SCIENTIFIC AMERICAN SUPPLEMENT No. 602

Scientific American Supplement, Vol. XXIV., No. 602.
Scientific American, established 1845.

NEW YORK, JULY 16, 1887.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE MAXIM AUTOMATIC GUN.

IN our SUPPLEMENT, No. 592, we published drawings of the later arrangements of the Maxim automatic gun, and we now give from *Engineering* illustrations of a very ingenious form of carriage on which it is proposed to mount these guns for service in the field. As will be seen from the engravings, the carriage is mounted on a pair of disk wheels, and the muzzle of the gun projects through a light steel shield which serves as a protection to the gunner, who sits on a movable seat slung to the shafts. The protection is completed by the steel disk wheels, which can be turned round diagonally, so that the gunner is completely sheltered. In our illustration, Figs. 1 and 2 show the gun mounted for horse or hand transport, and Fig. 3 shows it ready for operation. Fig. 4 is a front view, and illustrates the complete nature of the protection afforded by the wheels and the shield.

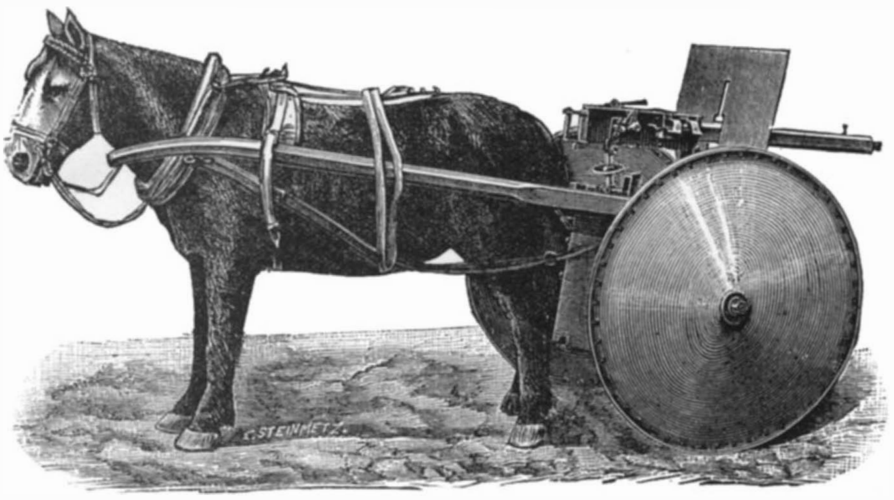


FIG. 1.

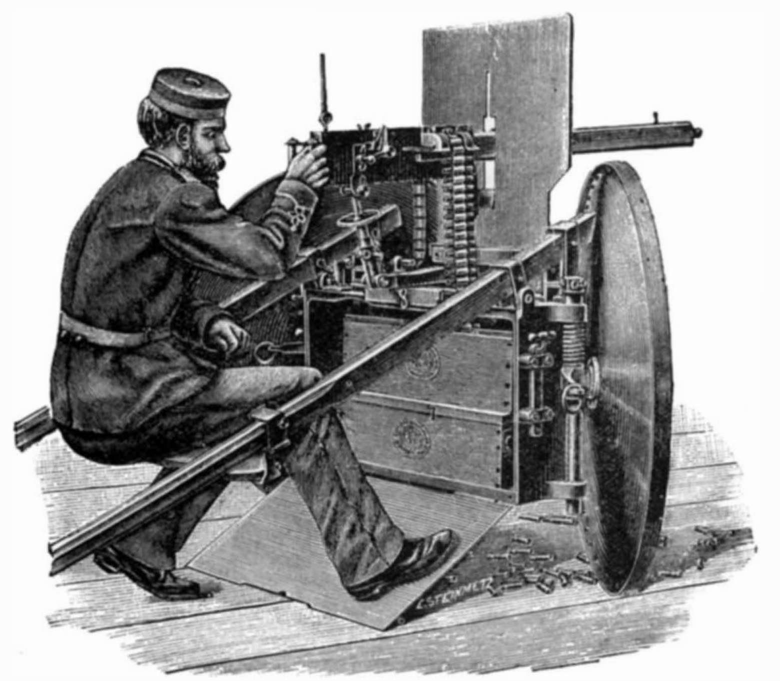


FIG. 3.

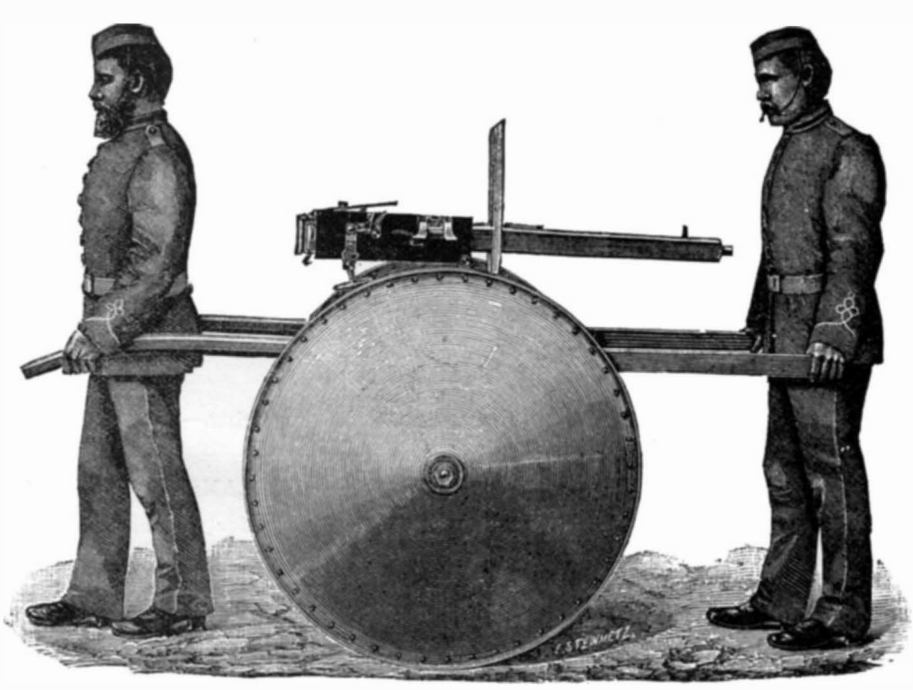


FIG. 2.

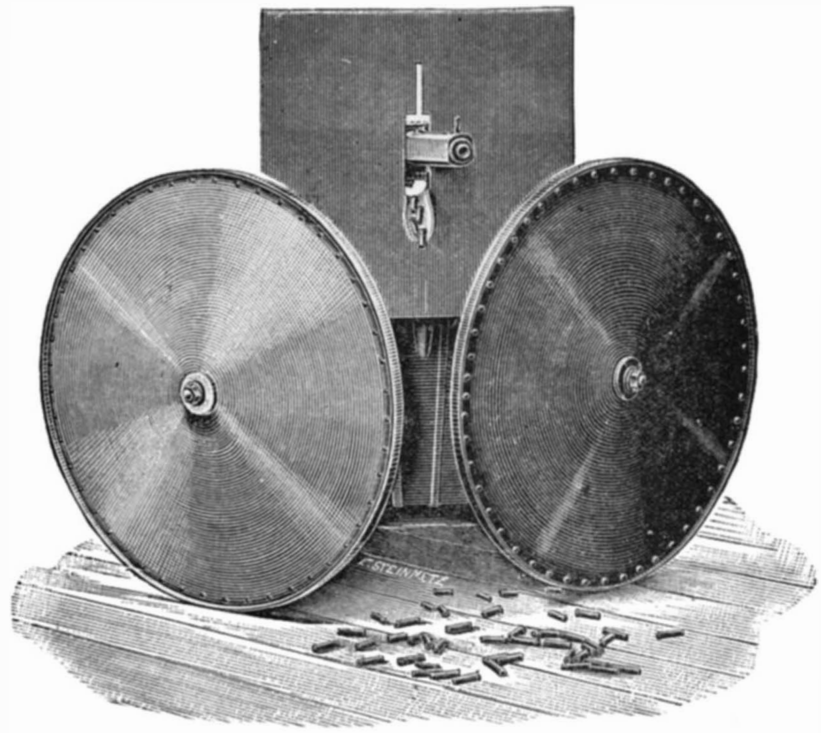


FIG. 4.

THE MAXIM AUTOMATIC MACHINE GUN ON STEEL CARRIAGE.

THE NEW STEAMSHIP OROYA.

THE Oroya is the second vessel of her kind which the Pacific Steam Navigation Company has recently added to its large and magnificent fleet, and is intended to ply between London and South Australian ports in conjunction with the steamers of the Orient Steam Navigation Company. The sister vessel, Orizaba, has completed her first voyage with remarkable success.

Both these steamers have been constructed at Barrow by the Barrow Shipbuilding Company, which has turned out a large number of very successful vessels of that class. These vessels are undoubtedly the finest of the Pacific Steam Navigation Company's fleet, and may be fairly entitled to rank among the best examples of modern naval design. The remarkable success which these ships have achieved, both upon the official steam trials and at sea, cannot fail to add to the reputation of the builders.

The Oroya is 460 ft. in length, 49 ft. in breadth, and 35 ft. 6 in. depth of hold, and has a gross register tonnage of 6,200 tons. She is fitted for the reception of 126 first-class and 154 second-class passengers in the state rooms, which extend along nearly the whole range of the main deck, and has also accommodation for over 400 emigrants in the 'tween decks below. Forward of the machinery compartments is situated the first-class saloon and a spacious apartment 32 ft. long communicating by a handsome staircase with an elegant drawing-room and a comfortable smoking-room in a broad deck-house overhead. The second-class saloon, which is aft, is about 28 ft. long, and, like that of the first-class, extends the whole breadth of the vessel. There is a handsome smoking-room above, and in point of comfort and fulfillment of the wants of intending voyagers no pains have been spared to make this after cabin, no less than the forward one, as desirable a place of abode as life on the ocean will admit of. The first and second class passengers are berthed in two-berth, three-berth, and four-berth family state-rooms in the vicinity of their respective saloons, and are provided with every possible convenience and luxury. The saloon state-rooms and passages are well lighted and ventilated by handsome sky-lights, deck-lights, and large side-lights; and by means of T. C. Green's patent system of artificial ventilation, which is applied to the whole of the cabin accommodation, a current of cool air may be set up at will. At night the vessel will be lighted by electricity by means of 400 incandescent lamps, the effect of which adds to the comfort and appearance of the already handsome saloons. The arrangement of the pantries and bars and other conveniences for the cooking departments and stewards is of the best description, and a complete system of pneumatic bells runs through the ship. Around the machinery casings on the upper deck are berths for the officers, engineers, and other officials of the ship, as also for the firemen and servants, the crew being berthed below the main deck right forward. At the after end, and covered by a long turtle back, are the after wheel-house, a hospital, and the wash-houses and other conveniences for the emigrants, a stairway for the latter leading to the quarters below. Abreast of the machinery openings, and beyond them to the end of the first-class drawing-room, the top of the deck-house is carried out to the side of the vessel, forming a magnificent promenade 178 ft. long with sheltered walk below.

The after end of the vessel is covered by a turtle back, which is carried forward to the after hatches and forms a promenade for the second-class passengers scarcely inferior to that of their fellow-voyagers forward. The fore-end of the ship is finished by a turtle back for working the anchors similar to that aft, and having store-rooms, wash-houses, etc., below it. The hatchways, of which there two forward and two aft, are arranged as stairways for the use of the emigrants who are berthed on the lower deck. Above the promenade deck, forward of the funnels, is the captain's house, with flying bridge above, and in wake of the foremast is arranged a second look-out bridge for use in foggy weather, having the side-lamps fitted in small towers at each end. The vessel's rig is that of a two-masted fore and aft schooner. For the convenient working of the ship, steam is called into use where-

ever possible; steam windlass, steam steering gear, with connections and telegraph to poop deck, promenade deck amidships, and flying look-out bridges, with the hand steering gear, all form prominent features in the general design. The steam winches are of very heavy construction.

In addition to the luxurious manner in which the vessel is fitted up for passengers, she also carries over 1000 tons of cargo; and in view of the increasing trade in meat from the antipodes to this country, there is provided on the orlop deck aft freezing machinery of the most modern and approved description.

The Oroya has been built under the special survey of Lloyds and the Liverpool Underwriters' Registries, and has received the highest classification.

The engines are of the triple expansion type, with three inverted cylinders working on three cranks. The high-pressure cylinder is 40 in. diameter, the intermediate pressure 66 in., and the low-pressure cylinder 100 in. diameter, with stroke of 72 in. Each cylinder is fitted with a hard, close-grained cast-iron liner, 1⅝in. thick, secured to the bottom of the cylinder by countersunk screws, and fitted with an expansion joint at top. The space, which is 1 in. wide, between the liner and the body of the cylinder is used as a steam jacket. Steam at boiler pressure is admitted to the high-pressure jacket, and, at pressures of 100lb. and 30lb. respectively, to the intermediate and low-pressure jackets. All the cylinders are fitted with the usual manholes, escape valves, drains, and indicator cocks, and the intermediate and low-pressure receivers with safety valves. The jackets drain to water traps, with pipes to the condenser. Auxiliary starting valves are fitted to the intermediate and low-pressure cylinders. The cylinder covers are hollow and well ribbed, and after casting were thoroughly annealed. The pistons, which were also annealed, are fitted with MacLaine's rings and springs. All the cylinders are fitted with piston valves, the high-pressure valve being 22in. diameter, the intermediate pressure cylinder having two valves, 22in. diameter, the low-pressure cylinder valves being Thom's patent, 32in. diameter, and all the valves are balanced by pistons attached to the top ends of the valve spindles. Hughes' metallic packing is used in all the stuffing boxes of the piston and valve rods. The top halves of the eccentric pulleys are made of cast iron, the bottom halves being wrought iron. The eccentric straps are lined with brass rings, secured by countersunk pins. The reversing engine is on the direct-acting "push" principle, with oil cylinder and pump fittings for working by hand. The crank shaft, built of mild steel, was made by Vickers, Sons & Co., the bearings being 21 in. diameter and 23in. long, the crank pins 22in. diameter and 20in. long. The shaft is made in three pieces, reversible and interchangeable, and bolted together with solid couplings, 5½in. thick by 39in. diameter, the coupling bolts, nine in number, in each coupling being 4¾in. diameter. The tunnel shafts, 20in. diameter, and the thrust and propeller shafts, 21in. diameter, were also made by Vickers, Sons & Co., of steel. The propeller shaft is cased with brass for the whole length of the stern tube; the rings were slipped on in sections, and are lap-jointed with burnt V joints. The thrust block is fitted with horse-shoe rings of cast steel, faced with Kingston's white metal, all the rings being separately adjustable; the bottom of the block is used for circulating water for cooling purposes. The tunnel bearing blocks, two to each length, are of cast iron, lined with Kingston's white metal. The shafting is so arranged that the propeller shaft can be withdrawn readily and easily, the after length of tunnel shaft being short for this purpose. The piston-rods, which are carried up through the top cylinder covers, are 9½in. diameter, and made of best mild steel, are fitted into each piston with a cone, having a collar below and a nut above, and all the piston-rods are interchangeable. The connecting-rods are forged from mild steel, with double bearings at the top ends, the lower ends being bushed with gun-metal lined with white metal. The diameter of the top end of the rod is 8½in., and the lower end 10in. The condenser, which forms part of the structure of the engine, is made of cast iron in three pieces, bolted together; the columns for supporting the cylinders are also bolted to the condenser. The tubes, which are in two lengths, are 10ft. 6in. long between tube plates, the condenser being divided in the middle into what is practically two condensers. The tubes, ¾in. external diameter, No. 18 B. w. g. thick, 5604 in number, have a cooling surface of 11,546 square feet. The condenser may also be worked by jet injection. The air pumps, two in number, are 30in. diameter by 33in. stroke, worked from the low and high pressure crossheads by levers and links. The barrels, buckets, and seats are made of brass, the valves being India-rubber; the rod of magnanese bronze is attached to the crosshead, and guided by strong brackets bolted to the cover. The feed and bilge pumps, two of each, are worked from the air-pump crossheads, with plungers 7in. diameter, and made entirely of brass. The valve-chests and valves, of large size, are made of brass; and to each air-pump crosshead is also attached a sanitary pump with 4½in. plunger.

The circulating pumps are of the centrifugal type, two in number, each capable of supplying the requisite quantity of water when the engines are worked full power. These pumps are driven by independent compound engines, with cylinders 8in. and 16in. diameter, and 10in. stroke. Weir's feed heater and engine is fitted on board for feeding the boilers. An auxiliary donkey pump of large size is also supplied for pumping from sea and bilge to boilers and overboard, and along with two fire engines, specially provided for fire purposes, may be used as a fire engine and for washing decks. In addition to these engines, a No. 7 pulsometer is fitted to draw from the sea, bilge, and ballast tanks, and discharge on deck and overboard. A special centrifugal pump driven by an independent engine, and capable of discharging 200 tons per hour, is also fitted for ballast purposes. The connections to the auxiliary engines are of the most complete description. The boilers, six in number, are of the ordinary marine multitubular type, constructed entirely of steel, for a working pressure of 160lb. per square inch. Each boiler is 13ft. 6in. diameter and 18ft. long, with six corrugated furnaces, having a mean diameter of 3ft. 1in. The total heating surface in all the boilers is 17,640 square feet, and the bars are 6ft. long, giving a bar surface of 627 square feet.

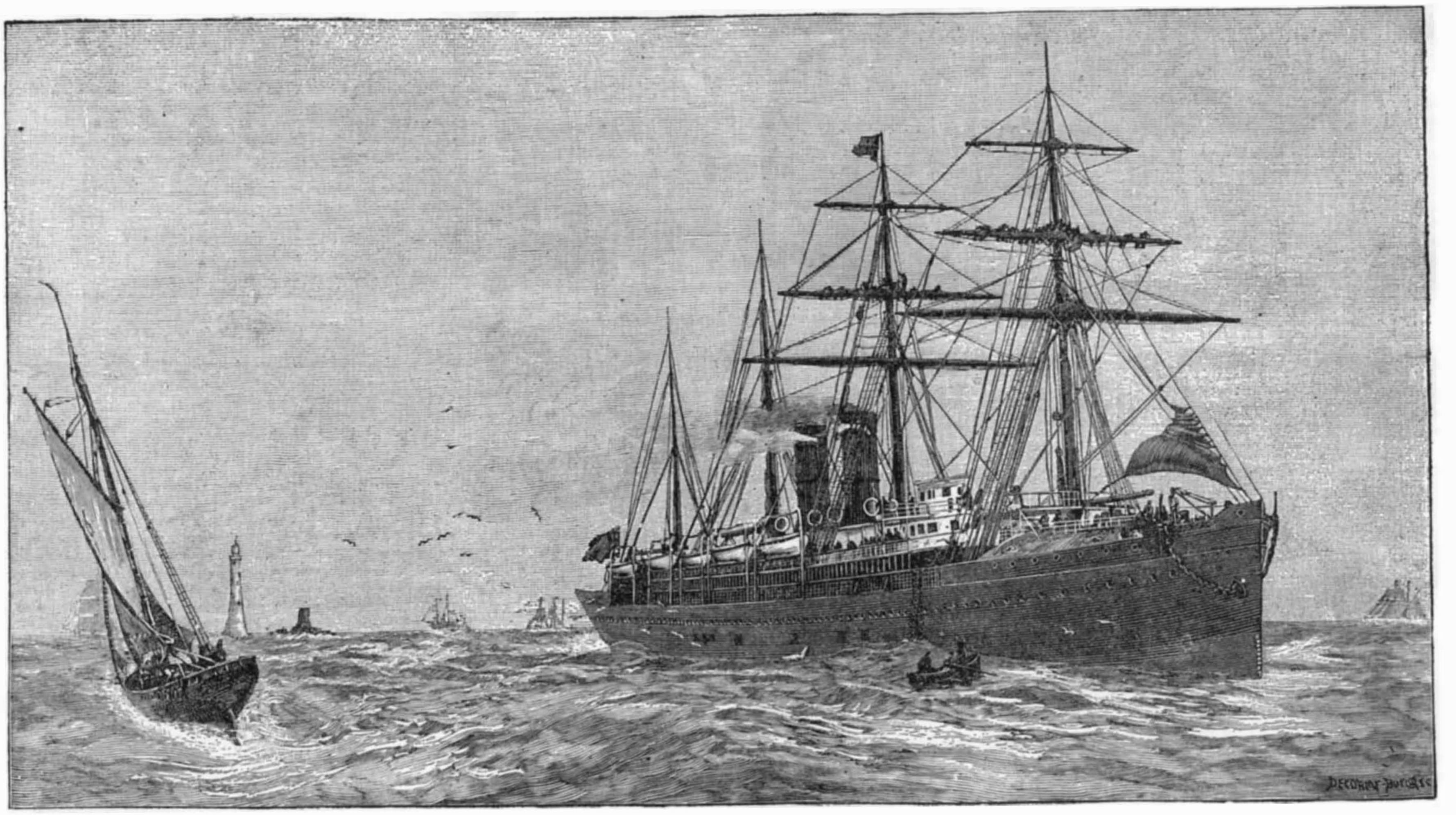
During the very successful twelve hours' trial in the Irish Sea, on January 21 and 22 of this year, the highest indicated horse power developed was 6,751, with 64·5 revolutions and a steam pressure in the boilers of 160 lb., the vaccum being 26in. The mean speed of the twelve hours' run was 16·5 knots, the mean displacement being 8,840 tons, on a mean draught of 22ft. 7in. The mean indicated horse power for the whole run was about 6,500, with 64 revolutions, and this without the slightest sign of heating in any of the bearings. Diagrams taken gave the following: Steam, 160 lb.; vacuum, forward, 26in., aft, 25½in.; revolutions, 64; horse-power, high pressure cylinder, 1,888; intermediate, 1,908; low pressure, 2,649; total, 6,445.

The propeller, with loose blades of manganese bronze, securely bolted to a cast steel boss, made by Vickers, Sons & Co., is 22ft. diameter, with a pitch of 28ft. 6in. The pitch may be varied from 27ft. to 30ft., the flat area of all the blades being 149·6 square feet.—*The Engineer.*

THE NEW STEAMER ORMUZ.

THIS fine ocean steamship, the latest addition to the famous "Orient" line between England and Australia, has achieved a wonderful home passage, leaving Adelaide on April 4 and delivering her mails in London at a quarter past five o'clock on May 1, the shortest time that has yet been recorded, eleven thousand miles within twenty-seven days. Her departure from Sydney, on March 28, was acclaimed by the admiring cheers of many thousand assembled spectators. Thence to Melbourne and Adelaide. She consumed only 110 tons of coal daily, on the average.

One of the passengers, Dr. C. L. Cunningham, who left the ship at Port Said and came home by Italy, has favored us with sketches of the Ormuz in the teeth of a full gale, steaming fourteen knots an hour; of her entering the Red Sea at the Straits of Bab-el-Mandeb; and of her passing through the Suez Canal. The Ormuz was built on the Clyde, by the Fairfield Shipbuilding and Engineering Company (Limited), late John Elder & Co., from special designs, expressly for the Australian passenger service of the Orient Steam Navigation Company (limited), and was completed in nine months after signing the contract. She is 481 ft. in length over all, 465 ft. between perpendiculars; in breadth, moulded, 52 ft.; in depth, 37 ft.; her displacement, at the load line, 26 ft., is 10,500 tons; the gross tonnage registered, 6,116; and the triple expansion engines, with cylinders of 46 in., 73 in., and 112 in. diameter, with 6 ft., stroke, have 8,500 horse power effective, with seven cylindrical steel boilers, working pressure 150 lb. The hull is wholly constructed of mild steel, carefully tested. It is formed with a turtle back at each end, and with a double bottom, divided and subdivided into many watertight compartments, as are the spaces above. Every door can be closed by machinery working on the main deck. This ship is admirably fitted for the accommodation of passengers, to which the whole of the main deck and great part of the lower deck is devoted. Elegance and luxury in the saloons, a vast promenade deck, comfortable state rooms and cabins, and baths of hot or cold water, are provided for those of the first class. The second class saloon passengers have a promenade deck 100 ft. long. The ship is illuminated by Swan and Edison incandescent electric lights.—*The Illustrated London News.*



THE NEW STEAMSHIP ORMUZ.

CRANK DIAGRAMS.

VARIOUS methods are in use for finding the corresponding positions of cross head and crank pin without the necessity of drawing the connecting rod at full length. One of these methods, which is very little known in this country, is due to M. Marcel Deprez, and has lately been improved upon by M. H. Léauté. The original method, as well as the improved construction, was described by M. H. Léauté in our contemporary, *Le Genie Civil;* and since the degree of accuracy attainable is very great, and the construction exceedingly simple, we make no apology for bringing the matter before the notice of our readers. The original method of Deprez will be understood by reference to Fig. 1, where A B represents the horizontal diameter of the circle described by the crank pin around the center, O, and C D represents the stroke of the piston, or the distance traveled over by the cross head pin. Let the stroke of the piston be divided into ten equal parts, marked in the diagram 1, 2, 3, etc.; then the true position of the crank pin, for any position of the piston, can be found by describing a circle, with a radius equal to the length of the connecting rod, round the corresponding point as a center, and noting the point of intersection with the crank circle. These circles are indicated in our diagram by dotted lines, and the points of intersection are marked 1, 2, 3, etc., on the upper half of the crank circle, corresponding with the points 1, 2, 3, etc., on the line, C D, for the out stroke. If we perform the same operation for the in stroke, we obtain the points 1, 2, 3, etc., marked on the lower half of the circle; and by drawing the lines 1 1, 2 2, 3 3, etc., we find that, for a connecting rod equal to or exceeding three cranks, they intersect the horizontal diameter, A B, nearly in the same point. The connecting rod shown in Fig. 1 is

equal to four cranks, and in this case, the distance of this point of intersection, O_1, to the true center, O, is equal to one eighth of the crank radius; generally, this distance is equal to the ratio $R^2/2l$, where R is the radius of the crank, and l the length of the connecting rod. It is, therefore, possible to calculate the position of the point, O_1, in every case. Let the circle, A_1 B_2, be described round the point, O_1, with a radius equal to that of the crank, and let the positions of the crank, which would correspond to a connecting rod of infinite length, be marked on that circle. The radii to these points are found to intersect the true crank circle very nearly at the points 1, 2, 3, etc., which mark the true positions of the crank pin. The positions of the corresponding points on the auxiliary circle, which is dotted in our diagram, can easily be found by subdividing the diameter, A_1 B_2, into ten equal parts, erecting perpendiculars, and marking their points of intersection with the dotted circle. A somewhat lengthy analytical investigation, given by M. H. Léauté, which we need not here reproduce, shows that, for a connecting rod equal to four cranks, the maximum error which can occur, if the angular position of the crank pin is determined by this method, is only 47′ 25″. But if, instead of joining the points on the auxiliary circle with O_1, we join them with O, and mark the intersection with the true crank circle, the points thus determined give the angular position of the crank, with a maximum error not exceeding 19′ 28″. A further improvement, however, is possible, by which the maximum error is reduced to 5′ 17″. This construction is shown in Fig. 2, where the point, O_2, is marked off to the left of the true crank center, O, and the distance, O O_2, equals one-half the length, O O_1, the point, O_1, being ascertained as before. In our diagram, a_1 represents the position of the crank corresponding to the first tenth of the out stroke, if the connecting rod were infinitely long. If this point, a_1, be joined by a straight line with the point, O_2, the intersection, a, with the true crank circle gives the true position of the crank pin, with the given length of connecting rod equal to four cranks. To find other positions, we have only to determine the corresponding points on the dotted circle, and join these by straight lines to O_2; their points of intersection with the true crank circle give, within the limits of accuracy mentioned above, the actual positions of the crank. It will be seen that this method is very easy of application, requires very little space on the drawing board, and insures almost mathematical accuracy.—*Industries.*

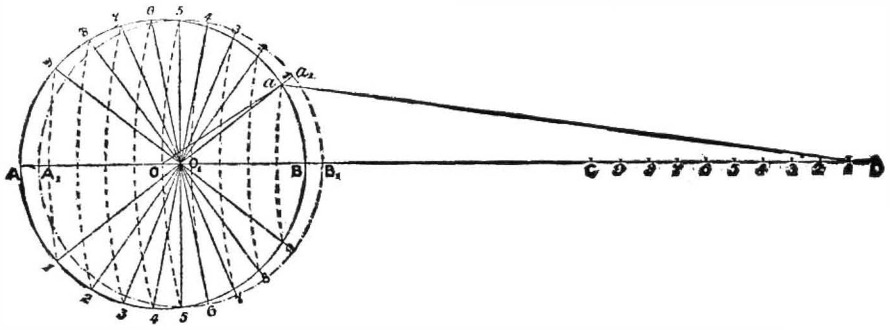


FIG. 1.—CRANK DIAGRAMS.

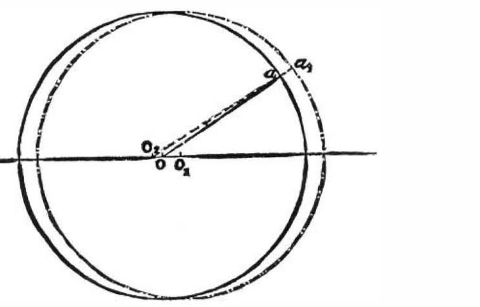


FIG. 2.

WATER RAISING MACHINES.

AN interesting experiment has lately been made in Messrs. Cail's workshops. The trial was of an apparatus, the outcome of a laboratory machine, a description of which was given in 1882 at the Academie des Sciences, and more recently at the Societe de Physique. The elevation of water has for a long time been effected by rotary machines. They all consist of a fixed case, in which winged disks raise water by centrifugal force. The height attained by these machines is at the most 30 meters.

Messrs. Gwynne and M. L. D. Girard have each successively invented machines. That of the latter has attained a water elevation of 40 meters. M. F. De Romilly has since obtained by his laboratory machine a water elevation of 200 meters. This machine, of very simple construction, is formed on different principles from the others. It is the outer casing which revolves, and in this cylinder a fixed tube bearing an especial ajutage or nozzle, Fig. 1, plunges into the circulating water. The turbine being set in rotation, the liquid under the action of the centrifugal force forms a ring clinging to the interior wall, just as the milk does in a cream separator. The tube, T, presents its orifice to the current, and thus receives the water as it whirls within its circle. The water rises in this tube to a height corresponding to its speed. It is seen by this that the height to be attained is only limited by the speed.

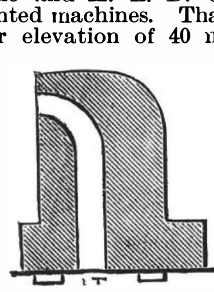


FIG 1

Several circumstances may present themselves in practice. The turbine may be placed on the level at which the water enters, its only work being to throw it to a determined height. This is the most simple case. If the water runs in above the level of the rotating case, the fall of water can be utilized to increase the ascending force, or the water level may be below that of the turbine and necessitate suction, as will be seen further on. One of the most important parts in a machine of this kind is the lubricating apparatus. This has led the inventor to a particular arrangement, as shown in Figs. 2 and 3. A good result has been obtained by employing two small turbines, R R, placed upon the axis itself which it has to lubricate, each inclosing one of the points of the axis and the hollow fixed screw. They work like the large turbine. The oil is conducted from the small turbine into the hollow screw by a small tube, from thence to the extremity of the axis, which by its rotation throws it into the small turbine, from whence it returns to the hollow screw in increasing circulation.

A sight feed lubricator is inserted into the tube, L L, that the passage of the oil may be seen. These small turbines turn in a contrary direction to one another, whatever may be the plane in which the large turbine revolves—Fig. 2. The inventor has, besides, invented two suction apparatus. The first is formed on the following principle: If a jet of liquid be made to fall upon a surface of the same liquid in repose, the air is drawn into its depth in numerous bubbles, which afterward rise to the surface; but if the level can be placed above the jet, the bubbles, once produced, coming from below, cannot return to their original level.

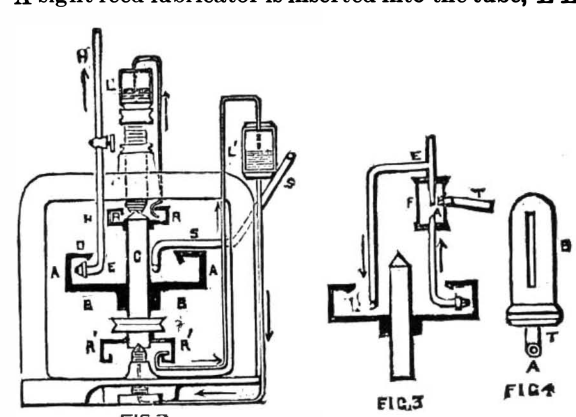


FIG. 2 FIG. 3 FIG. 4

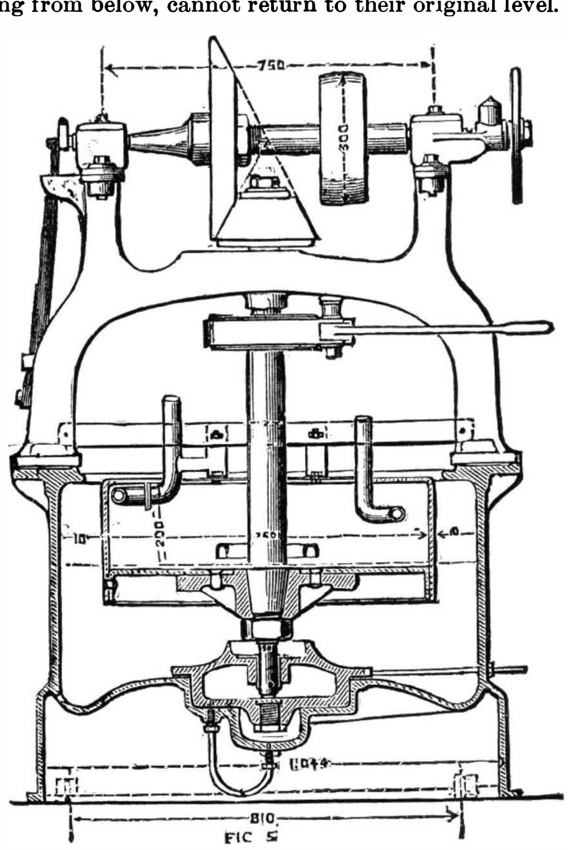


FIG 5

If a liquid jet be drawn into the tube, A, the air or the gas which surrounds it will be separated from it in the chamber, F—Fig. 3—which is interposed between the supply tube, E, and the driving tube, A, and into which the tube, T, penetrates, communicating with the emptying recipient. The liquid, which is then made use of, returns to the turbine and repasses into the tube A, indefinitely, carrying with it fresh air or gas bubbles.

With this arrangement the exhaustion can be done with mercury. At 700 mm. of mercury it can be carried off in eight minutes into a receptacle of 5 hectoliters. By the second method the same pneumatic results can be obtained by employing a suction tube called a "spirelle"—Fig. 4—which plunges into the water, and is provided with a slot running in the direction of the circle; one of the edges of this slot should be $\frac{4}{10}$ mm. lower than the other. The other end of the tube communicates with the emptying receptacle.

There is one objection to the use of this machine, which *Le Genie Civil* calls a pneumatic machine, and that is the necessity of largely increasing the volume of the jet in order to have a greater periphery for carrying off the gas. The single jet has therefore been replaced by a series of small circular orifices, to the whole of which the same circumference must be given. To find what number of orifices are equal to a given section, they proceed as follows:

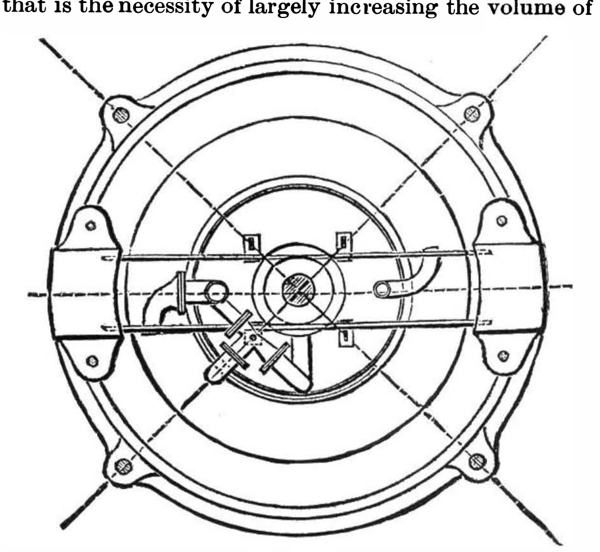


FIG. 5A.

R, the exterior circumference of the annular channel or groove;
a, breadth of the channel;
r, circumference of the small orifices;
n, their numbers;

We get—

$$R = n\,r,$$

$$\pi R^2 - \pi (R - a)^2 = n\,\pi\,r^2$$

Thus

$$2\,Ra - a^2 = n\,r^2$$

Dividing by the first equation, we get

$$2\,a - \frac{a^2}{R} = r;$$

a^2 being very small may be dispensed with, $\frac{a\,r}{R}$, and finally obtain

$$r = 2\,a$$

then

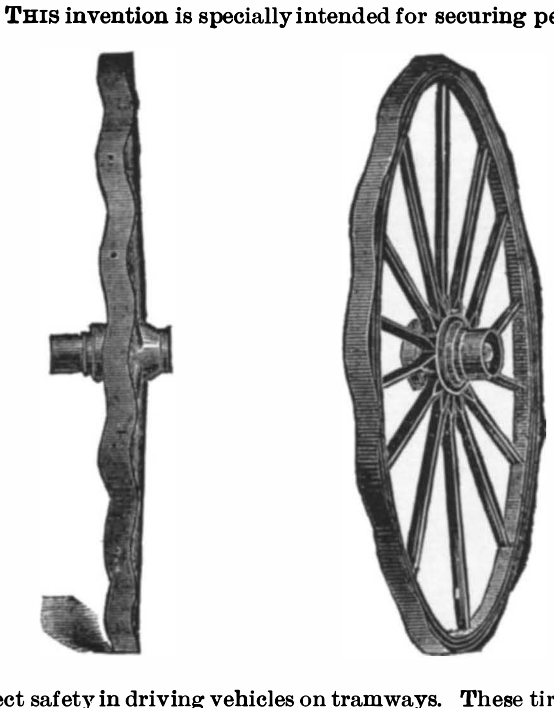
$$n = \frac{R}{2\,a}$$

For a machine of 10 horse power, 2,400 orifices would be required, an impracticable number. A more practical solution will have to be found, but meanwhile the apparatus working as a pump gives very satisfactory results.

In the apparatus which has been constructed and tried, the design of which is given in Figs. 5 and 5A, very satisfactory results have been obtained in dealing with small volumes of water; what its capabilities might be under further experiments are yet to be determined. The most important organ of the apparatus is the ajutage at the end of the raising tube, A.—*The Engineer.*

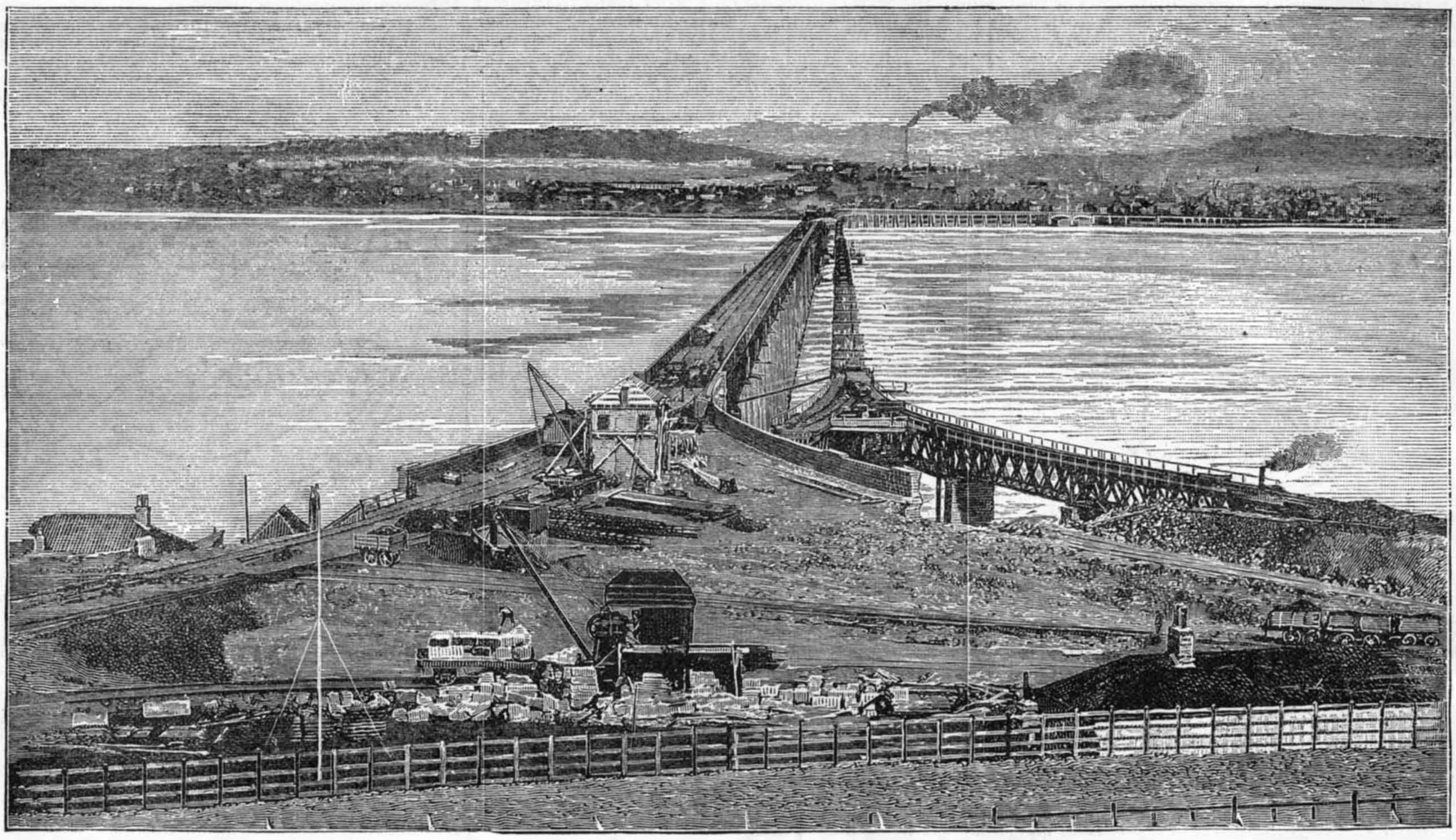
CORRUGATED TIRES.

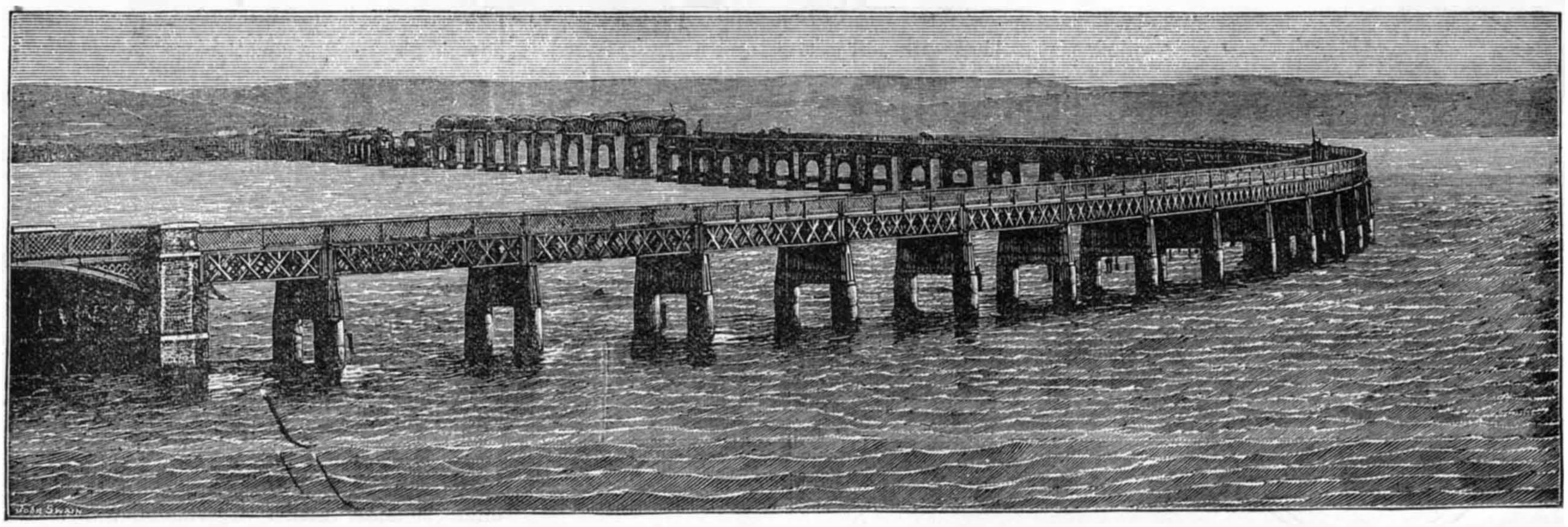
THIS invention is specially intended for securing perfect safety in driving vehicles on tramways. These tires thoroughly protect the wooded fellies of the wheels from being in any way damaged by the edge curb stone of streets or roads, or in turning corners of the same, while they can be as easily fixed to the present form of fellies of wheels as the ordinary plain tires.

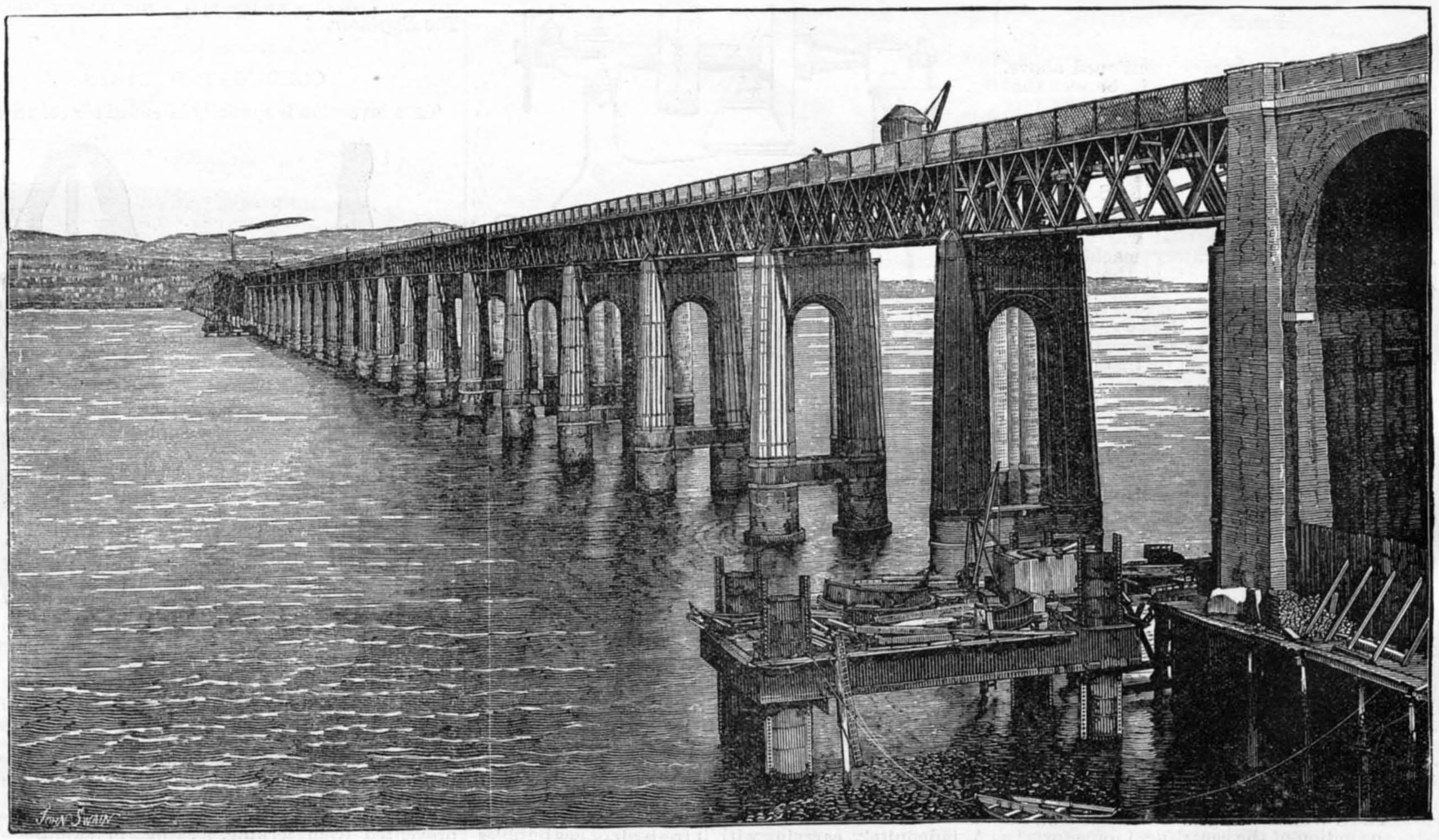


Vehicles fitted with these new tires are effectively prevented from jerking, locking, or skidding, when driving on or about tram lines, no matter at what angle. And the presence of the tram rails can scarcely be detected, owing to the route being rendered so smooth and easy.

THE NEW TAY BRIDGE. MR. W. H. BARLOW, M.I.C.E., F.R.S., ENGINEER.







THE NEW ENGLISH MULTICYCLE.

OF late years attempts have often been made to apply velocipedes to military purposes, the results of which have been so favorable that one might well expect to see companies of troops mounted on these vehicles. But heretofore only velocipedes have been tried, so that the new English invention, the military multicycle of the London firm, Singer & Co., is a decided advance in the methods for the transportation of infantry from one place to another. It will carry twelve men, who, in case of necessity, can draw a light baggage car or ammunition wagon. As the operators are seated in line, one behind the other, the vehicle can easily be steered, and offers less surface to unfavorable winds than if two or four men rode abreast. The multicycle can be propelled remarkably fast, making ten English miles an hour, or with practiced hands fifteen to sixteen miles an hour. And it suffers less than other velocipedes from bad roads, and can easily pass over railroad tracks. The entire control and guidance of the machine lies in the hands of the first man, and at a recent trial in London he had no difficulty in carrying out his part of the work, even in the most crowded streets. The multicycle required less room than a hansom for turning, and made its way without accident among numberless vehicles of all kinds. Military evolutions can easily be carried out on the machine, and, in case of attack, it can serve as a protection for the men, who can fire from behind it. The war department are trying to make the multicycle practicable for war purposes.—*Illustrirte Zeitung.*

THE NEW ENGLISH MULTICYCLE.

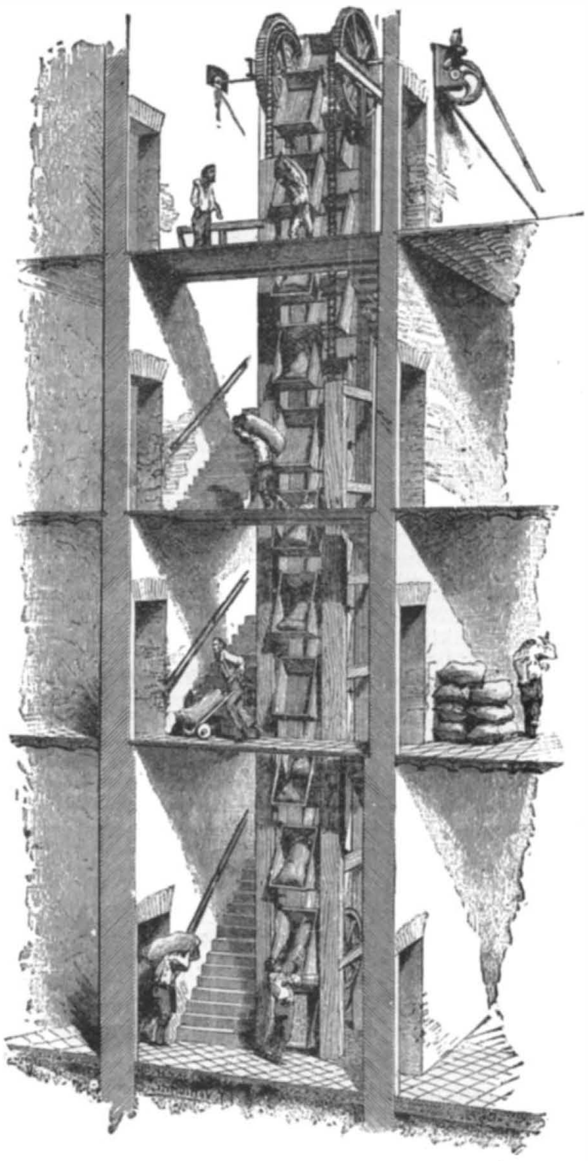
THE NEW TAY BRIDGE.

THE new Tay bridge is now finished, and has been lately tested prior to opening for traffic. The engravings which we publish are from *The Engineer*, and show the character of the bridge, and afford a good idea of the appearance of some of the main girders, both in place and in the process of raising to the top of the piers. The total length of the bridge is 3,600 yards—a little over two miles—and the height of the rails above high tide is from 79 ft. to 83 ft. For full accounts of the bridge we may refer our readers to our SUPPLEMENTS, 503 and 516, in which will be found drawings illustrative of the piers and the mode of sinking the pier foundations, together with the apparatus used for this work. There are in the bridge eighty-five spans, varying in length from 50 ft. to 230 ft., and the minimum clear headway for shipping is 77 ft.

CONTINUOUS WORKING BAG ELEVATOR.

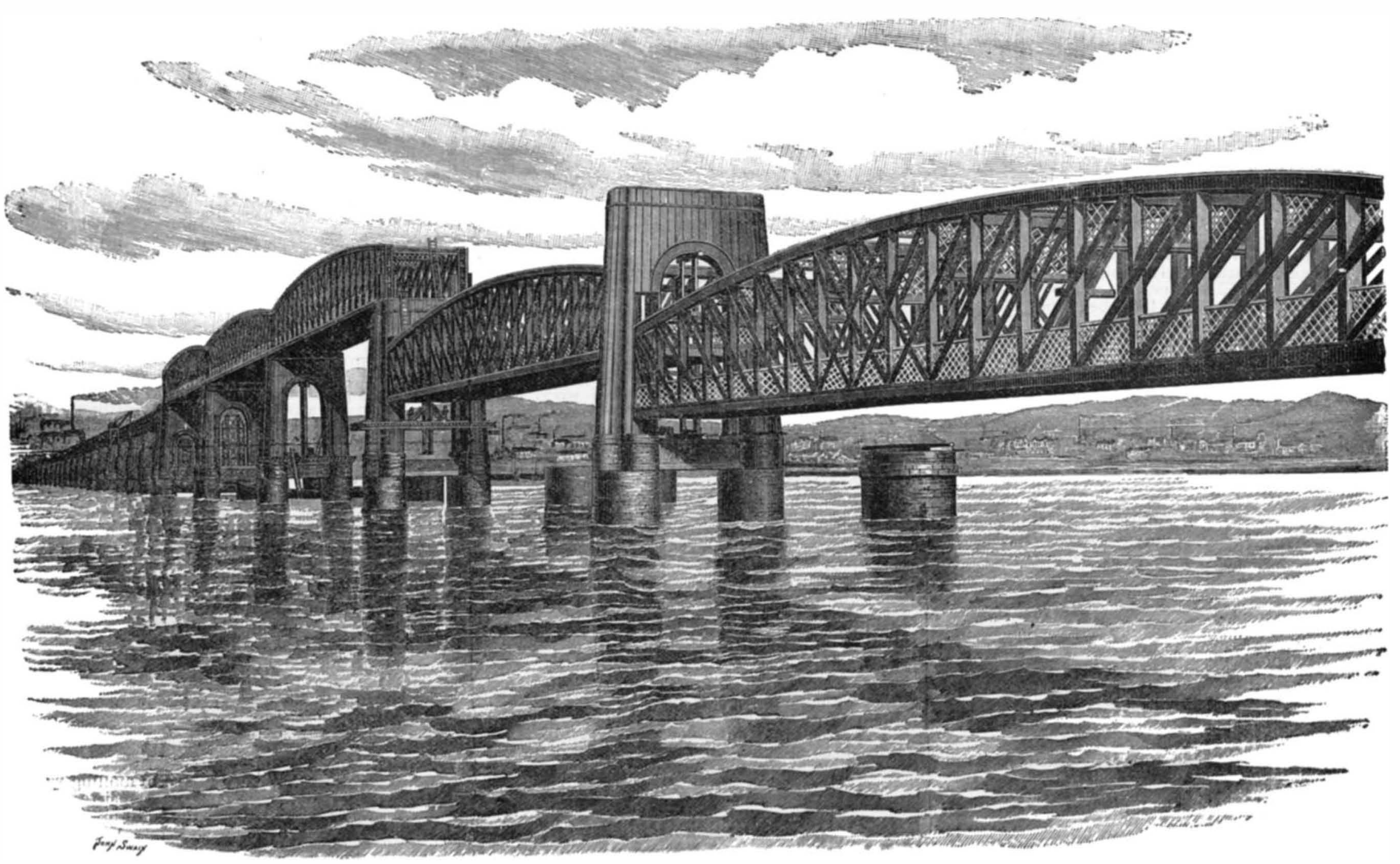
THE illustration shows an elevation of a continuous bag elevator, erected by Giuseppe Pouzio, engineer in the spirit distillery of Frat. Branca, in Milan. The excellent results attained by this machine, which has proved eminently practical and of certain and most regular movement, have induced us to call our readers' attention thereto.

It consists essentially of two Gall chains, continuous and parallel, passing below around two pulleys of 1,170 mm. (47 inches) diameter, and keyed upon the same arbor. Above, the same two chains pass around sprocket wheels, diameter 1,203 mm. (48 inches), 72 teeth, width



CONTINUOUS WORKING BAG ELEVATOR.

52½ mm. ($2\frac{1}{10}$ inches), which wheels when rotated carry around with them the chain, of which one part ascends as the other descends. The two chains are united every 1,365 mm. of their length by a round iron bar 25 mm. (1 inch) diameter, which passes through an iron pipe 38 mm. (1½ inches) external diameter, to which is hung by two iron links a wooden box, strengthened with iron hooks designed to receive the sacks to be lifted. Of such boxes in the case illustrated there are



THE NEW TAY BRIDGE.

twenty-four, which as they ascend and are drawn up by the chain carry up the sacks placed in them. As these boxes are only open in front, they can only be filled and emptied from one side. A sack, if placed in one of them, at whatever elevation, rises, and if not removed, reaches the highest point, and descends the entire height of the machine, always resting in the box, and having reached the bottom, begins again to ascend. The boxes always retaining the same position, a sack not removed will continue to ascend and descend, without the least inconvenience. The machine serves both for lifting and lowering. It is placed in the stair well of the grain magazine, and the boxes present their faces, corresponding to the working portion, to the part where the landings are. A gang of workmen on the lowest floor load the sacks, other gangs on all the landings remove them from the boxes as fast as raised. On account of the continuous motion of the machine, and its carefully chosen velocity, the labor is easy, well distributed, and rapid.

The boxes as shown in the illustration have a characteristic shape. It was established by careful trials so as to offer a secure receptacle for a sack, which, though somewhat carelessly thrown in, by its own weight tends to place itself in a secure position, without presenting too much difficulty for the removal at the proper time. These points have been fully developed. The loading is done by the workman, who carries the sack on his back to the front of the machine, and throws it in the instant a box appears at the proper altitude, depending on the height of the workman himself. The unloading can also be done on the back of the workman, he seizing the sack, placing his back against it, and carrying it off as the box, gradually rising, reaches a point where the operation can conveniently be executed. A workman, with but little practice in thus unloading, is exposed to no danger either from moving parts of the machine or sudden and exceptional movements. The boxes have a velocity of 120 mm. (5 inches) per second, and, taking into account the inevitable losses of time, it can be depended on to raise 300 sacks per hour. The boxes hold bags of 100–140 kg. (220–308 lb.), so that in a day of ten hours over 300 tons can be raised. The power required if all the boxes on the rising side are loaded does not exceed 4 horses for every 10 meters (32½ feet) of elevation. To give additional support to the sprocket wheels, small rollers are carried by hangers attached as shown in the drawing, which small wheels or rollers press up against the sprocket wheels, thus obviating any tendency of the axle to bend.—*L'Industria.*

TANNIN: ITS PRESENT AND FUTURE SOURCES.*

By Prof. HENRY TRIMBLE, of Philadelphia.

TANNIN is a colorless, shining, amorphous, astringent body found in many plants.

It varies according to the source from which it is obtained, but all varieties appear to have the common property of forming a dark blue or dark green color with ferric salts, giving precipitates with gelatin, and converting animal membrane into insoluble and imputrescible material called leather.

The use of tannin for converting hide into leather was well known to the ancients, but the separation of the principle as a distinct substance was not accomplished until 1793, by Deyeux. This compound, known as tannic acid when in the pure state, is prepared from galls when the pure acid is desired; this source giving it the name of gallotannic acid, to indicate its origin, and at the same time distinguish it from numerous other tannins from other sources. This gallotannic acid has been fairly well studied, and the opinions of chemists regarding it are much more in harmony than they are in reference to the numerous compounds under the general name of tannin. We will first consider the present sources of tannin which yield us the pure acid.

Galls are the most valuable and important of all tannin materials.

The oldest and best known variety being the oak gall, which results from the sting of an insect called *cynips* in the tender bark of the young shoots of *Quercus lusitanica*, variety *infectoria*, a small shrub three to four feet in height, indigenous to the eastern part of the Mediterranean basin.

The puncture causes the juices of the plant to collect around the eggs; and the resulting galls should be collected before the insect matures sufficiently to pierce the coating and escape, for after that time the amount of tannin is very much lessened. Galls at this stage of maturity are nearly globular, about three fourths of an inch in diameter, and of a blackish gray color. Those of a white color have been collected after the insect has escaped, and are consequently of inferior quality. The best galls come only from warm countries, those found in this country only yielding thirty to forty per cent. of tannin, while good Aleppo galls (the best commercial variety) yield from sixty to eighty per cent. tannin.

The *Chinese* variety of galls, found on the leaves of *Rhus semialata*, were not a regular arcticle of commerce until 1844.

They are very light, hollow, distorted by numerous protuberances, and completely covered by a thick velvety gray down. These galls are much used for the preparation of tannin, of which they yield from seventy to eighty per cent.

Tamarisk galls are obtained from *Tamarix orientalis*, growing in India and northern Africa. They are said to yield fifty per cent. of the purest tannin, and to impart to leather the best color and texture of any tanning material.

Barks.—Much attention has been given by our government to the development of tannin-yielding materials, by carefully determining the percentage of this constituent in the most promising plants.

Mr. Sargent, in his *Report of the Forests of North America*, says: "The amount of tannin contained in the bark of various trees of the United States has been determined. These determinations give the percentage of tannin; they do not indicate the real value of the bark of the species for tanning, which can only be determined by actual experiment made on a large scale, other properties in the bark, besides the percentage of tannin, affecting the value of the leather prepared with it. These determinations must therefore be regarded as approximations, which will serve in some cases to indicate species not now in general use for this purpose, which may be looked to as possible sources of tannin supply."

* A lecture delivered at the Franklin Institute, February 14, 1887.

Quercus tinctoria, or quercitron oak, is largely used in tanning, giving a reddish fawn colored leather, and depositing a fine bloom. It contains 5·90 per cent. of tannin and yields no gallic acid. The tree flourishes in the Northern and Middle States.

Quercus prinus, chestnut oak, yields a bark rich in tannin to the extent of 6·25 per cent., and is largely used in preference to all other white oaks in the Northern States.

Quercus falcata, Spanish or red oak, gives 8·59 per cent. tannin, and grows in the eastern United States from New York south to Florida.

Quercus densiflora, tan bark oak, grows west of the Rocky Mountains, and yields a bark containing 16·46 per cent. of tannin, which fact has made it the most popular of all tanning materials on the Pacific Coast.

In Europe, the bark of the *Quercus robur* and *pedunculata*, which grow there, are used more than all other tanning agents, but in this country there is a bark which, on account of its abundance, exceeds all others in importance in the tanning industry, namely, the *Tsuga canadensis* or *Abies canadensis*, popularly known as hemlock bark.

Varieties of this tree grow abundantly in the northern United States and Canada, and the bark yields, according to the variety and locality, from 13·11 to 15·72 per cent. of tannin. So great is the value of this material, that not only is it used in enormous quantities in this country, but it is largely exported. In order to reduce the cost of transportation and at the same time furnish a more available form of this bark, it is exhausted with water and evaporated to a thick or solid extract. This is accomplished by heating in closed copper boilers the ground or chipped bark with successive portions of water until exhausted, running the resulting liquid into a large copper vacuum pan, and evaporating *in vacuo* to the desired consistence, when it is run while warm into barrels or boxes for shipment.

The annual production is not far from 15,000 tons. This extract, containing from twenty to twenty-five per cent. of tannin, is one of the cheapest sources of this important material, and the use of it is undoubtedly on the increase; not only for tanning, but very largely also for dyeing purposes, where it forms an important adjunct to many of the more expensive extracts. It is well known that oak tanned leather is superior in texture and color to that tanned with hemlock; nevertheless, the demand for the latter steadily increases, both here and abroad.

According to the last census report, the annual production of hemlock was 1,101,526 tons, and of oak bark 353,245 tons. So great is the consumption, that the apparently inexhaustible forests of this wood are rapidly and surely disappearing; not alone on account of the bark, but also on account of the wood, although in many places the trees are felled, stripped of their bark, and allowed to rot. In Warren County, Pa., 5,000 acres were cut in 1880 for the bark.

Picea engelmanni, white spruce, on account of the large amount of tannin in the bark—20·56 per cent.—has been employed for tanning in Utah. The barks of some other species of spruce are likewise very astringent.

Castanea vesca, chestnut; both bark and wood are made into an extract. Such an extract is also largely made in France, and some of it occasionally finds its way to this country. A sample which came into my possession, said to represent a large lot, was heavily adulterated with molasses, which goes to show that it is the determination of the cultivators of the beet root to find an outlet for their products. Chestnut extract is largely used in dyeing, where it is valuable not only as a mordant, but also on account of the clear black which it gives.

Rhizophora mangle, mangrove, is a tree indigenous to all tropical countries, on the banks of rivers and in marshy places. On account of the rapidity and luxuriance of its growth, this tree may become an important source of tannin, which exists in the bark of the root to the extent of twenty to thirty per cent. The great objection to it is that it gives a bad color to leather, which must be corrected by the use of other more expensive astringents.

Acacia decurrens, mimosa, a handsome tree, eighty feet in height, indigenous to Australia and Tasmania, yields a bark very rich in tannin, said to reach as high as forty-two per cent. This material, and an extract of it, has been much used in England, and efforts have been made to encourage the cultivation of this and allied species in the colonies. In five years, the tree will yield a large quantity of bark. It has been suggested to introduce it in this country, and when our supplies from oak, hemlock and chestnut are exhausted, it may become a necessity, but not until then can we look for any artificial sources.

Quebracho (*Loxopterygium lorentzii*), indigenous to Argentine Republic, yields a bark and wood containing twenty per cent. of tannin. The wood is very hard and is, therefore, to a great extent put in the form of an extract before using in the French markets, where it is very popular. It is claimed for some of these extracts that they contain seventy to seventy-five per cent. of tannin. In all the above barks, it has been found that the proper time for collection is in the spring, when the sap is flowing. The bark is easily stripped off, and is much richer in tannin than that collected late in the season. It is also well known that trees growing on a limestone soil do not yield as much tannin as those growing on other ground.

Fruits.—Dividivi (*Cæsalpinia coriaria*), the seed pods of a tree, twenty to thirty feet in height, indigenous to West Indies, Mexico, Venezuela, and north Brazil. The pod dries in the form of the letter S, and contains from thirty to fifty per cent. of a valuable tannin, which, however, is depreciated by the other constituents, which cause rapid fermentation. On this account, the leather tanned with dividivi is soft, rapidly becomes discolored and spoiled in a damp atmosphere. The use in dyeing is not attended with the same objections, and I have seen them largely used by a dyer in Bradford, England, who told me they obtained from dividivi a better black than from any other tannin material.

Myrobalans (*Terminalia chebula*).—The fruit of a tree, forty to fifty feet in height, indigenous to India. This, like dividivi, is much used in dyeing and for toning the color of other tanning or dyeing materials. The amount of tannin is from forty to forty-five per cent.

Valonia (*Quercus ægilops*).—This oak tree grows in the vicinity of the Mediterranean, and we obtain from it the acorn cup, which, when ground, gives us a most valuable tanning material, imparting to leather both firmness and weight. When used alone, it renders the leather too hard and brittle, so that it is largely used in connection with myrobalans and mimosa.

Leaves.—Sumac is a name applied to various species of *Rhus*. In Europe, the *Rhus coriaria* is the most important, and furnishes to commerce the leaves which are so much esteemed by dyers and for certain kinds of tanning. This small tree, or shrub, grows extensively in the countries bordering on the Mediterranean, and especially in Sicily. Contrary to the experience in the United States, it is said to flourish best in a limestone soil. From 10,000 to 12,000 tons are said to be annually imported of this variety. Of course, it has been suggested that we cultivate our own, as several species grow wild in this country.

R. glabra and *R. copallina* have been recommended for this in addition to the Sicilian. Considerable attention has been given to this subject by our government, and valuable reports were published in regard to it in the agricultural reports for 1878 and 1881–82.

The plants are propagated from the young shoots which are found each year about the base of the older plant. These shoots are planted very much in the manner adopted for potatoes, and the cultivation is conducted similarly to that applied to Indian corn. They are planted in the spring, and when well started are cut down to within six or eight inches of the ground. The second summer they will yield a crop of leaves.

The leaves are gathered either by cutting the small branches or by stripping directly, leaving the small leaves on the ends of the shoots. A plantation is said to yield profitable crops for ten years. The average yield is 2,600 pounds per acre. After the second year, the leaves are more valuable. When the collecting is accomplished by cutting, the branches are allowed to wither, and are then carried to a shed and dried. The drying must be conducted carefully, in order to prevent heating and consequent fermentation and spoiling.

The branches when dry are beaten with a flail, and the leaves separated by sifting. When ground, the leaves are ready for market. The grinding is accomplished by heavy stones set on edge. Virginia is the State in which most attention has been devoted to this industry, and the crop reaches 7,000 to 8,000 tons. There is said to be a difference between the American and European products. The former yields from six to eight per cent. more tannin, but the accompanying yellow or dark color is a great objection to those who wish to have a fine white leather. This color is supposed to be identical with the quercitron in oak bark. The government chemists have decided that this coloring matter exists in large proportion in the leaves collected late in the season, consequently it is recommended to collect not later than the last of June. The amount of tannin reaches its maximum in July, but it is thought best to sacrifice this small amount, being 22·75 per cent. in June against 27·38 per cent. in July. The Sicilian product yields 24·27 per cent. of tannin. There are many difficulties in the way of sumac becoming a universal tanning material. A very considerable one is the tendency which the infusion possesses of becoming sour. This has been obviated by the use of extract of sumac which has been deprived of much of its coloring matter, and consequently is better in two ways.

The process consists in adding to the thin liquor, which has been run from the extractors into a large tank, oxalic acid in the proportion of one gramme to 100 liters. This saturates the lime which has come from the water used in extracting. Gelatinous alumina (aluminum hydrate) is then added in the proportion of 250 grammes to 100 liters. On filtering, a clear tannic extract is obtained, which is evaporated *in vacuo* to the desired consistency. I have examined such an extract, and found it very rich in tannin. Mucilage may also be removed by increasing the amount of alumina to four times that above mentioned. Such a process might be advantageously employed in this country for removing coloring matter from the infusions of sumac, which would admit of the leaves being gathered in July, when the proportion of tannin is the greatest. There are no means of knowing the exact amount of sumac produced in this country, but at least as much is gathered here as is imported, and probably a great deal more. This industry will undoubtedly become a very important one, for when the oak and hemlock fail, we must look to artificial growing for our tannin supply, and sumac is by far the most promising source for this object.

Canaigre root has also been considered as a possible tannin supply. The plant, *Rumex hymenosepalum*, from which the roots are obtained grows abundantly in a large part of Texas. The roots are in clusters, like sweet potatoes, weighing several pounds, and are quite fleshy, but become much wrinkled in drying. When dried, they are said to yield forty per cent. of tannin, and as at present they grow on waste ground, they are worth our consideration as a supply. There is, however, considerable red coloring matter present, which may limit their use.

Cutch is a dried extract from *Acacia catechu*, a tree thirty to forty feet in height, indigenous to India, Burma, and East Africa, and from *Acacia suma*, growing in South India and Bengal. The extract is prepared by cutting the trees when they are one foot in diameter, reducing all the woody parts, except the small branches, to chips, and digesting these chips in water in earthen vessels over slow fires. When sufficiently thickened after decantation and further concentration, the extract is poured into rude clay moulds or mats, and allowed to harden, in which form it comes into commerce.

Gambier is another variety, being an extract of the leaves of *Uncaria gambier* and *U. acida*, a climbing shrub indigenous to Ceylon and Sumatra. The leaves and young shoots are exhausted by boiling with water, the decoction is evaporated to the consistence of a sirup, when it is placed in buckets. A man plunges two sticks into two of these buckets, and works them up and down until the mass sets—a result which could not, it is said, be attained in any other way. This thick, yellowish mass, resembling clay, is poured into shallow

boxes, cut into small cubes, and dried in the shade. The importation of cutch, all varieties, in 1880, reached 23,000 tons, while in 1882 it fell off to 7,000 tons. England imports about 20,000 tons annually of gambier alone.

Polygonum amphibium, water knotweed, has attracted some attention as a source of tannin in Illinois, where it has been used by a few tanneries.

To summarize, it may be said that the future supply of the imported tannin-furnishing materials is not likely to become a concern to us, as the supply is either well nigh inexhaustible, or else the product of cultivation. We cannot afford, however, to depend on foreign supply to furnish material for the tanning and dyeing industries, consequently our own resources must be taken care of or developed. At present, the hemlock, oak, and chestnut give us all we need, but as this supply will soon be exhausted unless provision for a continuation of it is made, we must face the necessity of artificial sources at no distant date.

The sumac has already become a reality among the artificial sources, to be followed by such promising materials as mangrove and mimosa, which having objectionable features, will have to be studied so as to adapt them to our needs.—*Jour. F. I.*

IMPROVED CAMERA CLAMP AND TRIPOD HEAD.

THE well known tripod screw for securing a camera firmly to the head of a tripod has many disadvantages, which have several times been pointed out, particularly when the camera is used in photographing architectural subjects. The object of the device shown in Figs. 1 and 2 of the engravings is to overcome the defects incident to the common screw clamp, by avoiding all separable parts and the wear of the screw thread, and at the same time to permit the camera to be easily and quickly secured to the tripod. A truncated cone shaped casting, having a projection provided with a socket or seat set flush with the top of the tripod head, is secured by screws to the under side of the head. The lower face of the casting is planed or filed off on a bevel. Passing through the hole drilled in its center is the fastening spindle, having a solid head turned on its upper end, and a thumb-actuated disk, held rigidly by suitable screws, at its lower end. The upper face of the disk is beveled to correspond with the bevel on the casting above.

Located in a slot in the spindle is a very light steel spring (see Fig. 2), which, in pressing against the walls of the hole, holds the spindle, by friction, in any position, as it is elevated or depressed, and at the same time allows the spindle to be freely rotated. When the spindle is not secured to the camera, its head is drawn down into the seat in the upper face of the casting, so that nothing will project above the surface of the tripod head.

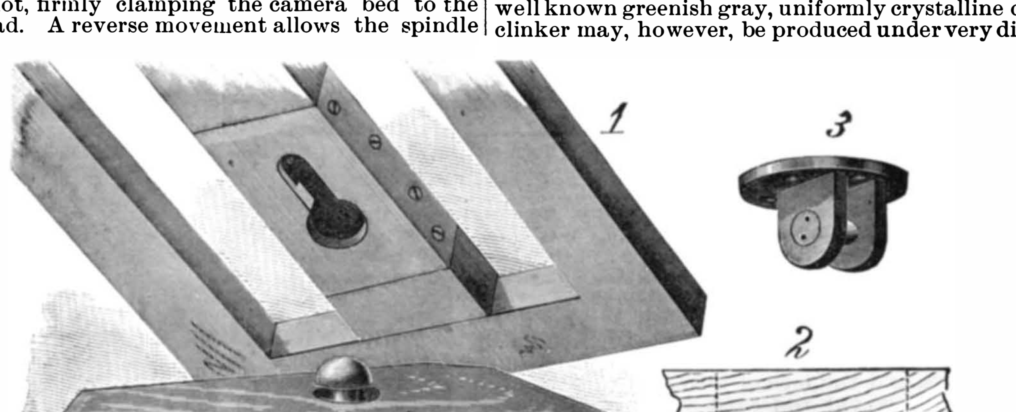
A light metal plate, having its ends bent up around the sides of the central bar of the camera bed frame and secured thereto by screws, as shown in Fig. 1, has a key hole slot in which the head of the spindle of the clamp fits. The wood of the camera bed is dug out back of this slot, forming a recess, as shown in Fig. 2. It will be noticed this method of fastening the plate to the camera bed frame secures unusual strength, since the pull on the screws is at right angles to their length. To prevent any possible slipping of the camera after it is secured, a slight depression is provided in the inner surface of the plate at the end opposite the entrance slot, clearly seen in Figs. 1 and 2.

To clamp the camera on the tripod head, it is only necessary to rotate the spindle by the thumb disk until the two beveled faces are parallel with each other, then to push the spindle upward until the faces meet, which leaves the spindle head projecting above the tripod head. When the camera is then set upon the tripod, the head of the spindle enters the key hole slot, and by a slight movement lengthwise the head is brought directly over the seat of the slot. By slightly rotating the spindle by the fingers with the thumb disk the beveled faces act upon each other like a cam, and at once draw down the spindle head into the seat of the key hole slot, firmly clamping the camera bed to the tripod head. A reverse movement allows the spindle to be pushed up, so that the camera may be quickly removed.

It will be observed that the clamp is very simple, effective, and strong, is, in fact, more durable than a screw, not liable to get out of order, and with it a camera can be very quickly adjusted to a tripod.

The inventor prefers the triangular form of a tripod head, made either of wood or vulcanized fiber, as shown in Fig. 1, and has the tripod legs rigidly secured thereto, to avoid the wear and racking motion incident to detachable legs, which frequently occurs when photographing in a brisk wind. The fastening for the leg of the tripod is shown in Fig. 3, and consists of a round plate, provided with two projecting ears having a pin riveted between them, which passes through a hole in the extremity of the tripod leg. The plate is secured to the underside of the tripod head by screws. This construction makes a very rigid and steady bearing for the tripod head and camera. Both may be carried about on the shoulder without in any way straining the clamp.

Different sized cameras may be used on the one tripod head. The improved clamp may be fitted to any tripod head or camera. Further information may be had from the inventor, Mr. M. P. Warner, Holyoke, Mass., who is prepared to furnish the improved clamps and fit them to tripods.

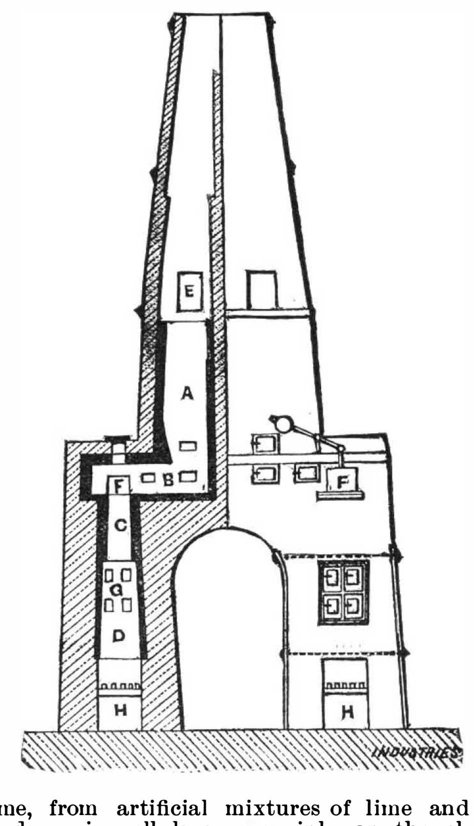


WARNER'S CAMERA CLAMP AND TRIPOD HEAD.

THE DIETZSCH CEMENT KILN.

AT a meeting of the North of England Cement Manufacturers' Association, held during the past winter session, a paper was read by Dr. Otto Trechmann, on the process of burning cement in the Dietzsch kiln; and the following is a brief abstract of the details then given:

The possibility of making cement of permanent indurative properties, combined with permanency of volume, from artificial mixtures of lime and clay, depends, as is well known, mainly on the chemical combinations which ensue when the exactly gauged and closely approximated particles clinker together under the influence of a high temperature. Consisting, as such a mixture does, of substances of very different fusibility, of which the lime and the silicate, represented by the clay, are the extremes, the process of calcination will be a gradual one, commencing with the fusion of the clay, which, gradually taking up more and more lime, results in a mass requiring, for the completion of the clinkering process, a very high temperature, estimated at 1,650° C. (lime requiring 900° C. to 1,000° C.). Though experiments are now in progress, definite data are as yet wanting to determine the time required to produce efficient clinker under given circumstances of temperature. The practical cement maker takes the color and structure of the product as his guide. The well known greenish gray, uniformly crystalline cement clinker may, however, be produced under very different influences of heat. Thus, the sample burnt within an hour in a small laboratory furnace gives as perfect a cement as the slow burnt kind of the dome or circular kiln, and it may be taken as an axiom that a short clinkering temperature will suffice to thoroughly burn moderately sized pieces of cement. The main hindrance to the adoption of a continuous process is the fact that with cement the mass remains neither unaltered in form, as a brick or burnt lime, nor does it become fluid, as metals or slags, but, approaching the latter state, becomes soft and viscid, the pieces welding together and to the sides of the kiln. Obsolete experiments with the ordinary kiln failed, because the superincumbent weight of the unburnt cement and fuel compressed the clinker into a solid, immovable mass; while the circular kiln, originally intended for use upon materials that do not undergo a change of form, though perfectly successful for burning cement, involves the necessity of constantly heating up cold wall spaces, with a further drawback that the cement around the holes requisite for the insertion of fuel is clinkered and welded in advance of the remainder of the charge, thus interfering with the draught, and prolonging the period necessary for calcination.



In the present kiln, it has been sought to combine the principle of the cone kiln with the advantages of the circular kiln, and instead of allowing the heat to circulate through the mass, to pass the material, with the aid of gravitation, through a canal kept at a constant high temperature. This is achieved by dividing the vertical shaft of the former horizontally into two parts, and connecting the upper with the lower by a horizontal channel, thus reproducing in a manner several chambers of the circular kiln; not in a horizontal plane, but vertically superimposed. The upper part of the lower shaft is retained at a clinkering temperature by the addition of fuel, and all superincumbent weight on the clinkering cement is obviated, thus permitting it to descend by its own weight, so soon as the decrease in volume, due to the completion of the calcining process, takes place. With this movement a disturbance of the mass ensues, and the cooling operation, aided by a slightly conical form of the shaft, tends to prevent adhesion.

The figure represents a double kiln, produced by simply building two kilns back to back. The individual kiln consists of three essential parts, of which the two lower ones, C and D, lie in a different vertical plane from the upper one, A. A may be called the warming or preheating chamber, C the calcining chamber, and D a continuation of it, the cooling chamber. At E are doors or openings for charging A with dried slurry. The covered calcining chamber, C, is connected with A by means of the arched horizontal channel, B; and the cooling chamber, D, terminates with ordinary fire bars, H, through which the air to supply the whole system enters. The finished clinker is drawn at H, and the calcining chamber, C, as the central point of the system is the one where the main operation of burning is carried out, where the cement becomes soft and plastic, alters its form, and eventually welds into larger or smaller blocks, and inclines to adhere to the walls of the furnace. This part is, therefore, arranged in such a manner that it is accessible from all directions by means of small openings, G, for the removal, when necessary, of adhering lumps. In order to put the kiln into operation, A is filled with dried slurry, D with clinker, and C with alternate layers of dried stuff and coal or coke. After the fuel is fired, the heat escaping from C strikes through the dried slurry lying on B and in A, and is almost totally absorbed, only sufficient passing through to keep up the requisite draught in the chimney-like continuation of A. As soon as the cement is sufficiently calcined in C, a quantity of clinker is drawn at the bars, causing the whole mass in C and D to sink; thereupon fuel is introduced through the furnace doors, F, and preheated slurry is, with the aid of flat shovels, turned over from B into C, the fuel and dried mass being placed in layers until C is filled again. This operation is repeated at intervals of half or three-quarters of an hour, and the burning proceeds continuously without further interruption than may be caused by the adhesion of clinker to the sides of the furnace. It is apparent, from this description, that the fuel is utilized to its utmost extent, for the cold air entering at the fire bars, coming into contact with the hot descending clinker, becomes gradually heated to a white heat before reaching the fuel, thus producing a combustion akin in intensity to that of the regenerative furnace. It is, however, not completed at this point; but the mixed products of combustion, which entail such an enormous loss of available heat in the ordinary kilns, here strike the dried mass lying at B, and which at this point is in a state of bright cherry redness and incipient fusion, and are completely burnt.

This system of burning cement, lime, etc., therefore, offers a double advantage to many previous systems—first, in the complete utilization of the fuel, combined with a minimum loss of heat, since the unavoidable radiation is restricted to one part of the kiln; secondly, because the mass to be burnt remains for the shortest possible time at the point of greatest heat, the critical period where over or under calcination so easily takes place. The amount of fuel required for each of the three principal systems in use for cement burning is, approximately, per ton of clinker: For the open or chamber kiln, 22 to 33 per cent. of coke, or 4½ to 6½ cwt.; Hoffmann type, 17 to 18·5 per cent. of coke, or 3½ cwt.; Dietzsch type, 10 to 16 per cent. of small coal, or 2 cwt. to 3 cwt., or, roughly, one-third to one-half of the weight of a cheaper and cleaner fuel.

This extraordinary saving is explained in part by the manner in which the combustion of the coke takes place in the ordinary kiln. Analyses of the escaping gases reveal a large amount of only partly consumed carbon, in the form of carbonic oxide.

One of the chief difficulties of the inventor, and the cause of great skepticism regarding the success of the invention, was the tendency of the clinker to hang. It was solved, after many experiments, by adopting a basic lining. The acid lining of the ordinary fire brick coming in contact with the basic cement produces a flux, which, running down the walls, cools and cements the already solidified clinker to the lining. With a material of slightly greater basicity than the cement itself, and a consequent greater infusibility, a fairly permanent lining, free from this objection, can be made. Bricks of such a nature are prepared from cement with the addition of lime or magnesia, in a special brick-making machine, and are placed for a depth of some six feet in the calcining chamber. This lining requires renewal about three times per annum, at a cost of about £20 in labor and materials for each time, and four days are requisite for the purpose. With care, however, the lining will often last much longer, and has occasionally not required renewal for ten months. Increased experience will, doubtless, reduce this item of expenditure. The quantity of cement burned with this kiln varies considerably with the nature of the raw materials; a double kiln will put

out from 15 tons per twenty-four hours of limestone cement, and up to 30 tons with chalk cement. Exhaustive comparative tests made by Professor Tetmeyer, of Zurich, have, as might be expected, shown that the quality of the cement is superior to that burnt in other kilns. The quantity of impurities in the form of ash, etc., being very materially lessened, will account in part for a better quality. Two very important factors in favor of this system are the small capital outlay and ground space required for a comparatively large output. Professor Tetmeyer estimates the relative cost of ordinary dome kilns, the circular, or Hoffmann, and the present kiln, for a production of 20 tons of clinker per day: Six dome kilns, at 25 tons per charge, £333 each—£2,000; half of a circular kiln of eighteen chambers, at 40 tons of clinker per day at £2,500—£1,125; and one double Dietzsch kiln, at £700; in each of the latter instances without the surrounding buildings, or about two-thirds the cost of a circular kiln plant, and one-third of the capital required for dome kilns. The space required for the Dietzsch kiln, including building, is given at 130 square yards.—*Industries.*

TECHNICAL TRAINING CONSIDERED AS A PART OF A "COMPLETE AND GENEROUS EDUCATION."*

By R. H. THURSTON, M.A., Doc. Eng., Director of Sibley College, Cornell University, Ithaca, N. Y.

GENTLEMEN OF THE INSTITUTE, LADIES AND GENTLEMEN: On an occasion like the present, when we are called together to witness the final act in a long course of special training which has, it is presumed, fitted our young friends for entrance upon their life's work, the question naturally arises: What is the real object of this preliminary labor and of this carefully schemed and conscientiously prosecuted course of instruction in literature, the sciences, and the arts? Why is education here given its peculiar form and its definite limitations? What is the purpose and why is this the method of preparing young men for the duties, and to take advantage of the opportunities, that life may be expected to offer them? What is a real education? What a complete education? What the limitations that may be admitted, as difficulties arise in the endeavor to secure a "complete and generous education," as Milton so expressively denominates it?

Euripides has said that "one wise head is worth many hands;" but here we have seen young men brought into a scheme of education which seeks to make the hands cunning as well as the mind, and we would further ask: What part of education is this? Why teach it here?

Milton, in his well known "Tractate on Education," thus defines education: "I call, therefore, a complete and generous education that which fits a man to perform justly, skillfully, and magnanimously all the offices, both private and public, of peace and war."

No better definition has been produced in the nearly two and a half centuries which have intervened between our time and that of the great poet. A "complete and generous education" is what every man needs and what every citizen should be aided to gain. The student of an art is not by that vocation made an educated man; no complete education can be gained by following a single or even a dozen lines of study; a generous education is not that of the great literatures, of the classics, of mathematics, of the sciences alone. The completely educated man is he who has given time, thought, noblest endeavor, to the attainment of some satisfying knowledge of the sciences, the literatures, the arts, the philosophies, the moral, intellectual, and physical attainments and accomplishments of highest life in this wonderful world of ours, in which we are so apt to live the narrow, isolated life of the sea anemone, rather than that of the heaven endowed soul, free to traverse earth, air, and sea, to explore every world, and to test every good of the seen and the unseen. The generously educated man has every faculty trained and developed to its best estate, and is given such strength, such usefulness, such power of acquisition of pleasure and highest profit, as his Maker has intended.

The development of the individual has a natural history which accords with the rational history of the complete education of the citizen the more perfectly as that education the more perfectly approaches the ideal to which our study of the best education leads us. It requires no argument to convince the thoughtful mind that the building up of an intellect and the training of a mind must have some natural and most efficient method and scheme, or that this natural order of procedure must correspond thoroughly with the plan of development of the faculties, and of their application to the purposes for which they were designed. We may, therefore, give a moment's thought, with profit, to the consideration of this individual history and to this natural process of development of the faculties and powers of man.

I am inclined to divide the life of the individual into five distinct periods or sections:

I. The stage of perception;
II. The period of absorption;
III. The time of action and accomplishment;
IV. The period of direction and counsel;
V. The time of meditation and culmination of wisdom.

A child has its perceptive faculties in highest efficiency at the very start; its mind is engaged constantly in the survey and examination of all that constitutes its environment; it thinks but little; it perceives much and accurately; it acts only by intuition and impulse; it is perpetually engaged in receiving impressions through the senses and in seeking new experiences; its mind is mainly employed in the perception of these new experiences, and its memory is stored only with such as it distinctly appreciates. All its mental operations are like those of the lower creatures; it sees, feels, hears, enjoys the operation of the senses, remembers all that is pleasing and all that is unpleasing or painful, and seeks to repeat the former and to avoid the latter; just as the birds see, as the insects feel, as the animals of whatever kind seek to repeat pleasing and to avoid the repetition of painful experiences. The young child does not distinctly reason, and has no consciousness of the processes by which it is becoming a man.

The youth retains something of this first characteristic of humanity; but his most striking attribute is the facility with which he avails himself of the perceptive faculties, and of his memory, to acquire all that kind of knowledge which can be transmitted from one individual to another; his is the period of absorption of information and experiences from others, either through the study of books or the conversation of his elders and companions. His perceptives are less acute than before; but his memory for impressions conveyed from others and his understanding of lines of reasoning and of argument originated by his elders have become sufficient to make them the means of his education in the next higher stage to which he has now attained. He is passing from the period in which the kindergarten and the Froebelian method are his only proper means of education into the next higher condition, in which, while the child's school may still contribute much in matter and method, the use of books and of oral communication of ideas, facts, and reasoning may be made an important if not the principal means of instruction. Object teaching is supplemented properly by abstract thought. It is by the combination of the two methods of gaining knowledge that the school education of the individual is completed; the brain, like the body, is thus matured and made ready for life's work, for action.

The young man or the young woman, mature in body and developed as to faculties and all natural powers, instinctively seeks to apply those powers, and enters upon the period of action and of accomplishment. The perceptive faculties have stored the memory with all the familiar impressions received by the senses during the ordinary operations of life; the mind has been enriched with useful knowledge and prepared by study and carefully directed thought to meet successfully the opportunities and the tasks that life is about to present to the now active and ambitious, earnest and energetic novice, in a world full of work to be done and of rewards for the intelligent and earnest ones among the crowd of incapables. It is in this stage of life that the work of the world is accomplished, that all great tasks are done, that every mighty revolution is effected. Our young men and our young women are they who directly apply the lever of Archimedes and move a world.

Middle age is the period of contriving thought, of the carrying out of plans, and of the direction of the energies of the youth coming into manhood and womanhood to do the work of the rank and file under the supervision of these captains and colonels and generals of the great armies of peace, and of war as well. "Old men for counsel, young men for war," most certainly! But it is the steady thought, the quick observation, the trained faculties of middle life, that give the talent for successful direction and guidance in the struggle, for leading the bravest troops on to victory, and which confer correctness of judgment and promptness of action in emergencies, power of concentrating and guiding all available energies by well-planned strategy, and, throughout long campaigns, for most effective work. Middle life is the time for grandest generalship.

Age, before senility, is the time of meditation, of wisdom deduced from long experience, and, by habitual thought, from all the paths of life. This is the period in which counsel can be most safely given, and in which the great lessons of life may be safely taught. The work of life is done; all its great experiences coming of work and action have been gained, and the thoughtful mind of the old man seeks a reason for all and a lesson from all—reasons and lessons which he alone can perceive and he alone can teach. "Old men for counsel"—old men who have traversed all the length of life's devious and labyrinthine ways, who have seen all and felt all, who have been many years studying the problems of life and seeking the meaning and purpose of all.

And thus the education of the individual should be similarly divided into its periods of instruction through the perceptive faculties, first; through the processes of intellectual absorption with perception, secondly; thirdly, by giving opportunity of action and of application of elementary knowledge while acquiring wisdom; and, fourthly, by opportunities for direction of others in the various paths of learning and experience; while, as in the order just indicated, the time for meditation follows at the last, so here should the final period of the education of the intellect and of the soul be one in which meditation, thought, comparison of experiences, and a general survey of the whole field which has been traversed give perfect completeness, so far as human wisdom may, to human education. The child should learn through the processes indicated by Froebel and his followers; the youth should be taught, without giving up these methods entirely, by text-book and lecture, always illustrated as much as possible by real phenomena and by his own stimulated and original thought; while the young man should be shown how to begin to do and to accomplish, to enter upon his apprenticeship in the great work of existence. Then the men of middle age become our best directors and active leaders, and the men of gray heads and beards become naturally our respected counselors and our legislators, the guides and the regulators of this wonderful mechanism of social life.

In following this order of education, we are thus led to the presentation to the budding soul of all that a child can perceive and comprehend without reasoning, to the youth those facts which constitute science and those principles which are easiest of comprehension, and which demand least logical power, and to complete their education by finally presenting to them the higher philosophies and all that wide range of human knowledge which has been the product of highest genius, and which can only be well comprehended by a fully developed and well-trained mind.

For the child we would teach observation; for the youth we would prescribe study; for the mature mind, or for the youth approaching maturity, we would provide inducements to reflection, to reasoning, and to original thought. The child should be taught to use its faculties, and especially its physical powers; the youth to apply them to definite purposes; the advanced student to make use of mind, as well as body, in the accomplishment of defined ends having useful application in "the sequel of his life." Give language to the child, but reserve grammar for youth. Teach the little ones the entrancing facts of natural history, but leave for a few years the classifications and all biological philosophy; let the baby learn of itself to count, if you will, but force no heavy mathematical processes or formulas through its tender brain; wait for that until the child begins to take them in naturally, and can find pleasure in their conquest. Give boys and girls manual training; teach the youth every branch of industrial art and of trade education; offer to young men and women every opportunity to apply usefully in their chosen professions all the arts, all the sciences, all that literature can bring to aid them. Thus the complete education may be secured for all at least possible cost in time and strength, the slowly developing mind taking in one after another of its parts, each in proper order, and each coming forward as the mind is becoming fitted to take it up and to profit by it, the memory accepting first the facts of perception and observation, and later the results of reasoning and deliberate thought.

Not every youth can be made an Admirable Crichton or a Leonardo da Vinci; but every one of these young minds can be made the best that its Creator has intended. Only here and there can be found the material for a Bacon, a Newton, a Franklin, any more than for a Milton, a Tennyson, or a Longfellow. But we may, nevertheless, give to each body its highest development, its maximum strength, endurance, health, and symmetry; to every mind its noblest development; to every memory all the knowledge that careful selection, systematic arrangement, and proper correlation can enable it to store within its utmost capacity; and to every soul all the thought and wisdom that its Maker has given it capacity to gain and to use. Our task is not to give to the individual a definite amount of learning and working power, but to seek to awaken every power, to develop every faculty, to strengthen every fiber of every muscle and every ganglion and lobe in nerve and brain, in such manner that he shall be all that God's gifts may give him power to be.

The form and the scheme of a well-planned education must thus be determined partly by the natural aptitudes of the race, partly by the tastes, talents, and idiosyncrasies of the individual, and partly by the specific purposes which the education is intended particularly to subserve. That the purposes of education have not in the past been fully met by the usual and generally approved methods is evident from the testimony of innumerable witnesses of unimpeachable judgment, as well as by the fact that we are seeing a great revolution and the introduction of a so-called "new education," which is rapidly taking the place of the old with the great masses of the people, though to a less extent with the great body of educators of the world. The change is a protestant movement against the established systems of the past centuries. Its Luthers and its Calvins are to be found, as in the reformation of the church, among the ablest of former communicants. The most effective and well-directed protests are made by the most eloquent and most scholarly of the alumni of the older institutions. Let me quote a few of these revolutionists, and, as I quote, note the various points in the indictment, and observe how perfectly the newer education meets every objection to the old, and provides for the filling of every hiatus in its curriculum. Note, too, how it meets every demand of the more philosophic scheme for a true education of the people, for the life and work of the people. Compare the new system with the old, and then compare both with the natural system to which we are approximating here.

The late Dr. Draper, the author of that great work, the "Intellectual Development of Europe," and the greatest historical philosopher that has yet appeared, if I may venture an opinion, in his "Thoughts on the Future Civil Policy of America" asserts that "education should represent the existing state of knowledge, but in America this golden rule is disregarded, especially in the case of the higher establishments. What is termed classical learning arrogates to itself a space that excludes much more important things. It finds means to appropriate, practically, all collegiate honors. This evil has arisen from the fact that our system was imported from England. It is a remnant of the tone of thought of that country in the sixteenth century; meritorious enough and justifiable enough in that day, but obsolete in this. The vague impression to which I have referred, that such pursuits impart a training to the mind, has long sustained this inappropriate course. It also finds an excuse in its alleged power of communicating the wisdom of past ages. The grand depositories of human knowledge are not the ancient but the modern tongues. Few, if any, are the facts worth knowing that are to be exclusively obtained by a knowledge of Latin and Greek, and, as to mental discipline, it might reasonably be inquired how much a youth will secure by translating daily a few good sentences of Latin and Greek into bad and broken English." But Dr. Draper was something of a radical and an iconoclast, and his testimony may not be accepted by those who are of a more conservative disposition, and we will turn to one who was distinguished for his exactitude no less than for the breadth and amplitude of his learning.

Sir William Herschel, while engaged in his astronomical observations at the Cape of Good Hope, many years ago, in a letter to Dr. Adamson, relating to the proposed scheme of instruction in the college in which that gentleman was interested, in South Africa, says: "A good, practical system of education ought, in my opinion, to be more real than formal. I mean should convey much of the positive knowledge, with as little attention to mere systems and conventional forms as is consistent with avoiding solecisms. This principle carried into detail would allow much less weight to the study of language than is usually considered its due in our great public schools, where, in fact, the acquisition of the latter seems to be regarded as the one and only object of education; while, on the other hand, it would attach great importance to all those branches of practical and theoretical knowledge whose possession goes to constitute an idea of a well-informed gentleman." And, in a letter to the public school commissioners, he writes: "I should consider any system radically faulty which should confine itself to the study of the classical languages, and to so much of Greek and Roman history as is necessary to understand the classical authors, as its main and primary feature; and should admit, and that reluctantly, a mere *minimum* of extra-classical teaching. Such a system must necessarily, I conceive, suffer the reasoning faculty to languish and become stunted and dwarfed for want of timely exercise in the years between fourteen and twenty, when the mind has become capable of consecutive thought and of follow-

* An address delivered at the seventeenth annual commencement of the Worcester Polytechnic Institute, 1887.

ing out a train of consecutive argument to a logical conclusion."

It will be observed that we have not here the condemnation of the classics as valuable, as essential, elements of a complete and generous education, but only a protest against their exclusive use as a means of education. The assertion is that they alone cannot give a complete and generous education, since they do not include any part of that almost infinite accession of learning which the world has gained during the past twenty centuries. These studies contain none of modern science, of recent philosophy, of modern thought and late research in the thousand and one fields which the ancients were only able to touch without ever entering or, in many cases, which they were never allowed even to see from a Mount Pisgah, as a promised land into which their posterity might pass. This protest is against the assumption that all progress in education ceased when the Greek and Roman civilizations perished; that Plato and Socrates had no successors; that Aristotle left nothing for moderns to study; that Cicero monopolized the wisdom of all statesmen; and that Archimedes and Euclid and Diophantus came of races as perfect in mind and as inimitable in attainments as were, physically, the forms represented by Phidias or the heroes of Homer. It is in this indictment that all our great minds join; it is here that the mightiest intellects perceive the weakness of the systems which, say what we may of them, gave those intellects all the material of which they have made such glorious use in the erection of those beautiful temples which give them fame.

That grand old thinker, my old friend and preceptor, the late Dr. Wayland, in his address at Union College a half century ago, nearly, says that he would have every study so taught that "it should not only increase our knowledge, but also confer valuable discipline; and that, if it does not accomplish both of these results, there is either some defect in our method of teaching, or the study is imperfectly adapted to the purposes of education." He urges that "there seems no good reason for claiming pre-eminence for one study over another, at least in the manner to which we have been accustomed;" and he concludes that "our whole system of education and instruction requires an honest, thorough, and candid revision. It has been for centuries the child of authority and precedent. If those before us made it what it is, by applying to it the resources of earnest and fearless thought, I can see no reason," he says, "why we, by pursuing the same course, might not improve it. God intended us for progress, and we counteract his design when we deify antiquity and bow down and worship an opinion, not because it is either true or wise, but merely because it is ancient." And we are thus led to ask: What are the missing links in this chain, and how are they to be gathered up, shaped into appropriate form, and introduced into the structure to perfect our complete and generous education? What have we moderns that the ancients had not? and what is the place which the new must take beside the old? How are we to complete the edifice which, noble in its unfinished state, is to become inconceivably greater and more magnificent when the missing parts are built into it.

Prince Albert, the late noble Consort of the Queen of England, in an exceedingly interesting and remarkably thoughtful address delivered in Birmingham many years ago, contrasting the results of the study of science and of the progress of scientific knowledge, in promoting the welfare of the race, with other forms of knowledge says: "The study of the laws by which the Almighty governs the universe is therefore our bounden duty. Of these laws our great academies and seats of education have, rather arbitrarily, selected only two spheres or groups—as I may call them—as essential parts of our national education; the laws which regulate quantities and proportions, which form the subject of mathematics, and the laws regulating the expression of our thoughts through the medium of language, that is to say, grammar, which finds its purest expression in the classical languages. These laws are the most important branches of knowledge. Their study trains and elevates the mind, but they are not the only ones. There are others which we cannot disregard, and which we cannot do without." It is these other as yet unquarried and uncut stones that we are to seek to introduce into our edifice. It is these parts which we are endeavoring here to make good use of in the production of the ideal education; it is by the introduction of these parts that we form the new education. It is not necessarily, nor even desirably, the fact that the new must exclude the old; on the contrary, the new should include the old whenever possible; but it is the new which we think essential and the old less essential if we must choose.

Emerson says of books in his address on the American scholar:

"What is the right use? What is the one end which all means go to effect? They are for nothing but to inspire. I had better never see a book than to be warped by its abstractions clean out of my orbit, and made a satellite instead of a system. The one thing in the world of value is the active soul. This every man is entitled to; this every man contains within him; although in almost all men obstructed and as yet unborn. The book, the college, the school of art, the institution of any kind, stops with some past utterance of genius. 'This is good,' say they; 'let us hold by this.' They pin me down; they look backward, not forward. But the eyes of man are in his forehead, not in his hindhead; man hopes; genius look forward; genius creates."

The book is like the mechanic's tool; it is a means to an end; it gives us the wisdom and the thought of the good and the great, the wise and the far-seeing; but it must be properly used, or all our time and labor, our patience and our expended energy, go for naught. Rightly used, complementing the study of life, of men, of nature, of art, and of the flowing currents of industry and commerce, as in actual existence all about us; read with thought and clear apprehension, marking each sentiment and each fact with attention; digesting every proposition thoroughly, and giving the author a carefully balanced judgment at every step, the book becomes the means of the highest culture and of the noblest training.

Richter, the prophet of education, in his "Levana," his beautiful treatise on education, concludes by saying, "Give natural philosophy and natural history, astronomy and geometry, and abundant supplies of 'bread studies,' in the school rooms and lecture rooms of your gymnasiums; and in so doing, you will give your boys ten times more pleasure than they will receive from the unfolding of the mummy bandages of the ancient graces; thus too you will impart the common nourishment needed by both the future divisions of your pupils into sons of the muses and sons of labor."

With Emerson we would say: Give us no books, if books be all. With Richter we would say, as say all our witnesses against the weakness of the older ways: Give us knowledge of the works of the Creator, before we learn the smaller ways of humanity; teach us through the book of nature before we learn from the printed volume, rich as it may be in the thought of man. It is thus that we would amend the older system of education; it is thus that we would better prepare the youth of our country for the work and the life into which they are to enter so soon and, with such diffident steps. Teach them to study the world as it appears to their senses, and to glean the rich harvest of facts and the wealth of knowledge which the investigation of the laws and processes of nature gives. What philosopher, however keen of intellect, and however grayed with the wisdom that meditation brings, knowing nothing of nature, could give to the young mind just growing into form in this world such wisdom and such thought as nature gives?

In his great "Essay on the Athenian Orators," Lord Macaulay asserts that "unfortunately, those grammatical and philological studies without which it were impossible to understand the great works of Athenian and Roman genius have a tendency to contract the views and to deaden the sensibility of those who follow them with extreme assiduity. A powerful mind which has been long employed in such studies may be compared to the gigantic spirit in the Arabian tale, who was persuaded to contract himself to small dimensions in order to enter within the enchanted vessel, and when his prison has been closed upon him, fancied himself unable to escape from the narrow boundaries to the measure of which he had reduced his stature. When the means have long been the objects of application, they are naturally substituted for the end."

I am not fully in accord with Macaulay in this matter. But the study of natural science certainly gives no such tendency to narrowness; it gives, on the contrary, the grandest stimulus to every faculty, to the memory, to the reasoning powers, to the faculties of observation, of comparison, and of deduction; it helps every mind, however constituted, to gain a real breadth and a true insight into the wonders of the seen and the unseen. It complements and rounds out the system to which we have hitherto been so generally and often so exclusively bound. Besides all this, it gives us the sole means of promoting the material welfare of the race; it is only through applied science that the world grows richer, that it gains leisure for study and for thought, and for the enjoyment of the intellectual as well as the physical side of life.

Draper, speaking of science, says: "For her the volume of inspiration is the book of nature, of which the open scroll is ever before the eyes of every man. Confronting all, it needs no societies for its dissemination. Infinite in extent, eternal in duration, human ambition and human fanaticism have never been able to tamper with it. On the earth it is illustrated by all that is magnificent and beautiful; on the heavens its letters are the suns and worlds." And thus it is the grandest means of promotion of the growth of the human soul, as well as of giving the world the means of securing that leisure which is indispensable to the opportunity of growth. It is to pure science that we are beginning to look for the greatest stimulus of the mind that the race has yet discovered; and it is to applied science that we must always look for the means of gaining all that is desirable in this world, as aiding the advancement of civilization. It is in the introduction of this element into education, mainly, that the new education becomes distinguished from the old. The educator of to-day who studies the work to which he is to apply himself with intelligence and conscientious thought, endeavors to make a careful survey of the whole field of all human attainments, and, from the illimitable realms of moral, intellectual, and physical knowledge, seeks to glean out such as is best adapted to the purposes of his vocation—to the training of the faculties, the development of all the powers, the acquisition of the most profitable and useful knowledge; he seeks to give to every growing soul such of this nutriment as will most effectively nourish the intellect and the soul.

Professor Goldwin Smith, in his "Lectures on History"—lectures in which are stored the product of a long and fruitful life devoted largely to classical pursuits—says: "There are changes in the circumstances and conditions of education which cannot be left out of sight in dealing with the generality of minds. Great discoveries *have* been made by accident; but it is an accidental discovery, and must be rated as such, if the studies which were first pursued as the sole key to wisdom and knowledge, now that they have ceased not only to be the sole, but the best, key to wisdom and knowledge, are still the best instruments of education." This is unquestionably true; but it is easy to see, to-day, that it is not the whole truth. It fails of the whole truth in that it assumes that wisdom and knowledge, in the scholar's sense, are the sole elements of a complete and generous education. As we shall see, after very little study of the philosophy of education, we must add some thought of the development of the body to our consideration of the wants of the mind. The two parts of the human being are inseparably interlocked, and the soul of the sage cannot be fully developed to its highest perfection except in the body of a sound and healthy man. Further, as we have seen in the education which is now called technical, and which has now been brought here to highest perfection, the mutual influence of mind and body, of intellect and of the tactual faculties, is essential to success in every art, as well as to the complete development of all human powers. It is thus that we pass out of the old into the new.

Humboldt noticed the tendency of the schools to go on in a beaten track, following a long established routine and held in their invariable orbits by a force of inertia which seems well nigh invincible, and says: "The thing is *not* to let the schools and universities go on in a drowsy and impotent routine; the thing *is* to raise the culture of the nation ever higher and higher by their means." It has demanded all the influence of the greatest minds, acting through generations, to enable us to break clear of the conservatism which has held us so long in chains, and to establish a new education that is freed from shackles and which may give us, all and each, just that education which the individual needs for the successful prosecution of his work in life, in whatever path or in whatever province that work may lie. It is only in a country like ours, in which the people have the power to proclaim what are their needs and to demand that they be considered, or in a country like old France or modern Germany, in which the classes having control of the educational systems have the privilege of calling to their aid the wisdom of the wisest of their fellow citizens or fellow subjects, and have the power of acting unimpeded by conservatism or by the ignorant prejudices of the vulgar, that such a revolution could be effected either promptly or thoroughly. But we have seen such a revolution as the Marquis of Worcester demanded, such as the philosopher Descartes proposed, such as Vaucanson and Froebel, each in his way, working at points far remote the one from the other, began within the century. It is this revolution that we find of interest, and the results of which are visible so plainly to-day and here.

Education should evidently fit each individual most effectively for the life work that may be expected with reasonable probability to open to him, to give him the means of preserving himself from danger of suffering and want, of securing a competence for himself and safety against poverty for his family, of gaining some leisure for thought and for enjoyment, and some opportunity of taking advantage of the good fortune which has been his in coming into the world at this advanced period of its history. It should fit him to perform all the duties of the citizen, of the head of a family, of a friend, and such as he owes himself to perform every duty which he owes to himself, to his family, to the nation, to the race. In the light of such a definition, we may study the form which is best given modern education.

Were it possible to study the future of each individual, it would be easy to say what would be the best general course to take with each. But this cannot be done, and we must do as we would in any other attempt to meet ill-defined conditions. We must take a course dictated by the probabilities of the case. For the man or woman who has wealth, and for whom a life of leisure is probable, we may study how to give a gymnastic training that will give the mind as well as the body its best and most symmetrical development. For the life of a person who must work for a living, we must prepare such a training as will, while giving as much of this gymnastic culture as may be practicable, provide with certainty and efficiency so much of knowledge and of special training for the work of life as will at least make him capable of taking up that work with fair prospect of success. We must make him secure against poverty first, and must give the less essential, though still important, elements of the general education second. For the average citizen, manual training and trade education are the necessaries of life, while the languages and the literatures and the sciences, so far as they are not contributory to his technical training, are for him luxuries. We may also put it down as one of the duties of the state—for it is the state which usually undertakes to supply education—to give such a training as will fit the youth to rise above the plane in which his life starts him on his journey. But it is evident that it is folly to educate the youth whose life is probably to be that of an artisan as if he were to be probably a gentleman of wealth and leisure, simply because, here and there, one among ten thousand such may possibly find use for a higher range of intellectual study. The average citizen, fortunately for our country, has neither the opportunity nor the desire to enter upon a life of leisure. Even our wealthiest men are above the old superstition that riches bring the privilege of idling in such a busy world as this, and the wealthiest among our wiser citizens are giving their boys useful as well as gymnastic training, supplementing a general education with professional or trade instruction.

There are two principal classes among the people for whom we must provide education: the one comprises those who are, by natural powers and by inclination, fitted for intellectual pursuits. The other comprehends those, in vast majority, as we are all aware, who have the constructive faculties most highly developed. Thus it is at once evident that, where a youth has shown a decided bent in either direction, his education should be modified in accordance with the talent so exhibited. But, whichever course is finally to be adopted, it is obvious that the proper first step is to begin by training together mind and body to give facility of mental and of physical action, and I would propose in every case the adoption of manual training, and teaching the use of the familiar tools of the common trades. If it were certain that the child would never need to care for himself, it might possibly be well to content themselves with giving him his gymnastic exercises only. But the son of a king may be compelled to earn his bread by the sweat of his brow, and the princes of royal houses are wisely taught trades. Every son of an American citizen should be at least as well cared for, and manual training is coming rapidly to be recognized as one of the divisions of every well-ordered curriculum in the primary schools.

But this is not all. There is a still other reason for the introduction of this manual training into our schools.

One of the wisest and most thoughtful of physicians, one who, in his time, was considered a very great authority on the physiology of education, and who wrote one of the most interesting of treatises on that subject when acting as a scientific commissioner of the United States to the Vienna International Exhibition of 1873, the late Dr. Seguin, once sent me a paper written by himself, in which he described a case of extraordinary interest in this connection, and one which is wonderfully suggestive to him who is seeking the best method of raising our youth toward the heavens through education and training of his faculties. In this paper he describes one of those singular nervous ailments which so often present themselves to the physician, and gives an account of its treatment by a novice in medicine, but a genius in what I may be allowed to call intuitive pathology. It was a woman, of course, who performed the miracle.

He says that a child was born to healthy and intelligent parents, and, until six months of age, was one of

the most perfect and most beautiful of healthy, hearty, children. But, at that age, in consequence of some digestive irritation probably, it was seized with convulsions, and a paralysis of the left side of the body and limbs was produced. Its face lost the bright, intelligent expression formerly natural to it, and it was unable to use its limbs on the left side. In this condition it remained until six years of age, when a young lady, a friend of the family, visiting the house, became greatly interested in the case, and persuaded herself that she might, by careful training, enable the child to regain the use of its limbs. Taking up her residence in the family, she gave one year to the purpose which she thus conceived, each day carefully and systematically exercising the disabled limbs and teaching the little one to use them for all the purposes of its young life. A marvelous change took place. The child recovered the use of its limbs, and was able, at the end of the year, to handle them about as well as could any other child of its age. But a still more wonderful result, and a most unexpected one, was brought about at the same time. The child's face regained its natural and intelligent expression, and, most wonderful of all, it once more became a bright and active minded creature, and was restored to its mother hardly less perfect in form, feature, and mind than before the catastrophe occurred.

Was there ever a more convincing proof of the mutual interdependence of the mind and the body? What a revelation is this of the influence of mind upon matter and the effect of matter upon mind! Does it not show with absolute certainty that the healthy mind must have residence in the healthy body, and that the perfection of the body is essential to the best action of the mind, and even to the full development of the soul? The soul of the sage in the body of the athlete represents, and this combination only can represent, the perfect man. Physical perfection is a condition of the attainment of symmetry and efficiency in the intellectual and the moral side of human nature.

As Rollin the historian says, "there is an art of forming the body as well as the mind. This art, lost by sloth, was well known to the ancients, and especially the Egyptians." He tells us "the quantity, as well as the quality, of that which he ate was prescribed by the laws to the king; his table was covered with the most common food, because eating in Egypt was designed, not to tickle the palate, but to satisfy the cravings of nature." What was so well known to the ancients is not always recognized in our own day by even our most intelligent people, or by our physicians; but that lost principle is now being rediscovered, and we now and then meet an individual who recognizes practically by his life, as well as theoretically in his discussions, that the body is built up of what is offered it as food; but we are also learning by such incidents as that which I have just related, as well as by a general experience wherever the new methods are in use, that the training of the body is a helpful means of perfecting the operations of the mind, and that this is quite as important an element of success in the elevation of the race as that principle which gave basis to the dietetic laws of Egypt. Education, therefore, for many and important reasons, must include the training of the body, and may best be given this perfection through the development of the systems of manual training which are becoming accepted throughout the world. The primary education of all I would make one in which the perceptives are developed, the intellect given opportunity of initial growth, and the faculties symmetrically trained to maximum effectiveness, using tools as the earlier instructor used sword play. The secondary education, which commonly succeeds the primary, should include the latter part of the intellectual training of the youth and the preparation required for entrance upon the professional work which comes, naturally, later. Then comes the higher education and the professional training, the student going out into the world to take up his life's work, or on into the professional school to complete what is commonly spoken of as his "education" or, in the words of Paley, the preparation of youth for the sequel of his life. This is the modern scheme of education, and it is no difficult matter to see that this in which we live is the closing period of evolution of "the fittest education," and to perceive just what are the tendencies of the time, and of the changes now in progress, the direction taken by the course of change, and the outlook for the immediate future. The utilitarian unites with the æsthetic in the perfect whole.

We have seen that the work of the educator naturally divides itself into two principal departments, the one being the division in which the student is fitted for continuous growth in intellectual power, and in wisdom and knowledge, such as the author of the book of Proverbs contemplated, the other being that which gives essential instruction and training in technical directions, such as will best fit him for the pursuits of the life into which his tastes and opportunities may have guided him. The one department has for its object the cultivation of the individual, the other his training for the part which he is to take in the work of the world. It is evident that the primary studies of the public schools are essential as preparatory to both lines of work; that the ethical and the literary instruction should properly precede the technical where the latter is to be added to the former, and that the professional school should be post-graduate to the academic. In the "ideal education," as I have taken the liberty to call it, the general preparation and the gymnastic training should be first given; then should follow the advanced liberal training, that is intended to fit man for the profitable use of his leisure time; and finally should come the professional preparation and training, fitting him for the pursuit which he may have chosen as his life's work, whether it be law, medicine, theology, or engineering and the trades. Such an education should be the birthright of every citizen, and the time will, I am sure, some time come when it shall be open to every one who has the ambition and the capacity to profit by it. This ideal education is now rapidly taking form. We have every element, and it only now remains to secure that co-ordination and correlation of its several constituents in organized school, college, and university courses, all parts of one whole, such as will give symmetry, completeness, and generous proportions to the whole. A correct form of primary instruction is taking shape in all those cities and towns of our country in which our public school system is being completed by the introduction of manual training and of the useful arts. The liberal education which fits man for highest life is already, and has long been, in principle recognized. The relation of the technical and professional schools to the system is becoming rapidly acknowledged and well understood.

We have but a little way to go to give finish to this magnificent edifice, the grandest of all the structures which modern civilization has yet reared. When primary instruction has been adapted to the needs of the people, rather than to the demands of a fortunate few and of the most blind and dull form of conservatism; when our secondary instruction shall have taken form as introductory to the most truly liberal, as well as to the best technical, educations; and when our professional schools shall have ceased to be nondescript, and shall have become the final and crowning work, as already in Germany, for example, the capstone of the edifice—then will the ideal education be given form. But, after all, there must probably for generations, perhaps always, be many earnest and deserving young men and women who cannot find time and means to secure such a "complete and generous education." Many must always be content with primary; many more must take the technical before undertaking their work in life, to the exclusion of the liberal form of secondary and collegiate education, or must give up the hope of getting such preparation at all. The technical school must probably be always thus kept in such form that it may receive all who come to it capable of entering into its courses of professional instruction. But the number of those who are entering these schools from the classical and liberal courses of our colleges and universities is continually increasing, and we are seeing the good effect of this more thorough preparation in their more earnest spirit, their maturer thought, and their more thorough appreciation of the opportunities and privileges and advantages here provided for them. They find the highest opportunities coming to them later; and the completely and generously educated man, other things being equal, will always have the advantage when the competitions of professional life become severe, and wherever the opportunities of leisure permit him to give his mind to observation, to reading, to thought. His is the richest life in all its multifarious experiences, and his is the most productive of all good to self, to family, to friends, and to country, who has the most "complete and generous education."

ALUMINUM SOLDERING.

THE following is proposed by O. M. Thowless as an alloy for soldering aluminum:

	Parts.
Tin	55
Zinc	23
Silver	5
Aluminum	2

The pieces to be soldered should be cleaned with an alkaline solution, washed with water, and dried with a rag. The parts to be soldered are heated nearly to the fusing point of the alloy, are covered with a layer of the solder and are pressed together, care being taken that the opposite faces are covered with the solder. Finally the pieces are heated until the solder melts, and the cooling is allowed to take place slowly.—*L'Industria.*

TO REMOVE TAN.—New milk, half a pint; lemon-juice, one-fourth of an ounce; white brandy, half an ounce. Boil and skim clear. Use night and morning.

WILLIAM HENRY PREECE.

WE present a portrait of Mr. W. H. Preece, the well known head of the electrical department of the British Postal Telegraphs. Mr. Preece is a native of North Wales, having been born near Carnarvon, in 1834. After receiving his education at King's College, London, he entered the office of Mr. Edwin Clark, C.E., in 1852, and in the following year joined the service of the Electric and International Telegraph Company. Rising rapidly in this company, he became superintendent of its southern division in 1856, and held a similar position for the L. and S. W. Railway from the year 1860, as well as that of engineer to the Channel Islands Telegraph Company in 1858. On the transfer of the telegraphs to the state in 1870 he was appointed one of the divisional engineers, from which position he rose to that of electrician for the whole service in 1877, an appointment which he has held to the present time.

The remarkable gifts of Mr. Preece as a lecturer on science have brought him prominently before the general public, who crowd to the halls of the Society of Arts or the Royal Institution whenever he is discoursing on some of the electrical topics of the hour or explaining the mysteries of some inventive marvel. His original researches for the furtherance of the special science which he cultivates, and his various practical inventions, have also won the suffrage of his fellow workers, and given him a leading place among them. Moreover, the active interest which he manifests in all that relates to his profession, and the genial good humor of the man, are of themselves enough to make him popular with electricians.

Mr. Preece is also consulting electrician to the British Colonial Government. He is a fellow of the Royal Society and a member of the council of the Institution of Civil Engineers, to which he was elected in 1859. He was president of the Society of Telegraph Engineers for the year 1880, and he is a member of the Physical Society, Meteorological Society, the Royal Institution, the British Association, and the Society of Arts. Mr. Preece is the inventor of a new method of duplex telegraphy, patented in 1855; a new mode of "terminating" wires (1858); working miniature signals by electricity to assimilate electric signals with outdoor signals on railways (1862); the application of electricity to domestic telegraph purposes (1864); the application of electricity for signaling between different parts of a train in motion (1861); locking signals on railways by means of electricity (1865); improvements in railway signaling to counteract the effects of lightning (1873); a new telephone (1878); improved communication between passengers and guard (1882).

He is a joint author with Mr. Sievewright of a "Text-book of Telegraphy;" has edited several works, and written many papers for the scientific press, among which latter the following may be mentioned:

Before the British Association: "The Telephone," "Recent Progress in Telegraphy," "Lightning Protectors," "Recent Progress in Telephony," "Telegraphic Inter-communication," "Domestic Electric Lighting," "On the Watt and Horse Power," "On the Use of Secondary Batteries for Telegraphy," "On the Law of Incandescence and its Relation to Current," "On the Relative Merits of Copper and Iron" (1885), "On the Strength of Telegraph Poles" (1885). Before the Society of Arts: "On the Phonograph," "Cantor Lectures," 1879, "Recent Advances in Telegraphy," "Recent Advances in Electric Lighting," "Electric Lighting at the Paris Exhibition," "Electrical Exhibitions," "On the Progress of Electric Lighting," "Electric Lighting

in America." Before the Royal Society: "Studies in Acoustics" (jointly with Mr. Stroh), "On Some Thermal Effects of Electric Currents," "On the Conversion of Radiant Energy into Sonorous Vibrations," "The Effects of Temperature on the Electromotive Force and Resistance of Batteries," "On a New Standard of Illumination and the Measurement of Light," "On the Heating Effects of Currents" (1884), "The Edison Effect on Glow Lamps" (1885), "On Secondary Batteries" (1887). Before the Society of Telegraph Engineers: "On a New Telegraph Wire Gauge," "Telegraphy—Its Rise and Progress in England," "On the Advantages of Scientific Education," "On Lightning and Lightning Conductors." "On the Block System of Working on Railways," "On Shunts, and their Application to Electrometric and Telegraphic Purposes," "On the Measurement of Currents," "On the Phonograph," "On the Connection between Sound and Electricity," "On Winding Electro Magnets," "On the Durability of Iron Wire," "On Radiophony," "On the Electrical Congresses of Paris" (1884), "A Visit to Canada and the United States" (1885), "Long Distance Telephony" (1886). Before the Physical Society: "On Some Physical Points Connected with the Telephone," "The Phonograph." For the Royal Institution: "On the Applications of Electricity to the Protection of Life on Railways," "The Telephone." "On Duplex and Quadruplex Telegraphy," "On Wheatstone's Telegraphic Achievements." For the Institution of Civil Engineers: "On the Maintenance and Durability of Submarine Cables in Shallow Waters," "On Railway Telegraphs and the Application of Electricity to the Signaling and Working of Trains," "On the Best Means of Communicating between the Passengers, Guards, and Drivers of Trains in Motion," "On the Progress of Telegraphy" (lecture), "On Electrical Conductors."

It is not too much to say that owing to his exertions the scientific branch of the telegraph department of our post office has become a pattern to the world. The capacity of wires for the transmission of messages has been quadrupled; the quality of the apparatus used has reached well-nigh perfection; scientific methods of the strictest accuracy have been applied to every branch; and a healthful spirit of striving after technical superiority introduced among the staff—a spirit exceptional in government departments, and doubtless due to his early training in commercial enterprises.—*The Electrician.*

THE MEASUREMENT OF THE INTENSITY OF THE MAGNETIC FIELD.

M. ERIC GERARD has devised an instrument, which he calls a "magneto-dynamometer," for the measurement of the intensity of a magnetic field without the aid of a ballistic galvanometer. The necessity for some more convenient and more accurate method than that at present in use for determining this important quantity has long been apparent; and if the indications given by M. Gerard's instrument prove to be as reliable as its use is certainly simple, the magneto-dynamometer will be an invaluable addition to the apparatus of the testing room.

The principle upon which the instrument is based is that of sending a current of known value, C, through a conductor of known length, l, and noting the force exercised upon it by a magnetic field. If the quantities be given in C. G. S. units, we have then:

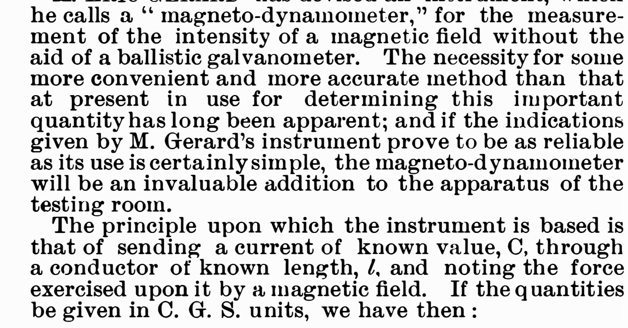
$$f = \text{H C } l \text{ dynes.}$$

C and l are known, and the measurement of f at once gives H. The application of this principle is made in what must be admitted to be a very ingenious manner. The instrument is shown in the accompanying figure.

It consists of two long and narrow strips of brass fixed at right angles to the handle, A, the upper strip being hinged at O, and provided with a counterpoise, P, which can be adjusted so as to cause the upper arm just to stand clear of the lower arm, B. The two arms are, however, joined together at the extremity, f, by a flexible wire, and a pair of sliders, S, moving on a graduated scale, also connect the arms in a similar manner at a second point. The object of this arrangement is to enable a current to be sent along the fixed arm, and back through any required length of the movable arm.

After crossing at the slider, S, the circuit is completed through an insulated wire laid along the arm, B. At R there is a spiral spring tending to oppose the separation of the arms, and provided with a micrometer screw, by means of which the force required to restore the arms to the parallel position can (after proper calibration) be read off.

The *modus operandi* is as follows: The arms being placed in a position in which they are at right angles to the direction of the field whose intensity is to be

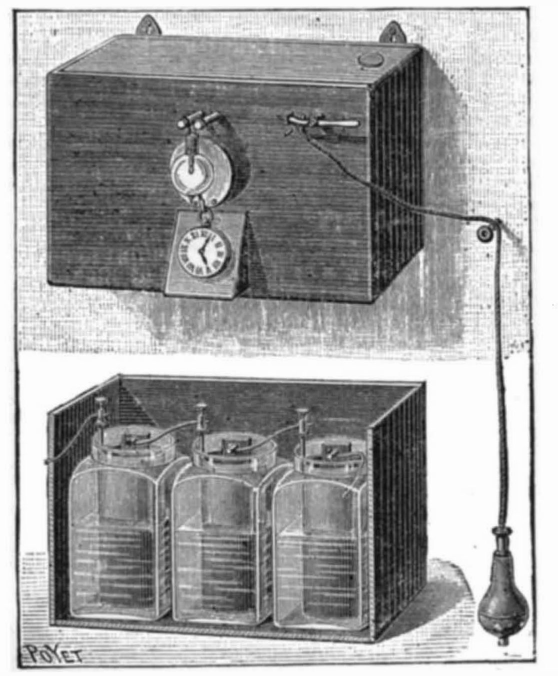


measured, the movable arm is first balanced by means of the counterpoise, P. A current of known strength is then sent through the arms, and the screw, V, is turned until balance is restored, the reading being taken from the micrometer scale. The length, l, is made adjustable, merely in order to give the instrument a greater range; for strong fields, l can be made shorter, and for weaker fields it can be lengthened.

M. Gerard points out that there are several obvious sources of error in the instrument, but he contends that for practical commercial use the errors are entirely negligible. Apart from the question of mechanical construction, the chief sources of inaccuracy are, (1) the force exercised by the earth's field, (2) the force of repulsion between the currents in the two arms. In *L'Electricien* M. Hospitallier works out a numerical example of the result of these errors, and shows that in a field of 500 C. G. S. units, with a current of 1 ampere in the instrument, the error is only 0·25 per cent. But it must also be remembered that the trustworthiness of the indications depends upon the accuracy with which the current in the arms is known. M. Gerard's instrument, at any rate, possesses in a high degree the merit both of novelty and of ingenuity.—*Electrician.*

MOMENTARY ELECTRIC LIGHTING.

ALTHOUGH by nature the Leclanche battery is very inconstant when a somewhat intense discharge is required of it, it may nevertheless be used for momentary illuminations lasting at least a minute, and separated by long intervals of rest. The little apparatus shown in the figure has been specially devised for applications in which light is needed but for a short space of time. It is capable of operating for a long period without any more attention being paid to it than is bestowed upon ordinary bell piles. It consists of three Leclanche elements of wide surface (Warnon model), coupled in tension, and arranged in a mahogany box, upon the front of which is mounted a small incandescent lamp provided with a reflector. In order to read the time at



LECLANCHE BATTERY FOR MOMENTARY ILLUMINATIONS.

night, it is only necessary to press a button that closes the circuit.

The light thus produced (about half a candle power) is more than sufficient to allow the hour to be easily read, even at the distance of a yard. When it is desired to keep the lamp lighted without the necessity of keeping the finger constantly on the button, it is only necessary to maneuver a small commutator to the right of the box.

This device will prove a very elegant and convenient domestic apparatus on condition that no other service be required of it than that for which it is designed, that is, for momentary lighting of short duration and at wide intervals.—*La Nature.*

THE STANDARD LAMP.

WE give an engraving of the latest form of the pentane standard lamp, the invention of Mr. A. Vernon Harcourt, of Oxford.

The lamp is the portable form of the standard which has been unanimously recommended by the Photometric Committee of 1881, and that appointed by the British Association in 1886.

The value of pentane as a standard combustible mixed with air was thoroughly established by the experiments of the 1881 committee, and Mr. Harcourt's experimental data with regard to the composition of the liquid have never been called in question.

But though the reliability of the pentane standard of light has been firmly established, and, in fact, is the standard by which the daily tests of the gas referee's office are made, yet the apparatus necessary, namely, a gas holder, governor, and meter, have led Mr. Harcourt to design a lamp which should be complete in itself, requiring no governor or artificial pressure of gas or other combustible, but only the force of gravity acting upon the very easily produced vapor of pentane.

The pentane lamp, as shown here, is the outcome of a very large number of experiments to produce a self-contained standard of light in a thoroughly practical and reliable form. A true standard must be designed so as to rely upon a few simple measurements. In the above lamp these are three in number, viz.: The height of head of air gas; the size of the opening in the burner; the size of the opening in the tap.

These are all capable of verification within exceedingly close limits.

In the upper part of the lamp will be seen a chamber into which pentane is admitted in the liquid state. It there becomes volatilized and mixes with the air-forming strata of least density above and gradually increasing density below. Inside the chamber is an open pipe down which the mixed air and gas flow (becoming more intimately mixed as they go), and passing through the tap at the lower bend, find their way to the opening of the burner, where they are consumed.

Now, Mr. Harcourt has shown that when pentane and air are mixed in certain definite proportions, then the light given by a flame of 2½ inches in height is an invariable quantity (subject only to correction for barometrical pressure), and equal to the mean value of the parliamentary standard candle. If, therefore, the dimensions of the lamp are such as to cause only exactly the right mixture of air and vapor to produce a flame of 2½ inches, and all others to give either too high or too low a flame, then, when the flame is exactly 2½ inches high, the light emitted will always be the same, and so becomes a true standard of light. The necessary dimensions are comprised in the three measurements given above.

When these are accurately gauged, then the correct mixture is the only one which will produce a flame of 2½ inches, and consequently of definite illuminating value.

But to produce this steadily and continuously, and to have it completely under control, requires the addition of a certain apparatus which will easily be understood from the sketch.

1. The feed of the lamp must be regular and at the proper rate; it is, therefore, produced by gravity, the pentane flowing down from the bulb reservoir on the top of the lamp, and dropping into a glass tube, by which it is conveyed to the mixing chamber. The rate of drop is regulated by a special device, consisting of a piece of thermometer tubing, which can be closed for more or less of its length by a platinum wire attached to a screw. By this method the rate of drop can be easily regulated to a nicety, and, when once the right rate is found, it is not necessary to alter it, and the lamp can be started with the certainty that the pentane will be supplied at the correct rate for the maintenance of a 2½-inch flame.

The tap attached to the reservoir bulb has only to be opened or closed to start or stop the feed. But as the height of the vapor in the mixing chamber will depend upon the temperature of the room in which the lamp is working, it is necessary to have the level of the pentane in the chamber under control.

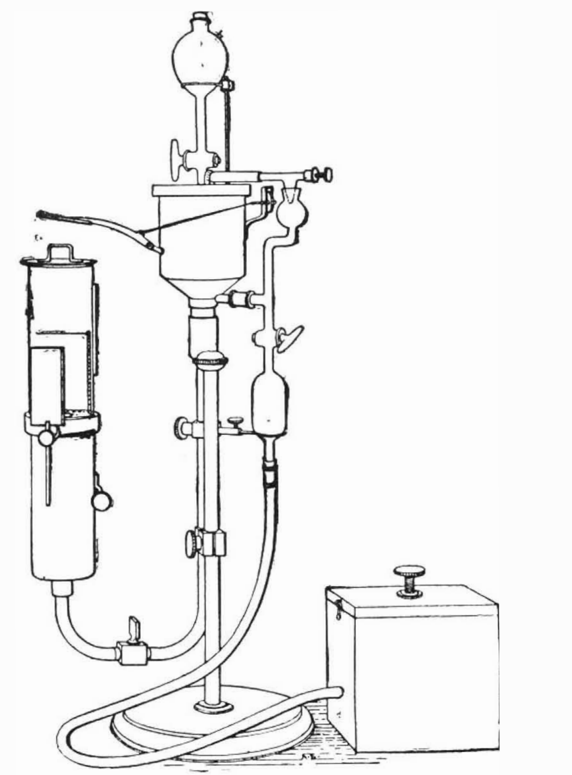
This is effected in a perfect manner by the action of the screw handle, seen above the square box, connected with the lamp by rubber tubing. Inside the box is a rubber ball containing water, which, by the action of the screw, is forced up into the bulb below the horizontal tube leading into the mixing chamber. If the flame is too low, more water is forced into the bulb, the height of the liquid in the chamber is raised, a richer mixture flows down the tube, and the flame consequently rises. If the flame is too high, a turn of the screw lowers the level, and the flame diminishes. In this way a flame of any required height can be immediately produced.

When, therefore, a constant temperature has been attained in the chamber, and the right level has been found for a required height of flame, the feed of the lamp maintains its level at a constant height, and the flame remains perfectly constant.

As the temperature of the room might be such as to produce volatilization of the pentane too slowly and in order to render the temperature inside the mixing chamber independent of the surrounding atmosphere, a copper disk is suspended vertically above the flame, and is connected with the copper body of the chamber by an arm; the heat of the flame is conducted to the chamber, which is surrounded inside the wooden jacket by non-conducting material, and so changes of temperature inside are avoided. A screw allows the disk to be raised or lowered, thus producing more or less heat, according to the temperature found necessary. It is found that this arrangement entirely removes any irregularity which might arise in the height of the flame due to the variation in temperature of the surrounding air.

An observer, therefore, working with the lamp merely requires to pour in some pentane into the small bulb leading to the mixing chamber, open the tap of the reservoir, and light the lamp. As soon as a steady temperature has been communicated to the chamber, which requires about 15 minutes, the height of the flame can be at once regulated by the screw of the box, and the flame will remain constant for a long time.

The height of the flame is determined by its just touching a platinum wire extended horizontally over it.



The wire is attached to a scale, engraved in millimeters, and capable of being raised or lowered by a rack and pinion movement. A pointer attached to the top of the burner, and level with it, marks the position on the scale, and so the wire can be immediately fixed at any height above the top of the burner.

The metal cylinder below the flame is of considerable value in steadying the flame by surrounding it with a cylinder of air, set in motion by the heat of the flame.

In a room fairly free from draughts, this is amply sufficient to keep the flame quite steady; but as it is sometimes necessary to use the lamp in exposed positions, such as, for instance, the gallery built for the lighthouse experiments at the South Foreland, where the lamp was used as the standard of light, a chimney

can be used surrounding the flame, and thus rendering it independent of draughts.

This addition has necessitated a number of careful experiments upon the absorption of chimneys, and it has been found that with glass of a constant quality and of a definite size there is a remarkably small difference in the absorption, even if the thickness of the glass is slightly variable.

The reflection of the glass at the back appears to compensate in a remarkable degree for the absorption in front, and the total absorption of a good chimney does not exceed 3 to 4 per cent. Mr. Harcourt has made use of an ingenious device of a perforated plate on the top of the chimney, thereby slightly damping the flame and necessitating a small increase in the density of the mixture required to produce a flame of normal height. In this way the absorption can be almost completely compensated, and the size of the perforations has been determined so that the flame has only to be raised 0·3 mm. when the chimney is used, the difference only amounting to 1 per cent. in the value of the light. The plate has also the advantage of producing a remarkably steady flame, quite free from the fluctuations ordinarily seen in a flame surrounded by a chimney.

For the convenience of observers wishing to verify the height of the flame without interfering with the delicacy of vision necessary for photometrical work, an arrangement has been added by which a movable screen is placed in front of the flame, whereby the extreme point only is seen over the top, while another screen, covered with black velvet, is put behind the flame, so that the exact position of the flame can be verified at any moment.

An adjustable arrangement of plumb line and bob attached to the lamp enables the lamp to be at once placed so that the flame is vertically above any required point on a table or photometer bar.

To further increase the accuracy of the lamp, Mr. Harcourt has established a law of correction of barometrical pressure, and the accuracy of this has been verified at the makers' factory during the periods of abnormal variations of atmospheric pressure.

In addition, the value of the light emitted by the flame at varying heights, from 40 mm. to 70 mm., has been accurately determined.

By means of this table it is very easy to make photometrical measurements by varying the height of the flame till equality of illumination is produced, and then lowering the wire till it touches the top of the flame, and reading the height by means of the engraved scale.

In some cases this method is preferable to any of the other well known plans.

The lamp is made by the Woodhouse & Rawson Electric Manufacturing Company, Limited, who are the sole makers, and in whose factory many of the details of the lamp have been designed and practically tested for many months of daily work with the lamp.

The lamps are tested by comparison with one of two verified standards in the possession of the makers, and also with that in daily use in the gas referee's office in London, but it is found that the light is identical in all lamps the dimensions of which have been accurately gauged.

The experiments have been carried on under the supervision of Mr. Harcourt during the last fifteen months, and the reputation of the inventor, as well as the practical experience and accurate workmanship of those intrusted with the work, insure the perfection of the instruments produced.—*Electrical Review.*

[Continued from Supplement, No. 600, page 9585.]

THE HARDNESS OF METALS.*

By Mr. Thomas Turner, F.C.S., Lecturer on Metallurgy, Mason College, Birmingham.

PART II.

Reference has been made to Moh's scale of hardness, commonly used by mineralogists. In spite of its great usefulness as a ready means of classification, it possesses imperfections which have long been recognized, and many attempts have been made to remedy these. One of the most successful and accurate of these attempts is represented by the sclerometer, which appears to have been first used in Germany in 1833, by Seebeck, in a study of the hardness of calc spar and gypsum. His results were published in the *Programm des Berlinischen Real-Gymnasiums,* his conclusion being that the hardness of gypsum was the same in all directions on the same face of the crystal, while that of calcite varied according to the angle at which the crystal was examined. The subject was afterward more completely examined by Franz, in 1850 (*Poggendorf's Annalen,* lxxx., p. 37), which is the earliest paper on the subject to which I have access. The apparatus itself, which is figured in the original paper, practically consisted of a diamond or steel point, balanced at the end of a beam, and upon which, by means of a small table, any desired weight could be placed. The specimen to be examined was fixed in a revolving table underneath the point, and the weight was gradually increased until a visible scratch was produced on drawing the crystal under the weighted point. Franz concluded that the hardness of a crystal was greatest in the direction of cleavage, and least in a direction at right angles to this. His average results are as follows:

Crystal.	Moh's Scale.	Weight. Steel Point. Grms.	Weight. Diamond. Grammes.
Gypsum	1·5	1·5	—
Calcite	3	9	—
Fluorspar	4	36	—
Dioptase	5	115	—
Apatite	5	163	12
Diopside	5–6	205	—
Feldspar	6	260	20
Pistazite	6–7	—	24
Quartz	7	—	34
Zircon	7·5	—	38·5
Tourmaline	7–7·5	—	39·5
Beryl	7·5–8	—	43
Topaz	8	—	43
Sapphire	9	—	51

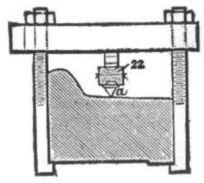
* Paper read before the Birmingham Philosophical Society, December 9, 1886.—*Iron.*

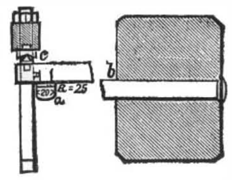
It will be seen from the table that with soft minerals Franz employed a steel point, while for hard minerals the diamond was used. The values obtained agree very closely indeed with what might be anticipated from Moh's scale, and in this respect form a striking contrast with some other forms of apparatus previously described. Since the experiments of Seebeck and Franz the sclerometer has been used by a number of observers, through its application appears to have been almost entirely confined to Germany. Recently an important modification has been introduced by Pfaff, who draws a weighted diamond a definite number of times over the surface of the crystal to be examined, and weighs the specimen before and after the experiment.

From the loss of weight and the known density of the material the depth of the grooves can be calculated, and Pfaff states that the hardness varies inversely as the depth of the groove. (*Munchener Berichte,* 1883, pp. 55, 372; 1884, p. 255; more readily accessible as abstracts. *Neues Jahrbuch fur Mineralogie,* 1884, ii., p. 4, Beiblatter, 1884, p. 278; 1885, p. 82.) This method was used for gypsum, calc spar, and other soft minerals, for which it appears to be specially suited. I believe the results obtained by such a method would correctly indicate hardness if the precaution be taken only to remove the mineral in the form of very fine powder. If, however, sufficient pressure were applied to remove definite shavings or cuttings of the material, then tenacity would interfere. The use of a diamond cutter in this manner is not admissible, however, in the case of soft metals, for while the diamond will cut the hardest hardened steel freely, it will not remove a cut from annealed steel or iron, or other soft metals, owing to the material clinging tenaciously and dragging under the treatment. (G. Jones, *Engineer,* lxii., p. 426.) This method not being suitable for hard minerals, Pfaff adopted another system in such cases, the principle of which had already been applied by Bottone. A weighted diamond borer was caused to rotate a given number of times, the depth to which it penetrated being measured by an ingenious lever indicator. The depth of the hole varies inversely as the mean hardness of the crystal.

Though it appears to be extremely difficult to suggest

Fig. 1. Fig. 2.





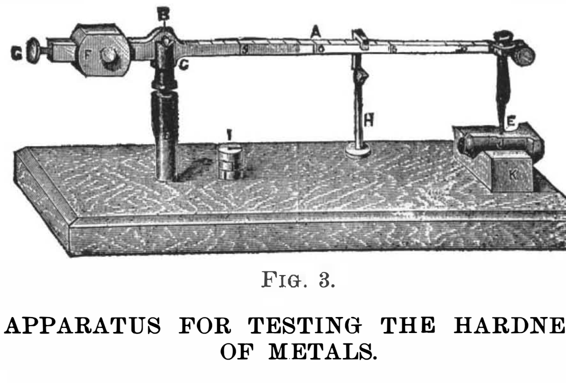


Fig. 3.

APPARATUS FOR TESTING THE HARDNESS OF METALS.

a method of determining the mean hardness of a mineral which should be open to less objection than that just described, still it may be pointed out that it is by no means perfect. As has been previously shown, if cuttings of any considerable magnitude were taken, then the tenacity of the substance would have an important influence; further, in cases where marked plasticity was possessed, this would introduce some error, while if the hole were not kept constantly clear of turnings a considerable amount of force might be expended on merely grinding these to powder.

The various methods employed for the determination of hardness by the mineralogist have been treated at somewhat considerable length, partly with the object of showing the methods we have at our disposal, and partly because the instrument I have employed is in reality only a modification of that originally described by Seebeck, and used by Franz over thirty years ago. My apparatus was constructed for use with cast iron, but it has since been applied to a number of other substances. Hitherto there have been few accurate observations of the hardness of iron and steel. The workman judges of this character by the facility with which the iron can be drilled, turned, or filed, the hardest metal producing most sound, and yielding the smallest quantity of turnings or filings when worked. Such observations are of course only qualitative. The earliest attempt to give a quantitative value to hardness tests is represented by the work of the American experimenters to which reference was made. Their method depended upon the production of a measurable indentation by means of a weighted punch, and the objections to such a system have been already mentioned. Doubtless the results obtained were of practical value, but they did not accurately represent the hardness of the metal. Two other methods depending upon similar principles have quite recently been brought under my notice.

1. Mr. G. A. A. Middleberg, of Amsterdam, writes to *Engineering,* 1886, ii., p. 481, as follows:

"For many years I have used the following apparatus to ascertain the relative hardness of railway tires, etc., and I find that it gives accurate and satisfactory results. A knife, *a* (see illustration above, Fig. 1), of hardened steel, ¾ inch long, with curved edge, is pressed by lever and weight, *b* (Fig. 2), on the surface of the metal, leaving there a line of a certain length, proportionate to the hardness of the metal. The range of the impression is about $\frac{1}{16}$ inch for copper and $\frac{5}{16}$ inch for hardened steel, and may be accurately measured. For softer metals a lighter weight, *b,* might be chosen." The practical value of such observations for certain purposes cannot be doubted, but it will be seen that any such apparatus must fail to give accurate values for true hardness. Obviously, with two samples of equal hardness, but differing in tenacity, a deeper indentation would be made in the less tenacious metal.

2. The following method has been communicated to me by Mr. Keep, of the Michigan Stove Company, Detroit, and from the tone of Mr. Keep's letter I conclude he would have no objection to my using the information it contained. A steel head ½ inch in square section was prepared, and carefully divided into 100 pyramids, each as nearly alike and as sharp as possible. The head was attached to a bar arranged to move easily and accurately by means of guides. The test piece was prepared by grinding its sides as nearly parallel and as smooth as possible. It was then arranged in such a manner that only a corner point of the tool rested on the prepared surface, and so that when one row of points had left its mark the next row just began to act. The tool was pressed on the metal by means of a swinging weight of 25 lb., which was allowed to fall one inch. The number of marks produced was then counted by means of a lens, while a light streamed across the surface. This method is very ingenious, but was not found to be very satisfactory. In some cases with iron, and especially with brass and copper, the whole surface was depressed instead of small indentations being produced. Mr. Keep also states that the number of marks does not vary as the force employed. Other objections will suggest themselves.

I have previously shown that hardness and tenacity are distinct physical properties, and that methods depending on the production of indentations or the use of cutting tools fail, at least in some measure, to distinguish between these two properties. It, therefore, becomes of interest to inquire what form of experiments is most likely to yield accurate results. Theoretically, hardness is measured by the force necessary to separate the smallest particles or molecules of the substance, as distinct from tenacity, which is measured by the force necessary to separate the aggregated molecules, or the mass as a whole. Hence hardness is just overcome when abrasion begins, and can be accurately measured if the force necessary to produce abrasion is determined. In the use of cutting instruments the results become less and less accurate expressions of hardness as the thickness of the turnings increases, and hence the methods employed by Pfaff only yield correct results when indefinitely small portions of the material are removed at each operation. Theoretically, therefore, the best method is to determine the force necessary to just produce an abrasion with a tool of a given size and shape; while practically this becomes a point to which a given force is applied. This method, however, though theoretically the most perfect, possesses an inherent difficulty, owing to the uncertainty as to the moment at which abrasion commences.

In connection with the subject of abrasion, Professor R. H. Smith, of Mason College, allows me to mention a method adopted in his laboratory, some time ago, for the examination of the effect of tempering on the hardness of steel. The specimen to be tested was first carefully weighed, and then pressed with a definite force against a revolving grindstone or emery wheel, the number of rotations of which was observed. In using an emery wheel sufficient water was made to flow over the specimen to prevent any considerable rise of temperature. The loss of weight of the specimen at the end of the experiment gave an indication of the hardness of the metal. It will be seen that the material is removed by means of abrasion, and hence the method is in this respect superior to those previously mentioned. I am, however, unaware how far results obtained in this manner agree with those given by other forms of experiment. But such a method is only suitable for hard substances, for, as pointed out by Gavin Jones (*Engineer,* lxii., 426), emery wheels, especially in dry grinding, will grind hardened steel freely, but will scarcely act on soft steel or iron, much less on copper. The hardened steel cuts with a crisp feel under the emery wheel, whereas the softer metals cling tenaciously and drag under the treatment, the particles yielding slowly, and being torn off with great force rather than cut.

My own original apparatus consisted merely of a balanced lath, capable of motion in a horizontal plane. Through one end of the lath, at right angles to its length, passed a cutting diamond, arranged so that it could be weighted as necessary. The weighted diamond point was drawn over the smooth surface of the metal to be tested, while the weight necessary to produce a visible scratch was observed; the weights were then diminished until no scratch was visible on again drawing the diamond over the metallic surface. The mean of these observations was taken as the measure of relative hardness. The results are given in table B, and will be again referred to. It will be sufficient now to say that the values obtained with this simple apparatus agree closely with those afterward obtained in similar experiments with a more perfect instrument and another diamond. Further, I have recently tested the specimen containing 2 per cent. of silicon with my newest apparatus, and obtained a hardness of 21, as against 22 with the same specimen and my first arrangement. During last summer I had occasion to perform a number of tests of the hardness of cast iron at the Rosebank Foundry, Edinburgh. In this case a diamond was employed as before, but a balanced and graduated metal beam was used, the pressure being obtained by means of a sliding weight of about 80 grammes. These results are given in table C, and will be again mentioned. They agree fairly well with my other observations, though another diamond was employed with the modified apparatus. My present arrangement is as follows (Fig. 3):

It consists of a balanced and graduated beam of gun metal, A, working on steel knife edges, B, and counterpoised by means of the large sliding weight, F, the final adjustment being obtained by the screw, G. When balanced, it is sensitive to 0·01 gramme at E, though such delicacy is probably not required. The knife edges rest upon planes in the support, C, which is capable of rotating on a steel pivot connected with the rod, D. The diamond is mounted in a brass tube, having a milled head, and which is fixed by means of a screw at E. The specimen to be tested, which often takes the form shown, J, is supported by a wooden block, K. The weight, H, is arranged so that each division on the graduated scale shall correspond to a pressure of a gramme at the diamond point. Thus at division 12 we have a pressure of 12 grammes on the diamond. Three extra weights, I, are used when necessary; they are

each of the same weight as H. Hence, with one weight, scale division 10 corresponds to 10 grammes on the diamond, with two weights 10 corresponds to 20 grammes, with three weights to 30 grammes, and with four weights to 40 grammes; the other scale divisions being read in an exactly similar manner. It will be noticed that the specimen is stationary, while the diamond is moved, thus differing from the sclerometer as applied to minerals. The method of supporting the beam and of applying the weight is also different. n ordinary experiments, where considerable weights are applied, the diamond may be moved by the finger, and, as the apparatus is very steady in its action, with a little care this gives very concordant results. For more delicate observations, with smaller weights, the diamond may be drawn by means of a horizontal string running over a small pulley.

The surface used is prepared roughly in the ordinary way by chipping, filing, etc., and then with a smooth file; it is finished with emery paper, using at last the finest variety, or flour emery, and oil, according to the material. It should be finished all one way, so as not to leave small, irregular scratches, and should be smooth and bright as possible. As a rule, an experienced workman should not take more than half an hour in preparing such a specimen, through occasionally a hard material will take longer. If the surface tested be rough, the results are erroneous, being generally higher than with a good surface. It can, however, be told at once on inspection whether a surface is suitable for the purpose. If any doubt should exist, another smooth face must be prepared, and the experiment continued until uniform results are obtained.

Reference has already been made to the difficulty of reading the scratch, or, in other words, of detecting when abrasion begins. If the scratch is always read in the same way, uniform results can be obtained, but the actual value will depend upon the standard scratch used in the experiments. It is doubtless from this cause that my own values are higher than those of Franz, as will be shown later, through each set of experiments is in itself uniform.

In viewing a scratch on a smooth metallic surface there are two principal appearances observed. When viewed at certain angles, so that the metal is dark, the scratch is seen as a bright line; while if the metal is seen in another direction, the scratch appears as a dark line on a bright surface. A smaller weight is required to produce a visible scratch if it be viewed as a bright line than if it appear a dark line on a bright surface. In my experiments the scratch was always viewed as a dark line, for the following reasons:

1. With a little experience, uniform results can be obtained in different observations on the same specimen.

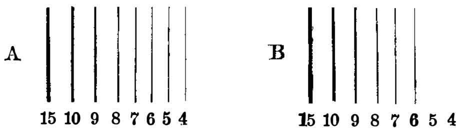
2. The scratch produced being somewhat deeper when read by this method, a greater range is obtained with the instrument.

3. Because, as will be afterward shown, this depth of scratch probably corresponds as nearly as possible with the beginning of abrasion.

Attempts were made to read the scratch by means of a lens or a microscope, but without much success. When magnified, the scratches produced by gradually increasing weights appear to change by almost imperceptible degrees, and no definite point can be fixed upon as that at which the action commences. But on comparing a deep scratch with a very faint one, a marked difference can be seen. In the case of a light scratch the surface appears to be merely smoothed over by the passage of the diamond, while with a deeper scratch the material is torn up, and a distinct ridge produced. In my method of observing the scratch I have endeavored to take that point at which this tearing up of the surface, or abrasion, begins. Even when viewed under the microscope this point is not definite, and hence the method I employed must be regarded merely as an arbitrary one, intended to approach as nearly as possible to the theoretical conception. In these experiments three different diamonds have been employed, and very concordant results obtained in each case, care being taken always to work as nearly as possible in the same manner. The diamond is octahedral, and set so that the point of the crystal is used to produce the scratch.

After considerable wear I have not detected any alteration in the weight required to mark a given specimen. The excellent wear of the diamond is probably due to the fact that the heaviest weight used is only 92 grammes, or about three ounces. But though the diamond thus appears to have little effect on the results, the influence of a rough surface, a bad light, or a different method of observation is very considerable. The character of the surface has already been sufficiently explained. A bright diffused light is best, and the specimen should be placed near to a window, and in such a position that the reflection from bright objects in the room, white walls, etc., should interfere as little as possible. From this cause it will be found extremely difficult to obtain accurate results in some positions. As it has been suggested that this apparatus might be very useful for practical purposes, and several practical men have already expressed their intention of adopting it, I shall venture to give a detailed description of the method of observation. (Arrangements are being made with a Birmingham firm for the supply of this form of apparatus to manufacturers and others to whom it might be useful. I shall be glad to examine each sclerometer before it is sent out for those who may desire it.)

The surface of the metal having been properly prepared, and a suitable position as regards light having been chosen, the specimen is fixed horizontally under the point of the diamond. By means of the movable weight, F, and adjusting screw, G, the diamond is now carefully balanced just above the smooth surface. The four weights are then placed on the beam in such a position that a definite scratch is produced on drawing the diamond over the metal; the point being drawn once forward and once backward over the same line. A definite scratch, necessary to guide the eye, having been thus produced, the weights are placed on a lower scale division and another scratch made parallel to the first; this being repeated as often as necessary, the weight meanwhile being gradually reduced. In the case of a mild steel requiring a weight of 21 grammes, the weights might at first be placed, say, at 15, then at 10, afterward at 9, 8, 7, 6, 5, and 4 in succession, a number of parallel lines being made which viewed as bright lines on a dark surface appear as in A, gradually becoming less distinct, but all clearly visible. But on viewing the same lines at the proper angle, as dark lines on a bright surface, they would appear as in B, No. 6 being very faint, while No. 5 is invisible, or only



seen with the greatest difficulty, and No. 4 is invisible.

The result is, therefore, as follows:

Scale Division.	Weight. Grammes.	Result.
15	15 × 4 = 60	Plainly visible.
10	40	"
9	36	Visible.
8	32	"
7	28	"
6	24	Faintly visible.
5	20	Value taken.
4	16	Invisible.

By means of the four weights, therefore, it has been shown that the hardness is somewhere between 16 and 24. A similar series of operations is now gone through with three weights on the beam, when probably a value of 7, equal to a weight of 21 grammes, would be obtained. On using two weights, probably a value of eleven would be obtained, corresponding to a weight of 22 grammes. It will be pretty certain from these experiments, if carefully performed, that the true value must lie about 20–22 grammes. The number is now determined by means of the single weight. For this purpose a distinct line is made, so as to guide the eye, and then a series of parallel lines are made, beginning with division 24 perhaps, and ending with about 18. The specimen is then carefully examined and the proper line chosen; the experiment being repeated until a satisfactory result is obtained. With practice, uniform values are obtained for the same specimen, and the error should not exceed ± 5 per cent. In cases of doubt, it is very easy to refer to a standard specimen, and the whole operation generally occupies about a quarter of an hour. A novice can at once distinguish between specimens that differ much in hardness, as for instance in the examples given in tables A and B; but experience is required before different specimens of pretty uniform hardness, such as mild steel, can be distinguished.

PART III.

It now remains to give an account of some results obtained by the form of instrument just described. It was thought it would be of interest in the first place to approximately calibrate the apparatus by comparison with a few substances of known hardness. Dr. Lapworth was good enough to select a few minerals for me, the specimens being considered pretty characteristic. Each specimen was examined on more than one face, and in two directions, at right angles to each other, on each surface. The values given therefore approximately represent the mean hardness of the specimens examined. In calcite considerable differences were noticed in the hardness of the faces employed. A few common metals were also tested, and for comparison several varieties of iron and steel are added, the results being given in table A. It may be mentioned that my present apparatus was designed for use with cast iron, and hence in the lower numbers the percentage error is probably greater than in the cases when 20 grammes or upward was employed. I am hoping, however, shortly to have a modified instrument for softer substances, with which to carry on the investigation, and to examine various alloys used in the arts.

TABLE A.

Substance.	Moh's Scale.	Weight. Grammes.
Steatite	1	1
Lead (commercial)	1·5	1
Tin lead alloy (66 per cent. Sn)	—	2
Tin (commercial)	2	2·5
Rocksalt	2	4
Zinc (pure, annealed)	2·5	6
Copper (pure, annealed)	2·5	8
Calcite	3	12
Softest iron tested	—	15
Fluorspar	4	19
Mild steel usually	4–5	21
Tire steel	4–5	20–24
Good soft cast iron	4–5	21–24
South Staffordshire bar iron	4–5	24
Apatite	5	34
Hard cast scrap	—	36
Window glass	5–6	60
Hardest cast iron tested	—	72

An examination of table A shows that the weights used correspond closely in order with what might be anticipated from the hardness according to Moh's scale. The values obtained for the various minerals are considerably higher than those given by Franz, but, as previously shown, this, in all probability, depends on a different method of observation. In table B are reproduced my original experiments on the hardness of cast iron as affected by the addition of silicon to white iron. (*Journal of the Chemical Society*, 1885, p. 904.) The effects here observed have recently been largely applied in England, Scotland, France, and elsewhere, in the production of a soft iron, with considerable tenacity, by the addition of silicon to a hard material, and already many thousands of tons of castings have been successfully prepared in this manner.

An examination of table B shows that the hardness, aa observed by means of a weighted diamond, agrees very closely indeed with the working qualities, as given by an experienced workman. Further, it will be seen that the tensile strength and hardness do not agree, but appear to follow almost in inverse order. These facts prove conclusively that the method employed is capable of distinguishing between tenacity and hardness. In table C are given the results of other experiments on the hardness of cast iron, conducted last summer at the Rosebank Foundry, Edinburgh. The first four specimens have been preserved, and have been recently re-examined. In the other cases, however, the experiments were conducted in a room with

TABLE B.—INFLUENCE OF SILICON ON THE HARDNESS AND TENACITY OF CAST IRON.

No.	Silicon. Per cent.	Tensile Strength. Tons.	Hardness.
1	0·19	10·14	72
2	0·45	12·31	52
3	0·96	12·72	42
4	1·96	15·70	22
5	2·51	14·62	22
6	2·96	12·23	22
7	3·92	11·28	27
8	4·75	10·16	32
9	7·37	5·34	42
10	9·80	4·75	57

WORKING QUALITIES.

No. 1. Very hard indeed.
No. 2. Very hard, though not so hard as No. 1.
No. 3. Hard, though softer than No. 2.
No. 4. Good, sound, ordinary, soft cutting iron, of excellent quality.
No. 5. Rather harder than No. 4.
No. 6. Like No. 4.
No. 7. Like No. 6, but rather harder.
No. 8. Rather harder than No. 7, though not unusually hard.
No. 9. Still harder, cutting very like No. 10.
No. 10. Hard cutting iron, though still softer than No. 1.

unfavorable light, and with an apparatus which has been since improved. Had opportunity offered, therefore, these specimens would have been tested again, but, unfortunately, they were destroyed at the works soon after our experiments were finished. The numbers are. therefore, probably not so rigidly exact as in other cases, though, doubtless, quite sufficiently near to be of practical value.

TABLE C.—CAST IRON SPECIMENS AT ROSEBANK FOUNDRY.

No.	Tensile. Strength. Tons.	Relative Hardness.
1	18·2	24
2	17·1	24
3	17	24
4	16·8	20
5	16·4	28
6	14·7	46
7	14·2	25
8	13	21
9	13	21
10	13	39
11	13	42
12	12·5	18
13	12·25	18
14	12·25	21
15	12	35
16	11·75	49
17	10·25	18
18	9·25	42
19	8·5	25
20	8	25
21	7·8	21
22	6·5	25
23	6·5	25

In this table we have a large number of specimens purposely selected so as to embrace as wide a range in tenacity as possible, and including, I believe, in the first five specimens, the highest recorded tensile strengths for British cast iron. It will be seen that we have practically the same hardness with the highest as with the lowest tensile strength, and that in this case also no definite connection can be shown to exist between hardness and tenacity. Founders are usually of opinion that cast iron can be made strong if it is made sufficiently hard. This is merely an old superstition, and the sooner it is exploded and forgotten the better for all concerned. So far as my experience has gone, it is quite the contrary. As a matter of fact, specimens with exceptionally high tensile strength are almost always good soft working irons, while special softness or unusual hardness is generally a sign of weakness. Leaving cast iron, we come to the consideration of the various varieties of soft steel.

TABLE D.—PUREST BESSEMER METAL, WITH SMALL QUANTITIES OF SILICON ADDED.

No.	Tensile Strength. Tons.	Elongation on Ten Inches. Per cent.	Hardness.
1	21·80	24·7	18
2	20·72	19·5	16
3	22·60	15·4	17
4	23·18	15·6	17
5	24·23	24	20
6	27·45	12·8	21
7	25·77	22	20
8	21·89	24·2	15

In table D we have the results obtained with the purest iron obtainable in commerce, viz., that in the Bessemer vessel at the end of the blow, and before any addition has been made. This was mixed with small but gradually increasing quantities of silicon pig, and the product examined. The specimens have not yet been completely analyzed, but they are arranged in order of silicon, beginning with a trace and ending with about 0·2 per cent. I hope shortly to publish full details (Since published in the *Journal of the Chemical Society*, February, 1887.) On comparing the hardness with tensile strength, it will be seen that they vary together in a remarkable manner, the effect being entirely unlike that noticed in cast iron. The fact that the material operated upon was a very near approach to homogeneous metal confirms the statement made in Part I., that in such material tenacity and hardness vary together. The results also appear to afford a proof of the correctness of the principle adopted in these experiments, as the values vary in different materials in a manner such as would be anticipated on theoretical grounds.

In table E are given the results obtained in the case of four specimens of tire steel, of which the analyses are given, but of which the tensile strength was not ascertained. It will be seen that they agree very nearly in chemical composition, and the hardness varies only

from 21 to 24, which is about the ordinary limits for such material.

TABLE E.—TIRE STEEL, WITH ANALYSES.

No.	C.	Si.	Mn.	S.	P.	Hardness.
1	0·58	0·23	0·64	0·03	0·03	24
2	0·59	0·40	0·63	0·04	0·07	23
3	0·52	0·23	0·61	0·01	0·06	21
4	0·62	0·15	0·57	0·01	0·04	22

I have also examined a number of specimens forwarded to me by Professor Kennedy, of University College, London. They were selected about three years ago for another purpose, for which, however, they were not employed. The results are given in table F. The tensile strength and extension were measured by Professor Kennedy, and are given for comparison. The specimens varied in tenacity from about 29 to 46 tons per square inch, and include specimens ranging from the soft steel for boiler plates up to the moderately hard metal used for tires or rails.

TABLE F.—STEEL SPECIMENS FROM PROF. KENNEDY.

University College No.	Material.	Breaking Load. Tons per Sq. Inch.	Extension. Per Cent.	Relative Hardness.
			On 2 inches.	
4684	Steel rail	40·87	18·5	23
4914	Steel wagon tire	42·30	25	24
4936	Bessemer steel	42·56	20	21
4081	Steel fish plate	45·13	25·5	22
5013	Steel tire	45·94	20·5	22
			On 3 inches.	
5073	Steel tire	36·93	20·7	21
5077	"	37·13	24·7	23
5072	"	38·63	24·7	21
5071	"	40·70	17·3	21
5074	"	40·89	25	21
5078	"	41·17	23·7	21
			On 7 inches.	
1284	Bessemer steel tire	31·31	22·9	21
1283	" "	34·65	18·4	22
1298	" "	35·79	16·1	21
1297	" "	35·92	18·3	20
1256	" "	36·14	18·1	22
			On 10 inches.	
275_3	Steel boiler plate	29·09	22·7	21
275_2	" "	29·36	25	24
275_1	" "	29·53	24	21
273_2	" "	30·95	18·8	21

It will be seen that the hardness is remarkably uniform throughout, and though there is a tendency for specimens with higher tensile strength to be slightly harder, still several exceptions will be found to this. Allowance must, of course, be made for the probable experimental error of about ± 5 per cent. But even then no direct connection between hardness and tenacity can be traced in this series of experiments. This would appear to point to the conclusion that in tire steel, and similar material, we have not a homogeneous and structureless material, as in the case of nearly pure iron, but that the metal has more or less internal structure, possibly crystalline, which causes the hardness and tenacity not to vary together as noticed in certain other cases.

TABLE G.—MR. J. T. SMITH'S EXPERIMENTS ON STEEL RAILS.

No.	Strain Required to Punch a Hole ⅞ Inch in Diameter through Web ¾ Inch Thick.	Tensile Strength. Tons per Square Inch.	Carbon. Per Cent.
1	46 25	30·91	0·28
2	46·33	30·08	0·28
3	46·97	31·03	0·28
4	47·18	31·56	0·28
5	48·21	31·53	0·29
6	48·27	32·85	0·30
7	48·50	33·37	0·30
8	48·86	33·07	0·29
9	48·89	31·88	0·31
10	49	32·33	0·29
11	49	33·37	0·31
12	49·07	32·09	0·30
13	49·41	31·97	0·32
14	49·50	32·75	0·31
15	49·68	33·18	0·29
16	50	33·59	0·30
17	50·11	33·08	0·30
18	50·27	32·67	0·30
19	51·05	33·65	0·32
20	52·50	33·49	0·32
21	56·79	37·01	0·36
22	58·16	37·42	0·40
23	58·44	37·93	0·40
24	61·24	41·41	0·39
25	61·34	39·10	0·43
26	64·42	42·82	0·44
27	65·19	44	0·45
28	65·31	39·23	0·44
29	74·50	45·79	0·50
30	82·47	50·42	0·57

A very interesting series of experiments on the conditions affecting the wear of steel rails is recorded in a paper by Mr. J. T. Smith (*Proc. Inst. C. E.*, 1875, xlii., p. 69). Extracts from these results are given in table G, from which it will be seen that "hardness" was measured by the force required to punch a hole ⅞ inch in diameter through a web of metal ¾ inch in thickness. It will be seen from the table that the tensile strength increases very regularly as the proportion of carbon becomes greater, and that the "hardness" increases with equal regularity and in the same manner. This appears to strongly support my contention, that the force required to make a measurable indentation will depend very greatly upon the tenacity of the material. It was found, contrary to what was anticipated, that the "softest" rails generally wore best. This observation is supported by Dr. Dudley and other writers of experience, though contested by some authorities. If the results of Mr. Smith's experiments are graphically represented, it is found that the curves of percentage of carbon, and the punching, tensile, and bending tests, are of the same general form, and show a close agreement. The curve of percentage of wear, however, does not agree with these, but is quite irregular, and the differences observed in this respect are not so great as might have been expected from the other tests. It would appear from this that in the softer classes of steels, when not hardened by rapid cooling, the so-called "hardness" due to carbon is really in a great measure due to tenacity, and that, when correctly measured, the true hardness of this class of material does not usually vary over very wide limits. To me it appears probable that the best rails to wear would be those in which true hardness and tenacity are both high, while the material is not so altered as to render it too sensitive to sudden shock. Internal structure doubtless also has a most important influence. Mr. Smith's experiments appear to conclusively prove the unreliability of the method of indentation as a measure of hardness, while his observations on the wear of this class of material fully support the results given in table F, in which it is shown that the hardness varies within narrow limits, and does not differ much from that of good wrought iron or of soft cast iron of good quality.

From these observations I am inclined to suggest the following values as results which may be anticipated from an apparatus like my own, used in the manner described:

Material.	Hardness.
Extra pure iron, tensile strength 22 tons.......	17
Soft and weak cast iron.......................	18
Mild steel, tensile strength 30 tons............	21
Tire steel, tensile strength 40 tons............	21–24
Cast iron, maximum tensile strength.........	21–24
Iron for rolls, about....	30
Hard scrap, about............................	40
Very hard white iron, about............... ..	70

Here the subject must be left for the present, but at some future time I hope to carry the investigations further.

HENDON SEWAGE WORKS.

THE new sewage works at Welsh Harp, near Hendon, constructed from the designs and under the instruction of Messrs. Edward Cousins, M.I.C.E., and Son, Westminster, were opened on the 23d April by Mr. E. R. Bartley Dennis, chairman of the Hendon Local Board.

The new sewers for the drainage of Hendon, Child's Hill, Cricklewood, Golder's Green, and Temple Fortune districts are completed, and connected with the new sewage works, and in future the whole of the sewage from these districts will be treated at the new works, and the old tanks at present in use will be abandoned. The total length of the sewers now in use for the drainage of these districts is 14½ miles, The Hendon local board district contains 8,382 acres, and the ratable value of Hendon is £101,000.

The plan used at the Hendon works for the treatment of the sewage is as follows: First: The removal of the coarse, solid, floating matter by straining. Secondly: The addition of lime for the purpose of defecation and the precipitation of some of the organic matter in solution. Thirdly: The removal, by means of settlement in tanks, of the suspended matter, and that precipitated by the lime. Fourthly: The decantation of the clear water from the tanks, and its purification by filtration through specially prepared filtering beds.

Experience has shown that unless sewage be previously defecated, filtration through land is not effectual, because the solid matter suspended in the sewage, and matters in solution readily removed, clog up the pores of the soil and destroy its efficacy, both as a mechanical filter and as a purifying agent. It is therefore necessary to remove the matters which would destroy the filtering bed, and leave only the clarified water from the tanks to pass through the soil. During this passage through the soil the organic matter in solution is decomposed by the organisms which exist in the soil, and live upon the kind of organic matter contained in the sewage. The result is that the nitrogenous matter which would otherwise putrefy is broken up and transformed into salts of ammonia, which are innocuous.

The treatment at Hendon, although lime is used, differs from the lime treatment pursued elsewhere, and in this respect: It has been found that the addition of what is called "milk of lime" is not so effectual as if the lime is added as lime water, because it is only the dissolved lime, or that in solution, which is effectual. All sewage is highly charged with carbonic acid, and the particles of lime in the milk of lime combine with the carbonic acid, and form a coating of carbonate of lime on the outside of the particle which is insoluble, and the lime cannot enter into solution and is prevented from doing its work.

This loss Messrs. Cousins claim to have avoided at the Hendon works by preparing lime water almost saturated with lime. One-sixth part of the whole sew-

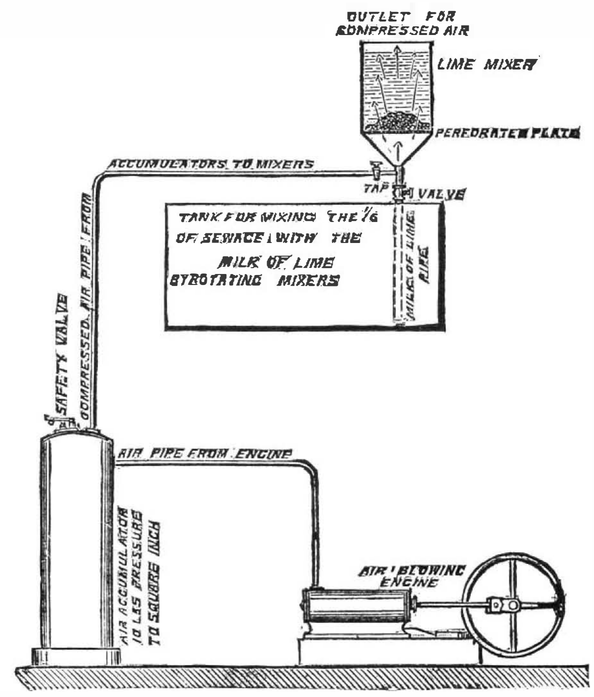
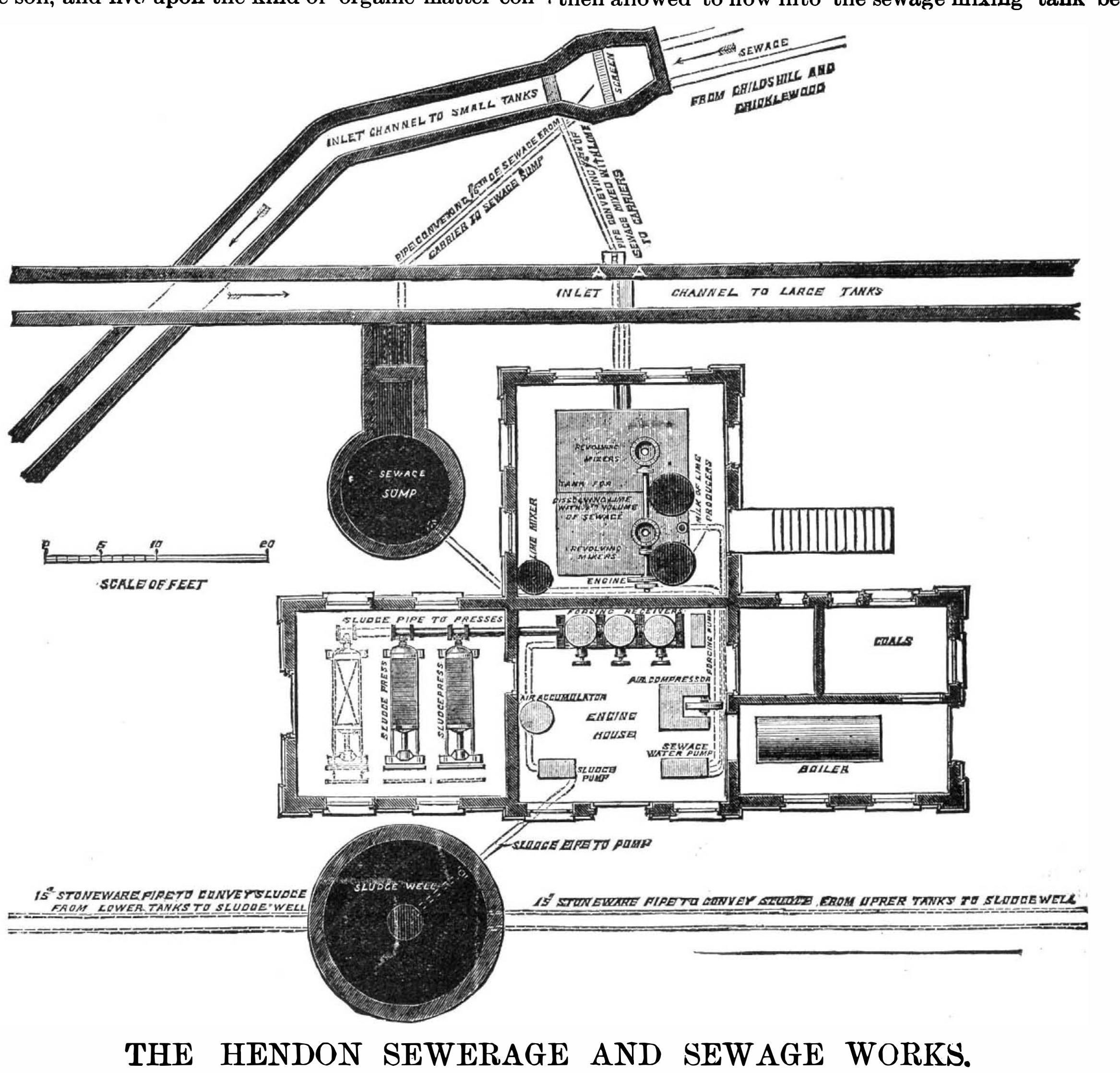


DIAGRAM SHOWING LIME AND SEWAGE MIXERS.

age is withdrawn from the two carriers, and pumped into a continuous mixing vessel provided with agitating arms. A thin milk of lime is added, containing lime equal to 15 grains per gallon on the whole sewage, or 90 grains per gallon on that passing through the lime-water mixing apparatus. The lime is thoroughly dissolved, and the lime water so obtained is added to the remaining five parts of the raw sewage, mixed by the Salmon ladder arrangement, and run into one of the settling tanks, where it remains in a state of quiescence; another tank is then filled, and so on.

The action of the lime mixers for making the milk of lime may be described as follows, with reference to the sketch annexed: An air-compressing engine forces air into an accumulator at a pressure of about 10 lb. per square inch. A pipe is connected with this accumulator and the lower part of the mixer as shown. After the lime and water has been put into the mixers, the air tap is opened, and the compressed air at 10 lb. escapes through the lime and water, and agitates and thoroughly mixes them. The milk of lime so made is then allowed to flow into the sewage mixing tank be-



THE HENDON SEWERAGE AND SEWAGE WORKS.

low, where it is thoroughly mixed up with one-sixth of the volume of sewage under treatment, by means of horizontal revolving rake arms.

From these mixing tanks the lime water and sewage pass out to the points, A and A, seen on the plan, where it mixes with the other five-sixths of sewage in the channels running to the subsiding tanks. After five or six hours' rest, the clear water is run off by a floating arm, which accommodates itself to the varying level of the sewage, and the effluent is run on to the filter beds, as before described, for the more complete purification. The sludge, or thin mud, remaining in the tanks is swept into a pipe, and run into a sludge well. In the condition in which it arrives there it contains 95 per cent. of water and only 5 per cent. of solid matter; it is very putrescent, as it contains the foul matter thrown down by the sewage, and if not dealt with would soon become a nuisance.

Up to within the last few years it was the accumulation of sludge on a sewage works which rendered it almost impracticable to work such a process without serious nuisance. The sludge could not be dealt with, and as it was run into pits, to attempt to drain the water from it—an almost impossible task—it entered into a vigorous state of putrefaction, and gave off all the evil odors which rendered sewage works so unbearable. All this it is intended to avoid by the method of disposing of sludge developed by Messrs. Johnson and Co., of Stratford.

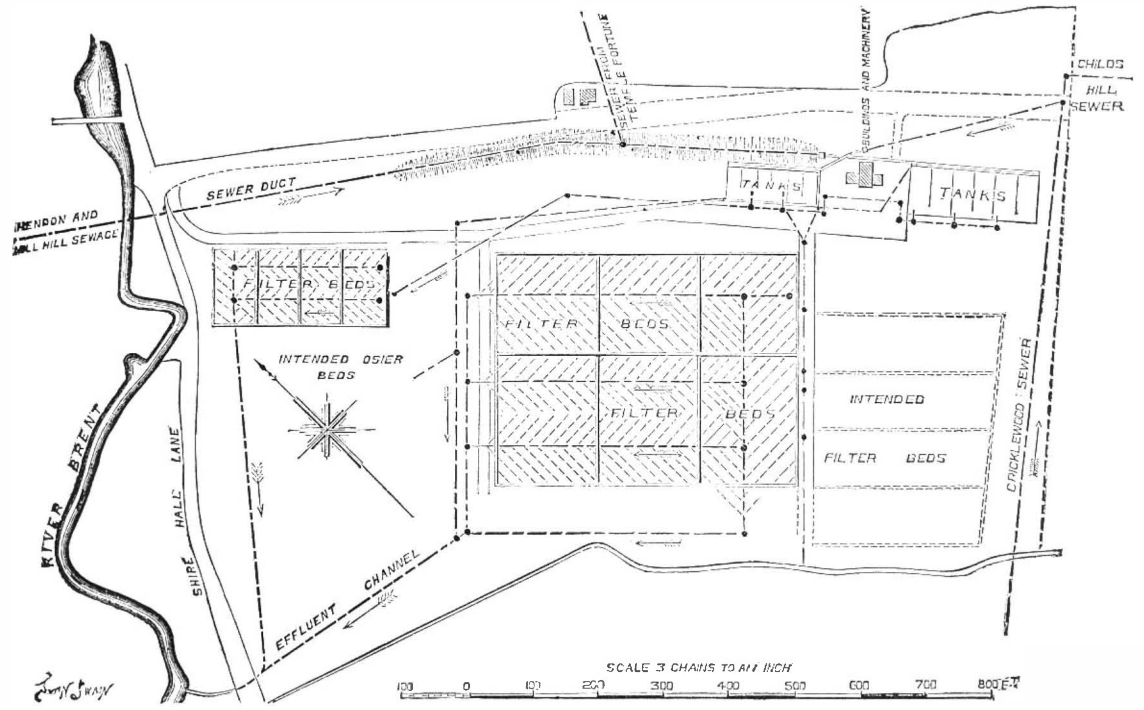
This method, on its most approved principle, has been adopted at the Hendon works, and sludge-pressing machinery has been there erected on the most modern and economical system. The sludge is first mixed with 1 per cent. of lime in forcing vessels, and from these it is forced into the sludge presses by compressed air stored at a pressure of 100 lb. per square inch. The sludge presses are so constructed that everything forced into them must pass through a straining-cloth before it leaves the machine. Consequently, nothing but clear water can leave the chambers, and the solid matter is retained between the plates, where it accumulates and, under the pressure produced by the air, forms a firm, coherent cake; 90 per cent. of the water originally present is got rid of, and the sludge is brought into a condition in which it cannot liquefy or putrefy again, and so cannot give rise to any bad smells.

Further, its comparative freedom from water enables it to be readily handled, and it can be carted away and used as a manure. In the condition in which it is delivered from the press it is said to be nearly twice the value of farmyard manure; and as at other sewage works it is sold in this condition to the farmers, it is to be hoped that those in the neighborhood of Hendon will use it in the same manner. Its value as a manure has been well demonstrated by practical experiments conducted by Professor Munro, of the Agricultural College, Downton, who regards it as a manure of considerable value. It remains to be mentioned that the new method employed of forcing the sludge consists in using a fixed volume of compressed air over and over again without allowing it to escape. And it has been demonstrated that at Crossness, where this system is also used, the sludge is forced with an expenditure of power of less than one-fourth of that needed when the old plan of allowing the air to escape to waste was used.

The treatment at the Hendon works results in a pure effluent collected from the filter beds and discharged into the Brent, and the inoffensive and not altogether valueless compressed cake from the sludge presses.

The appliances in use at the works are as follows: A duplex pumping engine for raising one-sixth part of the sewage; a continuous mixing apparatus, with milk of lime mixers for making the lime water; a blowing engine and air stove for mixing purposes, a sludge lift pump for elevating the sludge, a set of hydro-pneumatic forcing receivers, with hydraulic pumps; and two sludge presses, each capable of turning out 9 cwt. of pressed cake at an operation, which occupies about an hour. The steam is supplied to the whole by a 20 horse power semi-portable boiler. The settling tanks are six in number, capable of holding 651,000 gallons of sewage. The filter beds at present constructed are ten in number. Additional beds are intended to be shortly constructed, making a total of fourteen, fed by concrete and pipe carriers from the tanks, and covering an area of 30,300 square yards. They are constructed of a layer of soil 12 in. deep, under which is 12 in. of burnt ballast, the whole thoroughly underdrained, the trenches over the pipes being filled with burnt ballast, and communicating with the Brent by a white brick effluent carrier.

The works are capable of dealing with the sewage of a population of 24,000 as a maximum. The quantity of lime used for treatment is a little less than 2 cwt. for every 100,000 gallons of sewage entering the works, and about 100 lb. of lime for every ton of compressed cake turned out by the presses. The cost of the whole works is about £59,000, and the annual cost of working is estimated at about £570 per annum.



MAP OF THE HENDON SEWAGE WORKS.

The method of precipitation by the lime process as described, supplemented by land filtration, adopted at Hendon, was recommended by Professor Frankland and Dr. Stevenson, and approved by Dr. Duprez. They considered that any other addition as a precipitant is unnecessary. They consider that lime, when properly applied, affords as good an effluent as any other and more costly precipitant, except, perhaps, lime and sulphate of alumina; but they consider the use of sulphate of alumina is unnecessary, when precipitation is to be supplemented by land filtration, and that where possible the cost of this substance should be avoided. To carry out their recommendation for properly dissolving the lime in one-sixth the volume of sewage, and afterward mixing it with the remaining five-sixths, required specially designed machinery, which has been manufactured by Messrs. Johnson & Co., and which completely answers the purpose.—*The Engineer.*

THE MAP OF THE HEAVENS AT THE PARIS OBSERVATORY.

HAVING already announced the opening of the international conference in regard to making a photographic map of the heavens, we shall now give a summary of the resolutions that were adopted at the successive meetings held at the Paris Observatory. The following are the conclusions reached at the first general meeting, held on the 16th of April:

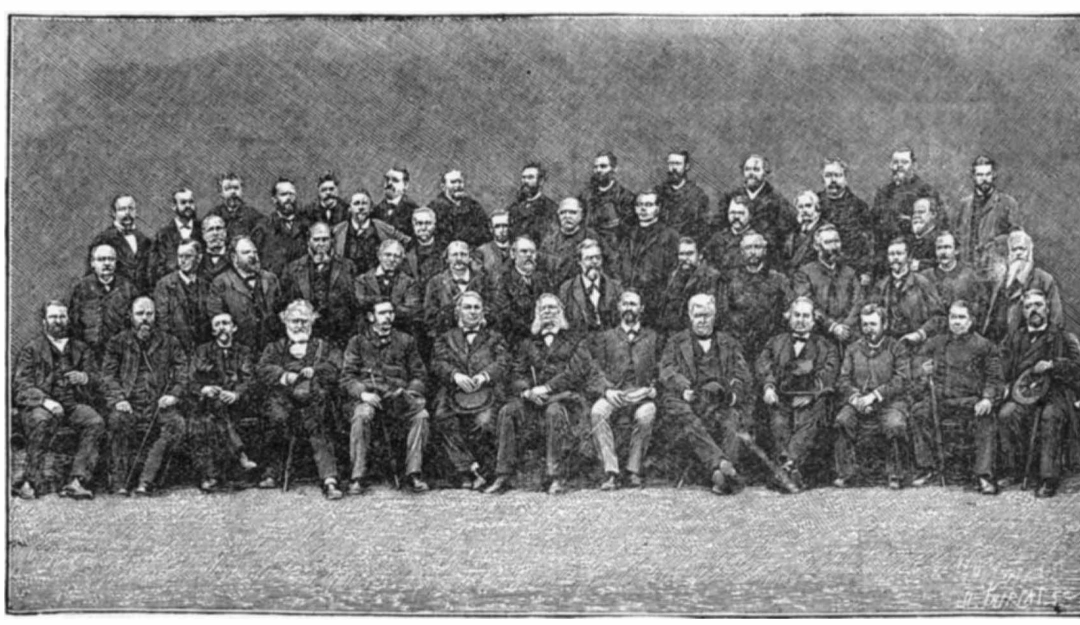
(1.) The progress made in astronomical photography renders it absolutely necessary that astronomers of the present century should, with one accord, undertake a photographic representation of the heavens. (2.) This work should be undertaken at certain stations that it will be necessary to select, and by means of instruments that are identical in their essential parts. (3.) The chief objects that an endeavor should be made to accomplish are the following: (*a*) A representation of the general state of the heavens at the present epoch, so as to obtain data that will render it possible to determine the position and brilliancy of all the stars up to a certain magnitude with the greatest precision possible. The magnitudes should be expressed conformably to a photographic basis to be determined upon hereafter. (*b*) An understanding as to the method of using, now as well as hereafter, the data furnished by photographic processes.

In order to understand the compass of this programme perfectly, it is well that we should know that, in order to facilitate the study of the stars, all the latter have been classed by order of magnitude. But astronomers do not use this word "magnitude" in its true sense; it corresponds simply to the apparent brilliancy of stars whose dimensions are as yet unknown.

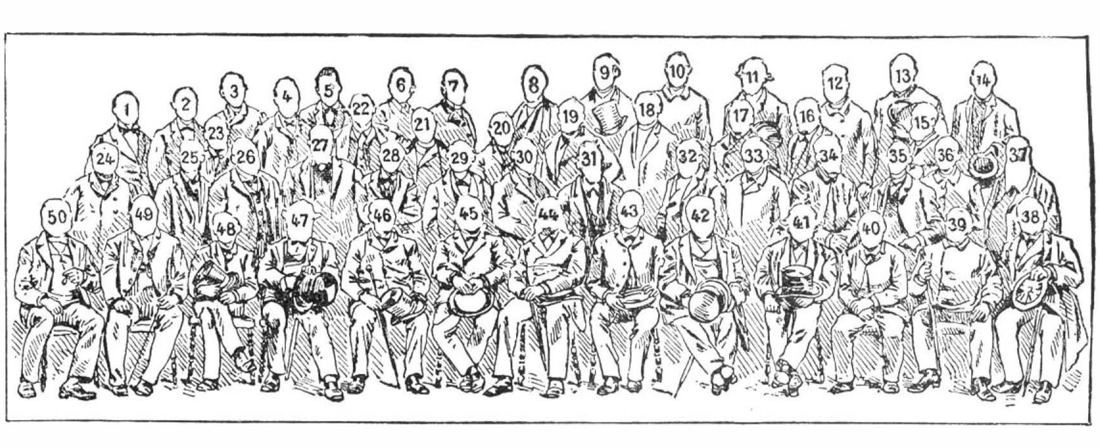
Now, we shall get an idea of the importance of the work that the international reunion proposes to accomplish, if we reflect that we have succeeded in distinguishing as far as to the seventeenth magnitude, that the total number of stars up to that magnitude amounts, perhaps, to at least a hundred million, and that we are constantly discovering new ones. It is the immense vault over which these myriads of stars are strewed that it is a question of photographing. The map of the heavens will consist of from 1,800 to 2,000 sheets, representing the 42,000 square degrees comprised on the surface of the sphere, and will give an image of all the groups of stars.

After voting the resolutions that we have above mentioned, the association appointed a technical committee of nineteen members to study the questions relating to the selection of the instrument to be used for photographing the stars, and to the limit of the stellar magnitudes to be adopted for such photographing.

This committee unanimously decided that it would be well (1) to adopt, for the photographing, a non-reflecting instrument (a combination of mirrors), and a refracting one, that is to say, a combination of lenses for throwing the image upon a plate sensitized with gelatino-bromide; (2) to adopt for the objective of the instrument an aperture and focal distance like those of the equatorial used at the Paris Observatory; (3) for the selection of the stars to be photographed, to fix those of the 14th magnitude as the extreme limit, which implies a clearly defined time of exposure. For determining the magnitude, the scale used in France will be employed.



MEMBERS OF THE INTERNATIONAL ASTRONOMICAL CONFERENCE.



1. Paul Henry. 2. Prosper Henry. 3. P. Gautier. 4. Thiele. 5. Beuf. 6. A. Cornu. 7. Bouquet de la Grye. 8. Cruls. 9. Winterhalter. 10. Eder. 11. Fizeau. 12. Baillaud. 13. Vogel. 14. Donner. 15. Steinheil. 16. Schoenfeld. 17. Krueger. 18. R. P. Perry. 19. Oom. 20. Pujazon. 21. Laussedat. 22. Tacchini. 23. E. Gautier. 24. Wolf. 25. Knobel. 26. Common. 27. Russell. 28. Peters. 29. Loewy. 30. Folie. 31. Weiss. 32. Gylden. 33. Gill. 34. Lohse. 35. Hasselberg. 36. Pechule. 37. Tennant. 38. Trepied. 39. Oudemans. 40. Tisserand. 41. Bertrand. 42. Faye. 43. Auwers. 44. Struve. 45. Mouchez. 46. Christie. 47. Janssen. 48. Bakhuyzen. 49. Duner. 50. Rayet.

When submitted to the association in full session on the 19th and 23d of April, these propositions were adopted without hesitation. The association first decided to divide itself into four committees, but finding that such a division would be very inconvenient, it was agreed that there should be but two committees—one on astronomy and one on astrophotography. Each of these began work without any delay.

The astrophotographic committee, under the chairmanship of Mr. Janssen, deliberated in succession upon the mode of constructing the objectives, the nature of the glass of which they were to be made, and the composition and mode of preparation of the gelatino-bromide of silver to be employed for making the sensitized plates. It was decided to use apparatus like those that the Messrs. Henry have constructed at the Paris Observatory.

The astronomical committee, presided over by Mr. Auwers, did not finish its labors until after three long sessions, at which were discussed both theoretical and practical questions of the highest importance.

On Saturday, April 23, the association, in full session, adopted the decisions of the two sections by a large majority. These decisions may be summed up as follows: (1) The map of the heavens shall comprise all stars up to the fourteenth magnitude; it will therefore include about twenty million stars, which will be reproduced in the negatives after an exposure of about fifteen minutes. (2) Along with the negatives designed for forming the map, there shall others be taken, for which the time of exposure will be reduced to about three minutes, and upon which will be found all the stars up to the eleventh magnitude.

These last named negatives will be submitted to micrometric measurements of great precision for the purpose of obtaining the astronomical position of the stars with very great exactitude. These measurements as a whole will then lead to a catalogue of about two million stars.

There will therefore be two series of photographic plates, one comprising stars up to the fourteenth magnitude, and the other those up to the twelfth. These complementary plates will have a reduced exposure, so that smaller images of the stars may be obtained. Each plate will contain all the elements necessary for the determination of the constants—scale and orientation.

Ruled lines upon the negatives, and of which the permanent committee will fix the spacing, will permit of measuring the errors or displacements of the images. The measurements on the photographic images will be effected with an apparatus like that which we have described in a preceding number.

As for the number of observatories that will take part in the work on the map and catalogue, that is not fully determined. It is known, however, that there will be reckoned among them the four French observatories of Paris, Bordeaux, Toulouse, and Algiers, the observatory of La Plata, that of Rio de Janeiro, and that of Santiago (Chili). The co-operation of other observatories is considered as certain, and among them those of the Cape of Good Hope, Potsdam, Vienna, Helsingfors, Sydney, and Melbourne. Still, the directors of these, who took part in the proceedings, do not wish to say that they will co-operate until they are certain of obtaining from their governments the funds necessary for the construction of the apparatus, the cost of which, not counting that of their installation and that of the plates, will amount to more than $8,000.

The association held its last meeting on the 25th of April. It finished its labors by the election of a standing committee, whose duty is to solve through experiment a few questions upon which astronomers are not thoroughly enlightened. This committee, whose duty is also to carry out the decisions of the association, is composed of such directors of observatories as have agreed to participate in the work of getting up the map of the heavens. Messrs. Mouchez, Rayet, Baillaud, Trepied, Beuf, and Creuls belong to this category so far. To them the association has added Messrs. Gill, Christie, Struve, Tacchini, Weiss, Vogel, Duner, Pickering, Henry, Loewy, and Janssen.

The standing committee has appointed a bureau of nine members, whose duty will be to pursue the studies and experiments decided upon by the association, and to hasten the preparations for carrying them out. Messrs. Mouchez, Struve, Christie, Gill, Janssen, Loewy, Vogel, Tacchini, and Duner have been appointed members of this bureau.

Before the conference came to an end, a photograph of all the members was taken in the court of the Observatory by Mr. Paul Nadar. This skillful operator has had the kindness to send us a proof, which was very quickly taken with the new Eastman paper, and we reproduce the same herewith, with the satisfaction of offering to our readers a group of the most eminent astronomers in the world.—*La Nature.*

GROOMING OF WASHINGTON'S HORSES.

AT Philadelphia, while Washington was President, the executive stables were in the charge of a man called "German John," and at another time of Bishop, the old body servant of Gen. Braddock. These chief hostlers had a number of negro boys under them, and George Washington Parke Custis says that Washington's horses were of the kind known as "muslin horses." This name came from the testing of the cleanliness of the horses with a fine handkerchief. This was brushed over their coats after they were dressed, and if the slightest spot of dirt came off upon the handkerchief, they were not considered well curried, and the stable boys were tied up and whipped for their negligence. The President drove a team of white chargers, "and the grooming of these," says Washington's adopted son, Custis, "will rather surprise the moderns. The night before the horses were expected to be ridden they were entirely covered over with a paste, of which whiting was the principal component part. Then the animals were swathed in body clothes, and left to sleep upon clean straw. In the morning the composition had become hard. It was well rubbed in, and the horses were curried and brushed. This process gave to their coats a beautiful, glossy, and satin-like appearance. The hoofs were now blacked and polished, the mouths washed, the teeth picked and cleaned, and the leopard-skin housings being properly adjusted, the white chargers were led out for service. Such was the grooming of ancient times."—*Magazine of American History.*

THE CAPRICIOUS CANDLE.

PUT a lighted candle behind a bottle, pickle jar, stove pipe, or any other object having a polished surface, then station yourself at about twelve inches from the object, so that it hides the flame of the candle from you, and blow with your breath. The candle will be very easily extinguished, in consequence of the currents of air that you have created around the object meeting near the flame. With a board or a sheet of cardboard of the width of the bottle, extinction would be impossible.

THE CAPRICIOUS CANDLE.

This experiment has a counterpart that has been communicated to us by Mr. Harmand, of Paris.

Take two bottles, instead of one, and place them alongside of each other, so as to leave a space of half an inch between them. Place the candle opposite this space, and, preserving the same distance as before between your mouth and the candle, blow strongly against the flame. Not only will the latter not be extinguished, but it will incline slightly toward you as if through the effect of suction. This phenomenon, which is analogous to the preceding, is due to the fact that as a portion of the air cannot pass between the bottles, it flows around their exterior and returns to the operator.—*Le Chercheur.*

TABLE OF CONTENTS.

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