzed	0·08
	100·00

THE AIR BRUSH.

THIS is a novel invention for producing drawings and paintings by means of an air jet instead of using pencils or brushes. By means of a jet of compressed air a stream of black lead, in finely pulverzed form, or a fine stream of liquid paint, is blown from the point of a needle, and made to impinge on the surface of the paper, in fine or broad lines, as required by the operator, who simply holds the delivering instrument in his hand, and directs the delivery of the pigment upon the paper, while with his foot he works the air compressor, as shown in Fig. 6.

The actual instrument itself, which the operator holds in his hand, is shown on an enlarged scale in Figs. 1 and 2. In Fig. 1 the outside cover has been removed in order to show the working parts, which we will describe.

The needle, A (Fig. 2), is hooked into the walking bar, B. The needle guide, C, may be raised or lowered at will. In D is shown the downward blast which carries the liquid on to the surface. This blast has to be so arranged that the needle, when coming out of the point of the spoon, passes directly into the blast. The needle set screw, E, is used to determine how far the thumb valve has to be pushed forward in order to be able to make the finest lines. The thumb valve just referred to is shown at F. The pressure of the valve can be adjusted by the aid of the small wheel, K (Fig. 1). H represents the blast which impels the wheel, and the "spoon" or color receptacle. It will be observed that the current of air does not touch the point of the spoon, and that the needle does not touch the air blast point when passing under it.

The mahl stick or guide, J, is used with the left hand when a bit of detail has to be worked out. It can be removed when not required. K, the main valve, which admits the air to the instrument, is connected with the thumb valve, F, as seen in Fig. 1. The screw, L, can be used to raise the downward air blast slightly in order to throw a more granular shadow, such as is required for very broad work. At M the rubber tube is attached which connects the instrument with the air chamber.

The action of the hand piece is entirely controlled by the thumb valve, and the artist can produce the finest line and instantly change to a broad shadow. These effects with a single stroke have a finish that only hours of toil can equal by any other known means.

The cut will give a clearer idea of its action.

It will be seen that holding the instrument low produces fine lines; and by elevating the instrument broad effects are produced, and the artist can go from line to shadow without stopping, as seen in the cut. Supposing the instrument moved from A to B, following dotted lines, the effect would be as seen on the paper from A to C. The increased quantity of liquid necessary to produce the broad effect at C is regulated entirely with the thumb.

Everything about the operation of the air brush becomes perfectly automatic after a little practice, and the artist will handle it with the same ease that he now handles the brush or stump In a word, it puts into the artist's hands at once many years of practical manipulation, which few would care to invest the large amount of time and study to attain.

It will be seen that this instrument is a legitimate artist's tool, and no more a "machine for making pictures" than crayon or camel's hair brush.

It will be understood that the mechanical contrivance is barely such as will furnish the constant, uniform current of air for carrying the color, and the means of so controlling this current, that it is in perfect sympathy with the slightest pressure of the thumb, the least movement of the wrist or hand on the part of the artist.

It will be seen that the color is thrown on the paper with the rapidity of this jet of compressed air. By brush or crayon the work is done only so fast as the hand or fingers move. Every artist can think faster than he can execute. What could be a greater aid than this means of quickly fixing the artist's finest conception, before it is lost or dulled in the slow task of working out by ordinary means?

The use of the air brush does not necessarily imply the entire abandonment of any of the methods now in use, though experience shows that when once an artist has become thoroughly master of the air brush, other methods are either absolutely laid aside, or become accessories of the air brush.

It is not claimed that the air brush makes skill and labor and talent on the part of the artist unnecessary. But it is known that with equal skill and talent, better results, with less drudgery, can be obtained by the use of this tool for putting on color than by any other means thus far discovered. It has also been repeatedly demonstrated that the use of the air brush can be more rapidly learned than that of stump or point, and that the very use of the instrument is in itself an education in shading.

All this makes plain why the air brush in no manner cramps the freedom of the artist.

Every artist will produce effects peculiar to himself, and will preserve his individuality, just as with other methods; but he will find his time so economized, and his labor so decreased, that he will attempt work from which he would shrink without the aid of the air brush.

The air brush is used especially in working with India ink and water colors, and in applying lithographer's ink to the stone. There is no dilute liquid pigment which cannot be applied by it. Any color or combination of colors can, of course, be used as with the usual methods.

Liquid pigment can be used with the air brush upon any surface known to art. It works upon paper,

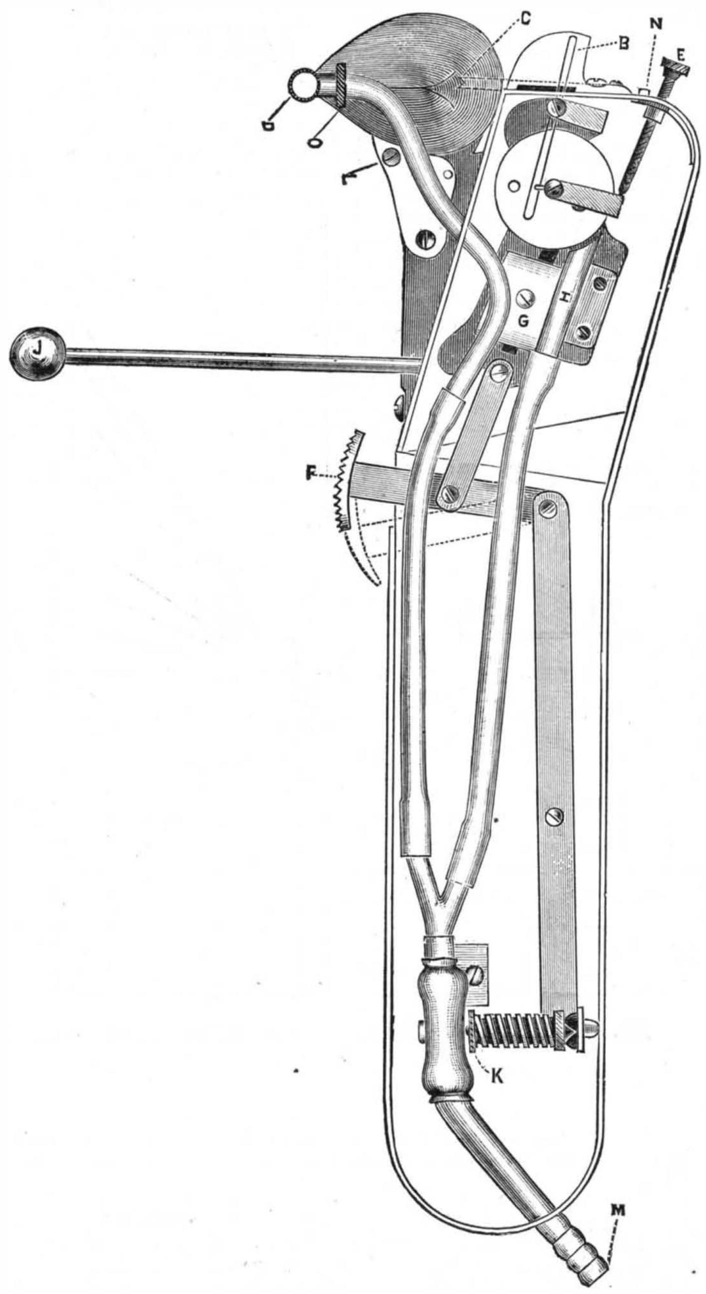
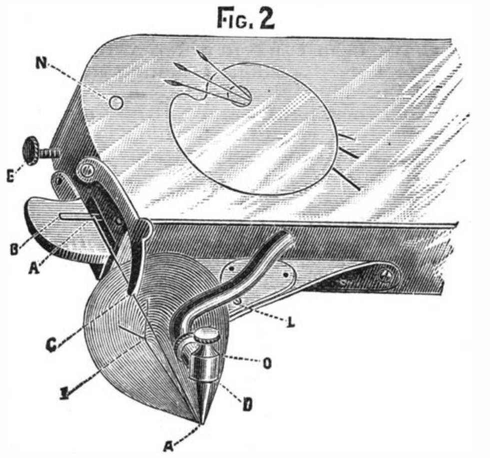


FIG. 1.—THE AIR BRUSH.

FIG. 2



canvas, parchment, negatives, solar prints, albumen paper, bromide paper, etc. It works upon vellum cloth without causing it to wrinkle.

For decorative work it gives exquisite results upon satin, bolting cloth, China silk, or velvet, without running of color upon satin or matting of pile upon velvet.

The work produced is excellent in itself. For instance, in portraiture, nearly all artists agree that (aside from likeness) brilliancy and perspective are the essentials. It is also known that pure high lights, delicately graded half tones, and clear, transparent shadows, together with receding or diffused outlines, give brilliancy and perspective; always having a proper regard for contrast and reflected light.

The work done by the air brush possesses diffusive qualities, naturally inclining to soft outlines; and a shadow produced by it, however deep, is (unlike wash or stump work) transparent in itself, being illuminated by minute interstices.

The air brush, by its wonderful rapidity, renders immediate results possible, so that the artist can secure likeness without going through the monotonous task of working it out with stump or point. He can thus place his original conception upon the parchment before it is lost or distorted by an unnecessary amount of drudgery.

One of the greatest advantages of the air brush is that the work will bear bad lighting with better grace

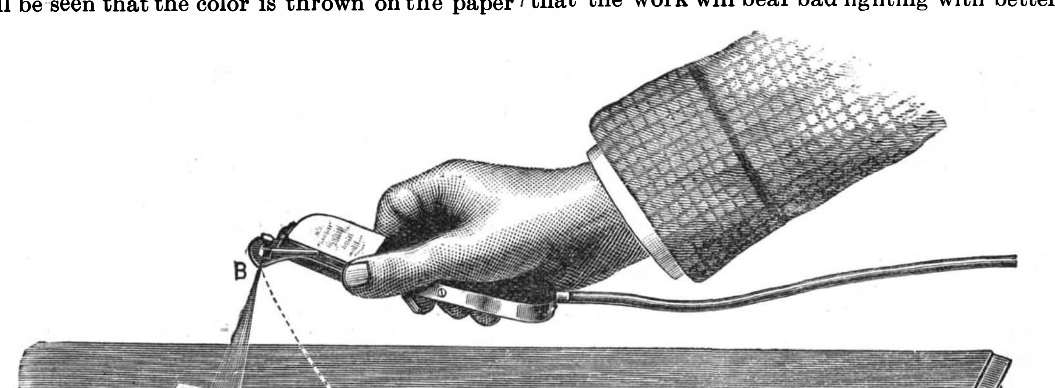


FIG. 3.—THE AIR BRUSH.

than any other work known, and perhaps a word of explanation will not come amiss.

The artist in working his picture under an upper left light, or whatever it may be, adapts everything to those conditions. He also has a given stroke which predominates, and thus the larger part of his work is on one side of the parchment tooth, while his light is playing more strongly upon one side of the tooth than the other. As a result the picture does not do him justice if it is shown under any other light. The difference between brush and crayon work and that of an air brush is briefly this: Instead of applying color with a side stroke, the artist will throw the color directly into the parchment with the air brush, and thus his work will be evenly divided on each side of the parchment tooth; and after having completed a portrait exclusively with this instrument, it will show equally well under right or left light.

Every artist appreciates how consoling it would be if he could feel that, no matter what light his pictures were afterward exhibited under, they would show to advantage in spite of the bad judgment displayed by inexperienced agents or picture buyers.

In water color work the artist finds himself relieved, in a great measure, from the mixing of tints before

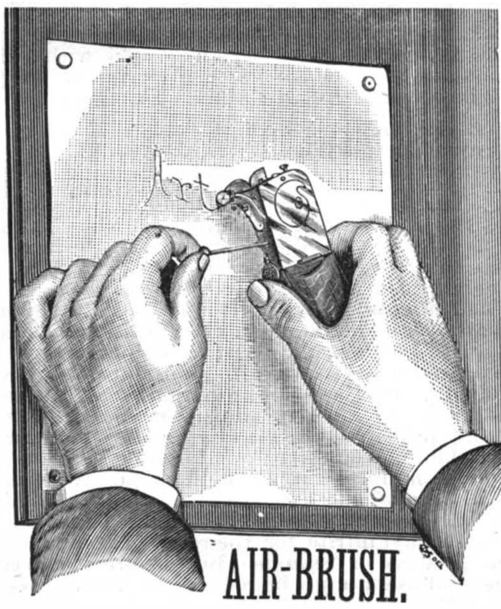


FIG. 4.

they are applied, as he can place one color over another to produce any given effect without the slightest danger from what is commonly called "washing up," and can with perfect impunity return to his modeling color, after having applied all his flesh color, grays, and carnations; and after doing what additional work may have been overlooked, he may then return to his flesh colors, and replace them as nicely as though never disturbed. In adopting the air brush for water color work, the artist may employ his usual tools if he desires, as the work of this instrument closely resembles wash and stipple, only it has much more purity of tone and additional softness.

THE AIR BRUSH IS INVALUABLE FOR THE FOLLOWING SPECIAL USES:

With its use there is no danger of "washing up." One color passes over another without the slightest disturbance.

The effects of crayon and pastel are exactly produced by the air brush, with this great advantage, the work is indelible.

The air brush produces *indelibly* the exact tone and effect of crayon work, whether in black and white, or colors. With stump or point, delicacy and finish are only obtained with much tedious labor. With the air brush, these results are, comparatively speaking, immediate.

The air brush does admirable work on large negatives, in building up lights in any part of the picture, or "bringing up" shadows that too often lack detail with our quick acting dry plates. The brush works on either side of the negative desired, and its results are highly satisfactory, because its action imparts a finish closely resembling the original film, thus giving a picture the appearance of having been perfectly manipulated from beginning to end, rather than exhibiting a tiresome amount of hand retouching and brush penciling. Every retoucher knows the difficulty of obtaining soft blending with the use of pencils. There is too likely to be a sharpness on the edges of the stroke. The air brush, on the other hand, affords a diffuse film, making the blending perfectly soft and even. And this also explains why the brush can be used to such advantage in retouching draperies, hair, etc., for giving cloud effects in view work, masking backgrounds, and the like.

It also works on albumen in a perfect manner, so that the photographer can match the tone of his prints, and put in any amount of work desired.

In these days of dry plates, when nearly all our photographers do more or less large work, the retouching becomes a matter of very great importance on account of the large amount of work involved. This instrument is the means of greatly relieving this department of the photographer's work, as after the operator has touched out the main spots and defects, the negative may, by the aid of the air brush, be graded up to suit the requirements.

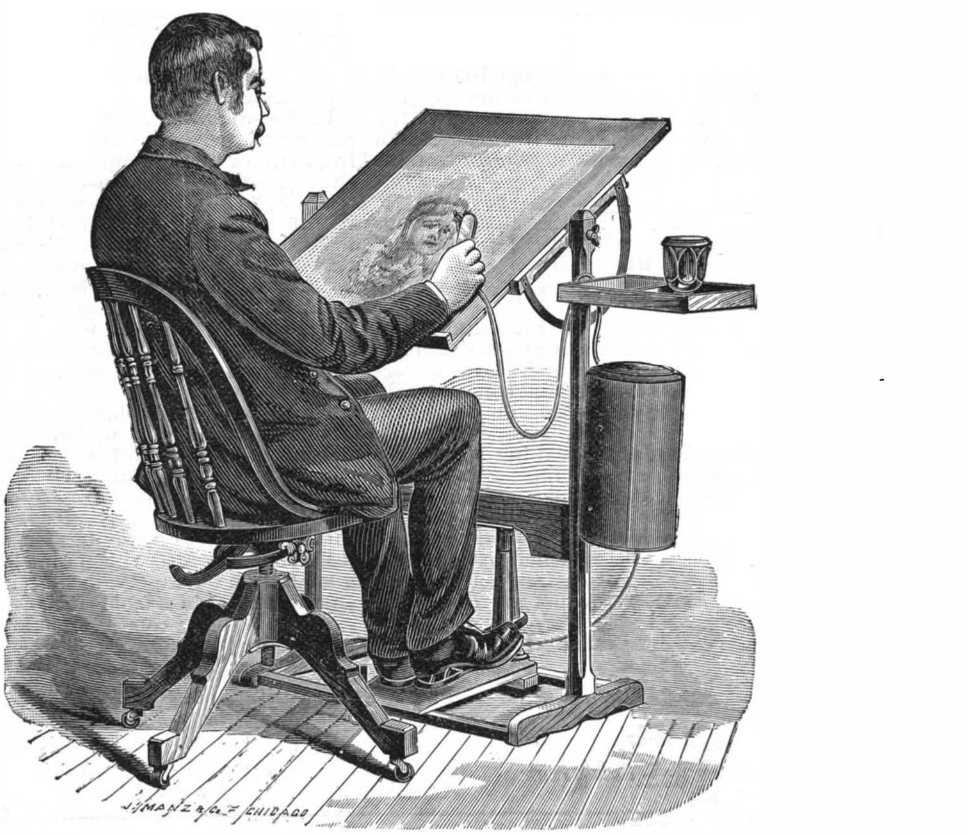


FIG. 6.—AT WORK WITH THE AIR BRUSH.

As a lithographer's tool, the air brush is exceedingly useful, both in the designing room and in placing the work upon stone.

The first consideration is that the work is accomplished with extreme rapidity, both in the designing room and upon the stone. Every stroke of the air jet deposits a finished stipple in any form desired—heavy shadow or fine line, at the will of the operator.

It is also a fact that the air brush process gives the most complete work, with fewer color plates than any other process thus far discovered.

These are considerations of economy; but it is no less true that the work executed by this instrument cannot fail to satisfy the artistic sense of the most exacting critic.

The air brush will distribute color on vellum cloth without the slightest danger of crinkling the parchment, or in any way disturbing the surface, thus enabling the architect to present his drawing with any degree of elaboration, in much less time than he now devotes to line shading or cross hatching. In fact, in all draughting and designing where much detail is desirable, the air brush is exceedingly useful; its rapidity permitting a degree of elaboration otherwise impossible in commercial work.

In monumental drawing, for example, the air brush enables the designer to execute a perfect facsimile of any stone with a perfection and rapidity almost incredible to those unacquainted with its work.

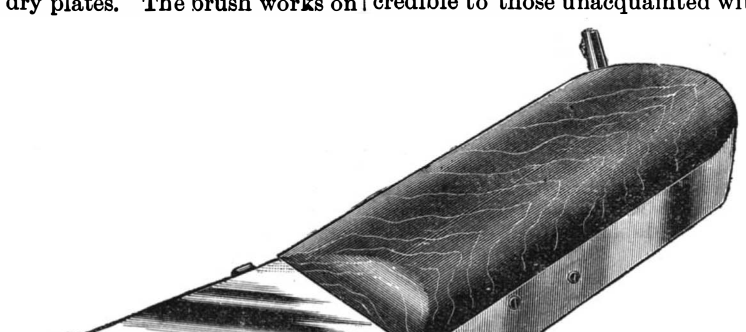


FIG. 5.—THE AIR BRUSH.

The air brush is manufactured solely by the Air Brush Manufacturing Company, at Rockford, Ill.

As a worthy recognition of this useful invention we have pleasure in printing the following report of the Franklin Institute:

PHILADELPHIA, August 30, 1886.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the air brush,

Report: That after an examination of the instrument and its uses, they regard it as deserving of the warmest commendation. The application of the principle of the air brush to a tool for distributing liquid pigments on to paper or other surfaces in the production of pictures is a great novelty in the arts, and as important in its economy of time as it is novel. In the hands of an accomplished draughtsman, it is an acquisition of rare value.

Of course, this instrument cannot make up for any deficiency of artistic skill in the operator, for as much proficiency in drawing practice is necessary with this as with any other of the pencils or brushes heretofore used. What is chiefly claimed for it by its inventor is that it facilitates his work by shortening greatly the time consumed in the execution, and that it is more durable than crayon or pastel when used in imitation of those styles. Artistic displays of freedom of touch can readily be added over the finished work of the air brush by those who prefer to do so, and still the work will appear homogeneous in method of execution when the same pigments are used in both cases.

One of its merits is that the tints laid on by means of the air brush possess the advantage of appearing equally well whether the light falls on them from one side or the other. This is not the case with tints made with the crayon, as is well known, for the reason that the toothed surface of the paper gets more completely covered on the side toward the light than it does on the shaded side. Consequently, a drawing that appears smoothly finished in the light in which it was drawn is apt to look rough and coarse when viewed with the light falling on it from the opposite direction. The reason of the difference is obvious—the air brush throws the color directly down into the pores of the paper, covering equally both sides of the projecting tooth of the surface, so that naturally the work looks well in whatever light it is shown.

The manner in which the air brush delivers the color to the paper may be described in few words, thus: The artist supplies liquid color from a brush to a spoon-like reservoir. Through this liquid a fine needle darts rapidly back and forth, its wetted point being carried forward beyond the edge of the spoon. A strong current of air blown against this needle's point carries off the small amount of color adhering to it in finely divided particles, thin and fine at the point of departure, but widening out as its distance increases. Hence, if the instrument is held near the paper, it will make fine lines when moved as in writing, but removed to a distance it will make broad, soft tints with gentle blendings. The greater or less length of stroke of the needle, as well as the current of compressed air playing on it, is all the time completely under the control of the artist by action of his thumb while working, the supply of air to the chamber being pumped in by action of his foot.

We have only to add that this remarkable invention is an important aid to the artist, and we believe it deserves the highest award that the Franklin Institute has in its power to bestow.

JOHN SARTAIN,
November 3, 1886. *Chairman.*

Amended to incorporate the award of the Elliot Cresson Medal, and as so amended adopted.

THE SIGNIFICANCE OF URIC ACID.

DR. JOHANNES MYGGE, while chief of Professor Trier's clinic in Copenhagen, having repeatedly remarked abundant and persistent deposits of uric acid coinciding or alternating with albuminuria, carried out a series of examinations on the urine of the 272 male patients under his supervision. Of 3,287 urines examined, 2,786 from 127 patients were entirely free from uric acid deposits, while they were found in 501 specimens from 105 patients, but only in any considerable quantity in 262 specimens from 59 patients. In 43 of these last patients the deposits were of a transitory character, that is, they were only observed once or twice, while in the remaining 16 they were found to persist for a week or more.

Deposits both of a transient and of a permanent

character were found, especially in rheumatic affections, whether of an acute or chronic form. Transient deposits were found also in pneumonia in 11 cases out of 25. In 27 out of the 59 patients in which uric acid deposits were observed, albuminuria was also present in appreciable quantity, and in many of the rest there was a doubtful trace noted.

Dr. Mygge's observations confirm Dr. Dickinson's statement that deposits of uric acid of a transitory character frequently coincide with the suppression of acute albuminuria. In the majority of cases where the deposit was examined microscopically, casts or tubal epithelium cells were found, indicating that some connection probably exists between uric acid deposits and functional renal disorder. In some instances, it may be supposed that a peculiar condition of urine, especially its supersaturation by uric acid or an increase in its acidity, has irritated the epithelium of the tubes, and has thus set up a renal lesion. In others, the latter condition doubtless precedes the precipitation of uric acid, and here Esbach's theory of the precipitation of uric acid being due to the existence of morphological elements in the urine may afford an explanation.—*Lancet.*

AN IMPROVEMENT IN THE PRODUCTION OF SULPHURIC ACID.

By H. SPRENGEL, Dr. Phil., F.R.S.

MECHANICAL operations, such as the pumping of water and the compressing of air, absorb in sulphuric acid works which possess Gay-Lussac and Glover towers a not inconsiderable amount of steam, and consequently of fuel. This steam, after having spent its energy in the engines, is (as a rule) allowed to escape into the open air. It is obvious that this escaping steam, the so-called "exhaust steam," might render a second service by virtue of its chemical properties, if it could be made to substitute (*without much trouble and expense, and without causing irregularities and disorder*) a part of another quantity of steam, which in sulphuric acid works has to be raised almost entirely for the sake of a chemical operation, viz., the formation of acid inside the leaden chambers.

This problem* I have solved in the following manner:†

comes more than 10 lb. per square inch, the valve, S, will allow an escape of steam into the open air until a pressure of 10 lb. is re-established in *e f*. In other words, and by way of an example, a 40 lb. pressure in the boiler will lift and overcome a 30 lb. weight plus a 9½ lb. counter pressure of steam at R, while a 10½ lb. pressure in *e f* will lift a 10 lb. weight at S.

Thus it will be seen that one boiler and one system of pipes are sufficient to supply simultaneously both the engines with high pressure steam and the chambers with low pressure steam.

To insure what is much to be desired, an even, constant, and regular pressure in *e f*, it is essential that these valves, R and S, should be sensitive, or, in technical language, not be liable to "stick."

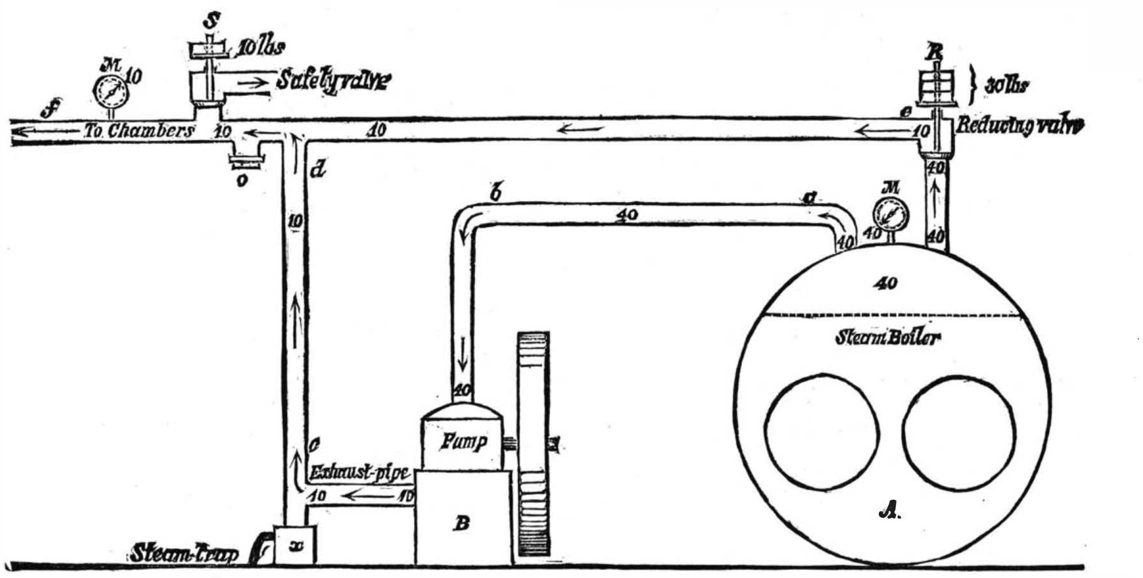
M and M' represent manometers for indicating the pressure inside the boiler, A, and the pipe *e f*; while *x* represents a steam trap and an outlet for condensed steam, which, in the form of water, will collect in the pipes above *x*.

In the same way as the exhaust steam from only one pump is shown here to be utilized, so the exhaust steam from two or more pumps may be utilized by connecting the same with *e f*, for instance at *o*.

Though this invention relates in the first instance to the utilization of exhaust steam of engines which are to be met with in every sulphuric acid works possessing Gay-Lussac and Glover towers, it is obvious that the exhaust steam from any other engine, which happens to be discharged into the open air in the vicinity of sulphuric acid chambers, may be utilized as before described, even if this exhaust steam should be derived from an engine supplied with steam from a different boiler at a different pressure, for the regularity of pressure needed in the chamber steam pipes will thereby not be affected, but will still be maintained by the valves, R and S. In fact, the use of exhaust steam in the manufacture of sulphuric acid may be carried with advantage to the point at which the sum total of the thus collected quantity of exhaust steam equals the total quantity of steam needed in the chambers.

Hence, only after this point has been passed is there good reason to employ, in the vicinity of sulphuric acid chambers, engines from which there is no escape of exhaust steam properly speaking, *e. g.*, the so-called condensing engines.

Finally, I beg to state that I do not restrict myself



Be it remembered that the work done by a steam engine is the result of the difference of pressure which exists alternately on the two sides of its piston. Supposing this pressure be 30 lb. per square inch on the one side and *nil* on the other, the work done will be due to the difference of these 30 lb. per square inch. Hence the same work may be done by the same engine, if the pressure be kept at 40 lb. per square inch on the one side of its piston and at 10 lb. per square inch on the other, for the difference of pressure remains unaltered, or 30 lb. per square inch.

In factories of an average size not more than one steam boiler serves, as a rule, to supply steam of a uniform pressure of about 30 lb. per square inch both to the engines and to the chambers. As, however, a pressure of 10 lb. per square inch is ample and to spare for the steam entering the chambers, I now, in harmony with the above view—

1. Raise the pressure in such a steam boiler by 10 lb. per square inch, *i. e.*, in this case from 30 lb. to 40 lb.
2. Drive the engines at this higher pressure.
3. Make the exhaust steam from the engines enter the chambers at a pressure of 10 lb. per square inch; and
4. Supplement, when needed, any deficiency of steam in the chambers by another quantity of steam of the same pressure, *i. e.*, steam of 10 lb per square inch, drawn from this very boiler, which is kept at a constant and regular pressure of 40 lb. per square inch.

How this may be done, in a convenient and inexpensive manner, will be readily understood by referring to the annexed diagrammatic sketch.

A represents a steam boiler, and B a pump supplied with steam of a constant pressure of 40 lb. per square inch by the pipe, *a b*. The exhaust steam of this pump escapes through *c d* into the main steam pipe, *e f*, which carries steam of a pressure of 10 lb. per square inch to the chambers. This main steam pipe, *e f*, is connected with the steam boiler, A, and is provided with two valves:

1. A reducing valve, R; and
2. A safety or escape valve, S.

These two valves are weighted in such a manner that, as soon as the pressure in *e f* becomes less than 10 lb. per square inch, the valve, R, will admit steam from the boiler until a pressure of 10 lb. is re-established in *e f*; while as soon as the pressure in *e f* be-

to the above stated pressures of 40 and 10 lb. per square inch as the only ones which may be used. I merely have given these pressures as those at which I have obtained very satisfactory results.

As experimental proof it may be mentioned that, by utilizing in this manner the exhaust steam from *four* small engines attached to the water pumps and air compressors at the works of my licensees—the *Lawes' Chemical Manure Company*, Creek's Mouth, Barking, Essex—I have been able to dispense with one of two steam boilers formerly in use, thus reducing the consumption of coal 34 per cent.; the quality of coal and the amount of work done remaining unaltered. The saving in coal alone, at a price of 9s. 3d. per ton, repaid, in this instance, the cost of the apparatus after having been in use for three months and eight days, while the profit on the investment amounted to 370 per cent. per annum. This apparatus has now been in daily use for one and a half years, delivering the steam, however varying and intermittent at its sources, with unfailing regularity and constancy of pressure at the chambers. It hardly need be said that this *regularity* and *constancy of pressure* is one of the factors on which a good yield of acid depends in no small measure.—*Chemical News.*

* For an attempt to solve this problem in a different manner by the help of *two* steam boilers, and in a case where the exhaust steam was derived from *one engine only*, see Dr. G. Lunge's excellent "Treatise on the Manufacture of Sulphuric Acid and Alkali." London: Van Voorst, 1879, vol. i., pp. 393 and 565.

† The author's British patent, No. 10,798, of Aug. 24, 1886.

METHYLAL.*

By B. W. RICHARDSON, M.D., F.R.S.

AT the meeting of the British Association for the Advancement of Science held at Norwich, in 1868, I brought out for the first time the chemical fluid called *methylal* as an anæsthetic and hypnotic, and at a meeting of the same association at Exeter, in 1869, I again drew attention to it, in order to make it useful in practice.†

Methylal is a colorless fluid of specific gravity 0·855; its vapor density is 38°, taking hydrogen as unity; and boiling point 42° Cent., 107·6° Fahr. Its solubility in blood is one part in three; its composition is $C_3H_8O_2$. It is made by distilling methylic alcohol with sulphuric acid in the presence of peroxide of manganese, but it requires several redistillations before it can be obtained in the pure state, for which reason it is at present a very expensive compound. The first specimens with which I experimented were made in my own laboratory; later specimens have been made for me, with much care, by my friend Mr. Williams, the well-known operative chemist.

When methylal is quite pure it is almost tasteless, but bites the tongue, and owing to its low boiling point quickly evaporates. The odor of it is fragrant, and not very powerful. The pure vapor creates no irritation on being breathed.

After long exposure to the vapor of methylal, in an atmosphere containing not less than 35 per cent. of the vapor, warm blooded animals may be made to pass into a sleep which, once established, is deep and prolonged. In my first researches the sleep so induced lasted for intervals of two and even three hours, but I believe now that this long narcotism was due to the presence of acetone, from the methylal not having been sufficiently purified. Last year, with a perfectly pure specimen, made by Mr. Williams specially for my work, I endeavored anæsthetize two dogs with methylal in order to enable Mr. Mavor, the veterinary surgeon, to operate upon them painlessly. After half an hour's inhalation of the vapor, narcotism was not produced. The fluid was then injected hypodermically in one animal to the extent of an ounce dose, upon which a gentle sleep, or rather intoxication, followed, but with no sufficient anæsthesia to allow of painless operating.

In my report of 1869 I showed that methylal, which is very soluble in water, could be administered by the mouth when diluted with water, or by hypodermic injection, and I have prescribed it occasionally, as a mixture several times. I usually begin with a fluid drachm dose, mixed either with glycerine or sirup of orange flowers and distilled water. Example:

Methylal, pure	ʒ vj.
Sirup of orange flowers	ʒ iv.
Distilled water	℥ vj.

Mix. To make a solution of six ounces; of which let one to two fluid ounces be taken in a wineglassful of water as directed. The dose may gradually be increased to twice the above quantity or more.

In action, as a medicine, methylal lies between alcohol and anhydrous ether. It quickens the action of the heart with reduction of arterial pressure; it makes the respirations slow and deep; it induces a tendency to sleep; and it is a sedative to pain, but not to a very deep degree. On the whole it would be best to keep it in the group of anodyne antispasmodics, in which I originally put it. It causes very little muscular excitement and no vomiting, but after long inhalation of its vapor it produces a free flow of saliva. As it mixes well with alcohol and with ether, it might be administered with either of these agents; and it might also be given with amyl nitrite for the relief of colic, asthma, angina pectoris, or tetanus. But before it can come into general use, it must be reduced in price.

Signor Personali, who has recently been experimenting with methylal, seems to have arrived at results similar to my own. But he adds that it may be used as an ointment or liniment for external application. It is true that it mixes fairly with oil and with lard; but as it boils at 107° Fahr., I cannot see how it can be of any service for external use, except in causing a slight local anæthesia by cold from evaporation.

* From the *Asclepiad*, No. 13.

† "Reports of the British Association for the Advancement of Science," vol. xxviii., pp. 183–4, Norwich meeting; and vol. xxix., p. 406, Exeter meeting.

FLUORINE BY THE ELECTROLYSIS OF HYDROGEN FLUORIDE.

IN June last, Moissan communicated to the French Academy the results which he had obtained by submitting liquid hydrogen fluoride to electrolysis. The anhydrous liquid was contained in a V tube of platinum cooled to —50°, and the current needed was supplied by 50 Bunsen cells. Hydrogen was evolved at the negative electrode, and there appeared at the positive electrode a gas having the following properties: In contact with mercury it was completely absorbed, forming yellow mercurous fluoride; with water, it formed ozone; phosphorus spontaneously inflamed in it, forming phosphorus fluorides; sulphur heated and melted; carbon had no action; fused potassium chloride was attacked in the cold, evolving chlorine; crystallized silicium carefully purified took fire in the gas, producing silicium fluoride. The positive electrode of platinum iridium was corroded, while the negative electrode of platinum was not affected.

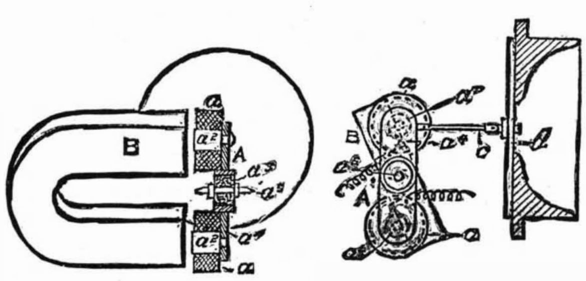
In a second paper, the author gives the details of subsequent experiments. The hydrogen fluoride was obtained pure and anhydrous by heating hydrogen potassium fluoride in a platinum alembic, and collecting the product in a platinum receiver immersed in ice and salt. In this way a colorless liquid was obtained, boiling at 19·5°, very hygroscpic and fuming strongly in the air. The platinum V tube used for the electrolysis carried a small evolution tube near the top of each limb. Its ends were closed by stoppers of fluorite, through which passed platinum rods to serve as electrodes; that on the positive side being alloyed with ten per cent. of iridium. This V tube was placed in a glass jar and surrounded with methyl chloride. The liquid hydrogen fluoride was then transferred to it, the methyl chloride boiling quietly at —23°, and the current of 20 Bunsen cells, having an ammeter in circuit, turned on. If a trace of water be present, ozone is at first evolved; and then as it disappears, the resistance of the liquid rises; so that the current ceases when it becomes anhydrous. A small quantity of hydrogen potassium fluoride must therefore be added; and then the evolution of gas is continuous and regular. At the positive electrode this gas is colorless, and silicium takes fire and burns brilliantly in it, as does adamantine boron, arsenic, antimony, sulphur, and iodine. The metals also burn in it but less actively. Organic matters are violently attacked by it. A fragment of cork, near the delivery tube, took fire, and alcohol, ether, benzine, turpentine, and petroleum are at once inflamed on contact with it. The gas combines with hydrogen spontaneously in the cold, and with detonation. Since direct experiment showed that neither ozone saturated with hydrogen fluoride nor hydrogen fluoride itself would produce these results, and that chlorine was entirely absent, the conclusion is that this gas is either fluorine itself or is a higher fluoride of hydrogen.

In a third paper, Moissan describes the production of this gas by the electrolysis of carefully dried hydrogen potassium fluoride kept in fusion at 110°. But the apparatus is rapidly attacked. In electrolyzing the liquid hydrogen fluoride, a yield at each electrode of from one and a half to two liters of gas per hour is readily obtained. To test the question whether this gas contained hydrogen, it was passed over red hot iron. The

delivery tube was connected first with a platinum tube containing dry potassium fluoride, to absorb any hydrogen fluoride; and second, with a similar tube, also 20 cm. long, containing a bundle of iron wires and previously tared. To the end of this tube is attached, by means of a rubber joint, first a test tube and then a flask, both inverted and filled with pure carbon dioxide. The liquid hydrogen fluoride is cooled to —50° by passing a rapid current of air through the surrounding methyl chloride, and the current is turned on. Immediately the platinum tube containing the iron is raised to incandescence by the chemical action going on within it, the form of the brilliantly burning wires being visible through the walls. After ten minutes, the operation was closed and the tube weighed. The iron was found as white crystallized fluoride, and on examining the collected gas remaining after absorption of the CO_2 by potassium hydrate, it was found to be only the air which the platinum tubes had contained. On the negative side 78 c. c. of hydrogen was collected, weighing 0·006942 gramme. Multiplying this by 19, to give the corresponding weight of the fluorine disengaged, gives 0·132 gramme; the increase in the weight of the iron having been 0·130 gramme. Hence the gas obtained must be fluorine.—*C. R.*, cii., 1543; ciii., 202, 256, July, 1886.; *G. F. B.*, *Amer. Jour.*

PROF. S. P. THOMPSON'S DYNAMO TELEPHONES.

A METHOD of making more powerful telephones than those of the well known type has, says the *English Mechanic*, been recently patented by Prof. Silvanus P. Thompson, who describes his invention as



FIGS. 1 AND 2.—SILVANUS P. THOMPSON'S DYNAMO TELEPHONE.

consisting of dynamo telephones which will serve either as transmitting or receiving instruments of great power.

It is well known that any dynamo-electric or magneto-electric machine will serve either as a generator of currents or as a motor. In such machines there are usually two distinct parts, respectively called the field magnet and the armature. The relative motion of one or both of those organs generate currents, or if currents from an external source traverse the armature, mechanical motion results. And in such machines it is usual to make the field magnet a very powerful magnet (either permanent or temporary) having great magnetic inertia, and the armature of small magnetic inertia and relatively light.

The improved telephones act on the same principle as that on which dynamo-electric machines (including magneto-electric in that term) of any one of the known types act; but Prof. Thompson makes the armature, or some part thereof, capable of vibration instead of the usual rotation on an axle, these vibrations being communicated either from the armature to the listener's ear or from the speaker's mouth to the armature by suitable mechanism or mechanisms, or simply by the intervening air. The form of the armature may be any of the well-known patterns—such as the Gramme ring, the Siemens drum, or other form—but he prefers in some cases to modify and simplify the manner of grouping or connecting the coils.

The commutator common in dynamo-electric machines is not used. It is of advantage that the coils of the armature should be so grouped that they occupy the position where the magnetic field is strongest, so that any small motion given to them may have the

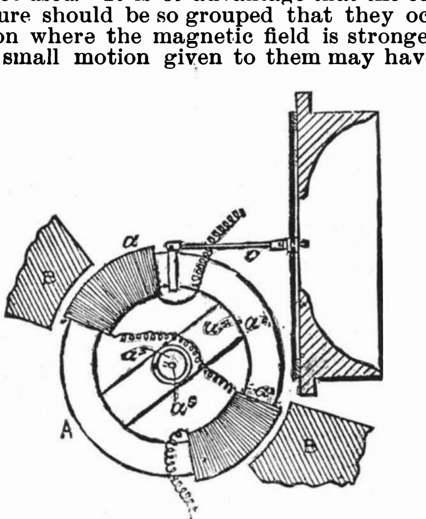


FIG. 3.—THOMPSON'S DYNAMO TELEPHONE, SHOWING RING ARMATURE.

greatest induction effect in transmitting or receiving, and so that any small current traversing the coils may produce the most powerful effect in receiving the coils of the armature, which may be of fine, well-insulated copper wire, connected in the line circuit.

The coils on the field magnets (if any) may be arranged either in a local circuit or in line or as shunt to the coils. It is advantageous to laminate the cores both of the armatures and of the field magnets. When the armature is pivoted on or about an axis, a cushion or sleeve of elastic matter may be applied at the said parts or axis. When the armature or its core is mounted on a spring, the spring may be either straight or coiled, or, instead of a spring or cushion, a mass of yielding material may be substituted.

Internal magnets or electro-magnets may be placed within the armature to reenforce the magnetic field, thus enabling the self-induction and resistance of the armature coils to be reduced.

Figs. 1 and 2 of the accompanying drawings show in views at right angles to each other a dynamo telephone on the magneto principle, the armature, A, being mounted to vibrate (on the pivot, a^5, mounted in any suitable supports) in front of the poles of a permanent magnet, B.

There are two coils, a, on the iron cores, a^2, carried by an iron yoke, a^4, mounted on an elastic hub, a^3, and suitably pivoted. A short and light stiff connecting rod, c, makes the necessary communication between the armature and the diaphragm, d. It is found desirable in setting up the instrument to give to the armature a slight lead with respect to the field magnets.

This has double effect. It causes any small change in position to have a greater influence on the magnetic field and it also gives a mechanico-magnetic back attraction which serves to keep the diaphragm in a state of initial tension. The diaphragm may be of mica, celluloid, parchment, aluminum, or any metal, whether magnetic or not, its functions being purely acoustic.

Fig. 3 shows a ring armature, resembling that of the well-known Gramme dynamo, but having coils grouped in two sets only, connected in series (or parallel, if desired, for low resistance). The ring is pivoted as before described and connected to the diaphragm as shown, and corresponding parts to those shown in Figs. 1 and 2 are marked with the same letters of reference. The ring may be made with protruding teeth, as in the Pacinotti dynamo.

The patentee does not limit the invention to the precise details described in his specification, for they can be varied without departing from the nature of the invention. For example, the armature may be a soft iron piece without coils, mounted and connected as described in proximity to the poles of an electro-magnet.

THE MONTAUD ACCUMULATOR.

THIS accumulator is of the Plante type, and is modified so as to obtain a more rapid formation, a larger surface, and a symmetrical distance of the plates from each other.

If into an alkaline bath saturated with litharge (added in excess) we plunge two lead electrodes and pass in a current of suitable tension and intensity, there is deposited upon the anode a layer of peroxide of lead varying in thickness with the intensity of the current, and more or less rich in oxygen according to the intensity of the bath, while the cathode is covered with a stratum of reduced lead. The liquid of the bath supplies material for both deposits, while in galvanoplastic operations the anode supplies it to the cathode. The principle of the formation consists in introducing in an efficacious manner currents of a great intensity, and thus abridging its duration.

Of two plates thus treated, the one becomes positive, and is covered with a thick layer of peroxide of lead. On leaving the bath it undergoes various preparations

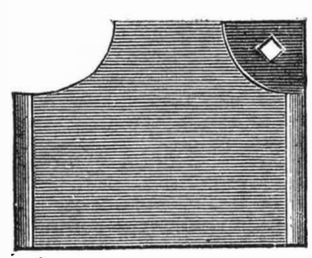


FIG. 1.

and several washings, and is then fit to be mounted along with others to form an accumulator ready to be charged and to work.

The second, or negative, plate is covered with a thick sponge of lead. It is carefully washed, preserved in water with exclusion of air, and submitted to a very considerable pressure After this operation it presents the appearance of ordinary sheet lead, but though the physical porosity has disappeared, the chemical porosity is intact, and this alone comes into play in accumulators.

When a negative plate is constructed in this manner, it is ready to be combined with the positives to form an accumulator.

The inventor has sometimes put into the bath at the positive pole negative plates prepared as just described. They become very easily peroxidized, but they have the grave defect of requiring two preparations in place of one.

To secure an accumulator against any leakage from plate, the solderings and the entire plates must be submerged in the liquid, so that nothing projects up out of the acidulated water except two strong rods for making contact. These rods are covered with an insulating varnish from their origin to above the point where they issue from the liquid.

The plates are of a rectangular form (Fig. 1). They are sloped out at one corner, and as two plates in juxtaposition are cut together, when they are separated the sloping out of the one serves for the handle of the other. This handle is doubled back on the plate which is suspended in the bath, so that the part which has to be soldered does not undergo any preparation.

A hole pierced in this corner of the plate serves to receive a square rod of lead which connects the plates together and supports one of the poles or contacts of the accumulator.

At the point of soldering the doubled-down handle gives a double thickness, and the margins of the plate are folded in such a manner as to insure their solidity.

The sloped out corner affords the free space necessary for the rod of the opposite pole, and one and the same plate may be indifferently connected either to the + or the — at the right or the left.

The plates are made of four different sizes: No. 1, 19 of which serve for an accumulator of 1 square meter; No. 2, 21, 25 or 29 of which serve for accumulators of 2, 3 and 4 square meters; No. 3, which with 21, 25 or 29 plates composes accumulators of 5, 6 and 7 square meters; and No. 4, which with 21, 23, 25, 27 or 29 plates forms accumulators of 8, 9, 10, 11 and 12 square meters.

As the plates are entirely submerged in the liquid their entire surface is active, and the entire surface being absolutely flat, it is sufficient to preserve their respective distance at any one point in order to have it everywhere alike.

The weight of the plate depends on the intended duration of the plate and its capacity.

As for the negative plate, its thickness is the most important factor of its capacity. The proportion has yet to be established for daily practice.

The inventor uses in practice positive plates of 0·002 meter in thickness.

On the other hand, the negative plates have a body of only 0·001 meter in thickness, their greater thickness being due only to the deposit of compressed lead.

The rod which fixes the plates to each pole (Fig. 2) is

FIG. 2.

formed of a special alloy of lead and antimony, not attacked by acid. This gives rigidity to the rod and hinders it from binding when the accumulator is taken out of its case. The copper piece which surmounts it is fitted at its base with an iron cramp which is fixed in the lead, and above which is a wide furrow with two grooved parts, which, being immersed in the lead, hinders the copper from slipping round under the action of the screw.

The rod is square and is cast in a single piece. Against one of its surfaces the ends of the connected plates press flatly up. A square form has been selected to give more surface for soldering.

This soldering is autogenous (as in the lead chambers at vitriol works).

The soldering as well as the entire plates is entirely immersed in the liquid, and to prevent any leakage an

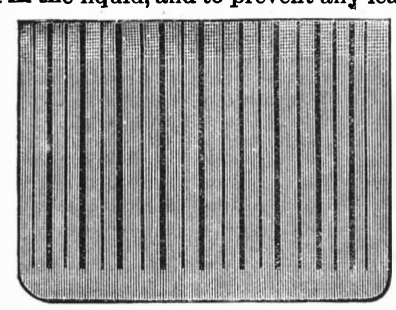


FIG. 3.

insulating varnish, perfectly proof against the acid and the current, is laid over the rod from the part soldered upward.

If it is wished to lift the accumulator from its chest for any verification, hooks passing between the plates seize hold of the rods, and thanks to the rigidity of the antimony-lead, they effect the removal of the apparatus without bending the rods in the least.

All the parts of the plates must be kept at exactly the same reciprocal distances, and a difference of only 0·001 meter between two points is sufficient to affect the yield considerably.

For an insulating material, wood, when plunged in dilute acid, is preferred by the inventor. He makes a comb of wood, the teeth of which vary according to the thickness of the plates to be lodged between them. Fig. 3 represents a comb having $\frac{15}{10}$ths of a millimeter for the negative plates and $\frac{25}{10}$ths for the positive plates.

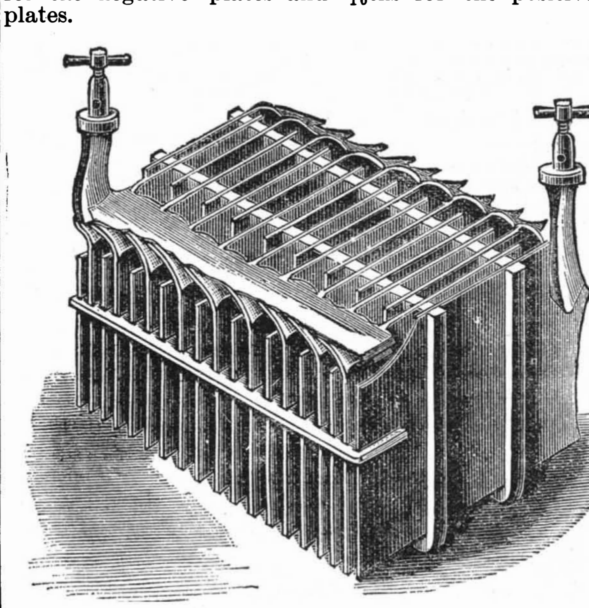


FIG. 4.

This appliance, which is 0·01 meter in thickness and 0·02 meter in width in the back, is made very cheaply by machinery.

The weight of the accumulator bears entirely upon the back of the combs, which are all placed back downward, and the number of which varies according to the size of the plates.

Small combs of wood clasp the plates at their extremities, and make the entire accumulator quite compact and manageable.

The entire accumulator is shut up in a wooden chest, which the outer teeth of the comb serve to insulate from the leaden chest, and to prevent any loss of electricity along the sides.

Fig. 4 shows the arrangement of the side combs. A single glance at this figure shows that it would be difficult to have more surface without having recourse to

curved undulated or folded plates, in which the distances are variable, and consequently defective.

In the Montaud accumulator, the weight is simply proportional to the intended duration.

For the notion "so much capacity and so much yield per kilo," Montaud substitutes the notion "so much capacity or yield per square meter, the weight not being taken into consideration."

These Montaud accumulators are classified as follows: they have from 1 to 12 square meters of surface, and the number corresponding to the surface indicates its weight of useful lead, its manner of charging, its capacity, and its manner of discharge.

According to the inventor's experiments, the square meter of active surface can receive a charging current of 10 amperes, and furnish on discharging a current of the intensity of 20 amperes.

For a "No. 10" accumulator we have an active surface of 10 square meters, a charging current of 100 amperes, and on discharging a current of 200 amperes.

A square meter of lead of the thickness of 0·001 meter weighs about 11 kilos. As both surfaces of the lead are utilized, their weight is reduced to 5½ kilos. A No. 10 therefore requires 55 kilos. of useful lead.

It will be seen that to increase the thickness of the sheet of lead merely augments the duration of the accumulator, without affecting its capacity or its manner of charging and discharging.

Nos. 1, 2, 3, and 4 may be placed in vessels of stoneware, glass, or ebonite, or in boxes of pitch pine, painted with three coats of gum-lac and lined with sheet lead. Nos. 5 to 12 are only sent out in pitch pine boxes lined with lead.

The box is supported on feet of porcelain of the shape of a mushroom. If a drop of water falls upon this foot, it cannot give a communication with the earth, since, falling upon the broad part of the mushroom, it will glide off without running along the foot, which serves as the stalk of the mushroom. A slip of glass is placed under each foot; the part which supports the mushroom is covered with an insulating varnish, which prevents the formation of climbing salts and preserves the screws from rust. A second layer of insulating varnish is applied under the head of the mushroom.

As regards the advantages of the Montaud accumulator we notice, first, its longevity.

Dr. D'Arsonval points out that the accumulators of the Plante class have a great advantage over the Faure type as regards duration, and that the most striking quality of the Montaud accumulator is its longevity.

The inventor has in his possession positive plates, five to six years old, completely peroxidized, though there remains in the interior a thin core of metallic lead sufficient to give passage to the current. The adhesion of the peroxide is such that to detach it, it must be beaten with a hammer upon an anvil.

The next four points, *i. e.*, the rapidity of charge; the yield, much greater than that of any other system in proportion to its surface; its small weight in comparison with its yield; and its capacity, which for an equal weight is greater than that of any other accumulator.

In his experiments in September, 1885, Dr. D'Arsonval obtained with an accumulator of 2 square meters of surface—

Useful capacity	40 ampere hours.
Total	62 " "
Surface	2 square meters.
Charge	10 amperes per square meter.
Discharge	20 " " " "
Useful weight of lead	10 kilos.

Representing a total capacity of 6 ampere hours per kilo. and of discharge of 4 amperes per kilo., or a total capacity of 31 ampere hours per square meter and a useful capacity of 20 ampere hours per square meter.

Subsequently the modification of the negative plate has greatly improved these figures, which will certainly become much more advantageous in future.

The total capacity of an accumulator having exactly 1¾ meters of surface has become 87 ampere hours, which, if referred to an accumulator of 2 square meters of surface, would give the following results:

Useful weight of lead per square meter	5½	kilos.
Total capacity of useful lead per kilo	9·1	ampere hours.
Total capacity per square meter	50	" "
Useful capacity per kilo. of useful lead	6·23	" "
Useful capacity per square meter	34·30	" "
Current of charge per square meter	10	amperes.
Current of charge per kilo. of useful lead	2	"
Current of discharge per square meter	20	"
Current of discharge per kilo. of useful lead	4·56	"

The next advantage of the Montaud accumulator is the ease with which it can be taken out of its box and repaired without special tools and experience.

A capital defect in this respect has hitherto much interfered with the use of accumulators. In case of accidents, several kinds of which are possible, it is found very difficult to rectify the apparatus. The Montaud accumulator is much less liable to accidents, on account of the firmness and compactness of its construction, and if any accident happens, the repairs are simple and easy.

Lastly, the stout framework secures the apparatus from any accident due to a disproportionate charge or discharge. The peculiarities of the combs and rods already described solve this problem.

On September 8, 1885, Dr. D'Arsonval, Professor at the College of France, wrote as follows: "The Montaud accumulator is of the Plante type, and is extremely well conceived from a mechanical point of view. The wooden combs prevent the plates from coming in mutual contact, and give the apparatus great solidity.

"The process of formation is ingenious and rapid. To give 1 square meter a capacity of 20 ampere hours, there is required only a quarter of an hour's treatment. To obtain the same result by Plante's method months are required.

"The entire experiments have been effected with No. 2, which has a surface of 2 square meters. This apparatus, if charged to saturation, gives 62 ampere hours as its total capacity, and, as in the Plante, this capacity constantly increases with use. The normal rule for the charge is 10 amperes per square meter, and for the discharge double this quantity. This apparatus has always given me on discharging 40 amperes at the E.M.F., of 1·85 volts during 60 or 65 minutes. The charge is effected in two hours up to 20 amperes, without any appreciable loss of electricity.

"The points to be aimed at in an accumulator are longevity and energy, or, rather, rapid yield per kilo. From both points of view accumulators of the Plante type (and consequently those of Montaud) are far superior to those of the Faure type.

"My opinion, therefore, is that the Montaud accumulator is very practical, that it is a great improvement on the Plante type, and that it can compete successfully with the other systems in use."—*Revue Internationale de l'Electricite; Elec. Review.*

NATURAL SOLUTIONS OF CINNABAR, GOLD, AND ASSOCIATED SULPHIDES.

By GEORGE F. BECKER.

IN the course of investigations on the geology of the quicksilver deposits of the Pacific slope I have taken up the question of the state of combination in which quicksilver is dissolved in natural waters. Pyrite or marcasite almost invariably accompanies cinnabar, gold is known to be associated with cinnabar in a considerable number of cases, copper sulphides or sulphosalts are also not infrequent in quicksilver mines, and sulphides of arsenic and antimony are known to occur in a similar association. Zincblende too has been found with cinnabar. The solubility of these substances has been incidentally examined. In performing the experiments I had the assistance of Dr. W. H. Melville, who also made all the quantitative analyses involved. The results obtained seemed interesting enough to justify their publication, in an abbreviated form, in advance of the monograph of which they will form a part. They also possess some value from a purely chemical point of view, and may interest readers of this journal who are not geologists.

The waters of Steamboat Springs are now depositing gold, probably in the metallic state; sulphides of arsenic, antimony, and mercury; sulphides or sulphosalts of silver, lead, copper, and zinc; iron oxide and possibly also iron sulphides; manganese, nickel, and cobalt compounds, with a variety of earthy minerals. The sulphides which are most abundant in the deposits are found in solution in the water itself, while the remaining metallic compounds occur in deposits from springs now active, or which have been active within a few years. These springs are thus actually adding to the ore deposit of the locality, which has been worked for quicksilver in former years, and would again be exploited were the price of this metal to return to the figure at which it stood a few years since.

At Sulphur Bank also there is reason to suppose that ore deposition is still in progress, though the opportunities for determining this point are greatly inferior to those presented at Steamboat Springs. The waters of the two localities are closely analogous. Both contain sodium carbonate, sodium chloride, sulphur in one or more forms, and borax as principal constituents, and both are extremely hot, those at Steamboat Springs in some cases reaching the boiling point. In attempting to determine in what forms the ores enumerated can be held in solution in such waters, it is manifestly expedient to begin by studying the simplest possible solutions of the sulphides and particularly of cinnabar.*

Solubility of HgS *in mixtures of* Na_2S *and* NaOH.—A series of experiments were made in my laboratory with a view of testing the relative effect of the quantity of sodium sulphide and sodium hydrate on the quantity of mercuric sulphide which a given mixture of the solvents would take up. It is almost impossible to make experiments of this kind with the same accuracy which can easily be attained in precipitations, because, if one or more drops of either fluid reagent is added to a mass consisting of mercuric sulphide partially dissolved in the menstruum, it is not practicable to say how long a time will elapse before the additional drop will have become saturated. Approximate results are, however, readily obtained, and these appear in the present case to be sufficient.

* *Previous Investigation.*—The solubility of mercuric sulphide in alkaline compounds containing sulphur has long been recognized by experimental and industrial chemists. This fact is the foundation of the methods of preparation of vermilion in the wet way, first described by G. S. C. Kirchoff in 1799 (Scheerer's Allgem. Journ. der Chem., vol. ii, p. 290). In 1829. C. Brunner (Pogg. Ann., vol. xv., p. 593) discovered the double soluble salt HgS, K_2S, + $5H_2O$. Later Dr. Rheinhardt Weber (Pogg. Ann., 1856, vol. xcvii. p. 76) re-examined the properties and formation of this salt, which he found could exist only in the presence of free caustic alkali. In opposition to Prof. Stein, Dr. Weber is extremely positive in his statements that mercuric sulphide is entirely insoluble either in the simple sulphides of sodium and potassium or in the sulphydrates of these metals, excepting in the presence of free hydrates. Dr. Weber's solvent was not, as he evidently supposes, a mixture of hydrate and sulphydrate, but of simple sulphide and sulphydrate.

In 1864, Mr. C. T. Barfoed (Journ. fur prakt. Chemie, 1864, vol. xciii., p. 230) investigated the behavior of mercuric sulphide to sodium sulphides. He, like Dr. Weber, found the metallic sulphide wholly insoluble in the sulphydrate, but soluble in the simple sulphide, and in mixtures of the latter either with the sulphydrate or with the hydrate. He insists that the necessary and sufficient condition for the solubility of mercuric sulphide is the presence of sodic monosulphide.

The assertion is frequently made in chemical writings (for example Graham-Otto, 5th ed., part 3, vol. ii., p. 1119), in spite of the result obtained by Weber and by Barfoed, that mercuric sulphide is soluble in sodic sulphydrate. In 1876, Mr. M. C. Mehu (Russian Journ. of Pharm., reported in Jahresbericht der Chemie, 1876, p. 282) examined the soluble crystalline mercury sodium salt corresponding to Brunner's potassium compound. He found mercuric sulphide insoluble in sodic hydrate or in the simple sulphide of sodium, but highly soluble in mixtures.

Alkaline pentasulphides convert amorphous quicksilver sulphide digested with them into cinnabar (Gmelin-Kraut, Handbuch der Chemie, vol., iii., p. 756, where many references may be found), and this process implies a certain degree of solubility. Mr. Barfoed, however, found mercuric sulphide insoluble at ordinary pressures in sodium sulphydrate to which sulphur had been added, and the solubility in the pentasulphide is probably slight.

The conversion of the black sulphide into the red does not appear to imply more than a mere trace of solubility, for Messrs. H. Sainte-Claire Deville and Debray produced rhombic crystals of cinnabar by heating precipitated sulphide with chlorhydric acid to 100° C. in a closed tube (Fouque and Michael-Levy, Synthese des Min. et des Roches, p. 313). No statement is made in the account of this experiment of any means being employed to produce any great pressure. Mr. S. B. Christy (this journal, vol. xvii., 1879, p. 453) found that at pressures of from 150 to 500 pounds per square inch and temperatures of from 180° to 250°, various liquids heated with precipitated mercuric sulphide convert it into vermilion. He experimented with polysulphides of potassium, potassic sulphydrate, acid sodic carbonate charged with sulphydric acid, and a spring water containing acid sodic carbonate which he charged with sulphydric acid. He reached no conclusion as to the state of combination of the mercury in solution. The fact that glass is greatly attacked at high pressures and temperatures by alkaline solutions of course leaves many possibilities open. Prof. R. Wagner (Journal fur prakt. Chemie, vol. xcvii., 1866. p. 23) has shown that mercuric sulphide is soluble in barium sulphide, and Prof. Roth (Allgem. u. chem. Geol., vol. i., p. 264) thinks it probable that calcium sulphide possesses a similar power.

It was found that, provided a small quantity of free hydrate exists in the mixture, the solubility of HgS depends solely upon the quantity of Na_2S in the solution. The average of fourteen experiments made with varying proportions of sodic hydrate gives 1 HgS to 2·03 Na_2S. From the nature of the experiments, a slight excess in the quantity of solvent employed is to be expected. One experiment was made by mixing mercuric sulphide and sodic sulphide in the proportion of two molecules of the latter to one of the former, and adding a few drops of caustic soda. A mere trace of mercuric sulphide remained undissolved, and this completely disappeared on the addition of a single drop of a solution of sodic sulphide, so that less than one drop completed the solution.

Chemists of course regard cases of solution such as that under discussion as due to the genesis of soluble double salts, which are formed according to ordinary laws of composition. The above experiments show that this soluble double salt can be represented only in the formula HgS, $2Na_2S$. The soluble mixture given by Mehu answers to HgS+2·07 Na_2S, and is thus, so far as it goes, confirmatory of the above experiments.

Solubility of HgS *in* Na_2S.—The most carefully prepared solutions of sodium sulphide dissolve mercuric sulphide freely. This statement is directly contrary to that which some of the chemists referred to have made, and it would be a rash one if the evidence to be adduced for it depended simply upon bringing solutions of sodic sulphide into contact with mercuric sulphide. For it is impossible to make certain that there is no trace of free caustic alkali or of sulphydrate in a solution of sodic sulphide, however closely its analysis may correspond to its theoretical composition. If, however, a solution of sodic sulphide containing sodic hydrate is treated with hydrogen sulphide, it is gradually converted into sodic sulphydrate, and passes through a point at which the only compound present is the monosulphide. If mercuric sulphide is dissolved in a mixture of sodic sulphide and caustic soda, and the clear filtrate is treated with hydrogen sulphide, the mercuric sulphide begins to be precipitated when very little free caustic alkali is left, and is continuously precipitated until the entire amount of sodium present is converted into sulphydrate. The purest preparations of Na_2S which we have been able to make dissolve mercuric sulphide less freely than mixtures of sodic sulphide and sulphydrate. Different preparations, however, shown by most careful analysis to correspond very accurately to the formula Na_2S, give somewhat different results, possibly indicating a minute variation from absolute purity. It does not seem *a priori* improbable that the soluble salt when the sodic sulphide is absolutely pure is HgS, $3Na_2S$; and one of our preparations gave almost exactly this result. It may also be that mixtures of HgS, $2Na_2S$, and HgS, $4Na_2S$ are formed in proportions varying with other conditions than the purity of the sodium sulphide, such as temperature and concentration.

Insolubility of HgS *in cold* NaHS.—Repeated experiments and analyses undertaken during this investigation have shown that mercuric sulphide is totally insoluble in sodium sulphydrate at ordinary temperatures, and that any preparation of this compound which will dissolve a trace of mercuric sulphide can be shown by analysis to fall short of complete saturation. A long time and an enormous quantity of hydrogen sulphide are required to completely saturate even a small amount of caustic soda with sulphur. As already mentioned, both Weber and Barfoed were aware of the insolubility of mercuric sulphide in sodium sulphydrate at ordinary temperatures. It will be seen later that the behavior of these compounds varies with the temperature. If mercuric sulphide is left in contact with cold sodic sulphydrate for twenty-four hours, just a trace of mercury goes into solution. This is due to the spontaneous loss of hydrogen sulphide which the sulphydrate is well known to undergo.

The absolute want of power of a preparation of sodic sulphydrate to dissolve a trace of mercuric sulphide is perhaps the best known test of its freedom from the alkaline monosulphide. This test does not show the absence of polysulphides, however, for we have frequently found mercuric sulphide totally insoluble in solutions of sodic sulphydrate which possessed a yellow color, and which were proved by analysis to contain an excess of sulphur. This corresponds to Barfoed's observation. The occurrence of alkaline polysulphides in nature, excepting near the surface of the earth, seems so improbable that I have undertaken no investigations of the conditions under which they dissolve mercuric sulphide.

Solubility of HgS *in mixtures of* Na_2S *and* NaHS.—For the purpose of determining the character of solutions of mercuric sulphide in mixtures of sodium sulphide and sulphydrate, clear solutions of mercuric sulphide in sodium sulphide and sodium hydrate were made, all the reagents being carefully prepared for the purpose, and sulphureted hydrogen was passed through the solution until a large permanent precipitate of mercuric sulphide formed. The mass was then filtered, and of course the filtrate represented an absolutely saturated solution of mercuric sulphide in a mixture of sodic sulphide and sulphydrate. A portion of this solution was analyzed. The remainder was treated further with hydrogen sulphide, the precipitation being arrested before the separation of mercuric sulphide was completed; and the second filtrate, representing a second saturated solution of the metallic sulphide in a mixture of alkaline sulphide and sulphydrates, but one containing much less mercuric sulphide, was also analyzed.

These analyses, which formed the conclusion of a tedious series of experiments, show beyond any reasonable doubt that there is a compound HgS, $4Na_2S$ which is soluble in the presence of Na_2S, H_2S, and which is decomposed by hydrogen sulphide in the presence of the sulphydrate by the reaction,

$$HgS, 4Na_2S+4H_2S=HgS+4Na_2S, H_2S.$$

Conclusion from the experiments.—It appears from the above that there are at least three double salts of

the form HgS, nNa$_2$S, where n may be either 1, 2, or 4, and, judging from the analogy of the potassium compounds, there is probably also a compound of this group where n is ½. The possibility of a case where n is 3 has also been adverted to. Thus mercuric sulphide readily enters into combination with sodic sulphide in various proportions, while all the best known soluble compounds of mercuric sulphide and sodium have the same general formula. The presence of carbonates of the alkalies is also known, especially from Mehu's results, to be compatible with the existence of these compounds. The question therefore arises whether such double sulphides may not exist in natural waters.

Possible existence of Na_2S *in natural waters.*—This question resolves itself into two. It is to be considered whether Na_2S may exist in natural waters as such. In that case such waters must dissolve mercuric sulphide. It is also possible that alkaline monosulphides cannot exist as such in these waters, but that the affinity of sodic sulphide and mercuric sulphide is sufficient to overcome the obstacles to the formation of sodic sulphide, and that this compound will form when mercuric sulphide is present. The latter possibility is the more important one, but the former is manifestly one of interest to chemical geology.

A train of thermo-chemical reasoning, upon which it is not necessary to enter here, makes it extremely probable that, at temperatures exceeding 80°, a certain amount of sodic sulphide may form by the decomposition of neutral sodium carbonate and sodium sulphydrate in the presence of acid sodium carbonate. The behavior of such mixtures to mercuric sulphide at the temperature indicated is also such as it would be if the sodic sulphide actually formed; but a full and sufficient proof of the reaction which theory indicates as probable seems very difficult, and has not yet been accomplished.

It is certain, however, that a tendency exists to the formation of sodium sulphide under these conditions. When, in addition to this tendency, the affinity of mercuric sulphide for sodic sulphide is brought into play, it can be proved experimentally that sodic sulphide is formed. We found that at a temperature of about 90° a mixture of the two carbonates and the sulphydrate dissolves mercuric sulphide freely without a sensible evolution of gas. If the solvent does not contain sodic sulphide, it must contain the sulphydrate. Hence it becomes important to ascertain the behavior of mercuric sulphide to sodic sulphydrate at moderately elevated temperatures.

While sodic sulphydrate will not dissolve a trace of mercuric sulphide at ordinary temperatures, if mercuric sulphide is added to a solution of sodium sulphydrate which stands upon the water-bath, hydrogen sulphide is evolved and mercuric sulphide goes into solution. The fact that hydrogen sulphide is evolved demonstrates that sodic sulphide must be formed. Cooling does not reprecipitate the mercuric sulphide, and the compound dissolved is therefore of the form HgS, nNa$_2$S.

Though the solubility of mercuric sulphide in warm solutions of the alkaline sulphydrates at ordinary pressures has, so far as I know, never been explicitly stated, I have no doubt that chemists have observed it, and that, in consequence of this observation, the general statement of the solubility of mercuric sulphide in alkaline sulphydrates has remained in chemical literature in spite of the observation of Weber and Barfoed. The preparation in which I originally observed this important reaction was one from which mercury had already been removed by precipitation with hydrosulphuric acid. The experiment was afterward repeated by Dr. Melville with several preparations of sulphydrate which had been accurately analyzed and had been tested in numerous ways. Now, in a mixture of the carbonates and sulphides of sodium at the temperature of the water-bath, either sodic sulphide or sodic sulphydrate is present, or, more probably, both coexist. If, then, mercuric sulphide is added to such a solution, either sodic sulphide combines directly with mercuric sulphide, or sodic sulphydrate is decomposed by mercuric sulphide setting free hydrogen sulphide, which must be immediately absorbed by neutral sodic carbonate. Hence in any case the salt dissolved in the mixture must be of the form HgS, nNa$_2$S.

Effects of dilution.—Laboratory experiments are usually made with solutions which are much more concentrated than those found in nature. Hence the effect of dilution on solutions of HgS, nNa$_2$S are important. Whether mercuric sulphide is dissolved in a mixture of sodium monosulphide and sodium hydrate, or of the former and sulphydrate, dilution with cold water precipitates mercuric sulphide.

The cause of this precipitation, which is attended by some curious phenomena to be described hereafter, is clear. It is known through the investigations of Messrs. Kolbe, Thomsen, and others, that while in moderately concentrated solutions

$$NaHS+NaHO=Na_2S+H_2O,$$

this reaction is partially reversed on dilution; or that, in the presence of much water, sodic sulphide is decomposed by water, the proportion of the sulphide undergoing this decomposition increasing gradually with the dilution. It is evident that the decomposition of HgS, nNa$_2$S is effected in the same way, more and more of the monosulphide being converted into the sulphydrate as the dilution increases, probably without any limit. Since mercuric sulphide decomposes hot sodic sulphydrate, the effect of dilution in hot solvents will evidently be less than in cold ones.

Brunner* found that dilution of solutions of his salt precipitated a black mass in which, on examination with the lens, minute globules of mercury were visible. The quantity of mercury was extremely small, so that the precipitate on analysis corresponded very closely indeed to the composition expressed by the formula HgS. Gmelin-Kraut† appear to have some independent confirmatory evidence on this point. If metallic mercury is precipitated in diluted solutions, of course sulphur is liberated; and, as shown above, sodium hydrate must also be present. Now, when these two substances are brought in contact, sodic hyposulphite forms. Accordingly, Brunner found hyposulphite in the solution forty years before the decomposition of sodic sulphide in dilute solution had been elucidated.

As Brunner experimented with HgS, Na$_2$S, I thought it best to compare the action of HgS, 4Na$_2$S. A very concentrated perfectly clear solution of freshly prepared mercuric sulphide in a mixture of sodic sulphydrate and caustic soda, containing very little of the latter, was suddenly diluted with cold water to 200 times its volume and rapidly filtered. Minute globules of mercury could be seen with the black sulphide on the filter. On digestion (after thorough washing) with very dilute nitric acid, a solution was obtained from which sulphydric acid precipitated black sulphide. The decomposition thus appears to be the same in each of the compounds, HgS, Na$_2$S, and HgS, 4Na$_2$S.

* Loc. cit.

† L. c., vol. iii., p. 851.

Influence of foreign substances.—The fact that sodium carbonates do not prevent the solution of HgS in Na$_2$S is evident both from Mehu's result and from our own. Experiments show that borax solutions precipitate a portion of the mercury from solution, but not the whole. The precipitation does not appear to be progressive, like that accompanying dilution, but to reach a sharp limit, beyond which further additions produce no effect. A large amount of borax added to a concentrated solution of Na$_2$S and NaHS does not rob it of the power to dissolve HgS. It is easy to imagine reactions by which borax may precipitate a portion of the mercuric sulphide. But the behavior of solutions of borax to sulphydric acid and to alkaline sulphides is very peculiar, and, so far as I am aware, has not been thoroughly investigated.* Very concentrated solutions of sodium chloride do not precipitate mercuric sulphide from strong solutions in mixtures of sodic sulphydrate, and they even appear to delay, but not to prevent, precipitation by dilution.

Solubility of Fe_2S.—The sulphide which is most frequently associated with that of mercury is pyrite or marcasite. Indeed, these minerals in greater or smaller quantities are to be found in nearly every hand specimen of ore, and occur very abundantly in most quicksilver mines. On making the experiment I found that pyrite, marcasite, or precipitated ferrous sulphide when warmed with a solution of sodic sulphide diminished in quantity, while the solution changed color. The filtrates gave strong reactions for iron.

Pyrite dissolves in cold solutions of sodium sulphide without any evolution of gas. The solvent power seems to increase with the temperature. Pyrite, like cinnabar, appears totally insoluble in cold sodium sulphydrate, and, like cinnabar, pyrite dissolves to some extent in hot solutions of the sulphydrate. Pyrite is also soluble in solutions of sodium carbonate partially saturated with sulphydric acid, both hot and cold. Quantitative determinations have been made, but are omitted here for the sake of brevity.

Marcasite is more easily soluble than pyrite, and the simple precipitated sulphide goes into solution most readily of all. I think there can be no doubt that pyrite and marcasite form double salts with sodium sulphide entirely analogous to the soluble compounds of mercuric sulphide. Marcasite is more easily attacked than pyrite, just as metacinnabarite is more susceptible to the action of reagents than cinnabar.

Solubility of Gold.—The association of gold and pyrite is world wide. According to Gahn† there is no pyrite which does not yield traces of gold when carefully tested. This indeed does not accord with my experience, for extremely careful tests of some pyrite in my laboratory have failed to reveal any indication of gold. Gold is associated with quicksilver, however, at Steamboat Springs, at some points on the gold belt of California, at the Manzanita mine, at the Reddington mine, and some other localities both in California and in foreign countries. From these facts I concluded that gold should be soluble in sodic sulphide. On warming chemically pure, precipitated gold dust with a solution of sodic sulphide, the glittering scales of gold gradually disappeared. The filtrate, after proper manipulation, yielded a purple precipitate with phosphorous acid.

A solution containing 843 parts of Na$_2$S (by weight) dissolves one part of gold at the ordinary temperature of the atmosphere. Gold also dissolves at ordinary temperatures in sodic sulphydrate and in solutions of sodic carbonate partially saturated with sulphydric acid. The solubility appears to be increased and facilitated by heat.

Solubility of other sulphides.—Cupric sulphide dissolves less readily than pyrite in sodic sulphide and in mixtures of the sodic carbonates and sodic sulphydrate. Unlike pyrite, it also dissolves in thoroughly saturated sodic sulphydrate. Zinc sulphide is also soluble, and behaves much as pyrite does. Quantitative determinations of the solubility of these substances have also been made. The solubility of the sulphides of arsenic and antimony in sodic sulphide and in the sulphydrate is of course well known. In the presence of neutral sodic carbonate, sulphides of arsenic and antimony dissolve in sodic sulphydrate without the evolution of gas, because the sulphydric acid set free reacts upon the carbonate.

Natural solutions and precipitations.—The foregoing experiments show there is a series of compounds of mercury of the form HgS, nNa$_2$S, one or the other of which is soluble in aqueous solutions of caustic soda, sodic sulphydrate or sodic sulphide, and apparently also in pure water, at various temperatures. These solutions subsist, or subsist to some extent, in the presence of sodic carbonates, borates, and chlorides. There is the strongest evidence that the waters of Steamboat Springs contain mercury in this form, and that the waters of Sulphur Bank have contained mercury in the same form, if indeed they do not still carry it in solution. Bisulphide of iron, gold and zincblende form double sulphides with sodium, which appear to be analogous to those of mercury. Copper also forms a soluble double sulphide, but combines more readily with sodic sulphydrate than with the simple sulphide. All of these soluble sulphosalts may exist in the presence of sodic carbonates.

Mercuric sulphide is readily precipitated from these solutions. Any substance is more soluble in hot solutions than in cold ones, provided that increase of temperature does not resolve the fluid molecules into others which are less soluble; as happens with sodium chloride, neutral sodium carbonate, etc. Diminishing temperature is thus a cause of precipitation, and diminishing pressure appears to act in a similar way. There are also other methods of precipitation which may be carried out under natural conditions. If a natural solution of mercury comes in contact with strong solutions of borax, or with sulphydric acid, or any stronger acid, it will lose a portion of the mercuric sulphide in solution. At Steamboat Springs and Sulphur Bank large quantities of sulphuric acid are formed near the surface, and, percolating downward, must precipitate mercury in some form. The acid waters penetrate to a depth of at least 20 or 30 feet, and this explains the fact that the waters reaching the surface carry so little quicksilver. These same causes must also produce precipitation of the other ores and of gold from solutions.

* Gmelin-Kraut, l. c., vol. ii., p. 160.

† Bischof's Chem. Geol., vol. iii., p. 939.

Another method by which mercuric sulphide may be precipitated, as has been seen, is mere dilution. Now, ascending solutions of quicksilver must sometimes meet with springs; and when they do so, metacinnabarite, or black sulphide, will be precipitated, and with it also a small amount of quicksilver. In nearly all mines a small quantity of "virgin" quicksilver is found, and in most it constitutes a very small proportion of the entire ore.* Accompanying this precipitation is the formation of hyposulphite, which actually occurs in the waters of Steamboat Springs. Dilution of solutions of quicksilver with extraneous spring waters thus explains the occurrence of metacinnabarite found in at least four of the mines of California, and in New Zealand, and of native quicksilver. Native quicksilver, however, occurs in many mines in which no metacinnabarite has ever been seen. This does not preclude the supposition that the metal has been isolated by dilution; for black sulphides in the presence of solutions of mercury might readily be converted into the allotropic modification, and I know of no reason for denying that much of the cinnabar of the ore deposits may have been deposited in the amorphous state. Cinnabar and metacinnabarite are sometimes found mixed, as if the conversion to the red form were incomplete; and there is other evidence from observation that mercuric sulphide is slightly soluble in the waters of some of the cold mines.

While dilution will produce metallic mercury, and a *causa vera* of its existence is thus detected, there may be other ways besides this in which it is produced in nature. Thus sulphydric acid precipitates a mixture of quicksilver and mercuric sulphide from mercurous salts. Whether soluble mercurous salts can occur in nature, excepting near the earth's surface, is another question. But even light is well known to decompose this feeble sulphide, and it is not impossible that the decomposition of organic matter, which is associated in most cases with cinnabar deposits, and seems to be specially abundant in the mines in which metallic mercury most prevails, may yield ammonium sulphide and metallic mercury.

Conclusions.—The conditions of the solution and precipitation of ores traced in this paper appear beyond doubt those mainly instrumental in forming the deposits of Steamboat Springs and Sulphur Bank. Most of the other quicksilver mines in California show ores and gangue minerals of similar composition to these, and many of them are accompanied more or less closely by warm springs containing much the same salts in solution. Some of the gold veins also appear to bear so considerable a resemblance in many particulars to these deposits as to lead to the belief that they too were formed by precipitation from solutions of soluble double sulphides.

That pyrite, gold, and other ores are sometimes produced in nature by other methods is absolutely certain; for some auriferous pyrite is known to have resulted from the reduction of iron sulphate by organic matter. This particular process is probably confined to short distances from the surface; for I know of no indication of the formation of iron sulphate far from the oxidizing influence of the atmosphere. But there may be other solvents yet for these and other minerals which can form at great depths, and, if such there be, I am convinced they are cases in which they, and not those which it has been my good fortune to trace in the foregoing pages, have been instrumental in the segregation of ores.

United States Geological Survey, Dec., 1886.

—*Amer. Jour. of Science.*

[SCIENCE.]

THE MEDICO-LEGAL ASPECTS OF HYPNOTISM.

A. BINET, one of the leading French authorities on hypnotism, has written an appreciative but critical notice of the work* of Campili that gives an excellent view of the French and Italian standpoints regarding this subject, that is assuming so much importance there. Dr. Campili has had the advantage of numerous memoirs in France and elsewhere. M. Legeois has shown the possibility of making the hypnotic suggestion serve a criminal purpose, but has not discussed the subject.

MM. Binet and Fere set themselves to determine the conditions under which the reality of the hypnotic suggestion may be admitted by a tribunal—the judicial proof, in other words. Dr. Campili presents the problem from the point of view of the two schools of criminologists in Italy, the classical or spiritualistic school and the anthropological school, which differ not only in their theoretical conceptions, but also in their practical conclusions upon the application of punishment. Upon the question of hypnotism, however, the two schools admit the same conclusion. Dr. Campili examines what the civil and penal responsibility of the hypnotized subject is when criminal acts have been committed or obligations have been assumed under the influence of a hypnotic suggestion. According to the classical legal school, the hypnotized subject is not responsible, since he has not committed a voluntary and conscious offense. There can be no punishment where there has been no fault.

The anthropological school, which does not assume this subjective point of view, but considers that the judicial institutions have the simple function of social preservation and defense, arrives at the same conclusion, but by a different way. In a very detailed discussion the author arrives at the conclusion that the needs of social defense only demand the re-

* It is a very curious fact that from ancient times to the beginning of the last century virgin quicksilver was supposed to possess qualities superior to that of the metal reduced from cinnabar. Bruckmann, Magn. dei in loc. subt.

† *Il grande ipnotismo e la suggestione ipnotica, nei rapporti col diritto penale et civile.* By G. CAMPILI. *Revue philosophique*, October, 1886.

pression of criminal acts when these are the expression of the personality of the agent; and since in the hypnotic subject the individual reaction is abolished, the acts that he does under the influence of a hypnotic suggestion are simply those of an automaton.

These conclusions are at least debatable, says Binet, and rest on premises that contain an error of fact. The belief is too common to-day that it is possible to characterize the psychical state of hypnotism in a single word and say it is a condition of automatism. In a vast number of cases the subject preserves his intellectual and moral identity. When he receives a suggestion to act, he may resist if the act is in contradiction with his character, and he may examine the order, and even absolutely refuse to obey. Campili seems to have seen this difficulty, for he recalls that in an ingenious article M. Bouillier has admitted a moral responsibility in dreams, but he meets this objection with an argument of little weight, that the hypnotized subject does not preserve his personality in the same way that a sleeping person does.

Binet holds, on the contrary, that the closest connection exists between the effects produced by suggestion and the state of dreaming. The hypnotic suggestion is nothing else than a dream produced and directed by assistants. In fact, the somnambulist is not an automaton, he is an *individual*, and from the purely theoretical and moral point of view, he may be held partially responsible for his acts. These conclusions are in direct accord with those of M. Bouillier.

But what is the practical point of view? Has or has not society the right to defend itself against the crimes of hypnotism? Will it suffice for the assassin to show that he was under the influence of a suggestion for the judges to grant him his liberty and allow him to begin his work again? Clearly a uniform toleration is out of the question. Until recently hypnotism figured only accidentally in judicial proceedings, but now all this is changed, and hypnotic suggestion may readily enter into criminal proceedings.

This is exactly what has happened in Turin, where, says Lombroso (*Revue Scientifique*, June 19, 1886), there is a veritable epidemic of hypnotism. Society must protect itself against such a danger. Garfolo, in his remarkable work on *criminologie*, argues that we must apply to the criminal who has committed a punishable act in a state of hallucination or of somnambulism the same treatment that we give to those who have committed a crime in an epileptic or hysteric attack or from the effect of impulsive mania, that is, seclusion in a criminal asylum for an indefinite period until a complete cure is established, or until the patient passes into some other condition that renders a repetition of the act an absolute improbability.

Campili thinks that it would be difficult to apply the same punishment to an hypnotic criminal, since he did not commit the crime of his own accord, but under the influence of a third person, who is the true culprit. The hypnotic subject is simply an instrument of crime in the hands of the hypnotizer, the same as a revolver or a knife, and it is he who ought to bear the responsibility of the act. This is a subtle distinction. The hypnotic subject, like the epileptic, is a dangerous person, a veritable *malade*, since he allows a very simple maneuver to make him commit a crime. It is absolutely necessary to put him beyond the possibility of doing harm.

Moreover, it is probable that the dread of punishment exercises a restraining influence over the minds of those who submit voluntarily to be hypnotized. In fact, Binet holds, many persons who are slightly hypnotizable may resist hypnotization successfully, and ought to be responsible for consenting to submit themselves to the experiment. There is the strongest reason for this conclusion if the subject knows in advance, before going to sleep, that a criminal suggestion will be given to him.

There is one curious hypothesis that Campili has not anticipated, and one which well known facts render extremely probable, and that is that we may find some day in some band of thieves or assassins a hypnotic subject who of his own accord yields himself to criminal suggestions. The usefulness of hypnotic suggestion under such circumstances is easily understood, for those who are under the control of a suggestion have more audacity, more courage, and even more intelligence, than when they act of their own accord. There are patients who, dreading to be put to sleep by some one that they dislike, offer to the hypnotic suggestion of one of their friends a power of resistance that they do not have naturally. Others, wishing to accomplish some act, and fearing that their courage will fail at the last moment, suggest themselves the act that they wish to do. In these circumstances the subject should be punished as the principal and the hypnotizer only as an accomplice.

The Paris correspondent of the *Medical Record* writes last December that an epidemic of hypnotism prevails there, and he paints the prevailing distemper in exceedingly dark colors. Every steamer brings some new book on hypnotism or mental suggestion, and the amount of literature that has accumulated within the past year is enormous.

Public exhibitions of hypnotism have been interdicted in Germany, Italy, and Austria. This is but one side of the shield, however, and brilliant therapeutical results have been reported by the skilled coterie of French physicians that has advanced our knowledge of hypnotism so much within the past few years. Yet on the whole, perhaps, it is a matter for congratulation that the more stolid American mind has been little affected by hypnotism up to this time, not even to the extent of furnishing sufficient subjects for the Society for Psychical Research. It may be that the "mind cure" is our cross, and at any rate the connection between this and hypnotism offers a promising field to the investigator. William Noyes.

Bacillus Phosphorescens.—A luminous bacillus has been studied by Dr. Otto Hermes, at the Berlin Aquarium. If in contact with air, it gives out in the dark a peculiar bluish-green light, which reminds the observer of the electric light, and which can be communicated to dead fishes and to sea water. At temperatures exceeding 40° the bacillus loses its luminous property. If the phosphorescence has been transferred to sea water, it disappears in twenty-four hours. Fresh water cannot be rendered luminous by the bacillus.

[Nature.]

ON SOME PHENOMENA CONNECTED WITH THE FREEZING OF AERATED WATER.

The elimination in the gaseous form, on the freezing of liquids, of the air and gases held in solution presents some features in its process which may be worth recording.

Bubbles in ice are familiar; but their arrangement and progressive development in the process of freezing over present some points which I do not think have been generally observed.

Aquatic plants at the bottoms of ponds give off oxygen gas, and marsh gas is emitted from decaying vegetable matter. These two sources of supply will, to some extent, account for the entanglement of bubbles in ice on a pond surface, but only to a very small extent, and may be left out of consideration in dealing with the development of air bubbles in ice. This takes place independently of any extraneous source of supply other than atmospheric air, and may be as well seen in a glass or earthenware vessel as over a weedy pond surface.

The following facts must be noticed:

(1) Ice over deep water invariably contains fewer bubbles of included air and gas than ice formed over shallow water, and probably from this cause ice obtained from over deep water is more durable for storage than ice obtained from shallow pools.

(2) The upper or surface portion of a coating of ice invariably contains less included air than its under or lower portion, and this is more obvious in ice formed over shallow than in that over deep water. In each case there is a fairly regular gradation in the quantity of entangled air, increasing from the surface downward. I ascertained that the included air from the upper surface (*a*, Fig. 1) of a thin coat of ice was scarcely appreciable in quantity, and one pound weight from its lower surface (*b*, Fig. 1) contained 0·08 of a cubic inch of entangled air.

(3) There is more included air in ice formed over water in a small vessel (Fig. 1) than in ice formed over a large body of water.

(4) There is more included air (weight for weight of ice) in an entirely frozen mass of ice (Fig. 2, *d*) than in surface ice from a partly frozen vessel of water. In an entirely frozen mass (Fig. 2, *d*) 1 pound of ice contained

Fig. 1.

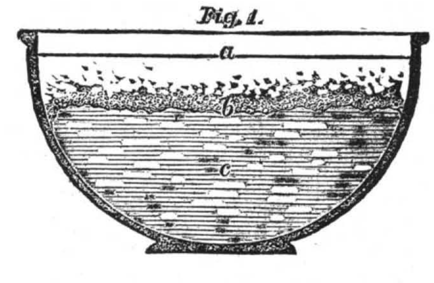
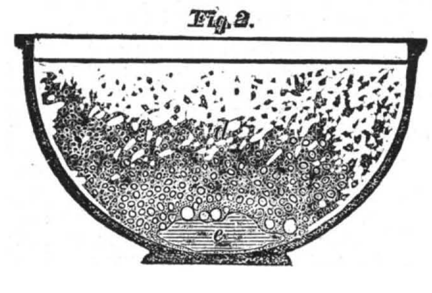


Fig. 2.



0·59 cubic inch of included air; and surface ice (*a*, *b*, Fig. 1), over unfrozen water, one pound weight contained 0·15 cubic inch.

(5) In freezing separately the water from which the first frozen coat of ice had been removed (Fig. 1, *c*), the ice contained a much larger proportion of included air (0·89 cubic inch) than either the surface ice (Fig. 1, *a*, *b*) or the ice obtained from entirely freezing a body of water (Fig. 2, *d*).

(6) On refreezing water which had been frozen and thawed, there was but a very slight further release of air, which had been almost entirely released in the first freezing; one pound of the second ice contained but 0·005 cubic inch of air.

(7) In completely freezing a vessel of water (Fig. 2), not only does the entangled air increase in quantity downward, but at the base of the frozen mass occurs a large air cavity (*e*, Fig. 2).

All these facts, and the results of the experiments, seem to point to the fact that, in the process of freezing, the elimination of the air and gases in solution is taking place in two directions: (1) a part of the air is taken into solution by the unfrozen water as it is progressively rejected by the thickening coat of ice; and (2) a part of it is extruded as bubbles of air, which become entangled in the ice.

If each stratum of ice eliminated the whole of its own proportion of air in solution in the gaseous form, the bubbles would be distributed with fair regularity throughout the collective mass, but their progressive increase in a descending direction exactly agrees with the continuous surcharging of the underlying unfrozen water with the air in solution rejected by the ice above, till, at the end of the freezing process of the mass, the remnant is extruded as one large bubble (Fig. 2, *e*) at its base.

The rejection of the air into continued solution would seem to take precedence of its extrusion in the gaseous form, and would go on as long as there was a sufficient body of adjacent water in a condition to receive it; but the gradual surcharging of a limited body of water with the rejected air is necessarily accompanied by its progressively increased extrusion in the gaseous form.

The comparative absence of air bubbles in ice over deep water is accounted for by the fact of there being a sufficient body of adjacent water in a condition to receive the rejected air into solution in preference to its extrusion as gas.

To briefly recapitulate the experimental results: (1) In a thin ice coating, the upper or surface half contains barely a trace of eliminated air, while its under or bottom half contained 0·08 cubic inch of air in each pound of ice. (2) A surface coating of ice 1½ inch contained 0·15 cubic inch of air in each pound weight, while an entirely frozen mass contained 0·59 cubic inch of air in each pound weight. (3) The freezing of a limited body of water which had been first frozen over and the surface ice removed points still more strikingly to the concentration of air in solution; for this contained 0·89 cubic inch of air in each pound weight, compared with 0·15 cubic inch in surface ice, and 0·59 cubic inch in an entirely frozen mass.

The water employed in these experiments was from the East Surrey Water Works.

George Maw.

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