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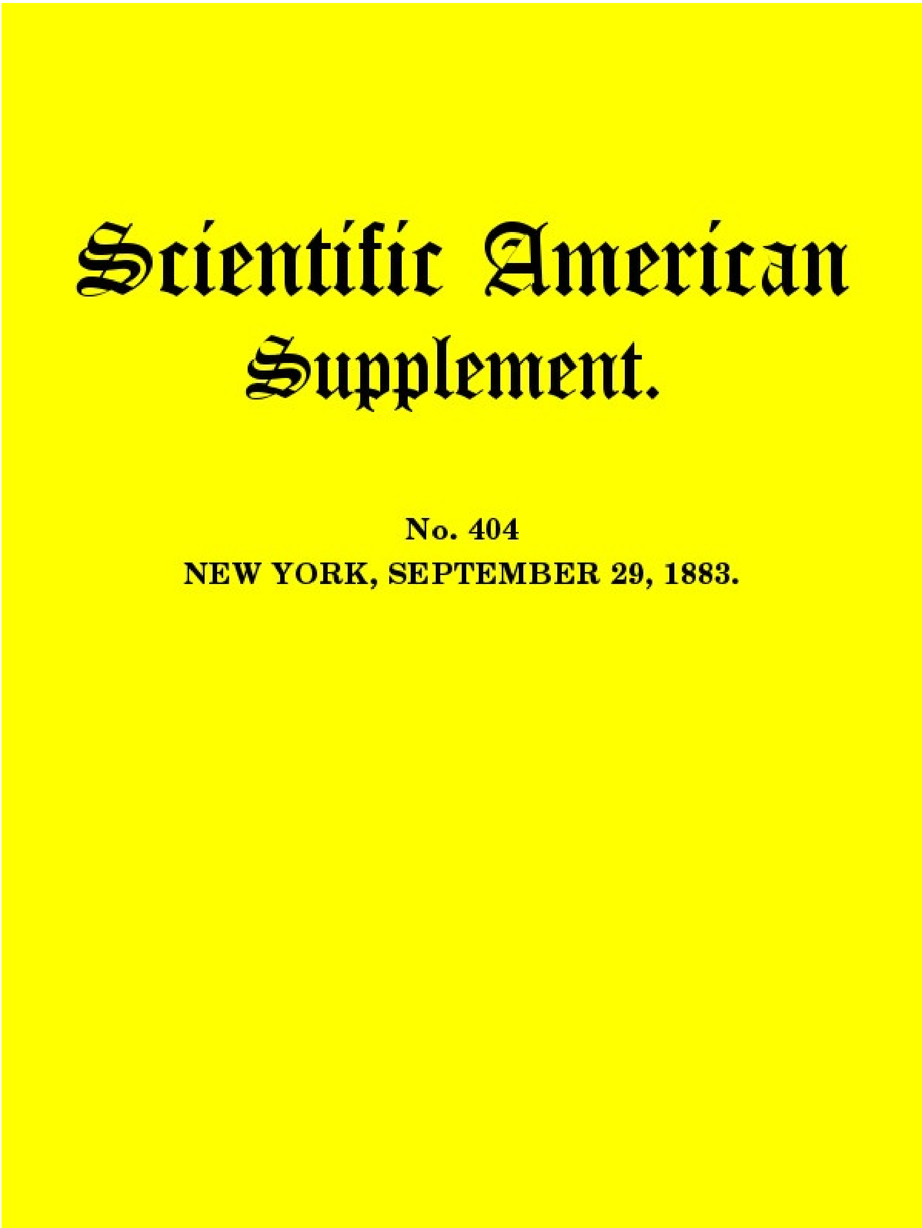

SCIENTIFIC AMERICAN SUPPLEMENT No 404

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Scientific American

Supplement.

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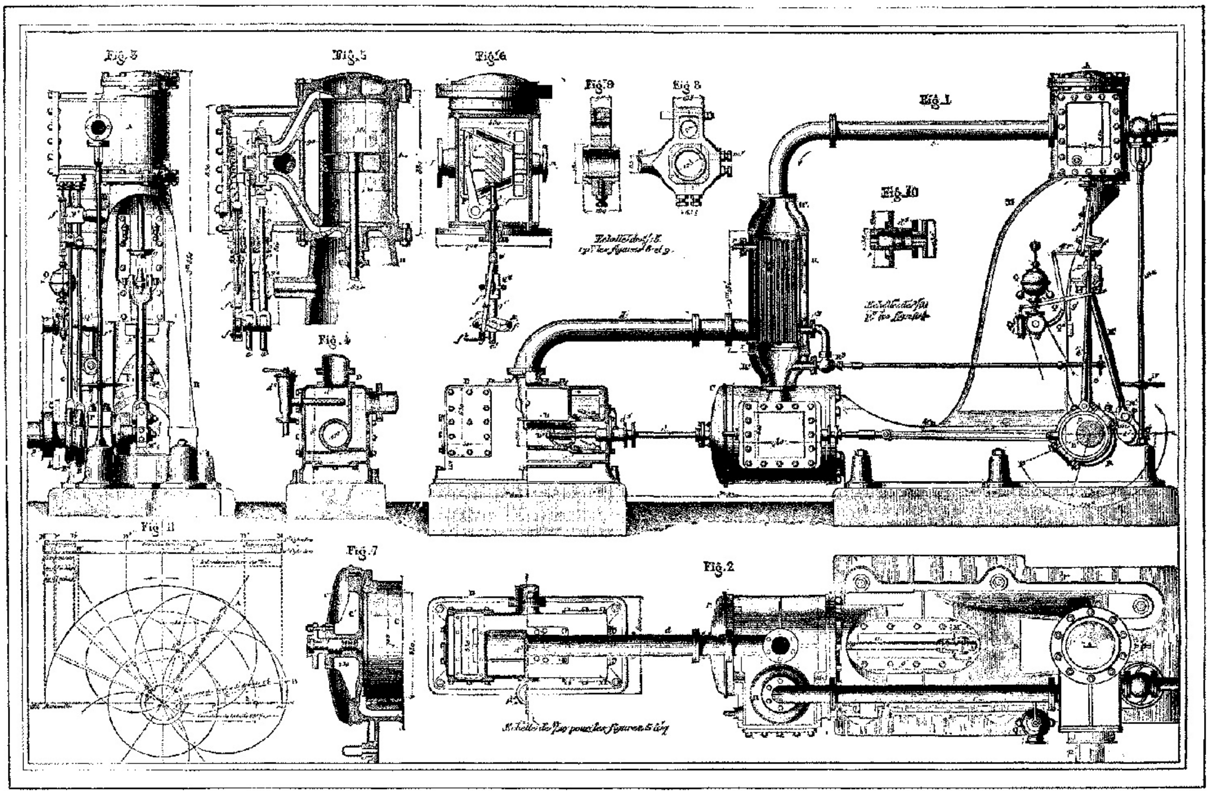
BIETRIX'S VERTICAL AND HORIZONTAL COMPOUND ENGINE.

Compound engines are tending to come more and more into use, inasmuch as they present many advantages over other kinds, especially as regards the saving they effect in fuel, and their great regularity, due to the adjusting of the cranks at right angles.

It is not surprising, then, to see our large manufacturers, who desire to maintain a reputation, seeking to create new types based upon this principle. But, in multiplying the parts, as is done in these motors, the engine is rendered more complicated, and the cost of installation is increased. Hence the difficulty of placing these motors, notwithstanding the saving in fuel that is gained by employing them.

Messrs. Bietrix & Co., of St. Etienne, however, have devised a type in which these two inconveniences seem to have been in a great measure overcome, and which we illustrate in the annexed engraving.



COMBINED VERTICAL AND HORIZONTAL COMPOUND STEAM ENGINE.

Description of the Engine.—The engine as a whole is represented in longitudinal elevation in Fig. 1, in plan in Fig. 2, and in side view in Fig. 3. Fig. 4 shows the condenser in transverse section.

The motor consists of a small vertical cylinder, A, and of a large horizontal one, C, both projecting over a strong hollow frame, B, which connects them and carries the guides, *g g'*, and the pillow block, P, of the driving shaft, *p*. The condenser, D, is in a line with the large cylinder, and the piston, D^2, of its pump is mounted upon the prolongation, *d'*, of the piston rod, *a*, of the cylinder, C. The expansion gear is controlled by the regulator, and the admission may vary from $^1/_{19}$ to $^1/_{85}$. Steam is admitted into the small cylinder through the pipe, *s*, and its entrance may be regulated at will by acting upon the hand wheel, *s'*, which controls the maneuvering rod, s^2. After expanding, the steam, in escaping from the smaller cylinder, passes through the pipe, *r*, into the feed-water heater, R, and then acts in the larger cylinder, *c*, in order to pass afterward to the condenser, D, through the pipe, *d*.

The frame, B, is in two parts, the vertical part being adjusted by keys upon the horizontal one, and strong bolts concurring with such a coupling to make the whole strong and solid. This frame carries plane slide bars, *g g'*, with beveled counter guides.

The pistons are of the Swedish type, of hollow iron, with steel rods. The segments are of cast iron. The horizontal connecting rod, M', is connected directly with the crank pin, *m*, but the vertical one is fixed to the head of the former, as may be seen in Figs. 3, 8, and 9.

The bearing of the horizontal connecting rod is in three parts, each having an anti-frictional bushing, and their play being regulated by bolts, m^2. Friction being slight in the bearing of the vertical rod, M, inasmuch as the latter's axis has but a short travel at each revolution of the driving shaft, it is not provided with an anti-frictional bushing.

The Small Cylinder (Figs. 5 and 6).—The small cylinder is shown in detail in Figs. 5 and 6, the valve box cover being removed in the latter. The diameter of this cylinder is 380 millimeters, the stroke of the piston is 650 millimeters, and the thickness of the sides is 25 millimeters. It is provided with a steam jacket; and the two ports are 45 millimeters in width by 200 in length. The exhaust is effected through an orifice 84 millimeters in diameter.

The distribution is a variable one, according to the Meyer system, the expansion being caused to vary automatically in the small cylinder, by means of a regulator, so as to proportion the motive to the resistant power.

The distributing slide valve, *t*, contains two steam inlets, whose orifices facing the cylinder are formed by two horizontal, parallel rectangles, while the inlets debouch toward the opposite surface (in contact, consequently, with the expansion slide valve, *t'*), according to two parallelograms, whose larger sides are oblique, and form between them a sharp angle, as may be seen in Fig. 6. These inlet conduits are therefore out of true. The slide-valve, *t*, is moved by an eccentric, E.

The expansion slide-valve, t', has the form of a trapezium, whose two like sides are parallel with the inclined openings in the slide-valve, *t*. It is held by a piece, *q*, which carries it along in its backward and forward motion, but does not prevent it from being moved in a horizontal direction under the action of the regulator. This piece, *q*, is keyed upon a rod, q', which is itself jointed at its lower extremity with the rod, e', of a second eccentric, E', which causes its vertical motion.

The backs of the valve, *t*, and the piece, *q*, are provided with grooves, which are designed for giving passage to the steam, the pressure of which on these surfaces partially balances that that it exerts in an opposite direction.

Automatic Regulation (Figs 5 and 6).—The upper part of the rod, e', carries a cam, *f*, that plays freely between two connecting rods, f^1, and the travel of which is limited by two rollers, f^2 and f^3, situated between the rods, *f*, which latter are themselves suspended from a rod, F. The latter slides in a support, F^2, which serves likewise as a guide to the rods, q' and t^2, of the slide-valves, and which is fixed upon a projection cast in a piece with the frame, B, and is suspended from the short arm of a bent lever, F', whose longer arm carries a roller that runs in a vertical groove, t^3, in the back of the expansion slide-valve. The lower extremity of the connecting rods, f', is connected with the sleeve of the regulator, Q, by a lever, f^4, and a bent lever, Q'. This latter revolves on an axis passing through its elbow and mounted at the extremity of a projection that is cast in a piece with the support of the regulator. This bent lever is prolonged beyond the sleeve, and carries suspended from its extremity a small piston-rod that plays in a dash pot, Q^3, and limits the too abrupt motions of the apparatus. The regulator is driven by a belt and through the intermedium of the bevel pinions, *u*.

It is easy now to understand the purpose and the *modus operandi* of the mechanism that permits the regulator to act upon the expansion gear. When running normally the connecting-rods, f', occupy a vertical position, and the rollers, f^2 and f^3, are placed exactly at the two extremities of the travel of the cam, *f*.

When the velocity exceeds the normal, the sleeve of the regulator rises and the lever, Q', tips to the right and forces the rods, f', to oscillate in the same direction around their upper joint. After that, the lower roller, f^2, being situated on the line of travel of the convex part of the cam, will be carried along by the latter and cause an oscillation to the right of the bent lever, F. The piece, t', will then be pushed back in such a way as to partially close the inlet orifices of the slide-valve, *t*, and, as the steam will thereupon enter into less quantity, the engine will quickly resume its normal velocity. If the velocity becomes less that the normal the action will be just the opposite of that just described.

The Large Cylinder (Figs. 1 and 2).—The two eccentrics, E and E', which control the distributing gear of the small cylinder, A, actuate at the same time that of the large one, C, through two rods, e^2 and e^3; such distribution is also effected by means of a sliding-plate valve. The two steam ports are 45 millimeters and the exhaust port 84 millimeters in diameter.

The large cylinder is 650 millimeters in diameter, and 930 in length. The stroke of the piston is 650 millimeters.

The Feed-Water Heater (Figs. 1 and 2).—The exhaust from the small cylinder enters the heater through a pipe, *r*, 140 millimeters in diameter. This feed-water heater consists of a large cast iron cylinder, 400 millimeters in internal diameter, and 1.15 meters in length, connected with the pipe, *r*, on the one hand, and with the cylinder, C, on the other, by means of two couplings, R' and R^2. In its interior are arranged 60 copper tubes, of 29 millimeters internal, and 31½ millimeters external diameter. These tubes are fixed at their extremities into two circular supports that are riveted to the interior of the cylinder. The exhaust from the small cylinder passes into these tubes, around which circulates steam coming directly from the boiler through the tube, r', and 6440 escapes toward the bottom, with the condensed water, through the tube, r^2. The heater is surrounded with a 2 mm. plate iron jacket.

A communication, r^3, with a valve-cock, R^3, permits of the introduction, into the large cylinder, of the steam from the heater. The exhaust steam from the large cylinder goes directly to the condenser, but there is likewise provided a pipe through which it may make its exit into the open air, in case, for example, the condenser needs repairing or there is a failure of water.

The Condenser (Figs. 1, 2, and 4).—The condenser is represented, half in section and half in external view and in elevation in Fig. 1, and in plan in Fig. 2; Fig. 4 is a transverse view of it. It consists of a large cast iron chest, D, bolted by means of its flanged base to a masonry support. This chest is cast in a piece with a pump chamber, D', in which works a piston mounted on the prolongation, d', of the piston-rod of the cylinder, C. The diameter of this piston is 210 millimeters, and its stroke is 650. The condensing jet, whose flow is regulated by the cock, d^2, is brought into contact with the steam by a rose, d^3, which divides it into small drops.

The pump is a double acting one. Its valves are of rubber, and the passage-way allowed the water is, in each of them, in section, one-half that of the piston. The rod, d', slides in a stuffing-box, with metallic lining, which is shown in Fig. 10.

Lubrication.—The lubrication of the crank-pin presents some peculiarities. Two stationary cups, *z*, are placed at the upper part of the guides, as seen in Fig. 3. These distribute their oil, drop by drop, into two reservoirs, *z'*, fixed to the upper axis of the vertical connecting-rod. Two small brass tubes, resting against the connecting-rod, lead the lubricator into cavities in the head of the horizontal connecting-rod, M'. One of these cavities corresponds to the crank-pin and the other to the lower axis of the vertical connecting-rod. The lubrication of the cylinders is effected automatically by means of a Consolin apparatus (Fig. 1), based upon the condensation of the steam and upon the difference between the density of the oil and condensed water.

Diagram of Distribution (Fig. 11).—We shall first examine that which relates to the small cylinder. The eccentric of the distributing slide-valves is adjusted to 123° with respect to the crank, and that of the expansion slide-valves to 170°, that is to say, so that the angles of advance are respectively 55 and 57 millimeters for these two cylinders.

Let us trace two axes, *o x* and *o y*, at right angles, and a semi-circumference of any radius whatever, *o m*, which shall represent the travel of the crank-pin. Let us draw the line, *o* A, making with *o y* an angle of advance of 33°, and the length of which is equal to the eccentricity of the distributing slide-valve, say 55 millimeters, and let us describe a circumference on this length taken as a diameter. Let us trace in the same way the line, *o* B, making with *o y* an angle of advance of 80°, and let us describe upon this line a circumference equal in diameter to the eccentricity of the distributing slide-valve, say 57 millimeters.

Finally, let us trace points, *o* and *c*, as centers of arcs of circles having respectively for radii the distance between the centers of the circumferences just mentioned and the eccentricity of the expansion slide-valve. These two arcs will intersect each other at a point, c^2, which is thus the fourth angle of a parallelogram whose other angles are the points, *c*, *c'*, and *o*. From the point, c^2, as a center let us describe a circle passing through *o*.

In short, we obtain three circles that are such that the vector radii, starting from the point, *o*, and limited at the said circles, represent, for the first, the deviations to the right of the distributing slide-valve beginning at the middle of its travel, the second the deviations of the expansion slide-valve, and the third the relative deviations of the distributing with respect to the expansion slide-valve.

Let us complete the diagram by describing, from the point, *o*, as a center, circumferences having for respective radii the length, *o e*, of the external overlap of the distributing slide-valve, and the lengths, *o i* and *o i'*, corresponding to the minimum and maximum of the interval between one of the edges of the expansion slide-valve and the external edge of the corresponding inlet orifice of the distributing slide-valve, when the axes of these two valves coincide.

These radii have the values: *o e* = 25 mm.; *o i* = 8 mm.; and *o i'* = 42 mm. Let us now prolong the radii, *o d*, *o d'*, *o* d^2, and *o f*, until they meet the crank circle, and let us then project these points of intersection upon a line, M M', parallel with *o x*, and we shall have all the elements that are necessary to study the different phases of the distribution in the small cylinder.

Let us complete this diagram in such a way as to study also the distribution in the large cylinder:

In this cylinder the distribution cannot be modified, that is to say, the active length of the expansion slide-valve is invariable. The interval comprised between one of the edges of this valve and the internal edge of the corresponding inlet orifice is equal, then, to 28 mm. when the axes of the two valves coincide.

Let us describe, from *o* as a center, a circle having this length for a radius, and let us again project the intersections of the radius, *o k*, with the crank circle upon a parallel at M M'. The external overlap, being the same as in the small cylinder, say 25 millimeters, the circle, *o e*, already traced for the distribution in the small cylinder, will serve for the distribution in the large one. Let us join its intersection with the circle, *c*, and the center, *o*, and let us trace also the circle of the internal overlap and the radii, *o g*, and *o h*, and we shall have all the elements of the distribution.

Advantages of the Engine.—The engine that we have just described presents all the advantages possessed by horizontal motors and double cylinder vertical ones without their many inconveniences. It, in fact, takes up less space than the former, while it possesses more stability than the latter. Its operation is as regular as that of an engine having two cranks adjusted at right angles.

The cranked shaft, a costly member of an engine, and one whose duration is always uncertain, despite the care that has been taken in making it, is here done away with.

The kind of distribution adopted is well adapted to the great variations in expansion, and, notwithstanding the two superposed slide-valves in each cylinder, two eccentrics suffice to operate them.

The regulator, thanks to the mechanism that connects it with the expansion plate, is freed from all exaggerated resistance, the eccentric rod alone supporting the entire stress. The regulator is consequently very sensitive, and is capable of giving a coefficient of regularity which is more than sufficient in most cases. The condenser, with its wide apertures, is capable of operating with great speed without shock.

We may add to this that the engine is simple and compact; the number of parts is few, and all can be easily got at; the bearings are long, and the wear is consequently reduced; the dimensions of the steam ports are wide and permit of great velocities being reached without counter-pressures; the mode of lubrication has been well studied, and requires but little attention on the part of the engine man; and, finally, the cylinder jackets and the superheating of the steam after it has begun to expand make this an economical motor aside from all the advantages that we have enumerated.—*Publication Industrielle.*

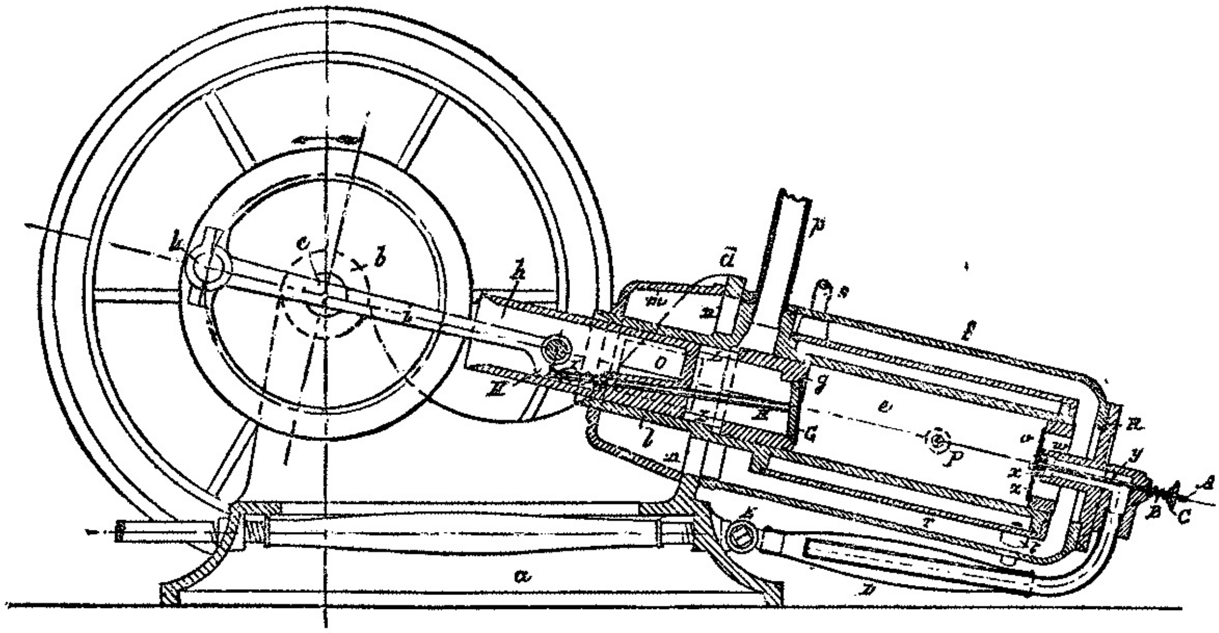
IMPROVED GAS ENGINE.

The accompanying engravings illustrate Edwards' patent gas engine, made by Messrs. Cobham & Co., Stevenage, Herts, recently exhibited at York. In our engravings, *a* is the foundation plate of the engine, having the bearing, *b*, in which the crank shaft, *c*, revolves; *d*, an inclined plate upon the foundation, *a*, to which the cylinder, *e*, and casing, *f*, are bolted; *g* is a piston working in the cylinder, *e*, and having a hollow rod or trunk, *h*, to which is jointed the connecting rod, *i*, which drives the crank pin, *k*. The guide, *l*, fits upon the hollow trunk, *h*, and is itself surrounded by the air casing, *m*, which communicates with the casing, *f*, through openings, *n n*, in the inclined plate, *d*. The guide, *l*, has openings, *o o*, through which air enters the casing, *m*, when the hollow trunk, *h*, is at the inner end of its stroke; *p* is the exhaust pipe, and *r* is a casing round the cylinder, *e*, through which water may be made to circulate by pipes at *s, t*. The valve seat, *v*, fits into the cylinder, *e*, and has holes, *w*, for the admission of air, and *x* for the admission of gas through the central pipe, *y*. The valve, *z*, consists of a disk of metal covering these holes and guided by a spindle, A, the outer end of which is fitted with a metal or India-rubber spring at B, and a regulating nut, C. The gas pipe, *y*, is shown supplied from a flexible bag, D, the supply to which from any convenient source is regulated by a cock or valve at E. The piston, *g*, contains a disk exhaust valve, G, the spindle, H, of which is fitted with a closing spring, I, and the end of the spindle is pressed down during the inner stroke of the piston by a tail-piece, K, on the inner end of the connecting rod, *i*. Holes, L, open from the hollow piston above the exhaust valve, G, into the cylinder round the hollow trunk, *h*, and thence to the exhaust pipe, *p*. At or near one-third of the stroke of the piston a firing valve, P, is arranged, having an inlet hanging valve of the usual kind, through which a flame burning outside is drawn when the valve is uncovered by the piston, *g*. The outer end of the casing, *f*, is closed by a cover, R, to which the valve seat, *v*, and gas inlet pipe, *g*, are connected.

The operation of the engine is as follows: The piston, *g*, being at the inner end of its stroke, the crank is turned round in the direction of the arrow, and the piston draws air in through the holes, *w*, and gas through the holes, *x*, the two mixing as they pass under the inlet valve, *z*. When the piston has advanced far enough to uncover the firing valve, P, the flame is drawn in and the inflammable mixture exploded, the expansion of the air and gas closing the inlet valve, *z*, and carrying the piston to the end of the stroke. The momentum of the fly-wheel then carries the piston back through its return stroke, during which the tail-piece, K, presses the spindle, H, and opens the exhaust valve, G, through which expanded air and gas escape to the exhaust pipe, *p*. It is claimed that this arrangement is very effective in securing a complete clearance from the cylinder of the products of combustion, which, when not wholly removed, vitiate the incoming charge and reduce efficiency.

When the piston arrives at the inner end of its stroke, the exhaust valve, G, is closed by the spring, I, and a fresh supply of air and gas are drawn in through the inlet valve seat, *v*, as the piston again commences its outer stroke. In order to keep the cylinder, *e*, sufficiently cool, whether the water casing at *r*, be used or not, the whole supply of air is drawn from the front end of the cylinder through the openings, *n n*, and thence between the cylinder, *e*, and the casing, *f*, and round the end of the latter to the inlet valve, *v*. And in order to prevent or lessen the noise of the explosions, the hollow trunk, *h*, is made of such length that its front edge closes the openings in the guide, *l*, through which air is drawn into the air casing *m*, and through the openings, *n n*, just before the explosion takes place, the noise of which therefore cannot escape. For the same purpose fibrous or porous material, such as mineral or slag wool, may be placed loosely in the space between the cylinder and the casing, *f*.

The engine may be made to revolve in the opposite direction to the arrow by turning the piston and connecting rod round so that the tail-piece upon the latter is above instead of below, and instead of the water casing, *r*, radial ribs may be formed upon the cylinder, *e*, from which the air passing between them inside the casing, *f*, absorbs the heat. The cylinder is arranged preferably in the inclined position shown, but it may, of course, be fixed in any other convenient position. —*Engineering.*



IMPROVED GAS ENGINE.

METERS FOR POWER AND ELECTRICITY.[1]

By Mr. C. Vernon Boys.

The subject of this evening's discourse—"Meters for Power and Electricity"—is unfortunately, from a lecturer's point of view, one of extreme difficulty, for it is impossible to fully describe any single instrument of the class without diving into technical and mathematical niceties which this audience might well consider more scientific than entertaining. If, then, in my endeavor to explain these instruments and the purposes which they are intended to fulfill, in language as simple and untechnical as possible, I am not as successful as you have a right to expect, I must ask you to lay some of the blame on my subject and not all on myself.

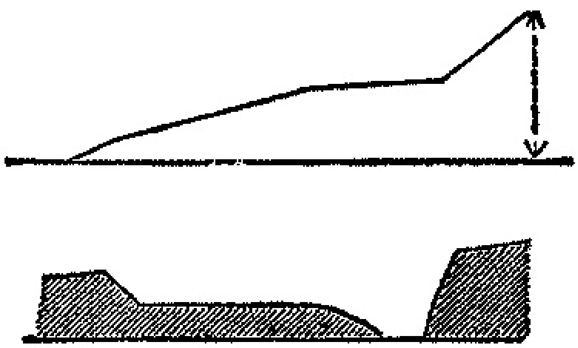
I shall at once explain what I mean by the term "meter," and I shall take the flow of water in a trough as an illustration of my meaning. If we hang in a trough a weighted board, then, when the water flows past it, the board will be pushed back; when the current of water is strong, the board will be pushed back a long way; when the current is less, it will not be pushed so far; when the water runs the other way, the board will be pushed the other way. So by observing the position of the board, we can tell how strong the current of water is at any time. Now suppose we wish to know, not how strong the current of water is at this time or at that, but how much water altogether has passed through the trough during any time, as, for instance, one hour. Then if we have no better instrument than the weighted board, it will be necessary to observe its position continuously to keep an exact record of the corresponding rates at which the water is passing every minute, or better every second, and to add up all the values obtained. This would, of course, be a very troublesome process.

There is another kind of instrument which may be used to measure the flow of the water—a paddle wheel or screw. When the water is flowing rapidly, the wheel will turn rapidly; when slowly, the wheel will turn slowly; and when the water flows the other way, the wheel will turn the other way, so that if we observe how fast the wheel is turning we can tell how fast the water is flowing. If, now, we wish to know how much water altogether has passed through the trough, the number of turns of the wheel, which may be shown by a counter, will at once tell us. There are, therefore, in the case of water, two kinds of instruments, one which measures at a time, and the other during a time. The term meter should be confined to instruments of the second class only.

As with water so with electricity, there are two kinds of measuring instruments, one of which, the galvanometer, may be taken as a type, which shows by the position of a magnet how strong a current of electricity is at a time; and the other which shows how much electricity has passed during any time. Of the first, which are well understood, I shall say nothing; the second, the new electric meters and the corresponding meters for power, are what I have to speak of to-night. It is hardly necessary for me to mention the object of making electric meters. Every one who has had to pay his gas bill once a quarter probably quite appreciates what the electric meters are going to do, and why they are at the present time attracting so much attention. So soon as you have electricity laid on in your houses, as gas and water are laid on now, so soon will a meter of some sort be necessary, in order that the companies which supply the electricity may be able to make out their quarterly bills, and refer complaining customers to the faithful indications of their extravagance in the mysterious cupboard in which the motor is placed. The urgent necessity for a good meter has called such a host of inventors into the field, that a complete account of their labors is more than any one could hope to give in an hour. Since I am one of this host, I hardly like to pick out those inventions which I consider of value. I cannot describe all, I cannot act as a judge and say, these only are worthy of your attention; and I do not think I should be acting fairly if I were to describe my own instruments only and ignore those of every one else. The only way I see out of the difficulty is to speak more particularly about my own work in this direction, and to speak generally on the work of others.

I must now ask you to give your attention for a few minutes to a little abstract geometry. We may represent any changing quantity, as, for instance, the strength of an electrical current, by a crooked line. For this purpose we must draw a straight line to represent time, and make the distance of each point of the crooked line above the straight line a measure of the strength of the current at the corresponding time. The size of the figure will then measure the quantity of electricity that has passed, for the stronger the current is the taller the figure will be, and the longer it lasts the longer the figure will be; either cause makes both the quantity of electricity and the size of the figure greater, and in the same proportion, so the one is a measure of the 6441
other. Now it is not an easy thing to measure the size of a figure; the distance round it tells nothing; there is, however, a geometrical method by which its size may be found. Draw another line, with a great steepness where the figure is tall, and with a less steepness where the height is less, and with no steepness or horizontal where the figure has no height. If this is done accurately, the height to which the new line reaches will measure the size of the figure first drawn; for the taller the figure is, the steeper the hill will be; the longer the figure, the longer the hill; either cause makes both the size of the figure and the height of the hill greater, and in the same proportion; so the one is a measure of the other, and so, moreover, is the height of the hill, which can be measured by scale, a measure of the quantity of electricity that has passed.

FIG. 1



The first instrument that I made, which I have called a "cart" integrator, is a machine which, if the lower figure is traced out, will describe the upper. I will trace a circle; the instrument follows the curious bracket shaped line that I have already made sufficiently black to be seen at a distance. The height of the new line measures the size of the circle; the instrument has squared the circle. This machine is a thing of mainly theoretical interest; my only object in showing it is to explain the means by which I have developed a practical and automatic instrument, of which I shall speak presently. The guiding principle in the cart integrator is a little three-wheeled cart, whose front wheel is controlled by the machine. This, of course, is invisible at a distance, and therefore I have here a large front wheel alone. On moving this along the table, any twisting of its direction instantly causes it to deviate from its straight path. Now suppose I do not let it deviate, but compel it to go straight, then at once a great strain is put upon the table; which is urged the other way. If the table can move, it will instantly do so. A table on rollers is inconvenient as an instrument, let us therefore roll it round into a roller, then on moving the wheel along it the roller will turn, and the amount by which it turns will correspond to the height of the second figure drawn by the cart integrator. If, therefore, the wheel is inclined by a magnet under the influence of an electric current, or by any other cause, the whole amount of which we wish to know, then the number of turns of the rollers will tell us this amount; or to go back to our water analogy, if we had the weighted board to show current strength, and had not the paddle wheel to show total quantity, we might use the board to incline a disk in contact with a roller, and then drag the rollers steadily along by clockwork. The number of turns of the roller would give the quantity of water. Instruments that will thus add up continuously indications at a time, and so find amounts during a time, are called integrators. The most important application that I have made at present of the integrator described is what I have called an engine-power meter. The instrument is on the table, but as it is far too small to be seen at a distance, I have arranged a large model to illustrate its action. The object of this machine is to measure how much work an engine has done during any time, and show the result on a dial, so that a workman may read it off at once, without having to make any calculations.

FIG. 2

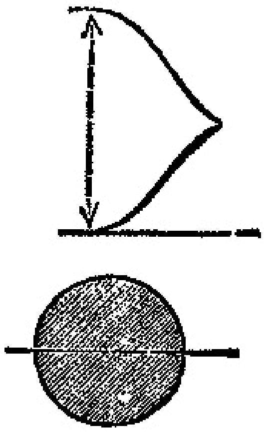


FIG. 3

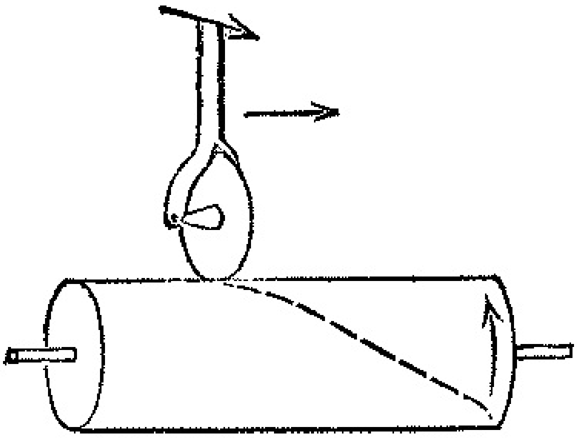
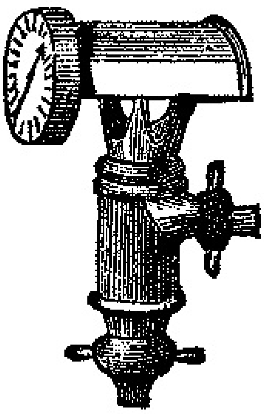


FIG. 4



Before I can explain how work is measured, perhaps I had better say a few words about the meaning of the word "work." Work is done when pressure overcomes resistance, producing motion. Neither motion nor pressure alone is work. The two factors, pressure and motion, must occur together. The work done is found by multiplying the pressure by the distance moved. In an engine, steam pushes the piston first one way then the other, overcomes resistance, and does work. To find this we must multiply the pressure by the motion at every instant, and add all the products together. This is what the engine power-meter does, and it shows the continuously growing result on a dial. When the piston moves, it drags the cylinder along; where the steam presses, the wheel is inclined. Neither action alone causes the cylinder to turn, but when they occur together the cylinder turns, and the number of turns registered on a dial shows with mathematical accuracy how much work has been done.

In the steam engine work is done in an alternating manner, and it so happens that this alternating action exactly suits the integrator. Suppose, however, that the action, whatever it may be, which we wish to estimate is of a continuous kind, such, for instance, as the continuous passage of an electric current. Then, if by means of any device we can suitably incline the wheel, so long as we keep pushing the cylinder along so long will its rotation measure and indicate the result; but there must come a time when the end of the cylinder is reached. If then we drag it back again, instead of going on adding up it will begin to take off from the result, and the hands on the dial will go backward, which is clearly wrong. So long as the current continues, so long must the hands on the dial turn in one direction. This effect is obtained in the instrument now on the table, the electric energy meter, in this way. Clockwork causes the cylinder to travel backward and forward by means of what is called a mangle motion; but instead of moving always in contact with each wheel, the cylinder goes forward in contact with one and backward in contact with another on its opposite side. In this instrument the inclination of the wheels is effected by an arrangement of coils of wire, the main current passing through two fixed concentric solenoids, and a shunt current through a great length of fine wire on a movable solenoid, hanging in the space between the others. The movable portion has an equal number of turns in opposite directions, and is therefore unaffected by magnets held near it. The effect of this arrangement is that the energy of the current—that is, the quantity multiplied by the force driving it, or the electrical equivalent of mechanical power—is measured by the slope of the wheels, and the amount of work done by the current during any time, by the number of turns of the cylinder, which is registered on a dial. Professors Ayrton and Perry have devised an instrument which is intended to show the same thing. They make use of a clock and cause it to go too fast or too slow by the action of the main on the shunt current; the amount of wrongness of the clock, and not the time shown, is said to measure the work done by the current. This method of measuring the electricity by the work it has done is one which has been proposed to enable the electrical companies to make out their bills.

The other method is to measure the amount of electricity that has passed without regard to the work done. There are three lines on which inventors have worked for this purpose. The first, which has been used in every laboratory ever since electricity has been understood, is the chemical method. When electricity passes through a salt solution it carries metal with it, and deposits it on the plate by which the electricity leaves the liquid. The amount of metal deposited is a measure of the quantity of electricity. Mr. Sprague and Mr. Edison have adopted this method; but as it is impossible to allow the whole of a strong current to pass through a liquid, the current is divided; a small proportion only is allowed to pass through. Provided that the proportion does not vary, and that the metal never has any motions on its own account, the increase in the weight of one of the metal plates measures the quantity of electricity.

The next method depends on the use of some sort of integrating machine, and this being the most obvious method has been attempted by a large number of inventors. Any machine of this kind is sure to go, and is sure to indicate something, which will be more nearly a measure of electricity as the skill of the inventor is greater.

Meters for electricity of the third class are dynamical in their action, and I believe that what I have called the vibrating meter was the first of its class. It is well known that a current passing round iron makes it magnetic. The force which such a magnet exerts is greater when the current is greater, but it is not simply proportional. If the current is twice or three times as strong, the force is four times or nine times as great, or, generally, the force is proportional to the square of the current. Again, when a body vibrates under the influence of a controlling force, as a pendulum under the influence of gravity, four times as much force is necessary to make it vibrate twice as fast, and nine times to make it vibrate three times as fast; or, generally, the square of the number measures the force. I will illustrate this by a model. Here are two sticks nicely balanced on points, and drawn into a middle position by pieces of tape, to which weights may be hung. They are identical in every respect. I will now hang a 1 lb. weight to each tape, and let the pieces of wood swing. They keep time together absolutely. I will now put 2 lb. on one tape. It is clear that the corresponding stick is going faster, but certainly not twice as fast. I will now hang on 4 lb. One stick is going at exactly twice the pace of the other. To make one go three times as fast it is obviously useless to put on 3 lb., for it takes four to make it go twice as fast. I will hang on 9 lb. One now goes exactly three times as fast as the other. I will now put 4 lb. on the first, and leave the 9 lb. on the second; the first goes twice while the second goes three times. If instead of a weight we use electro-magnetic force to control the vibrations of a body, then twice the current produces four times the force, four times the force produces twice the rate; three times the current produces nine times the force, nine times the force produces three times the rate, and so on; or the rate is directly proportional to the current strength. There is on the table a working meter made on this principle. I allow the current that passes through to pass also through a galvanometer of special construction, so that you can tell by the position of a spot of light on a scale the strength of the current. At the present time there is no current; the light is on the zero of the scale; the meter is at rest. I now allow a current to pass from a battery of the new Faure-Sellon-Volckmar cells which the Storage Company have kindly lent me for this occasion. The light moves through one division on the scale, and the meter has started. I will ask you to observe its rate of vibration. I will now double the current. This is indicated by the light moving to the end of the second division on the scale; the meter vibrates twice as fast. Now the current is three times as strong, now four times, and so on. You will observe that the position of the spot of light and the rate of vibration always correspond. Every vibration of the meter corresponds to a definite quantity of electricity, and causes a hand on a dial to move on one step. By looking at the dial, we can see how many vibrations there have been and therefore how much electricity has passed. Just as the vibrating sticks in the model in time to come rest, so the vibrating part of the meter would in time do the same, if it were not kept going by an impulse automatically given to it when required. Also, just as the vibrating sticks can be timed to one another by sliding weights along them, so the vibrating electric meters can be regulated to one another so that all shall indicate the same value for the same current, by changing the position or weight of the bobs attached to the vibrating arm. The other meter of this class, Dr. Hopkinson's, depends on the fact that centrifugal force is proportional to the square of the angular velocity. He therefore allows a little motor to drive a shaft faster and faster, until centrifugal force overcomes electro-magnetic attraction, when the action of the motor ceases. The number of turns of the motor is a measure of the quantity of electricity that has passed.

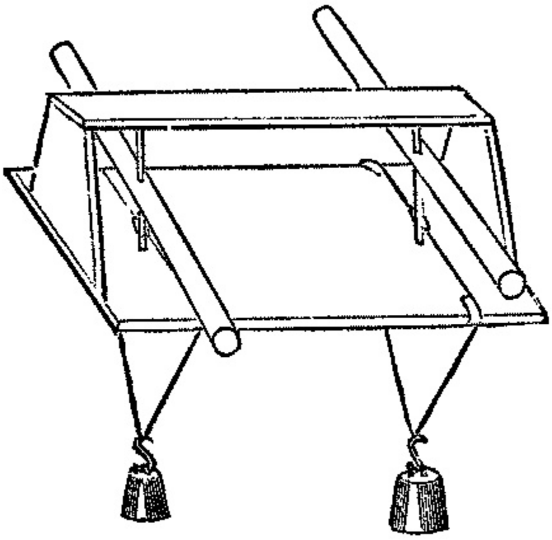


FIG. 5

I will now pass on to the measurement of power transmitted by belting. The transmission of power by a strap is familiar to every one in a treadle sewing machine or an ordinary lathe. The driving force depends on the difference in the tightness of the two sides of the belt, and the power transmitted is equal to this difference multiplied by the speed; a power meter must, therefore, solve this problem—it must subtract the tightness of one side from the tightness of the other side, multiply the difference by the speed at every instant, and add all the products together, continuously representing the growing amount on a dial. I shall now show for the first time an instrument that I have devised, that will do all this in the simplest possible manner. I have here two wheels connected by a driving band of India-rubber, round which I have tied every few inches a piece of white silk ribbon. I shall turn one a little way, and hold the other. The driving force is indicated by a difference of stretching; the pieces of silk are much further apart on the tight side than they are on the loose. I shall now turn the handle, and cause the wheels to revolve; the motion of the band is visible to all. The India-rubber is traveling faster on the tight side than on the loose side, nearly twice as fast; this must be so, for as there is less material on the tight side than on the loose, there would be a gradual accumulation of the India-rubber round the driven pulley, if they traveled at the same speed; since there is no accumulation, the tight side must travel the fastest. Now it may be shown mathematically that the difference in the speeds is proportional both to the actual speed and to the driving strain; it is, therefore, a measure of the power or work being transmitted, and the difference in the distance traveled is a measure of the work done. I have here a working machine which shows directly on a dial the amount of work done; this I will show in action directly. Instead of India-rubber, elastic steel is used. Since the driving pulley has the velocity of the tight side, and the driven of the loose side of the belt, the difference in the number of their turns, if they are of equal size, will measure the work. This difference I measure by differential gearing which actuates a hand on a dial. I may turn the handle as fast as I please; the index does not move, for no work is being done. I may hold the wheel, and produce a great driving strain; again the index remains at rest, for no work is being done. I now turn the handle quickly, and lightly touch the driven wheel with my finger. The resistance, small though it is, has to be overcome; a minute amount of work is being done; the index creeps round gently. I will now put more pressure on my finger, more work is being done, the index is moving faster; whether I increase the speed or the resistance, the index turns faster; its rate of motion measures the power, and the distance it has moved, or the number of turns, measures the work done. That this is so I will show by experiment. I will wind up in front of a scale a 7 lb. weight; the hand has turned one-third round. I will now wind a 28 lb weight up the same height; the hand has turned four-thirds of a turn. There are other points of a practical nature with regard to this invention which I cannot now describe.

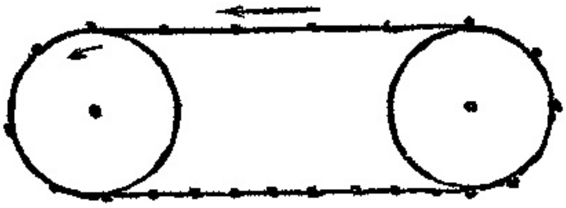
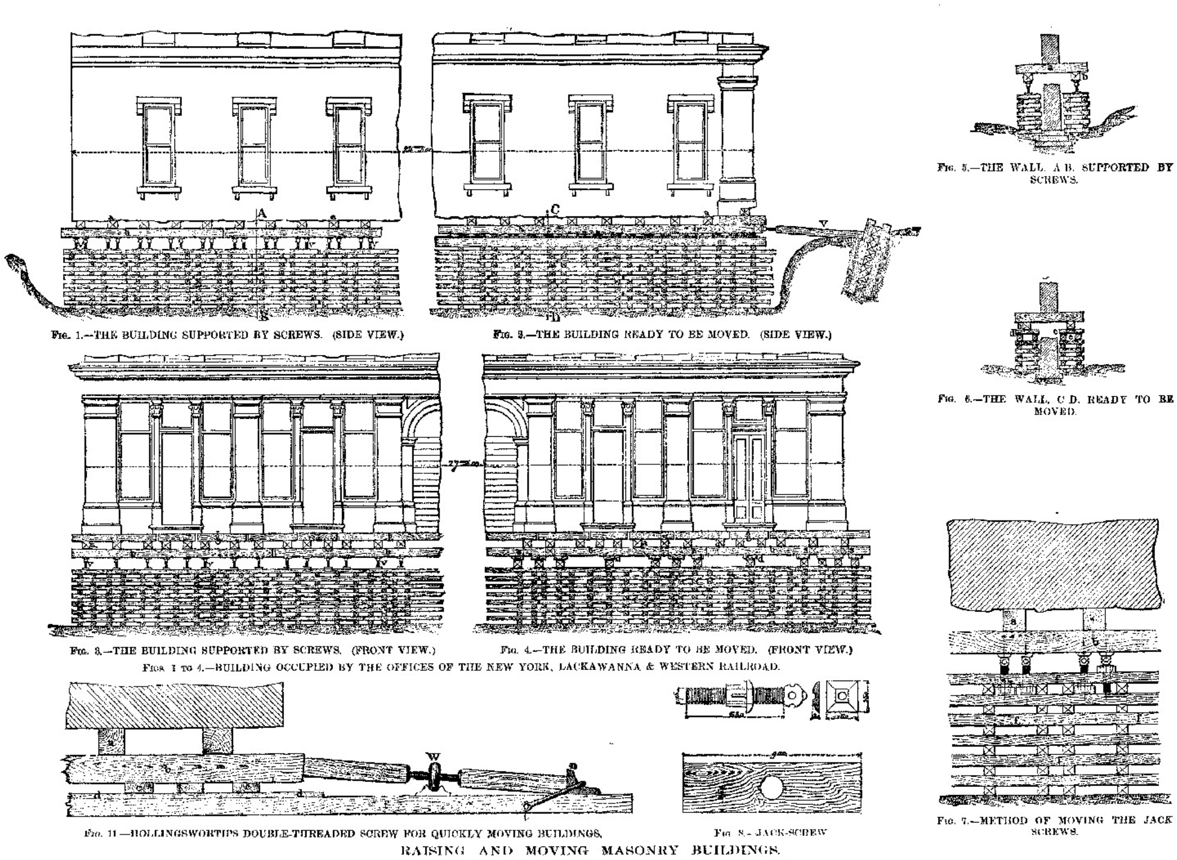


FIG. 6

There is one other class of instruments which I have developed of which time will let me say very little. The object of this class of instruments is to divide the speed with which two registrations are being effected, and continuously record the quotient. In the instrument on the table two iron cones are caused to rotate in time with the registrations; a magnetized steel reel hangs on below. This reel turns about, and runs up or down the cones until it finds a place at which it can roll at ease. Its position at once indicates the ratio of the speeds, which will be efficiency, horse-power per hour or one thing in terms of another. Just as the integrators are derived from the steering of the ordinary bicycle, so this instrument is derived from the double steering of the "Otto" bicycle. Though I am afraid that I have not succeeded in the short time at my disposal in making clear all the points on which I have touched, yet I hope that I have done something to remove the very prevalent opinion that meters for power and electricity do not exist. 6442



RAISING AND MOVING MASONRY BUILDINGS.

FIG. 1.—THE BUILDING SUPPORTED BY SCREWS. (SIDE VIEW.)
FIG. 2.—THE BUILDING READY TO BE MOVED. (SIDE VIEW.)
FIG. 3.—THE BUILDING SUPPORTED BY SCREWS. (FRONT VIEW.)
FIG. 4.—THE BUILDING READY TO BE MOVED. (FRONT VIEW.)
FIGS. 1 TO 4.—BUILDING OCCUPIED BY THE OFFICES OF THE NEW YORK, LACKAWANNA & WESTERN RAILROAD.
FIG. 5.—THE WALL, A B, SUPPORTED BY SCREWS.
FIG. 6.—THE WALL, C D, READY TO BE MOVED.
FIG. 7.—METHOD OF MOVING THE JACK SCREWS.
FIG. 8.—JACK-SCREW.
FIG. 11.—HOLLINGSWORTH'S DOUBLE-THREADED SCREW FOR QUICKLY MOVING BUILDINGS.

6443

RAISING AND MOVING MASONRY BUILDINGS.

The first important application of the method of lifting massive structures and moving them to another spot was made two years ago at Boston, Mass., in the moving back of a hotel that stood about fourteen feet on the line of a proposed widening of Tremont Street. Since that time several analogous cases have occurred in several cities of the United States, so that, for this sort of work, a general method of operating has been devised, notwithstanding the special difficulties that present themselves according to the different methods of construction and the surroundings.

All structures, before being moved, must first be separated from their foundations and then raised. These operations are certainly the most costly and those that take the longest time. It is necessary to take minute precautions and to exercise great watchfulness in order to succeed in planting solidly on the ground the timber work that has to support the pressure of the screws by means of which the entire building is to be afterward raised. The success of the operation depends absolutely upon the care and attention that are bestowed upon these preliminary operations, since the least negligence may lead to a disaster.

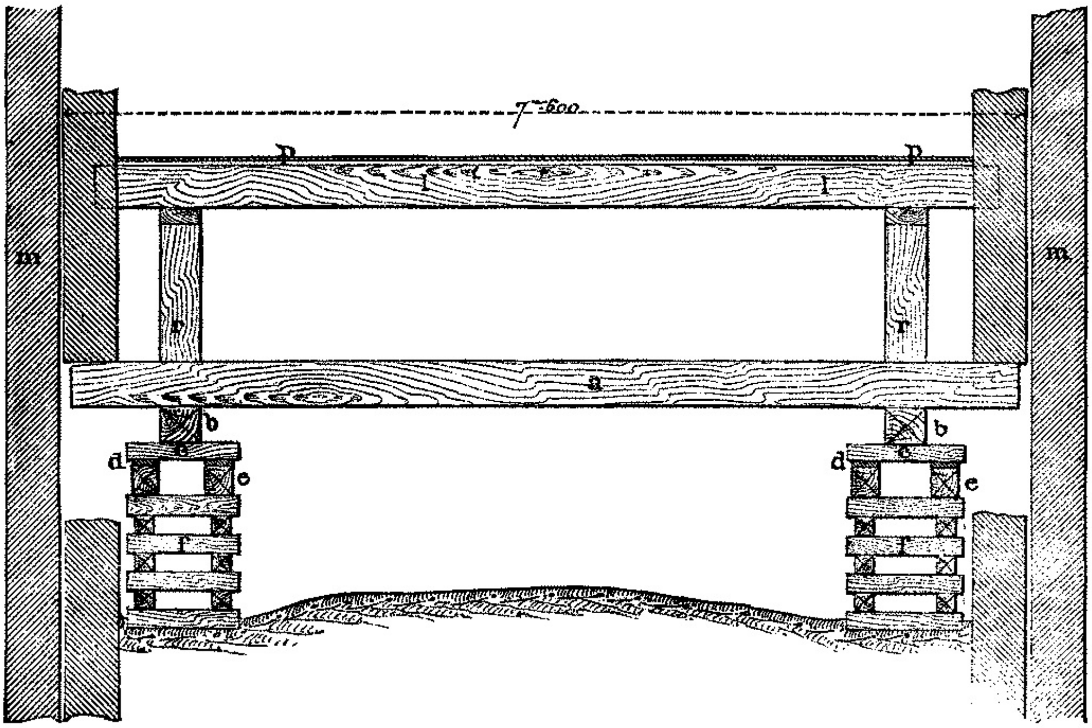


Fig. 9.—MOVING A HOUSE BETWEEN TWO FIXED WALLS.

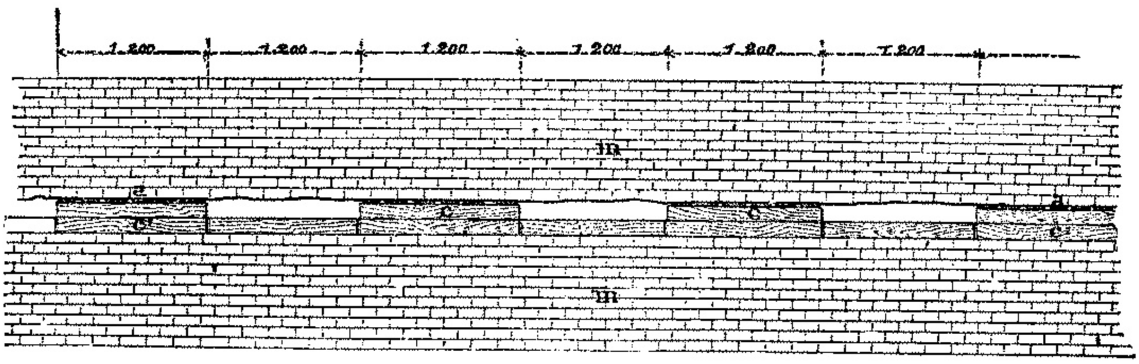


Fig. 10.—METHOD OF MOVING A HOUSE WITHOUT LIFTING IT.

RAISING AND MOVING MASONRY BUILDINGS.

The accompanying figures show the method employed in moving several buildings of different construction, and the peculiar arrangements that have been made, according to circumstances.

The instrument most commonly employed in the execution of such work consists of the following parts: (1) of a cast iron screw having a pitch of 0.56 inch; (2) of a nut provided with a shoulder and two projections that serve to fix it; and (3) of a cast iron plate that is interposed between the head of the screw and the beam upon which the latter is to exert its pressure. Moreover, each nut is set into an oak block, 4 inches in thickness, which rests upon the upper beams of the timber work that is designed to sustain the structure.

All the pieces of wood of the timber work, properly so called, are of spruce, and measure 6x6 inches. Those that are in a direction perpendicular to the foundation walls are 3 feet in length while the longitudinal ones must be long enough to support several screws in order to annul the effect of joints.

Figs. 1, 2, 3, and 4 represent a house at Buffalo belonging to the New York and Lackawanna Railroad Company, constructed of bricks and having a frontage of 90 feet. Between the openings in the latter there are pillars of dressed stone and cast iron columns. The building is four stories high, and the outer walls are 1 foot in thickness.

During the month of June, 1882, this structure was raised all in one piece and moved back 35 feet, in order to give greater width to the railway. This work was performed in so regular a manner that no interruption occurred in the business of the Company's offices.

The first operation consisted in running well squared spruce beams, 12 in. × 8 ft., through the walls and under the ground floor. These beams projected beyond the wall on each side and were spaced about 3¼ feet apart, and care was taken to have them in the same horizontal plane. After ramming down the earth upon which the timber work, f, was to rest, the first transverse beams forming the foundation platform were laid in place in such a way as to have between them the same spacing as between the cross-pieces, *a*, and so as to be exactly on the same level. These were afterward surmounted with longitudinal beams with alternate transverse ones until the desired height was reached. This framework having once been put in place, there were placed in the axis of each piece of timber work string-pieces, *b*, which ran without a break the entire length of the wall. Jack-screws, *v*, of the kind above described, were finally arranged in pairs under each of the cross-pieces, *a*.

On the front side (Fig. 3) particular precautions were taken to support the stone pillars and iron columns. To this end, apertures were made in the foundation, starting from the axis of the pillars and terminating at the axis of the neighboring columns. Spruce sills were put into these openings and others between the columns, the last-named ones having been put in place after the masonry had been completely severed. The cross-pieces, *a*, were thus under the sills, *g*, before the putting in place of the screws, *v*, and these latter were maneuvered in such a way as to merely support the structure without lifting any of its parts.

These preliminaries having been finished, all the pieces of the timber work were examined with the greatest care, while, at the same time, the joints were consolidated and the defects in leveling were rectified by means of spruce wedges.

During the time of lifting, the workmen were arranged in pairs opposite each other, and on each side of the wall, where each one had 12 to 14 screws to maneuver. In order to render the motion very uniform, the superintendent of the work gave signals by means of a whistle. At this moment each man gave the screw a half revolution, passed to the following one, and continued thus until all the screws under his supervision had been revolved to the same degree. At a fresh signal this operation was begun again, and so on.

When the building had been lifted to a height of twelve inches, it became necessary to raise the screws. To effect this, two rows of beams (Fig. 7) were added to the timber-work, and each screw was moved in succession, so as to always leave one in position. By these means the building was gradually lifted to the desired height, and it now became necessary to take the requisite measures for moving it back. With this object in view, spruce floor timbers, *e*, very smooth and well lubricated with tallow and soap, were laid upon the timber work and afterward covered with oak planks, *d*, one inch in thickness, and upon these latter were placed joists, *c*, that supported string-pieces, *b*, that were firmly fixed to the joists by means of spruce pins driven in with force. As the floor timbers that were employed had to be as long as possible, they were united end to end by a strong joint and prolonged as far as the new spot upon which the edifice was to rest. Throughout their whole extent they were supported by sleepers that were fixed firmly in the earth. The entire weight of the structure being carried by the pieces, *a*, *b*, *c*, *d*, *e*, and *f*, after the removal of the screws, the jacks, V, were then placed in position, their heads resting against the string-pieces, *b*, at the points marked S, and their other extremities being received by a framework set into the earth. It took but twelve jacks to move the entire mass, and these were maneuvered under the orders of a superintendent, who transmitted his signals with a whistle.

It took forty days to perform all these operations, and it required fifty men to lift the structure. After the jacks, V, had been put in place, the building was moved in three days, or at the rate of 11.68 feet per day. This is a medium rate of speed to be adopted in the moving of a structure like this, for, under very favorable conditions, it might be carried to over eighteen feet per day.

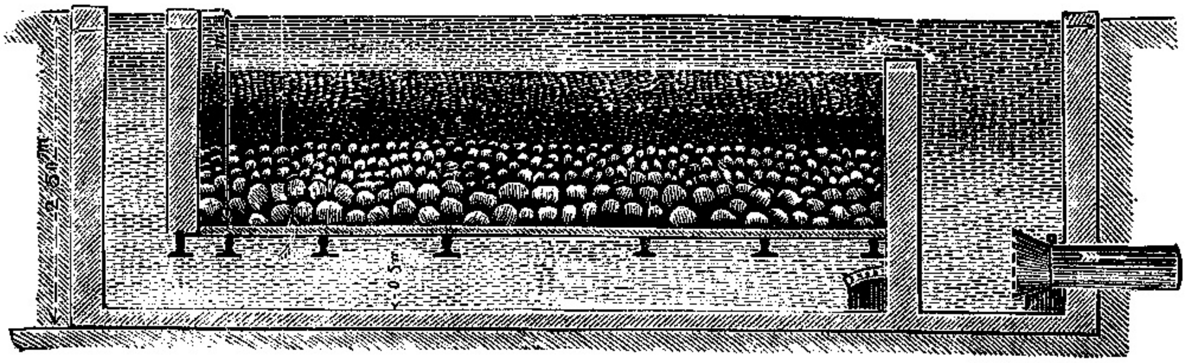
The timber work which was used in lifting the building was afterward put together again, in the same manner, around prolonged foundations, and the same were put in place a second time after the manner described above. After the floor timbers, e, had been removed by slightly lifting the load, and the structure had been lowered to its proper position, the intervals between the cross-pieces, *a*, and the walls of the new foundations were filled in with masonry; the mass was then allowed to settle gently down into its place and the cross-pieces were removed.

When buildings stand very near each other, timber-work cannot be put together outside of the walls, and it therefore becomes necessary to adopt the arrangement shown in Fig. 9, all the work being done here beneath the structure. The cross-pieces, *a*, occupy here the entire width of the house, and are spaced about 36 inches apart from axis to axis. The structure rests upon two pieces of timber work constructed like the ones mentioned above. Besides this, it is necessary to utilize the timbers, L, of the flooring, P, for supporting a part of the load.

During the widening of State Street, in Chicago, several three or four story brick structures were moved in this way. One of these houses was set back about four feet without the necessity of lifting it. Apertures (Fig. 10) four feet in length were cut in the foundation walls, the edges were made level, and planks, *c* and *c'*, were inserted and fixed in tightly by wedges. The intervening masonry was removed, and, after laying planks alongside of those already in place, the structure was put in motion in the ordinary way.

When single threaded screws are employed for moving buildings, it requires much time and manual labor to place and move the pieces. For the purpose of securing greater rapidity in these operations, Mr. Hollingsworth has devised a sort of jack-screw (Fig. 11) that consists of a steel screw about eight feet in length and three inches in diameter, provided with two threads, running in opposite directions. The nuts are set into the corresponding extremities of two beams, one of which abuts against a cast iron brace-block, *n*, held in place by a stirrup-iron, *t*, while the other bears against the string-pieces, *b*. Thanks to this arrangement, a structure may be moved at one time over a length of 6 feet instead of 1.3, the latter being the maximum travel with single screws.

The method in which slide beams, f, are prolonged in view of resisting the pressure of the jacks is scarcely employed at present, the objection to it being that it occasions changes of direction from the line formed by the timber work. For this reason, contractors prefer to use independent posts to receive the jacks.—*Revue Industrielle*.



FILTER FOR INDUSTRIAL WORKS

FILTER FOR INDUSTRIAL WORKS.

As a rule, bleach and dye works are established where there is a sufficiency of good and soft water, except in such cases where for special reasons it is desirable to use town water, and which then is generally clear. Where, however, water from brooks, rivers, or lodges is used, as is mostly the case, it is often discolored after heavy showers by earthy substances which are carried away by it. These impurities, all existing in the water in suspension, are not at all desirable for the dyer, and less for the bleacher, who generally allows the water to settle in a lodge, to give it time to deposit its impurities by gravitation. We understand that by means such as these even the water of the much-abused Irwell is made, in a Salford bleach-works, to produce some of the most beautiful whites possible. These lodges occupy, however, much space, which is not always available, and filtration is therefore the best where it can be carried out. We here produce the description of a cheap and efficient filter which bleachers or dyers may easily make for themselves. The dimensions are of course dependent upon the quantity of water to be filtered, and as a guide we shall describe a filter serving for a volume of water of about 1½ cubic yards per minute. In the first instance a hole is dug at a point where the water has sufficient fall to give it a head, and here a cistern set in cement is bricked out, measuring about 30 yards in length, 2½ yards in width, and 2½ yards in height. Across this cistern two partition walls are erected, one at the left resting upon rails, and the other going down to the bottom of the cistern. Between these two walls railway rails are laid crosswise, and over these a floor of wooden laths. Over this floor the filtering media are placed, consisting of a bottom layer of stones, then a layer of coke, then a layer of gravel, and lastly of a top layer of river sand. The water enters on the left-hand side into the space between the outer wall and the partition, and descends under the floor of the filter, through which it rises and passes in succession through the four layers of filtering substance until it issues at the top, when it runs over the partition, and out by the pipe shown in the right hand corner. It will be seen that the course of the water is upward through the filter, and in this respect contrary to the usual custom. The filter is cleaned about once a month by reversing the course of the water, and turning it indirectly on the top of the filter—causing it to run but at the bottom—and thus carrying all deposits with it. Both the central filtering compartments, as also the overflow cistern at the right hand, contain, near the bottom, doors, through which, when opened, the cleansing water runs off by a separate channel to the river. The dimensions of the cistern can, of course, be made to suit the situation.—*Tex. Manfr.*

THE VAL ST. LAMBERT GLASS WORKS.

During the recent meeting in Belgium of the Institution of Mechanical Engineers several interesting excursions were made, and by no means the least interesting was the visit to the glass works of Val St. Lambert.

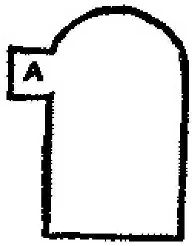
This is one of the largest glass works in existence, entirely devoted to the production of domestic articles, such as tumblers, wine glasses, lamp chimneys, and such like. A good deal of ornamental work is also turned out, a staff of highly competent artists being employed in painting glass vases, etc., such as are used for the decoration of rooms.

The Val St. Lambert works stand on the right bank of the Meuse, in the commune of Seraing, and about seven and a half miles from Liege. As the head offices of Cockerill's vast establishment are located in the old palace of the Bishops of Liege, so the Cristalleries of Val St. Lambert occupy the site of the Abbey de Rosieres. Up to the year 1192 the site was almost a desert, but about that period the abbey was founded. In 1202 Hughes de Pierrepont, Bishop of Liege, gave to the monks a tract of land and woods situated in what was then called the Champ des Maures, whereon was built the abbey. It prospered and became powerful. At the end of the last century it was reconstructed, and at that time were raised the fine buildings now used as a manufactory. The rebuilding had hardly been finished when the Revolution came, and with it the expulsion of the monks. It was sold by the nation, and was used for various manufacturing purposes, until the year 1825, when it was purchased by MM. Kemlin and Lelievre. There had previously existed, at Vonêche, near Givet, a glass works carried on by M. D'Artigues, its owner, aided by M. Kemlin, his nephew, and M. Aug. Lelievre. This latter gentleman had left the Ecole Polytechnique of Paris with distinction, and was the son of Mr. Anselme de Lelievre, Inspector-General of Mines, and a distinguished savant of the last century. MM. Kemlin and Lelievre both became naturalized Frenchmen. However, the frontier traced by the Congress of Vienna for the new territory of Belgium cut Vonêche off from France. The glass works accordingly lost their only market, cut off from it by a heavy tariff. M. D'Artigues left the place and went to France, while MM. Kemlin and Lelievre found in the old Val St. Lambert Abbey what they wanted in Belgium, and this was the origin of the glass works. Nor would it be easy to hit on a better site. In the heart of a rich country, on the borders of a fine river, in the center of a coal basin, and close to the Marihaye Collieries, well provided with railway accommodation, the Val St. Lambert glass works possess every advantage, and they have been proportionately successful.

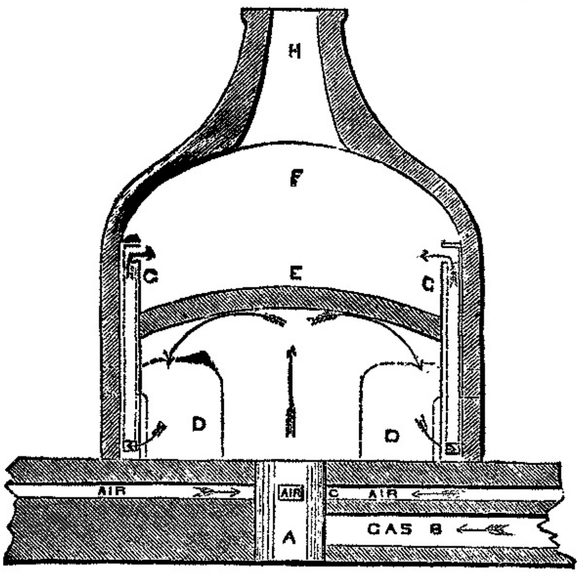
The establishment is worked by a company known as the Societé Anonyme des Cristalleries du Val St. Lambert, under the Presidency of M. Jules Deprez; and the company possess four distinct establishments, namely, that at Val St. Lambert; one at D'Herbatte, near Namur, founded in 1851; a third in the Rue Barre-Neuvill, at Namur, founded in 1753; and, lastly, one at Jambes, near the same town, founded in 1850.

We need not trace at length, says *The Engineer*, the history of the works. It will be enough to say that for a long time they were carried on with small or no profits; but a great advance was made when, in 1830, coal was first substituted for wood for heating purposes. Further capital was introduced in 1836, and operations have been carried on practically without intermission ever since. In 1850 the annual turn-over was about £60,000. In 1880 the turn-over of the company was £200,000. To give an idea of the magnitude of the operations carried on, we may say that no fewer than 120,000 pieces are turned out *every day*. To pack this there are used 50,000 kilos. of heather, 55,000 kilos. of straw, and 250,000 feet of boards per month. The sand of all kinds used per year weighs 7,000,000 kilogs., and the weight of the fire clay 1,500,000 kilogs. The weight of the finished goods sent out per year exceeds 9,000,000 kilogs. The company employs in all about 3,000 hands, 1,800 of whom are at Val St. Lambert. Much attention is paid to the welfare of the operatives by the company, and a species of co-operative store is worked with great success. Many of the hands have been on the works of the company for fifty years, and the managers speak in the highest terms of their servants. They know nothing of "St. Monday." They are laborious, assiduous, intelligent, and attached to the works and the locality, which they rarely quit. These conditions are the most favorable possible for the employers, and they are far too rare in Great Britain. The Val St. Lambert hands, men, women, and children, work uninterruptedly for eleven hours a day all the week through, and some of the men even longer. This affords a remarkable contrast with the hours of labor and customs of our English glass workers.

We take it for granted that our readers know generally how glass is made. That a mixture of sand and an alkali is fused into a kind of pasty mass. The fusion is effected in pots of refractory clay, of which the general form is something like that shown in the sketch. The mouth of the pot is shown at A. The pots at Val St. Lambert are of various sizes; the largest hold about 16 cwt. of glass. The duration of the pots is very variable; they last sometimes only a few days, at others several weeks or even months, much depending on the quality of the pot. The temperature to which they are exposed is not excessively high. The great thing to be effected in a glass melting furnace is the perfectly equal distribution of the heat. At Val St. Lambert gas is used, generated in Siemens or Boetius producers. There are in all twenty furnaces. They are grouped in threes or fours, in the large buildings, with high roofs. Formerly the furnaces were square, and held each eight melting pots, which did not hold more than 250 kilos. of glass. The modern furnaces each receive from twelve to fourteen melting pots. The modern melting pots as made by the Battersea Plumbago Crucible Company do not seem to be known here.



The peculiarities of the construction of the glass melting furnaces at Val St. Lambert will be gathered from the annexed sketch. The furnace is circular, 14 ft. or 15 ft. in diameter, and from the roof, E, to the floor is about 5 ft. 6 in. high. In the center of the floor is a cylindrical opening, A, through which rises the mixture of gas and air, the latter being introduced through four openings, three of which are shown. Two of the pots are indicated by dotted lines at D D. The equitable diffusion of the heat is effected in the following way: Inside the furnace are constructed as many vertical flues as there are pots. Two of these are shown at G G. They have small openings about 5 in. by 8 in. at the bottom. The course pursued by flame is indicated by the bent arrows. The flame rising strikes the crown, E, and is deflected downward and drawn off by the side flues, which deliver into the second vaulted space, F. In this, in some cases, are annealed the finished articles of glass. In others is fixed a boiler, steam being generated by the waste heat. In others there is no opening at the top of F at H, but there is one at the side instead, through which the flame is led to raise steam in Belleville tubulous boilers. The steam is used to drive the engines in the grinderies. Not much power is required, and it is very easily obtained from the waste heat.



SECTION OF CLASS FURNACE.

The operations of the glass blower have been too often described to need redescription here. One or two points, however, deserve notice. One is the large use made of wooden moulds. In these are formed all kinds of circular articles, such as tumblers and lamp glasses. The moulds are in halves, and are kept soaked with water to prevent them from burning. Inside they become lined with charcoal. The glass blower, getting a knob of glass on the end of his blowing rod, blows a very thick, small bulb; this he then places on the mould, which is closed by a very small boy; in but too many cases mere children, seven or eight years old, are employed. The child holds the two sides of the mould together while the blower rotates the bulb within, blowing all the time. The work is turned out very true. Up to a comparatively recent period the tumbler was cut to the proper depth while hot with a pair of scissors, but this has been abandoned, and an extremely ingenious little machine is now used for cutting lamp glasses, tumblers, etc. The article to be cut is placed vertically on a stand. At the proper height above the stand is fixed a sharp steel point, and by touching the glass against this a very small scratch is made. At the same level is fixed a little mouthpiece through which issues, under pressure, a tiny gas flame, not thicker than a sheet of note paper. This falls on the glass, which is turned round by the woman attendant. The glass is heated in an extremely narrow band all round. The touch of a moistened finger suffices for the complete separation of the two parts of the glass round the heated girdle. In fact, this is a very elegant application to manufacturing purposes of the well known hot wire method of cutting glass so often tried with indifferent success by the enterprising amateur.

Glass grinding is carried out on a very large scale at Val St. Lambert in huge well lighted shops. There are four grinderies at Val St. Lambert, and one at Herbatte, the total number of which is 800, and the floor space occupied is no less than 24,000 square feet. The first steam engine was put down to grind glass in 1836. A great deal of engraving is done with fluoric acid, the vessel to be engraved being protected with wax in which the design is etched. Tilghman's sand blast is also employed, as well as the old copper disk system; flats are ground on tumblers by automatic machinery.

It would be impossible to do more than give a general idea of the operations carried on in this vast establishment, every portion of which was thrown open to the members of the Institution, while numbers of heads of departments went round and answered every question, and explained every detail with a frankness and a courtesy beyond praise. It is impossible to inspect such an establishment as that at Val St. Lambert without feeling how hard is the battle which manufacturers in this country have to fight. There, as we have said, are to be found every advantage of position, and to this is added a body of workmen, active, sober, industrious, among whom is heard no talk of strikes, and who are content to work every day and all day long; such men, directed by heads possessed of no small scientific ability, and re-enforced by the command of ample capital, cannot fail to make a mark in any market, and we only speak the truth when we regret that we have not such works and such men on English soil as there are to be found at Val St. Lambert.

MEASURING STARCH GRANULES.

It is well known that the microscopist can readily distinguish potato starch from all other starches by the size of the grains. Saare has found that the size of the potato starch granules increases with the quality of the starch. In first quality starch they have an average diameter of 33 micro-millimeters, in second grade 21, in third grade 17, in the rinsing water 12, and in that floated off on the water only 8 micro-millimeters. Saare's paper may be found in full in the *Zeitschrift fur Spiritusindustrie*, vi., 482.

PROPER SHOEING.

In his article on horseshoeing Mons. Lavalard makes some good points, and also some that appear to me to be erroneous. He says, in regard to the frog, "It is evident, then, that the frog helps the hold, but strange to say, it alone of the three parts has a share in the hold when the hoof is shod."

We see nothing strange about this where horses travel over hard roads; the case is otherwise on soft roads or race tracks. It is easy to make the ground surface of such shape that it will have sufficient hold, without the action of the frog. In the shod foot, the frog has more to do with keeping the foot healthy than assisting in the hold. With horses used for speeding purposes, the frog helps to sustain the sole of the foot, as when the foot is brought down with great force and the road soft enough to receive the imprint of the shoe. He further says that: "Simultaneous with this preservation and regeneration of the frog, the hold of the horse becomes firmer, and more equally divided toward the heels, and when starting a load, there is no clamping with the toe of the hoof, but the foot is brought down flat."

Let us examine this statement and see if the reason why the horse brings the foot down flat is because the frog is good, and has a good hold on the ground. The reason appears to *us* to be because from the manner of shoeing the horse cannot put his foot in any other way. The shoes are much thinner behind than in front, and the heels pared low enough to insure the frogs resting on the ground. Excessive paring of the heels gives extra length to the shoe, which, being thick at the toe, props the toe up in such a manner that the horse is *forced* to let the foot remain flat when starting a load. Nothing is gained by keeping the foot flat while starting a load, and to prove this, we ask the reader to observe unshod horses when starting a load. The frog having free access to the ground, see if the horse does not clamp the ground with the toe when exhibiting the maximum of strength. Also examine the imprint of horses' feet (especially the hind ones) when drawing heavy loads over soft ground, and see if the shoe is not pressed more firmly into the ground at the toe than at the heel. This is not because he gets a better use of the frog by so doing, but because the foot is in a better position for the horse to exert his strength without injury to the back tendons. As a further test, place yourself on an incline facing squarely up hill, and see how much power you can exert; then place your feet exactly opposite in direction, and note how much power you can then exhibit. What has made the difference? Simply the relative position of the heels and toes. We do not, like Mons. Lavalard, wish to force our horses to travel up hill all the time, which is the case when shod as he describes.

Horseshoers, like other men who follow a special calling, are apt to think that their theories and practices relating to their special trade are superior to those of other men. I think it is safe to make the assertion, without fear of successful refutation, that there is not more than one horseshoer in ten thousand but what can convince the average horse owner that he (the smith) knows just about all that is worth knowing about horseshoeing.

And the same average horse owner is conceited enough to think himself a better judge of a good job of shoeing than the intelligent animal that wears the shoes till his feet feel as though they were full of thistles. A horse's foot is not a thing that can be cut and slashed into all shapes with impunity, but requires careful as well as intelligent treatment. It is a great mistake to suppose that every sound foot should be treated alike. Each foot has its individuality, which must be *recognized* and *respected* if good results are to follow shoeing. It is a lamentable fact, and one that cannot be disputed, that most horseshoers have but a faint notion of what is required to shoe a horse properly, even where no defects exist. If he gets pay for the work, he gives himself no trouble to improve on his methods. But with the owner the case is different. The usefulness and value of the horse are largely affected by the condition of the feet, and he must learn to know how his horse ought to be shod, and then see to it that the work is properly executed. We know from personal experience that this is hard to do. The smith must understand that you are in earnest about the matter, and that you are bound to have your orders obeyed. I have found some men very obstinate, and others always ready to do anything that was an improvement on the old way. First decide what kind of labor the horse is expected to perform. If he is expected to go fast, great care and skill will be required to get everything just as it should be, and don't blame the smith for charging extra for extra work.

It will often be necessary to make several trials before you find out just what suits the horse best, and don't fail to let the horse be judge in the matter, for when he is suited you ought to be.

Place the horse on a smooth, clean floor, and note the set of each foot, and whether it is in line with the limb above it. Cut away the wall of the foot until you come to where it joins the sole; except at the heels and quarter, it may not be quite as low; let the frog and bars remain intact, but see that the shoe will not bear much on the bars. Give the sole about its natural concavity of surface up to the wall, but no further. Place the foot on the floor and see if it is in line with the limb; if not, remove enough horn to make it so. The slant of the front part of the fore foot should, as a rule, be the same as that of the pastern; that of the hind ones a little steeper. Now stand behind the horse while he is made to walk, and see if when the foot approaches the floor both sides come down at the same time so that there is no rocking motion from one side striking first. Disregard the advice of some writers who recommend to have the sole bare on the iron; that theory when put into practice doesn't work worth a cent.

In most cases it will not be necessary to remove much, if any, of the horn from the sole, but there are cases where it will be found necessary to remove quite an amount, or the sole will become so inelastic that it will greatly interfere with the action of the internal organs of the foot. It is evident that nature made the sole of the foot so that it might be acted upon mechanically to remove its surplus growth in the same way as the wall, for in the unshod foot it receives the impact of all sorts of substances, from soft mud to sharp, flinty rocks; and that, too, without becoming dry and brittle.

The bearing surface should be half an inch wide and made *positively flat and level*, being without lumps or depressions, and not beveled either way unless they are hard and inclined to pinch, when it should be beveled to the outside, so that the weight of the horse when brought upon its 6445
surface will cause the heels to open, thereby causing a more healthy condition of the frog. The nail holes of the shoe should be further from the outer edge of the shoe, especially at the toe, than those usually seen in the market. The bearing surfaces of the foot and shoe should be as nearly approximated as possible, else the hoof will be bruised and the shoe soon loosened. The holes being further from the edge, allows the nails to take a deeper and lower hold than is usually given them; the direction of the nails is more nearly across the grain or layers of horn, causing less splitting of its substance, thereby securing a firmer hold upon the foot. Two large nails are usually chosen, 5s or 6s being large enough for ordinary shoes. It is not necessary to hammer down the clinches, if care has been taken to draw the nails, finishing with light strokes of the hammer. The shoes will stay just as long, as we can testify by four years' experience, and the advantages are that the horn is not injured by filing below the clinches nor by the strokes of the hammer during the operation.

Should the horse step upon the shoe, no horn will be removed with the shoe, as is usually done when the clinches are left long and then turned down with the hammer. In such cases, the shoe will be torn off, no matter how solid the clinches hold, and it is better to come away without breaking the hoof. We repeat and make emphatic that the bearing surface of the shoe *must not* *be concave*, as it is almost sure to make corns, and induce an inflammatory condition of the foot, and this inflammatory action is the forerunner of the long list of evils that are sure to follow, unless means are taken to relieve the parts. And yet almost every horseshoer in the country gives the bearing surface of the shoe a bevel to the center. Many smiths will deny this, but after they have the shoe ready to apply to the foot, take a square and place the edge across the bearing surface at the heel of the shoe, and ninety-nine times out of one hundred the outside will be the highest.

The front action of a horse may be greatly modified by the weight of the shoe, and here is where great caution, close attention, and a thorough knowledge of the principles involved are required, or one will be liable to throw his horse out of balance if he is used for speeding; for slow work it is better to have the shoe somewhat lighter than the horse might carry than to err in the opposite direction. It is not intended by me to take up all the points of horseshoeing that might be dwelt upon with profit, and no one who reads these remarks will be more ready than I to learn a better method of shoeing than that I now practice, and I sincerely hope that some reader of this paper will favor us with more information on this important subject.—P. D. B., *in Wallace's Monthly*.

[Milling World].

IDEAS.

By A. Looker-on.

I.

There is yet a good deal to do in successfully applying the roller process to small mills of from 25 to 100 barrels capacity. There has been a great deal done, no doubt, but one thing is lost sight of in all the patents that have been granted so far, and that is cheapness, not only in the price of the machine, but also in its application to the existing or original plant in the mill. It should be of such a nature that as few changes in the machinery as possible should be made.

If a grain of wheat is examined, it will be astonishing to see the chemical laboratory that is locked up in it. The most valuable substances, gluten, is placed near the air and light, while the little cells of the interior are composed of starch, which being the softest is the first to break up under the influence of the rolls. Hence, the flour of the first and second breaks is mostly composed of that substance.

About three and a half per cent. of woody fiber can be removed from a kernel of wheat by a moistened cloth; it is of no value, whatever. The next coating holds nearly all the iron, potash, soda, lime, and phosphoric acid. This wrapper is the granary, so to speak, in which is deposited all the wealth of the berry, and like a good safe is the hardest to open, by either the rollers or burrs.

The use of rolls in cleaning bran is now generally recognized, and they have proved very useful and practical for this purpose especially in large mills. Bran, however, can only be thoroughly cleaned by several operations, and the previous condition of the bran has a great deal to do with the number of operations it has to undergo on the rolls to be well cleaned.

Each passage through the rolls changes the condition of bran, and the oftener it goes through them the lighter and cleaner it becomes, until all the floury portion is removed.

The Austrians use corrugated rolls for the purpose of cleaning bran, the finest being on the last, as in the break rolls. It is more scientific and philosophical to clean the bran in this way than to rub off the flour between burrs in this way than to rub off some of the branny portion as well as the glutinous part.

Rollers for the first cleaning are from eight to ten inches in diameter and from three to five hundred corrugations are used, and this increases up to one thousand for the last rolls used; but fine corrugations wear out soon, and the rolls have to be frequently corrugated or the bran has to be finished on burrs.

The use of rollers is preferable to that of stones for bran, and their use is considered an important advance in milling by most German experts.

As the advantage of the use of rolls instead of burrs consists in the production of a greater amount of middlings, this advantage should be experienced in the cleaning of bran. As the small starchy particles adhering to the bran are separated in the shape of middlings instead of flour, a better quantity of flour is produced from these middlings both in color and strength than that which is made from the stones' product.

Differential speed in rolls is not only better in making middlings, but in grinding bran as well.

This has been proved by several experiments.

There is no doubt but that there is less care bestowed on the hanging and care of shafting than upon any other means used in applying power to manufacturing purposes. If the steam engine or the water wheel is in good order, and performing their work properly, and the machines driven by them are also in good order, there is seldom a thought bestowed upon the media between the actuating power and its ultimate development, except the necessary attention which must be paid to the belting, and oiling of the machinery.

Often, when the result of the power is not satisfactory, it is not the driving power that is at fault, but the result may be found in the shafting, or other intermediate transferers of the power. Generally, in such a case, the belts are examined and their condition assumed for the imperfect transmission of the power from the prime mover.

The condition of the belts is a very important point in all manufacturing, but more particularly in mills where a steadiness of motion is a desideratum, and attention to them will save many dollars in the course of a year; but there are other as important elements which are not always taken into consideration, and the principal one is the condition of the shafting. A line of shafting running perfectly true, without jumping or jerking, turning smoothly and noiselessly, is a delight to the mechanical eye; and the first thing always examined by a thorough millwright when he enters a mill, is the shafting.

Perhaps there is nothing will strike a person who has been out of the milling business for some time so much as the change in the system of bolting. This is caused by the numerous separations, and it is in this the whole secret of gradual reduction lies.

PHOTOGRAPHS FOR STUDYING THE MOVEMENTS OF MEN AND ANIMALS.

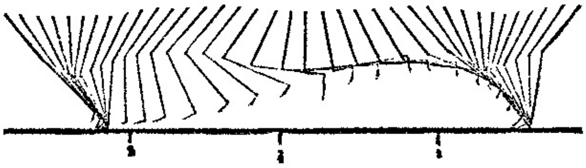
By M. Marey.[2]

When a series of photographs representing the successive attitudes of an animal is taken on the same plate, it is naturally desirable to multiply these images, for the purpose of getting the greatest possible number of phases of the movement. But when the animals to be reproduced do not move rapidly, the number of images is limited by their superposition and the resulting confusion. Thus, a man running at a moderate pace may be photographed ten times in a second, without the impressions on the plate being confused. If, at times, one leg is depicted on a part already bearing the trace of another leg, the superposition does not alter the image; the whites become only more intense in those portions of the plates receiving an impression twice over, but the contours of both limbs are still to be distinguished. In the case, however, of a man walking slowly, these superpositions are so numerous as to render the reproduction very confused.

It is to remedy this defect that I have had recourse to partial photography; that is to say, I have suppressed certain parts of the image, that the rest may be more easily understood.

In the method which I employ, only white and light objects affect the sensitive plate; it suffices, therefore, to clothe that portion of the body to be suppressed in black. If a man dressed in a parti-colored costume of black and white walk over the track, by turning the white parts of his apparel toward the camera—the right side, for instance—he will be reproduced as if he only possessed the right half of his body. These images permit the various successive phases of movement to be accurately followed, the rotation of the foot and leg when both on the ground and lifted up, and the oscillation of the limb at the hip joint while moving along in a continuous manner.

These partial photographs are also useful in the analysis of rapid movements, because they allow of the number of attitudes represented being multiplied. At the same time, as a man's leg is rather large, its reproduction cannot be multiplied very often, owing to confusion by superposition. I have therefore sought to diminish the size of the images, so as to an admit of repetition at very short intervals. The method consists in attiring a walker in a black costume having narrow bands of bright metal applied down the length of the leg, thigh, and arm, following exactly the direction of the bones of the limbs. This plan permits the number of images formerly produced to be increased at least tenfold; thus, instead of ten photographs per second, one hundred may be taken. To do this it is not necessary to change the speed of rotation of the disk, but instead of piercing it with one aperture, ten holes are made equally disposed around the circumference.[3]



The figure here shown is from one of the negatives projected on the screen from the lantern. The dotted lines have been filled in to form direct lines. The figure shows the successive phases of one step in running. Only the left leg is represented; the lines correspond to the thigh, leg, and foot; the dots to the joints at the ankle, knee, and hip.

This diagram shows pretty clearly the alterations of flexion and extension of the leg on the thigh, the undulating trajectories of the foot, knee, and hip, and yet the number of images does not exceed sixty in a second. A revolving shutter pierced with more holes would give more perfectly the angular displacements of the leg on the thigh, and the positions of the three joints. The finer the dotted lines expressing the direction of the limbs, the more the images may be multiplied; but in the present case, sixty times in a second more than suffice to show the displacements of the limbs when running.

In this photographic analysis the two factors of movements—time and space—cannot be both estimated perfectly; knowledge of the positions the body has occupied in space requires that one should possess complete and distinct images; in order to obtain such images, a sufficiently long space of time must elapse between the two successive photographs. If, on the contrary, it is desirable to estimate time more perfectly, the frequency of recurrence of the image must be greatly increased. To bring these two exigencies as closely together as possible, lines and points must be chosen for the partial photographs which best show the successive attitudes of the body.

It is curious to see that this expression of successive attitudes of the trunk and limbs, by means of a series of lines expressing the direction of the bones, has been precisely adopted by the ancient authors as being the most explicit and capable of making the phases of a movement understood. Thus, Vincent and Goiffon, in their remarkable work on the horse, have tried to represent by lines at different angles the displacements of the bones of limbs while taking a step.

It is not necessary to expatiate on the superiority photography has over actual observation for this purpose, giving the true positions of the limbs, while the eye is incapable of taking in such rapid actions in such short spaces of time.

At the commencement of this century the brothers Weber had recourse to the same mode of representation to explain the successive actions produced in the walk of a man. It was by reducing the walker to the figure of a skeleton that these eminent observers succeeded in presenting, without confusion, a number of images expressing different attitudes.

The method of constructing the bright metal bands which in the photograph explain the position of the joints, requires special mention. As the length of exposure is very short, a substance having great brilliancy must be employed. The strips of metal are not equally luminous down their entire length, because they do not reflect the solar rays at the same angle; they present lines of unequal intensity on the negatives. I have obtained the best results with small strips of black wood with nails having hemispherical bright metal heads driven in at regular intervals. Each little rounded surface reflected the image of the sun very brilliantly. In the photograph these lines of nails are reproduced as dotted lines. At the ankle, knee, and hip joints, nails of larger dimensions were inserted, showing these centers of movement by a much larger dot.

Partial photographs obtained by this method allow of the different acts of locomotion being analyzed, as well as the movements of walking, running, or jumping.

DETECTIVE PHOTOGRAPHY.

For several years Mr. D. N. Carvalho, the New York photographer, has made a specialty of the delicate use of photography which is brought into play more and more in connection with criminal cases in which disputed handwriting, forgeries, counterfeit money, etc., are features. The results now achieved are the outcome of years of experiment, and the photographic expert becomes in the end an expert in handwriting. Mr. Carvalho's gallery of records is an interesting illustration of what perseverance and ingenuity, aided by photography, can do toward solving apparently hopeless mysteries. To a reporter, who visited his studio, he said:

"We can do a great many things to bring the truth to light by the aid of photography. There is scarcely a case nowadays in which it is not brought into play if disputed handwriting is concerned. Of course the most famous case of late years was the Morey letter case. There is a photograph of the Morey letter up there in a corner. It yet remains a mystery, but we are certain that Garfield did not write it. I first found by photography that the envelope had been tampered with by the following process: Cutting the envelope open, so as to get a single thickness of paper, I put it between two sheets of plate glass, and placed it where the sun passed through it, the camera being placed on the shady side. Although no half-erased writing could be detected on the envelope with the naked eye or a glass, the difference in the thickness of the paper where erasures had been made showed plainly, as the light came through more clearly, and the erased words, which gave rise to so much discussion, were discovered.

"Below the Morey letter is a photograph of the signature of Alonzo C. Yates. Yates, you may remember, was a rich Philadelphia clothier, who, late in life, married a cook in the Astor House, and died, leaving a million or so to the wife. The daughters by a first wife disputed the signature to the will. I was employed by John D. Townsend to show the genuineness of the signature. We got thirty or forty genuine signatures of Yates admitted by both sides, and showed that a man never writes his name the same way twice. Then I took the signature of the will and another admitted by both sides, and enlarged them until each was 9 feet 4 inches long. The peculiarities of the writing became so apparent when shown upon that enormous scale—the signatures were so evidently by the same person—that the contestants gave up the case.

"There is a portrait of Theophilus Youngs. He married a clairvoyant many years ago in Boston and disappeared. His widow pretended to recognize his body in one that was found in the bay soon after, and he was given up as dead. Some years after his father died, and the widow put in a claim for a share of the property. The contestants, by whom I was employed, contended that Youngs was yet alive, and eventually produced him in court. The alleged widow refused to recognize him, and I was called upon to prove he was the man. The widow produced a photograph which she said was one of the pictures of Youngs, her husband. A good many years had passed, and although the likeness was a strong one, there was enough difference in the appearance of Youngs and the photograph to make a jury hesitate. I put Youngs in the same position in which he was taken in the picture, the genuineness of which was admitted, and made a photograph of the same size. Then the likeness became more apparent, and exact measurements showed the two faces to measure the same in all respects. For instance, the distance between the mouth and the eye, which is seldom the same in two persons, was exactly equal. Then one picture was made transparent and superimposed over the other, and the two faces matched perfectly. The jury decided that the claimant was not an impostor.

"In the case of Hall, the head clerk of the Newark Treasurer's office, everything depended upon showing that he changed a figure 5 into a figure 3. He ran away to Canada, and was brought back upon a charge of forgery. His counsel claimed that the figure had not been changed, and that if the mark of an eraser was found, and that the figure 5 had been changed, it was caused by the accidental slip of an ink eraser used in the margin. I made photographs of the page, and by means of a stereopticon threw a picture of that particular figure upon a screen 10 feet high. Upon that scale several interesting things came out. It was seen very plainly that the figure had been altered from a 5 to a 3, but the erasure had been made with a different material from the erasure in the margin. We tried a rubber ink eraser, and the result was the same as seen in the margin. Then we tried a steel penknife, and the result enlarged a thousand times was the same as seen over the figure 3. This disposed of the 'accident' theory, and Hall was convicted.

"I was employed in the Cadet Whittaker case, and worked for weeks at the famous letter of warning—a few words scribbled on a piece of paper, which Whittaker was suspected of writing. All the cadets were called upon to give specimens of their handwriting, and the writing of No. 27 was declared by the experts to be that of the note of warning. I believed that it was not, and, taking the specimen of No. 27's writing upon which he was suspected, I duplicated the note of 6446
warning, cutting the same letters out of 27's specimen, and placing them together as nearly as possible in the order of the famous note. It was a work of tremendous labor, but when done it showed the innocence of No. 27. It was suspected that the scrap of paper upon which the note of warning was written was torn from a letter sheet which Whittaker sent to his mother, but that theory was disposed of upon enlarging the two edges to the size at which a fine cambric needle looks like a crowbar. Then it was seen that the two edges had never been together. The verdict in the Whittaker case was finally reversed upon the ground that the court had come to a decision from the examination of lithographs of the note of warning, which I proved by comparison with a photograph were incorrect. Whittaker, by the way, is teaching school now in the northern part of this State. He made speeches for Cleveland in his neighborhood during the election campaign last autumn."

[Continued from Supplement No. 384, page 6127.]

THE HISTORY OF THE ELECTRIC TELEGRAPH.[4]

The first electric telegraph in which Volta's memorable discovery was utilized was that of Soemmering, of Munich, dating from 1809, and not from 1811 as the statement has too oft been made in print. Soemmering was led to take up electric telegraphy in a very curious way. It was during the wars of the Empire. "It cannot be forgotten," says Julius Zoellner, in the *Buch der Erfindungen*, "that the so rapid and consequently so fortunate enterprises of Napoleon were especially favored by the admirable means of communication which so rapidly transmitted the will of one man to all parts of his army, and that it was very often such rapidity alone that rendered its execution possible.

"The unfortunate blockade of General Mack in Ulm was an example that Bavaria had seen from too close a distance not to take it into account. And, when the entirely unexpected invasion of the Austrians, on April 9, 1809, and the flight of the King of Bavaria (who was obliged to leave Munich on the 11th) were announced so quickly to Napoleon, by the optic telegraph, that on the 22d of April Munich, that had six days before been taken by the Austrians, was occupied by the French, and when King Maximilian was enabled to re-enter his residence sixteen days after leaving it, then the Bavarian minister, Montgelas, directed his attention seriously to the high importance of telegraphy.

"On the 5th of July, 1809, while dining with Soemmering, a member of the Academy of Sciences of Munich, he expressed to him a desire to have this scientific body propose some systems of telegraphy. The savant accepted this idea with the greatest eagerness, and, three days afterward, under date of July 8, he wrote in his journal: ... 'Shall be able to take rest only when I shall have realized telegraphy by the disengagement of gas.'"

At this epoch, in fact, the decomposition of water was the sole phenomenon known that would permit the electric current to be used for telegraphy, and Soemmering had rendered himself perfectly conversant with it. He at once bought silver and copper wires, insulated them by means of sealing wax, and, on the 8th of July, constructed his first apparatus (Fig. 5). Five insulated rods, represented by the letters, *a*, *b*, *c*, *d*, *e*, dipped into a vessel, E, containing acidulated water. From these rods there started wires which, combined into a cable, *x*, *x*, and insulated from each other by sealing-wax, could be put in contact with the poles of a Volta pile, S, of 15 elements, formed of zinc disks, Brabant thalers, and felt soaked in dilute hydrochloric acid. On causing a variation in the wires that he put in connection with the poles of the pile, he was enabled to produce a disengagement of gas upon any two definite rods, and thus to transmit the letters that he had taken care to mark the different wires with.

The possibility of the system was recognized, and Soemmering at once had an apparatus constructed according to it. On the 22d of July he received it from the hands of the workman nearly such as it is shown in Fig. 6. The decomposing reservoir was of an elongated rectangular shape containing 35 gold rods that corresponded to 25 letters and 10 figures. From these rods started 35 wires covered with silk and combined into a bundle that was afterward covered with melted shellac. At the other extremity of this cable the wires ran to 35 pieces of copper fixed horizontally upon a wooden support, and each provided with an aperture into which could be inserted one of the pins in which the pile wires terminated.

When these latter were put in connection with the pieces corresponding to any two letters whatever, gas was observed to disengage itself in the reservoir upon the two corresponding rods, but in greater quantity on the one connected with the negative pole. This fact was not lost upon Soemmering, and he utilized it to render the dispatches more rapid; for it allowed him to transmit two letters always at the same time, with the proviso that the one upon the rod from which most gas was disengaged had been written first.

No demand arose for this first apparatus, so Soemmering soon devised one that operated by the aid of a paddle-wheel set in motion by the bubbles of gas. But, a little later on, in August, 1810, he replaced this by another and very ingenious apparatus which is shown in Fig. 6. An inverted spoon, arranged horizontally in the liquid, collected in its bowl the gases that were disengaged from certain rods, and then, rising, caused the inclination at the same time of a rod bent at right angles. This latter thereupon allowed a small copper ball to drop into a glass funnel, from whence it fell upon a cup attached to the end of a lever, and, through its weight, threw into gear a bell operated by a clockwork movement.

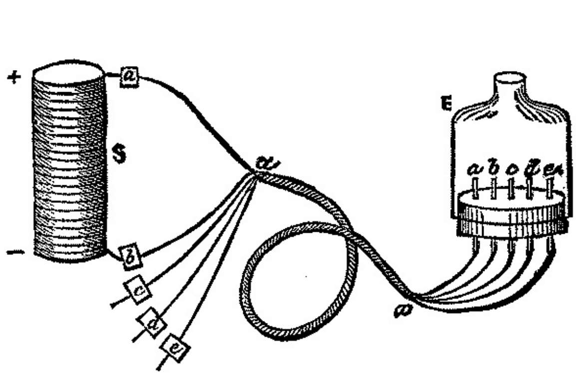


Fig. 5—SOEMMERING'S FIRST TELEGRAPH.

In 1811, Soemmering simplified his apparatus as regards the number of signs. Instead of having 25 letters (a complete alphabet minus *x*) and 10 figures, he did away with these latter and the letter J, and introduced the *x*, the period, and a sign of repetition. The apparatus was thus reduced to 27 wires.

The first experiments in telegraphy made with this system, on the 9th of July, 1809, were over a distance of 38 feet; on the 19th, transmission was effected to 170 feet; and, on the 8th of August, to 1,000 feet; but it was not until he had perfected the insulation of his wires by means of India rubber dissolved in ether, and had devised his paddle-wheel call, that Soemmering decided to present his telegraph to the Academy of Sciences of Bavaria during its session of August 28, 1809.

Some time afterward, Baron Larrey, Inspector General of the medical service of the French armies, carried Soemmering's telegraph to Paris and presented it to the Academy of Sciences at its session of December 5, 1809. This presentation gave rise to a series of letters addressed by Soemmering to the Baron. His son, now a member of the Academy, has had the goodness to communicate these to Count du Moncel, through whose kindness we are enabled to cite the most interesting passages from them.

Soemmering writes on the 10th of November:

"I have the honor to remit to you herewith a memoir which, conjointly with the trifles that you have had the goodness to charge yourself with, will explain my meaning clearly and briefly. I am desirous of learning the reception that His Imperial Majesty deigned to accord to these ideas. The memoir, as you will see, sir, makes mention, aphoristically, of a few quite varied experiments that I have been in a position to perform. I dare to flatter myself that they will please several members of the Institute. Independent of the major interest of which they seem susceptible, that of novelty belongs to them. In my opinion, there is no one who can dispute it...."

On the 5th of December, 1809, as we have said, the telegraph was presented to the Institute, but the inventor does not seem to have been at once informed of it; for he writes, under date of July 30, 1810:

"I have, sir, read your dissertation upon my telegraph with great pleasure.... Has my succinct memoir on the telegraph, sent from here on the 12th of November, reached you, sir, and have you had the goodness to communicate it to the Institute?

"As the old wires that were pretty badly treated by many manipulations had really suffered therefrom, and as it was only to save time that I did not have them renewed before sending the apparatus, I wish that they could be replaced by ordinary clavichord wires wound with silk, inasmuch as the material in these is more durable than the copper of the old ones. Had I been able to flatter myself, sir, that you would have taken enough interest in this invention to be at the trouble of carrying it to Paris, I should certainly not have failed to effect in advance this small and necessary improvement, which, leaving time out of consideration, will require but a care as to details. For, in fact, I strongly apprehend that not only the brittleness of the copper wire, but also the violence that trials anterior and even foreign to present use have submitted these wires to, have possibly got the silk out of order, or used it up here and there, thus producing immediate contacts of metal and bringing about a premature closing of the galvanic chain, whence would result a total disarrangement of the questions. I truly regret, then, having (through being too jealous of time, which you yourself know so well the value of) sent you the instrument in such a state of imperfection, and I cannot do better than ask to have it sent back here in good order. Permit me, then, to ask you at once to please not let Prince de Neufchatel nor even His Majesty the Emperor see it until the said repair has been effected, either by myself or (if the sending back would seem to you to take too long) by some one of our skillful artists at Paris. According to my convictions, there is but this means of preventing its effect from failing us, even for ever. It is a true pleasure to see it so infallible and complete as it is in the new instrument of absolutely the same structure that I have had constructed for the Academy of Munich."

The telegraph, which doubtless was repaired at Paris, was returned to Munich only in May, 1811. The same year it was carried to Vienna by the Russian Count Potocki, whom Baron Schilling had made known to Soemmering, and who presented the apparatus to Emperor Francis the First, on the 1st of July of the same year. Another model was sent by Soemmering to his son William, then at Geneva, who showed it to Augustus Pictet, to De la Rive, and to some other savants.

Despite all such presentations no high personage showed himself disposed to aid Soemmering in making an extended application of his invention. The committee named by the Academy of Sciences, and in which figured Monge, Biot, and Carnot, does not seem to have made any report. The apparatus was considered of small importance alongside of that of Claude Chappe, and Napoleon himself, says Mr. Zoellner, treated the invention as a German vision. On another hand, Bavaria and Austria showed just as little enthusiasm; but Soemmering, reduced to his own resources, continued his experiments none the less on that account. On the 4th of February, 1812, he found it possible to telegraph to a distance of 4,000 feet, and on the 15th of March of the same year he operated his apparatus with complete success over a line 10,000 feet in length.

This was certainly making great progress; but it is certain that, even if Soemmering had not encountered universal indifference, his telegraph would not have been able to become practical, because of the large number of wires employed. A modification, however, would have enabled it to play a role during the twenty-five years which preceded the invention of more easily realizable systems. This modification is the one Salomon Christopher Schweigger proposed in an appendix to the memoir of Soemmering inserted by him in 1811[5] in his journal, the *Polytechnisches Central—Blatt.*

His proposition was that two unequal piles should be employed instead of one, so that first one and then the other, or even the two combined, should act; and, besides, that the number of wires should be reduced to two, in taking into consideration the time during which the gases were disengaged, as well as the interruptions of varying length, and to which would succeed the action, first of the larger, and then of the smaller pile. With these different modifications, it certainly would have been possible to employ but two wires, and to render the laying of the wires less costly.

After Soemmering, we may cite in the same category John Redman Coxe, who, according to a note inserted in 1810 in the *Annals of Philosophy*, proposed to utilize for telegraphy the decomposition of water or metallic salts. Coxe, however, does not seem to have ever made any experiments.

In 1814 John Robert Sharpe claimed likewise to have made experiments in telegraphy in 1813; and these in all probability were based upon electro-chemical action.

Upon the whole, the only important one of these electro-chemical apparatus is that of Soemmering. This marks an epoch in the history of electric telegraphy, but it was not capable of the extension that can be given the apparatus based upon Oersted's discovery.

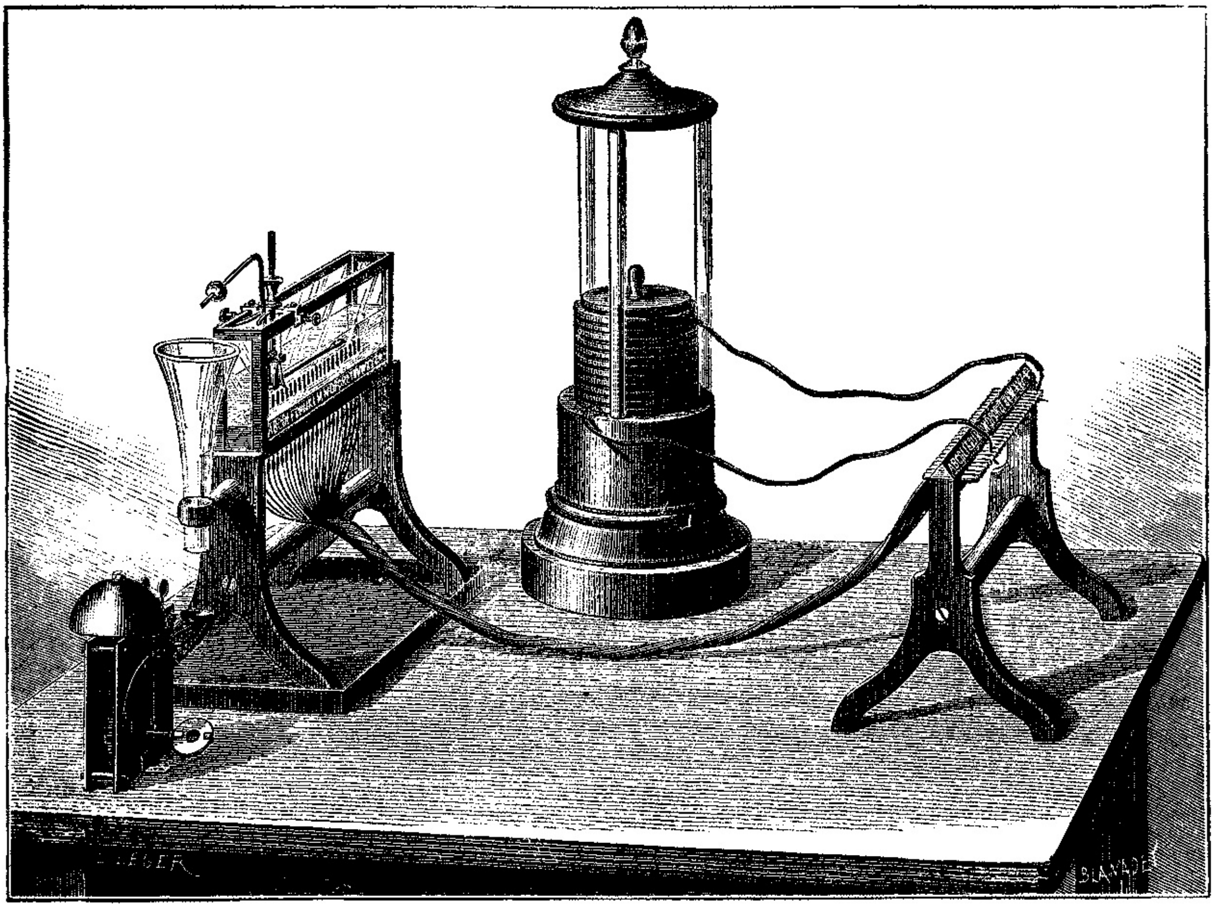


Fig. 6.—SOEMMERING'S PERFECTED TELEGRAPH.

To be continued.

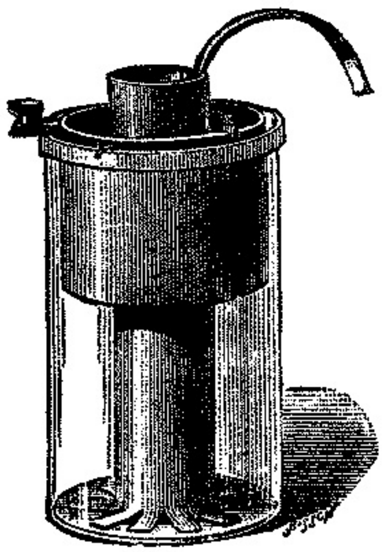
A NEW SULPHATE OF COPPER PILE.

Some studies made of the telegraph service of the Railway Company of the East (France) have resulted in a happy modification of the Callaud pile, rendering it easier of maintenance and reducing the consumption of the materials employed.

As well known, the Callaud pile, which is exclusively employed for telegraphic purposes by certain railroad companies, consists of a glass vessel, of a circular piece of zinc suspended by hooks from the upper part of the vessel, and of a strip of copper resting on the bottom of the

latter. This copper strip is riveted to a rod of the same metal which constitutes the positive electrode. In the bottom of the vessel there is placed a saturated solution of sulphate of copper, so that its level reaches to within a short distance of the lower part of the zinc, and the vessel is then filled with pure water. The zinc being attacked, there is formed a zinc sulphate, which always remains at the upper part of the vessel by reason of the difference in density of the 6447
solutions of sulphate of zinc and sulphate of copper, and the reduced copper deposits upon the strip in the center. It has been found necessary to cover the copper rod with a sheath of gutta-percha in order to keep it from being cut at the line of intersection of the two liquids, and this is the first inconvenience of the system. It is necessary, moreover, to keep the solution of copper at a certain degree of concentration by placing in the bottom of the vessel a supply of crystals of sulphate of copper. Hence it happens that the solution, being increased, eventually reaches the zinc, and the latter is thereupon attacked to no purpose, with a pure loss of copper through reduction. This is a second inconvenience, which can be remedied by introducing into the pile only a simply saturated solution without excess of crystals. It will be seen that, in this latter case, it is necessary to visit the pile quite frequently, to empty it by means of siphons, and to confide its maintenance to experienced persons only.

This is why, up to the present, railroad companies have preferred the Daniell to the Callaud pile for alarm bells that control signal disks, despite the serious advantages of the Callaud pile and the inconvenience of the porous vessel that enters into the composition of the other.



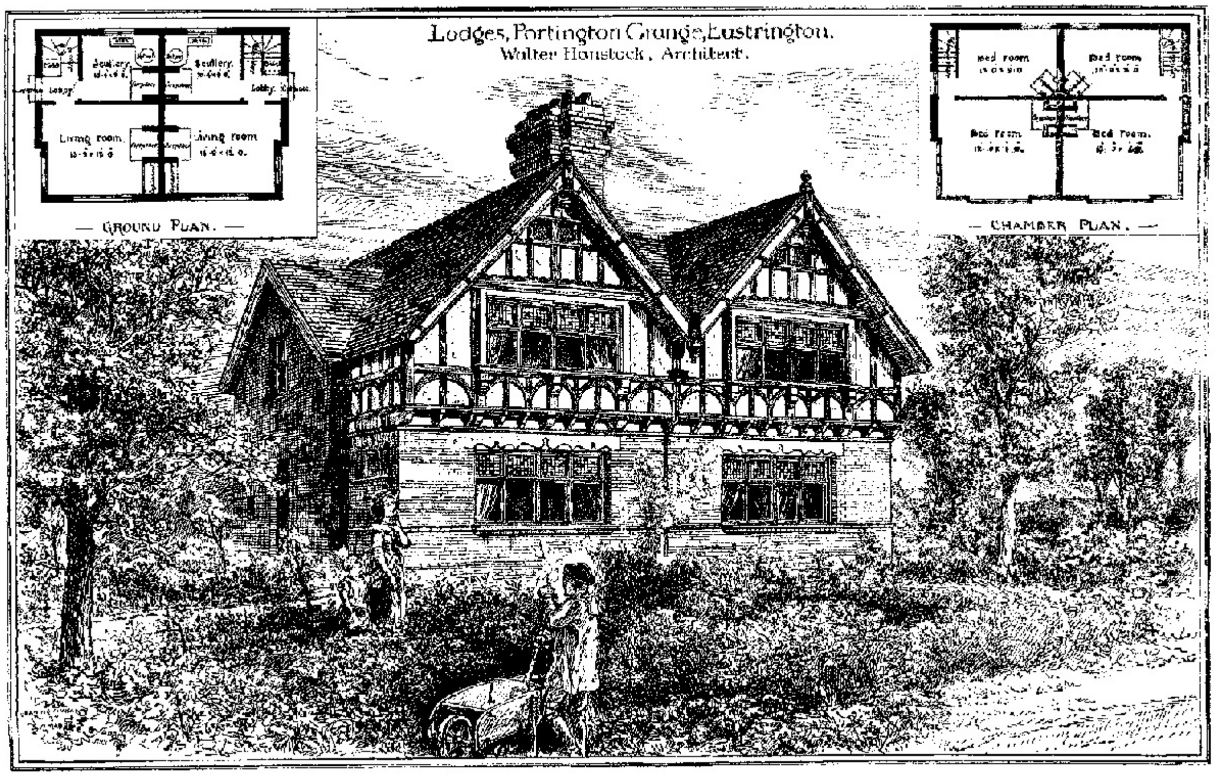
NEW SULPHATE OF COPPER PILE.

The modified Callaud pile is exempt from the defects that we have just pointed out. It differs from the old form in the substitution of a leaden tube, open at its extremities and dipping into the liquid of the pile, for the piece of copper or positive electrode. The lead, which is not attacked, and may serve indefinitely, is held in a vertical position by means of a foot made by cutting slits with a pair of scissors in the bottom of the tube, and bending back the strips thus formed. This foot also serves to prevent the tube from touching the zinc, by holding it in equilibrium.

In order to charge the element thus constituted, it is only necessary to fill the lead tube with crystals of sulphate of copper and to pour water into the glass vessel until its level reaches within a centimeter and a half of the upper edge of the zinc. In an hour the copper will have dissolved sufficiently to allow the pile to begin its action.

Experience has demonstrated that, whatever be the supply of copper that is put into the lead tube, the saturated solution *will never reach the zinc*, even in an open circuit.

In sum, the new arrangement given to the Callaud element presents the following advantages: (1) It permits of the maintenance being confided to anybody, since this consists simply in the introduction into the central tube of crystals of sulphate of copper when it is seen that the blue tint of the lower liquid is disappearing. (2) It permits of proportioning the expense to the work really effected.—*La Nature*.



SUGGESTIONS IN ARCHITECTURE.—ENGLISH LODGES.

LODGES.

The walls of the buildings are best scarlet pressed bricks with white tuck joints; the wood framing is stained brown-black and well varnished; the windows finished white; cement filling, flat cream white; and Broseley strawberry tiles for roof. The buildings are situated in the center of a plantation, and the combination of color is most satisfactory. They are built at the principal entrance to Portington Grange, Eastrington, near Hull, and belong to Thomas Brearley, Esq., J.P. The works have been carried out under the direction of Mr. Walter Hanstock, architect, Batley. —*Building News*.

THE DECAY OF THE BUILDING STONES.[6]

By Dr. A. A. Julien.

The paper, which will be published in full by the Building Stone Department of the Tenth Census of the United States, considers the building stones employed in New York city and its suburbs, *i. e.*, Brooklyn, Staten Island, Jersey City, and Hoboken.

I. THE BUILDINGS, THEIR NUMBERS, AND COMMON MATERIALS.

The materials of general construction occur in the following percentage proportion to the total number of buildings in the cities stated in the table below:

	New York.	Brooklyn.	Staten Isl'd.	Jersey City.	Hoboken.	Entire Metropolis.
No. of buildings.	100,193	75,526	7,725	20,880	6,284	210,608
Brick and stucco.	63.2	30.9	9.5	22.8	32.7	47.9
Frame.	24.3	50.9	90.0	75.2	64.7	42.5
Stone.	11.6	9.1	0.5	2.0	2.6	9.1
Iron.	0.9	0.1	..	..	..	0.5

In New York city proper, the several varieties of stone are used in the following proportion to the entire number of stone buildings:

Brown sandstone	78.6
Nova Scotia sandstone	

	9.0
Marble	7.9
Granyte	1.8
Ohio sandstone	1.6
Gneiss	0.9
Foreign sandstone	0.1
Bluestone and limestone	0.1

In Brooklyn, the Connecticut brownstone is the variety predominating among the stone buildings (95.7 per cent.), and is employed almost altogether for the fronts of residences. Very few iron buildings occur, but over three times as many stucco fronts as in New York. The frame buildings predominate, particularly in the outskirts, *e. g.*, Long Island City (80.5 per cent).

In Staten Island, stone enters in very small proportion into the fronts of buildings, though commonly employed, as in New York and throughout this district, for the dressing of apertures, the walls of inclosures, and other masonry.

In Jersey City, the proportions of the materials are much as in Staten Island. The selection of the dark trap from the Heights behind the city, for the construction of many fronts or entire buildings, is a local feature of interest.

In Hoboken, the same general features prevail as in Jersey City.

The annual reports of the Committee on Fire Patrol of the New York Board of Fire Underwriters, for the years 1881 and 1882, have yielded the following statistics, which, so far as they go, closely approximate my own:

	Number of buildings.
South of Canal Street	10,553
Between Canal and Fourteenth Streets	26,700
Between Fourteenth and Fifty-ninth Streets	33,815
Between Fifty-ninth Street and Harlem River	18,746
	———
Total	89,814

The materials of construction for this district, which does not include the 23d and 24th Wards, north of the Harlem River, are reported as follows:

Brick, with stone trimmings, and, in part, with stone facings	64,783
Brick and frame	3,616
Frame	21,415

II. THE BUILDING STONES, THEIR VARIETIES, LOCALITIES, AND EDIFICES CONSTRUCTED OF EACH.

An exceedingly rich and varied series is brought to our docks, and the number and variety are constantly increasing. A few of the more important may be here mentioned.

Freestones (Carboniferous sandstone), commonly styled "Nova Scotia stone," or "Dorchester stone," in various shades of buff, olive-yellow, etc., from Hopewell and Mary's Point, Albert, N. B., and from Wood Point, Sackville, Harvey, and Weston, N. B., Kennetcook, N. S., etc. A very large number of private residences in New York and Brooklyn, etc., the fences, bridges, etc., in Central and Prospect Parks, many churches, banks, etc.

Freestone (Mesozoic sandstone), commonly styled "brownstone," from East Longmeadow and Springfield, Mass., but chiefly from Portland, Conn., in dark shades of reddish-brown, inclining to chocolate. This is the most common stone used in the fronts of private residences, many churches, Academy of Design in Brooklyn, etc.

Freestone (Mesozoic sandstone), "brownstone," from Middletown, Conn., Trinity Church, Brooklyn, etc.

Red sandstone (Potsdam sandstone), Potsdam, N. Y. Several residences, buildings of Columbia College, etc.

Freestone (Potsdam sandstone), "brownstone," Oswego, N. Y. Part of Masonic Temple in 23d Street.

Freestone (Mesozoic sandstone), "brownstone," in several shades of light reddish-brown, orange-brown, etc., and generally fine-grained, from Belleville, N. J. Very many of the best residences and churches, *e. g.*, cor. 60th and 64th Streets, and Madison Avenue, etc.

Also, varieties of the same "brownstone" from Little Falls, N. J. (Trinity Church, New York), from the base of the Palisades (part of the wall around Central Park), etc.

Freestone (Lower Carboniferous sandstone), commonly styled "Ohio stone," from Amherst, East Cleveland, Independence, Berea, Portsmouth, Waverly, etc., Ohio, in various shades of buff, white, drab, dove-colored, etc. Many private residences and stores, the Boreel building, Williamsburgh Savings Bank, Rossmore Hotel, etc.

Freestone (Mesozoic sandstone), often styled "Carlisle stone," from the English shipping port, or "Scotch stone," from Corsehill, Ballochmile and Gatelaw Bridge, Scotland; in shades of dark red to bright pink. Fronts of several residences, trimmings of Murray Hill Hotel, the "Berkshire" building, etc.

Also, varieties from Frankfort-on-the-Main, Germany, etc.

Blue sandstone (Devonian sandstone), commonly styled "bluestone," from many quarries in Albany, Greene, Ulster, and Delaware counties, N. Y., and Pike county, Penn. The trimmings of many private residences and business buildings, walls and bridges in the parks, part of Academy of Design in 23d Street, Penitentiary on Blackwell's Island, house at 72d Street and Madison 6448
Avenue, etc.

Freestone (Oolite limestone), "Caenstone," from Caen, France. Fronts of several residences in 9th Street, trimmings of Trinity Chapel, the reredos in Trinity Church, New York, etc.

Limestone (Niagara limestone), Lockport, N. Y., Lenox Library, trimmings of Presbyterian Hospital, etc.

Limestone (Lower Carboniferous), styled "Oolitic limestone," from Ellitsville, Ind. Several private residences (*e. g.*, cor. 52d Street and Fifth Avenue), trimmings of business buildings, etc.

Also, varieties of limestone from Kingston and Rondout, N. Y., Isle La Motte, Lake Champlain, Mott Haven, and Greenwich, Conn., etc. Part of the anchorages of the Brooklyn Bridge, walls in Central Park, etc.

Granyte, Bay of Fundy, N. S. Columns in Stock Exchange, etc.

Red granyte, Blue Hills, Me. U. S. Barge Office.

Gray granyte, East Blue Hills, Me. Part of towers and approaches of New York and Brooklyn Bridge, etc.

Granyte, Spruce Head, Me. Part of towers of Brooklyn Bridge, bridges of Fourth Avenue Improvement, Jersey City Reservoir, etc.

Gray granyte, Hurricane Island, Me. Part of New York Post Office and of towers and approaches of Brooklyn Bridge, etc.

Granyte, Fox Island, Me. Basement of Stock Exchange, etc.

Granyte, Hallowell, Me. Trimmings in St. Patrick's Cathedral, Jersey City Heights, etc.

Granyte, Round Point, Me. Seventh Regiment Armory, etc.

Granyte, Jonesborough, Me. Welles' building, panels in Williamsburgh Savings Bank, etc.

Granyte, Frankfort, Me. Part of towers and approaches of Brooklyn Bridge, etc.

Granyte, Dix Island, Me. New York Post Office, part of *Staats Zeitung* building, etc.

Also, varieties from Calais, Red Beach, East Boston, Clark's Island, Mt. Waldo, Mosquito Mountain, Mt. Desert, Ratcliff's Island, etc., Me.

Granyte, Concord, N. H. Booth's Theater, German Savings Bank, etc.

Granyte, Cape Ann, Mass. Dark base-stone and spandrel stones of towers and approaches of Brooklyn Bridge, etc.

Granyte, Quincy, Mass. Astor House, Custom House, etc.

Granyte, Westerly, R. I. Part of Brooklyn anchorage of Brooklyn Bridge.

Granyte, Stony Creek, Conn. Part of New York anchorage of Brooklyn Bridge.

Also, varieties from St. Johnsville, Vt., Millstone Point, Conn., Cornwall, N. Y., Charlottesburgh, N. J., Rubislaw, and Peterhead, Scotland, etc.

Gray gneiss, New York Island, and Westchester county, N. Y. A large number of churches, Bellevue Hospital, the Reservoir at 42d Street, etc., and the foundations of most of the buildings throughout the city.

Gray gneiss, Willett's Point, and Hallett's Point, Kings county, N. Y. Many churches in Brooklyn, the Naval Hospital, etc.

Marble, Manchester, Vt. Drexel & Morgan's building, church cor. 29th Street and Fifth Avenue, etc.

Also, many varieties from Swanton, West Rutland, Burlington, Isle La Motte, etc., Vt. The "Sutherland" building at 63d Street and Madison Avenue, residences at 58th Street and Fifth Avenue, etc.

Marble, Lee, Mass. Turrets of St. Patrick's Cathedral, etc.

Marble, Stockbridge, Mass. Part of old City Hall, New York.

Marble, Hastings, N. Y. The University building, etc.

Marble, Tuckahoe, N. Y. Part of St. Patrick's Cathedral, residence on the cor. of 34th Street and Fifth Avenue, etc.

Marble, Pleasantville, N. Y., styled "Snowflake marble." Greater part of St. Patrick's Cathedral, Union Dime Savings Bank, many residences and stores, etc.

Also, many varieties from Canaan, Conn., Williamsport, Penn., Knoxville, Tenn., Carrara and Sienna, Italy, etc.; used generally, especially for interior decoration, etc.

Trap (Mesozoic diabase), from many quarries along the "Palisades," at Jersey City Heights, Weehawken, etc. Stevens Institute, Hoboken, N. J., Court House on Jersey City Heights, old rubble work buildings at New Utrecht, etc., on the outskirts of Brooklyn, etc.

Trap (Mesozoic diabase), styled "Norwood stone," from Closter, N. J. Grace Episcopal Church, Harlem.

Also, varieties from Graniteville, Staten Island, N. Y., and Weehawken, N. J.

Serpentine, Hoboken, N. J. Many private residences, masonry, etc., in Hoboken. Also, varieties from Chester, Pa.

In addition to the edifices referred to above, many public buildings of importance are constructed of stone, *e. g.*: Prisons in the city and on the islands, bridges in the parks and over the Harlem River, in which sandstone, limestone, granyte, and gneiss are used.

The sewers are constructed of gneiss from New York Island and vicinity, as well as of bowlders of trap, granyte, etc., from excavations.

The Croton Aqueduct, the High Bridge, the Reservoirs in the Central and Prospect Parks and at 42d Street, in which gneiss from the vicinity and granyte from New England were used.

The walls, buildings, bridges, and general masonry in the parks are constructed of the following varieties of stone:

Freestone (sandstone), from Albert, Dorchester, and Weston, N. B.

Brownstone, from Belleville and the base of the Palisades, N. J.

Bluestone and "mountain graywacke," from the Hudson River.

Limestone, from Mott Haven and Greenwich, Conn.

Granyte, from Radcliffe's Island, etc., Me.

Gneiss, from New York, Westchester, and Kings counties, N. Y.

Marble, from Westchester county, N. Y.

The fortifications in the harbor and entrance to the sound, constructed of granyte from Dix Island, Spruce Head, etc., Me., gneiss from the vicinity, brownstone from Conn., etc.

The stonework of the New York and Brooklyn Bridge, as I am kindly informed by Mr. F. Collingwood, the engineer in charge of the New York approach, is constructed of the following materials:

Granyte, from Frankfort, Spruce Head, Hurricane Island, East Blue Hill and Mt. Desert, Me., Concord, N. H., Cape Ann, Mass., Westerly, R. I., Stony Creek, Conn., and Charlottesburg, N. J.

Limestone, from Rondout and Kingston, N. Y., also from Isle La Motte and Willsboro Point, Lake Champlain, and vicinity of Catskill, N. Y.

In the anchorages, the corner stones, exterior of the cornice and coping, and the stones resting on anchor plates, consist of granyte from Charlottesburg and Stony Creek, in the New York anchorage, and from Westerly, in the Brooklyn anchorage. The rest of the material is entirely limestone, mainly from Rondout, largely from Lake Champlain. In the towers, limestone was chiefly employed below the water line, and, above, granyte from all the localities named, except Charlottesburg, Westerly, and Stony Creek. In the approaches the materials were arranged in about the same way as in the towers. Additional particulars are given concerning the quantity, prices, tests of strength, and reasons for selection of the varieties of stone.

For roofing, slate is largely employed throughout these cities, being mainly derived from Poultney, Castleton, Fairhaven, etc., Vt., and Slatington, Lynnport, Bethlehem, etc., Penn.

For pavements, the bowlders of trap and granyte from excavations have been widely used in the "cobblestone" pavements. The trap (or diabase) of the Palisades across the Hudson, immediately opposite New York city, and from Graniteville, Staten Island, is used in the "Russ" and Belgian pavement; also, granyte from the Highlands of the Hudson, from Maine, etc, in the "granite block" pavement in both New York and Brooklyn; large quantities of crushed trap from Weehawken and Graniteville, for the macadamized streets and roads in the parks and outskirts; and also wood, concrete, and asphalt in various combinations.

For sidewalks and curbstones, the material generally employed is the flagstone, a thinly bedded blue sandstone or graywacke from the interior of the State, the Catskill Mountains, and from Pennsylvania; also, granyte, chiefly from Maine. In the older streets, a mica slate from Bolton, Conn., and micaceous slaty gneiss from Haddam, Conn., were once largely used, and may still be occasionally observed in scattered slabs.

Additional facts were given concerning the ruling prices for the varieties of stone, tables presenting all the determinations obtainable in reference to the crushing strength of the varieties used in New York, lists of the dealers in building and ornamental stones, etc.

III. DURABILITY OF BUILDING STONES, IN NEW CITY AND VICINITY.

All varieties of soft, porous, and untested stones are being hurried into the masonry of the buildings of New York city and its vicinity. On many of them the ravages of the weather and the need of the repairer are apparent within five years after their erection, and a resistance to much decay for twenty or thirty years is usually considered wonderful and perfectly satisfactory.

Notwithstanding the general injury to the appearance of the rotten stone, and the enormous losses annually involved in the extensive repairs, painting, or demolition, little concern is yet manifested by either architects, builders, or house owners. Hardly any department of technical science is so much neglected as that which embraces the study of the nature of stone, and all the varied resources of lithology in chemical, microscopical, and physical methods of investigation, wonderfully developed within the last quarter century, have never yet been properly applied to the selection and protection of stone, as used for building purposes. Much alarm has been caused abroad in the rapid decay and fast approaching ruin of the most important monuments, cathedrals, and public buildings, but in many instances the means have been found for their artificial protection, *e. g.*, the Louvre, and many palaces in and near Paris, France, St. Charles Church in Vienna, Austria, the Houses of Parliament, etc., in London, England, etc.

In New York, the Commissioners of the Croton Aqueduct Department complained, twenty years ago, of the crumbling away of varieties of the gneiss used in embankments; the marbles of Italy, Vermont, and of Westchester county soon become discolored, are now all more or less pitted or softened upon the surface (*e. g.*, the U. S. Treasury), and are not likely to last a century in satisfactory condition (*e. g.*, the U. S. Hotel); the coarser brown sandstones are exfoliating in the most offensive way throughout all of our older streets and in many of the newer (*e. g.*, the old City Hall); the few limestones yet brought into use are beginning to lose their dressed surfaces and to be traversed by cracks (*e. g.*, the Lenox Library); and even the granytes, within a half century, show both discoloration, pitting (*e. g.*, the Custom House), or exfoliation (*e. g.*, the Tombs). To meet and properly cope with this destructive action, requires, first, a clear recognition of the hostile external agencies concerned in the process. These belong to three classes: chemical, physical, and organic.

The chemical agencies discussed were the following: sulphurous and sulphuric acids, discharged in vast quantities into the air of the city, by the combustion of coal and gas, the decomposition of street refuse and sewer gas, etc.; carbonic, nitric, and hydrochloric acids; carbolic, hippuric, and many other organic acids derived from smoke, street dust, sewer vapors, etc.; oxygen and ozone, ammonia, and sea salt.

The mechanical and physical agencies discussed were the following: frost; extreme variations in temperature, amounting in our climate to 120° F. in a year, and even 70° in a single day; wind and rain, most efficient on fronts facing the north, northeast, and east; crystallization by efflorescence; pressure of superincumbent masonry; friction; and fire.

The organic agencies consist of vegetable growths, mostly confervæ, etc., within the city, and lichens and mosses without, and of boring mollusks, sponges, etc.

The internal elements of durability in a stone depend, first, upon the chemical composition of its constituent minerals and of their cement. This involves a consideration of their solubility in atmospheric waters, *e. g.*, the calcium-carbonate of a marble or limestone, the ferric oxide of certain sandstones, etc.; their tendency to oxidation, hydration, and decomposition, *e. g.*, of the sulphides (especially marcasite) in a roofing slate or marble, the biotite and ferruginous orthoclase in a granyte or sandstone, etc.; the inclosure of fluids and moisture, *e. g.*, as "quarry-sap," in chemical combination, as hydrated silicates (chlorite, kaolin, etc.), and iron oxides, and as fluid cavities locked up in quartz, etc.

The durability of a stone depends again upon its physical structure, in regard to which the following points were discussed: the size, form, and position of its constituent minerals; *e. g.*, an excess of mica plates in parallel position may serve as an element of weakness; the porosity of the rock permitting the percolation of water through its interstices, especially important in the case of the soft freestones, and leading to varieties of discoloration upon the light-colored stones, which were described in detail; the hardness and toughness, particularly in relation to use for pavements, sidewalks, and stoops; the crystalline structure, which, if well-developed, increases the strength of its resistance; the tension of the grains, which appears to explain especially the disruption of many crystalline marbles; the contiguity of the grains and the proportion of cement in their interstices; and the homogeneity of the rock.

Again, the durability of a rock may depend upon the character of its surface, whether polished, smoothly dressed, or rough hewn, since upon this circumstance may rest the rapidity with which atmospheric waters are shed, or with which the deposition of soot, street dust, etc., may be favored; also upon the inclination and position of the surface, as affecting the retention of rainwater and moisture, exposure to northeast gales and to burning sun, etc.

IV. METHODS OF TRIAL OF BUILDING STONE.

In such methods, two classes may be distinguished, the natural and the artificial.

The former embrace, first, the examination of quarry outcrops, where the exposure of the surface of the rock during ages may give some indication of its power of resistance to decomposition, *e. g.*, the dolomitic marbles of New York and Westchester counties, some of which present a surface crumbling into sand; and, secondly, the examination of old masonry. Few old buildings have survived the changes in our restless city, but many observations were presented in regard to the condition of many materials, usually after an exposure of less than half a century.

Another source of information, in this regard, was found in the study of the stones erected in our oldest cemeteries, *e. g.*, that of Trinity Church. There could hardly be devised a superior method for thoroughly testing by natural means the durability of the stone than by its erection in this way, with partial insertion in the moist earth, complete exposure to the winds, rain, and sun on every side, its bedding lamination standing on edge, and several of its surfaces smoothed and polished and sharply incised with dates, inscriptions, and carvings, by which to detect and to measure the character and extent of its decay. In Trinity Churchyard, the stones are vertical, and stand facing the east. The most common material is a red sandstone, probably from Little Falls, N. J., whose erection dates back as far as 1681, and which remains, in most cases, in very fair condition. Its dark color, however, has led to a frequent tendency to splitting on the western side of the slabs, *i. e.*, that which faces the afternoon sun. Other materials studied consisted of bluestone, probably from the Catskills, black slate, gray slate, green hydromicaceous schist, and white oolitic limestone, all in good condition, and white marble, in a decided state of decay.

The artificial methods of trial of stone, now occasionally in vogue, whenever some extraordinary pressure is brought upon architects to pay a little attention to the durability of the material they propose to employ, are, from their obsolete antiquity, imperfection, or absolute inaccuracy, unworthy of the age and of so honorable a profession. They usually consist of trials of solubility in acids, of absorptive power for water, of resistance to frost, tested by the efflorescence of sodium-sulphate, and of resistance to crushing. The latter may have the remotest relationship to the elements of durability in many rocks, and yet is one on which much reliance of the architectural world is now placed. Sooner or later a wide departure will take place from these incomplete and antique methods, in the light of modern discovery.

Reference was made to certain experiments by Professor J. C. Draper on the brownstone and Nova Scotia stone used in this city, by Dr. Page, on a series of the building stones, and by Professors J. Henry and W. R. Johnson on American marbles, in some cases with conflicting results, which were probably due to the limited number and methods of the experiments.

V. MEANS OF PROTECTION AND PRESERVATION OF STONE.

We have here to consider certain natural principles of construction, and then the methods for the artificial preservation of the stone used in buildings. Under the first head, there are four divisions.

Selection of Stone.—As it is universally agreed that the utmost importance rests upon the original selection of the building material, it is here that all the resources of lithological science should be called in. Only one investigation, aiming at thorough work, has ever been carried through, that of the Royal Commission appointed for the selection of stone for the Houses of Parliament. But the efforts of these able men were restricted by the little progress made at that time in the general study of rocks, and were afterward completely thwarted by the discharge of the committee and by the delivery of the execution of the work of selection to incompetent hands. There will be hereafter, from investigations made in the light of modern researches, no excuse for such annoying results and enormous expenses as those which attended the endless repairs which have been required, since a period of four or five years after the completion of the great building referred to.

Seasoning.—The recommendations of Vitruvius 2,000 years ago have been observed at times down to the day of Sir Christopher Wren, who would not accept the stone which he proposed to use in the erection of St. Paul's Cathedral, in London, until it had laid for three years, seasoning upon the seashore. Since then little or no attention appears to have been paid to this important requirement by modern architects, in the heedless haste of the energy of the times. Building stone, even for many notable edifices, is hurried from the quarries into its position in masonry, long before the "quarry-sap" has been permitted, by its evaporation to produce solid cementation in the interstices of the stone.

Position.—The danger of setting up any laminated material on edge, rather than on its natural bedding-plane, has been widely acknowledged; yet it is of the rarest occurrence, in New York city, to observe any attention paid to this rule, except where, from the small size or square form of the blocks of stone employed, it has been really cheapest and most convenient to pile them up on their flat sides.

Form of Projections.—The principle is maintained by all the best English and French architects that projections (*i. e.*, cornices, sills, lintels, etc.) should be "throated," that is, undercut in such a way as to throw off the dripping of rainwater, etc., from the front of the building, but in New York this principle is almost universally neglected. It was pointed out that the severity of our climate even requires the further care that the upper surface of projections should be so cut as to prevent the lodgment or long retention of deposits either of rainwater or snow. It is immediately above and below such deposits that the ashlar of our fronts is most rapidly corroded and exfoliated, an effect evidently due mainly to the repeated thawing and solution, freezing and disintegration, which are caused by the water, slush, and snow, which rest, often for weeks, upon a window-sill, balcony, cornice, etc. Thus from the initial and inexcusable carelessness in the 6449
construction and form of the projections, and, later, the neglect of the houseowner, due to ignorance of the results involved, to remove the deposits of snow, etc., as fast as they accumulate on the projections, is derived a large part of the discoloration of the marble, Nova Scotia stone, or light colored granyte, and especially the exfoliation of the brownstone beneath the window-sills, balconies, etc., by the water alternately trickling down the front and freezing, by day and by night, for long periods.

The artificial means of preservation are of two classes, organic and inorganic. The former depend on the application of some organic substance in a coating or in the injection of fatty matters; but, as the substances are with greater or less rapidity oxidized, dissolved, and carried away by the atmospheric fluids, the methods founded on their use have been properly denounced by many authorities as only costly palliatives, needing frequent repetition, and therefore exerting an influence toward the destruction of delicate carving. The following were discussed: coal-tar; paint, which has been used in New York for many residences, as in Washington for the Capitol, and in London for Buckingham Palace, etc., but lasts only a few years, and often even permits the disintegration to progress beneath it; oil, often used in New York, but as objectionable as paint; soap and alum-solution; and paraffine, beeswax, resin, tallow, etc., dissolved in naphtha, turpentine, camphene, oil, etc.

The preparations of an inorganic nature, which have been proposed and used abroad, have in some cases met with success; but the exact nature of their action, and the conditions to which they are each suited, are yet to be investigated, especially with reference to the entirely different climate by which the stone in our city is being tried. The processes which have been proposed, and in some cases practically used, involve the application of the following substances: waterglass, in connection with salts of calcium or barium, or bitumen; oxalate of aluminum; barium solution, in connection with calcium superphosphate or ferro-silicic acid; copper salts, used by Dr. Robert in Paris to stop the growth of vegetation on stone, etc. There is certainly a call for processes by which, at least, those stones which are used in isolated, exposed, and unnatural positions may receive artificial protection, such as the stone sills and lintels of windows, stone balusters, projecting cornices, and ashlar-stone set up on edge. It will doubtless be found that only those stones which possess a coarse, porous texture and strong absorptive power for liquids will be found particularly available for protection by artificial preservatives, and that such stones should indeed never be used in construction in a raw or crude state. In the spongy brown and light olive free-stones, a marble full of minute crevices, and a cellular fossiliferous limestone, a petrifying liquid may permeate to some depth, close up the pores by its deposits, and incase the stone in solid armor; while, upon a more compact rock, such as a granyte or solid limestone, it can only deposit a shelly crust or enamel, which time may soon peel off. The carelessness with which stone is selected and used, and the ignorance in regard to its proper preservation, when the decay of a poor stone becomes apparent, have led to an increased use of brick and terra cotta, much to be deplored; durable stones are to be obtained in great variety, methods for the preservation of the porous stones can easily be devised, and stones of a fireproof character do exist in this country in abundance.

In conclusion, three suggestions were offered: 1st, that householders invoke the magic use of the broom on the fronts of their residences as carefully as upon the sidewalks; 2d, that house-builders insist upon the undercutting of all projections, and the exclusion of brackets or other supports to sills and cornices, which only lead to the oozing of water and a line of corrosion down the ashlar; 3d, that house repairers recut the projections in this way, whenever possible, and entirely avoid the use of paint, oil, or other organic preservatives.

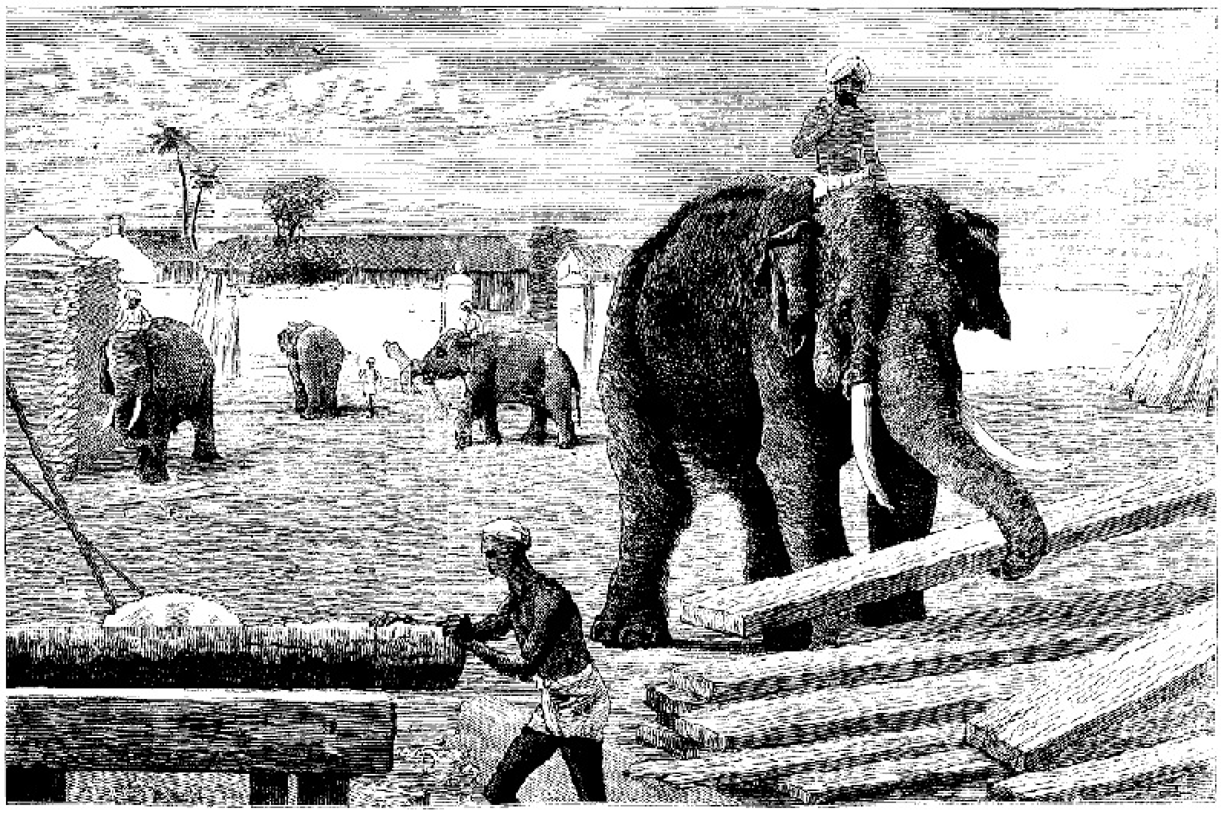
ELEPHANTS MOVING TIMBER AT MOULMEIN, BURMAH.

"Elephants," says Mrs. A. H. Brackenbury, of Singapore, to whom we are indebted for our sketch, "work in the timber yards of Moulmein, carrying huge planks, sometimes two or three together, and with great care and exactitude piling them in stacks one over another. The old hands take a sidelong view with one eye closed to test the perpendicularity of the stacks. The elephants lift the planks with their proboscis on their tusks, and then tuck their trunks around the burden, and march majestically off as if they were carrying nothing. A man sits on each elephant's neck to direct him, which he does by kicking or pressing behind their ears.

"In Africa the elephants are being so persistently slaughtered for the sake of their ivory that they are likely soon to become extinct.

"Would it be possible to breed them on farms as ostriches are bred, and then to employ them in navvy work, for which they are probably as well suited (education being supplied) as their Asiatic cousins?

"Moulmein is a very pretty place, and its charms are enhanced by its being out of the beaten track of tourists. It is up a river, and there are many islands on which are perched the daintiest little gilt and painted Burmese pagodas. The scene recalls the well known view on the willow-pattern plate of our childhood, which plate has once more become fashionable."—*London Graphic*.



ELEPHANTS MOVING TIMBER AT MOULMEIN, BRITISH BURMAH.

STRENGTH OF YELLOW PINE.

It is reported that a comparison of the relative strength of yellow and Norway pine was made at

Dayton, O., with the following results: The specimens were dressed exactly one inch square, and these were broken in a testing machine by placing them on bearings, one foot apart, with the weight in the center. The southern pine had been air seasoned for two years and upward, the Norway from a year to fifteen months. The weakest yellow pine broke at 763 pounds, the strongest at 1,102; average of eight specimens, 904 pounds. The weakest Norway broke at 501 pounds, the strongest at 790 pounds; average of ten specimens, 702 pounds, showing the yellow pine to be 28.7 per cent. stronger than Norway, and that a yellow pine sill 4x8 inches dimensions is equivalent to a Norway sill of 5½x8 inches, with the further advantage in favor of the yellow pine that it can be got much freer of knots and consequently stronger in comparison than these figures show, which are based on clear timber. Another test was made at a meeting of the Master Car Builders' Association, with the following results: Five pieces of each variety, one inch square and eleven inches between bearing points, were experimented upon, the pressure being applied in the center. The outcome showed strength of yellow pine at 500, 510, 500, 490, and 530 pounds breakage strain, or an average of 506; while Norway stood a strain of 620, 645, 730, 650, and 630 pounds or an average of 625 pounds. These experiments do not appear to throw much light on the question of relative strength.

THE EDUCATION OF GERMAN WOMEN.

"Our women in Germany," said the professor of a German university to me, a few days ago, "must by all means be acquainted with the different departments of housekeeping, and must interest themselves therein. Those who stand highest as well as those who stand lowest, from the wives and daughters of a Minister of State to the wives and daughters of the meanest peasant. The Princess-Royal attends to the skimming of the milk in her dairy." "I beg your pardon for interrupting you," I said, "but an American lady would think that quite out of her sphere; and if I were not convinced of your seriousness, I should imagine you were amusing me by a piece of fiction." "I do assure you," replied the professor, "that it is a well known fact that the Princess-Royal keeps cows and superintends personally the management of her dairy, and I have heard that the Queen of England does the same." "Please to instruct me further regarding the education of women in Germany," I said. "I am very much interested in that subject, as, from my own observations, I have seen that as a general thing the German ladies are well read, not only in the literature of their own country, but also in that of France and England." "Our women," he replied, "also speak French and English, especially French, and many of them are able to read the authors of those countries in the original." "This is the more surprising to me," I remarked, "as they seem to be much occupied with the cares of housekeeping, and I would like to know how they find time to learn foreign languages, and to read all the principal works of the poets and romance writers of three countries." "That," said the professor, "is a part of their education, and in order that you may understand in what manner German girls must utilize their time at school, I will give you a brief explanation of the system of education employed and of that knowledge which it is incumbent upon every German girl to possess, whatever be her position in life, and afterward of the different grades of education from that of the peasant girl to that of the lady of the highest position in the State. Every girl in Germany must learn to read and to write, to sew and to knit, to cook and to do general housework, and to acquire besides some general knowledge of grammar, geography, mathematics, and history. Beginning at the daughter of the *Bauer*, or, as you say in America, *farmer*, the above mentioned knowledge, which is the starting point for the education of the other classes, is the limit of her education; and as it may be interesting to you, I will mention that when the daughters of the Bauer have learned thus much they quit school and labor in the field until they are married, when they leave aside the field work and enter upon the duties of the household and its immediate attachments, such as the dairy, the chicken yard, the gardens, etc.; and while the products of the field belong to their husbands, the garden stuffs, and the milk, eggs, butter, etc., become their own property, and from the profits of these, which they carry to the markets and sell, they provide their pantries with the necessary teas, sugar, coffee, etc., and themselves and their children with clothes.

"Between the peasant class and nobility there are many grades and classes varying more or less in the refinement of their manners as well as in the extent of their education, but as it would not be possible and is also unnecessary for our purpose to describe them all in particular, I prefer to include them all under the head of gentry, and for these a more ample education is provided. The daughters of the gentry must, in addition to the aforesaid rudiments of knowledge, have a very thorough education in history as well as in grammar, mathematics, and natural and physical geography. They must know French and English, and have an intelligent understanding of the 6450
literature of those countries, as well as of that of Germany. They must learn fine needle-work and the art of governing a house and of educating young children. They must also acquire a knowledge of good manners and an understanding of society. They must be able to receive company and do the honors of the house. In addition to this they will have an intelligent understanding of music and art. For all of these branches of knowledge there are schools provided, and according to the position or wealth of the parents, or the intelligence and application of the daughters, will vary the refinement and education of each. As, for instance, the education of a country squire's daughter will be superior to that of a wholesale merchant's daughter, and that of the wholesale merchant's daughter will be superior to that of the retail merchant's daughter. The daughter of a very wealthy banker will be educated above the

daughters of the merchants; the daughter of a professor of the University above that of the daughters of a professor of the Gymnasium, and so on; and each will fill a position in life differing from that of the others, according to the respect in which the position of the parents is held.

"The same system of education which we have described for the daughters of the gentry will be incumbent on the daughters of the nobility, with the addition of a more finished and thorough education in regard to the manners and formalities which attach to their station of life, and these will also vary in kind and extent, according to the position of the persons concerned. A Duke's daughter, for instance, will be more accomplished than a Count's. But the difference will be more apparent than real; the actual knowledge of both will, as far as their education provides, be the same. In the society of the Court, the ladies will naturally acquire some knowledge of the affairs of State, which those in private life and a more retired existence will not care to learn. But in matters of art, in literature, in the general business of life, all German ladies are expected to be well informed and to be able to converse intelligently regarding them, while the special faculties of law, of medicine, of theology, of chemistry, etc., etc., are left to the higher ambition of their fathers and brothers, and they do not meddle with them. But, above all, as I remarked in the beginning, a German girl of whatever rank or condition must understand fully all the matters concerning a *household*."

When the Professor had finished, I thanked him and expressed so much admiration at the system of education provided for the women of Germany, that he promised me at some future time a brief explanation of morals and manners in Germany, which I shall be most happy to present before the reader at the proper time.

K.G.D.

SCIENCE IN ANTIQUITY.

HERON'S PNEUMATIC AND COMPRESSING APPARATUS.

The most ancient of such instruments is certainly the syringe. The Egyptians, says Herodotus (ii., 87), employed the latter in the embalming of common people, for filling the belly with oil of cedar, through injections made *per ano*, without opening the body and extracting the intestines. Heron, in his "Pneumatics," describes an instrument of this kind, called *Pyulgue*, which was designed for sucking pus out of wounds.

The following apparatus, also described by Heron, is the first step that was taken toward the production of the pneumatic apparatus properly so called

"*Construction of a cupping glass that sucks without the aid of fire*."

Let *ΑΒΓ* (Fig. 1) be a cupping glass (like that which is usually applied to the skin), divided by a partition, *ΔΕ*. Through the bottom let there be passed two tubes that slide one within the other by friction—*ΖΗ* being the external and *ΘΚ* the internal one. In these two tubes, external to the glass, there are two apertures, *ΛΜ*, that face each other. The extremities of the tubes situated within the apparatus should be open, and the external extremity of *ΘΚ* should be closed and provided with a key. Beneath the partition, *ΔΕ*, there is another cock, *ΝΞ*, like the one just described, save that the corresponding apertures are within the cupping-glass, and are in communication with an aperture in the partition, *ΔΕ*.

"Things being arranged thus, the keys of the cock are revolved in such a way that the apertures of the one at the bottom of the instrument are in a line with each other, while the cock above the partition remains closed, inasmuch as its apertures do not correspond. The chamber, *ΔΓ*, being full of air, if we apply the mouth to the orifices, *ΛΜ*, and suck out a portion of the air, and turn the key of the cock without removing the mouth from the tube, we shall be able to thus keep up a rarefaction of the air in the chamber, *ΓΔ*. The oftener we perform this operation, the more air we shall remove. Let us now apply the cupping-glass to the skin in the usual way, and open the cock, *ΝΞ*, by turning the key. A portion of the air contained in *ΑΔΕ* will pass into *ΓΔ*, and we shall then see the skin, as well as the subjacent matters that pass through its interstices, that we call unexplored spaces, drawn into the space in which the air is rarefied."

As for the pressure fountain, this had reached perfection as long ago as the Alexandrine epoch. The following description of it is borrowed from the "Pneumatics:"

"*To construct a hollow sphere, or any other vessel, in which, if a liquid be poured, the latter may be made to rise spontaneously with great force so as to empty the vessel, although such motion be contrary to nature*."

"The construction is as follows: Let there be a sphere of a capacity of about six cotyles (about 2¾ pints) made of some metal tough enough to withstand the pressure of the air that is to be produced. Let us place this sphere, *ΑΒ*, upon any base whatever, *Γ*. Through an aperture in its upper part we introduce a tube which runs down to that part of the sphere which is diametrically opposite the aperture, but which leaves sufficient space there for the water to pass. This tube projects slightly above the sphere, to whose aperture it is soldered, and divides into two branches, *H* and *Z*, to which are affixed two bent tubes, *ZMNΞ* and *HΘKΛ*, that communicate internally with *H* and *Z*. Finally, in these tubes, *HΘKΛ* and *ZMNΞ*, and in communication with them, there is adapted another tube, *ΠO*, from which issues at right angles a small tube, *PΣ*, that communicates with it and terminates at *Σ* in a fine orifice.

If, taking the tube, *PΣ*, in hand, we revolve the tube, *ΠO*, the two apertures that face each other can no longer establish a communication, and the liquid that rises will no longer find an outlet. Then, through another aperture in the sphere, we insert another tube, *TτΦ*, whose lower orifice, *Φ*, is closed, but which has upon the side, toward the bottom, at *X*, a round hole to which is adapted a small valve of the sort called by the Romans *assarium*. Into the tube, *τΦT*, we insert another and closely fitting tube, *ΨΩ*. Let us now remove the tube, *ΨΩ*, and pour liquid into the tube, *τΦT*. This liquid will enter the cavity of the sphere, through the aperture, *X*. The valve will open in the interior, and the air will escape through the apertures in the tube, *OΠ*, of which we have already spoken, and which have been so arranged as to communicate with the tubes, *HΘKΛ* and *ZMNΞ*. When once the sphere is half full of liquid, we incline the small tube, *PΣ*, so as to shut off all communication between the corresponding apertures, and then push down the tube, *ΨΩ*, and drive into the interior of the sphere the air contained in *TτΦ*. This requires some force, as the sphere itself is full of liquid and air, but the introduction is rendered possible through the compression of the air, which shrinks into the empty spaces that it contains within itself. Let us now take out the tube, *ΨΩ*, again so as to fill the tube, *TτΦ*, with air, and let us push down the tube, *ΨΦ*, again and force this air into the sphere. On repeating this operation several times in succession we shall finally have in the sphere a large quantity of compressed air. It is clear, in fact, that the air introduced by force cannot escape when the piston-rod is raised, since the valve, pressed by the internal air, remains closed. If then, replacing the tube, *PΣ*, in a vertical position, we set up a communication again between the corresponding apertures, the liquid will be driven to the exterior through the compressed air, and the latter will assume its normal volume again, and press in the liquid beneath it. If the quantity of compressed air is considerable, there will occur an expulsion, not only of the entire liquid, but also of the excess of air.

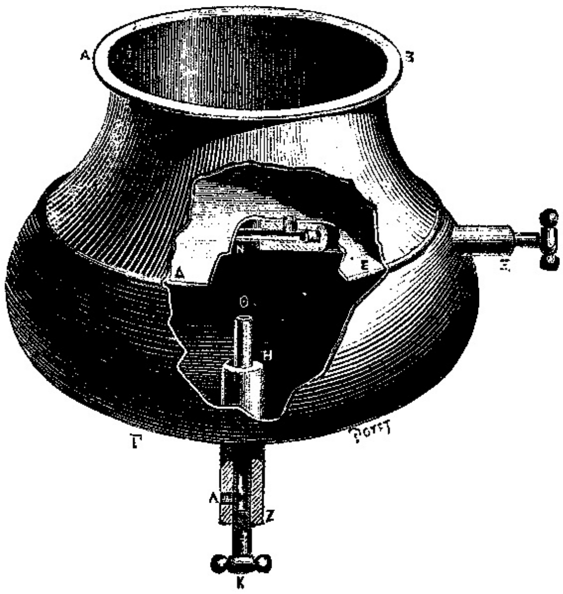


Fig. 1.—HERON'S CUPPING GLASS.

The valve of which I have spoken is constructed as follows (Fig. 2, 1 *bis* and 1 *ter*): Take two pieces of brass about one inch square, and about as thick as a carpenter's rule, and rub their surfaces against each other with emery, that is to say, polish them so that neither air nor liquid can pass between them. In the middle of one of the pieces bore a circular aperture about $^4/_{10}$ an inch in diameter. Then fitting the two plates together by one of their edges, unite them by a hinge so that the polished surfaces shall coincide with each other. When this valve is to be made use of, the part containing the aperture is adapted to the aperture that is designed for the introduction of the liquid or air that is to be compressed. The pressure causes the other part of the valve (which moves easily on its hinge) to open and allow the liquid or air to enter the tight vessel, wherein it is afterward confined and presses against the unperforated part of the valve and thus closes the aperture through which the air entered."—*A. de Rochas, in La Nature*.

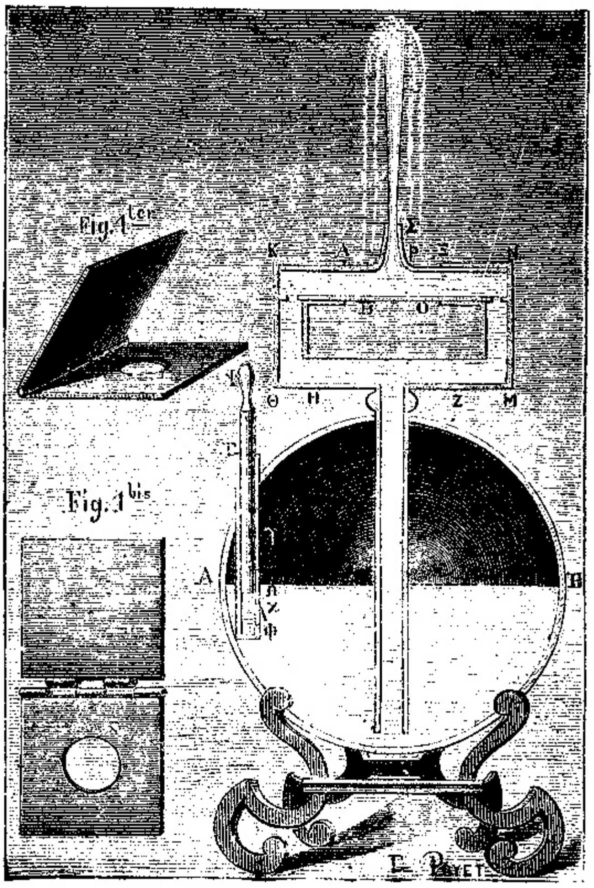


Fig. 2.—HERON'S FOUNTAIN.

Professor Adolf Meyer has been experimenting upon the relative digestibility of natural and artificial butter. The experiments were made on a man of 39, and a boy of 9 years. He found that there was but little difference, but in these individuals the natural butter seemed to be more easily digested. While natural butter was all digested, at least 98 per cent. of the artificial butter was also digested.—*Chemiker Zeit.*

FILTH DISEASES IN RURAL DISTRICTS.

By Alfred L. Carroll, M.D., New Brighton, N. Y.

An editorial comment in *The Medical Record* of April 14th, upon a paper by Dr. Hamilton, of Philadelphia, may serve as an apology for some remarks on a subject which ordinarily seems to possess scarcely more interest for practicing physicians than for "practical" laymen; both being wont to lay the finger of incredulity against the nose of scorn when they turn their deafest ears to the voice of the sanitarian. In the present very unsettled condition of professional opinion as to the diagnosis of typhoid fever—passably good authorities in India, on Western mountain peaks, and even nearer home, differing widely thereanent—I shall not attempt here to discuss its etiology, or to single out for reprobation any particular one of the several kinds of bacteria which have been respectively described as its exclusive cause. Suffice it merely to hint that there may be possible source of error in statistical arguments touching its relative frequency in town or country. But, waiving this, I am not aware that "professed sanitarians" have ascribed to "sewer-gas" alone such pre-eminence over other vehicles of filth or fungi as the article in question imputes. On the contrary, I believe that the majority of cases of enteric fever which have been traced accurately to their origin have been traced to other and more tangible contaminations of food or water. Nevertheless there is strong evidence, which has stood the test of much cross examination, that the so-called "filth diseases" deserve their name in this respect: that whatever be the specific *tertium quid* which determines their occurrence in the individual, filth-poisoning (*i. e.*, the imbibition, through some channel, of the products of organic decomposition) is an essential factor in their genesis.

The first source of fallacy in the arguments referred to lies in the misinterpretation of the term "sewer gas," connecting it with sewers in particular instead of with sewage in general. Thus, I find it stated that typhoid is "more prevalent in the suburbs and surrounding country than in the cities subjected to the contamination of sewer gas;" that diphtheria and scarlatina occur most fatally "in the country, where sewer gas is wanting;" and that in Philadelphia the extension of the sewage system into the rural sections has diminished the sickness from fever. Now the facts on which most sanitarians lay great stress are, that unsewered rural districts are more exposed to danger from fermenting filth than cities, that the ineffable atrocities of leaching cesspools and privy-vaults (those perversions of barbarism to which the American rustic clings as to his most precious birthright) do infinitely more to poison air, and soil, and water than all the blunders of city engineers and plumbers combined; and that, granting the worst that can be said of some city sewers which shall be nameless, even a bad sewer is better than none at all—which is merely equivalent to saying that it is better to carry away as much of one's sewage as possible than to keep the whole of it on the premises to decompose under one's nose. And the peril from this fount and origin of evil is augmented a hundredfold where the mania for "modern improvements" has invaded rural households. Long before sewers are thought of—even before the importation of the agonizing pianoforte—the suburban housewife insists on having a bath-room, including that sum and substance of vileness, a pan water-closet on the bedchamber floor, and a kitchen sink and "stationary tubs" down stairs; and these fixtures, commonly constructed in the cheapest and nastiest manner, are connected with an unventilated cesspool, serving as so many inlets to insure the constant pollution of the house atmosphere with the gases of decomposition. Then, in an uncemented basement a "portable furnace" is arranged to transport to the upper rooms not only the cellar-air, but the freely indrawn "ground atmosphere," laden with noxious vapors from the soil-soakage of cesspools or privies. It is not saying too much to affirm that for every one channel of filth-poisoning in a paved and sewered city there are at least three in the average village settlement, and if the evidence of insanitary conditions be found in "not more than one house out of five," it is because, unfortunately, very few physicians in this country have cared to learn how to look for it—familiarity with the doses of drugs and the results of disease being regarded in most of our medical schools as vastly more important than *rerum cognoscere causas*.

I am not sufficiently informed of the morbility statistics of African cities to appreciate the full weight of reasonings based upon their alleged comparative salubrity; the occasional scattered returns which I have seen from a few of them show death-rates ranging from 30 to over 40 per 1,000. But I am free to admit, on general principles, that it is less dangerous to let organic matter decompose fully exposed to atmospheric oxygen than to store it in unventilated receptacles to form sulphureted and carbureted compounds, or to saturate an undrained soil with it. It is to be remembered that few, if any, sewage substances are suspected of pathogenic power while in their fresh solid or liquid state: the products of their subsequent chemical changes are what we have to fear; and if these products be liberated *al fresco* as fast as they are formed, they are diluted to homœopathic insignificance by the surrounding air. Of the two evils, therefore, the Africo-Hibernian practice of throwing house refuse promiscuously upon the surface is preferable to the American village method of fostering and festering it in cumulative concentration.

As regards the allegation that "the young men at work in the fields were more frequently attacked (by typhoid fever) than the females, who were generally engaged in domestic duties in or about the house," it may be observed: First, that agricultural laborers do not spend all their time in the fields, but sleep in rooms from which, as a class, they carefully exclude all ventilation; second, that, for some unexplained reason, enteric fever seems to have a selective affinity for robust young males. It is an affair of common observation that, under apparently precisely similar conditions, fragile women may resist the infection to which strong men succumb.

Facts, however, are more forcible than words, and I therefore subjoin a few examples of coincidences which have very much the air of causes and consequences. I have excluded instances where water-pollution could be supposed to bear a part, and also those where careful inquiry did not seem to eliminate the possibility of immediate or mediate importation of contagium from a pre-existing case. And let me, at the outset, deprecate the Liebermeisterian criticism that if an adynamic fever with peculiar temperature curve, abdominal symptoms, etc., be not directly traceable to a preceding patient, it is not true typhoid, but only something otherwise indistinguishable from it; or that, without evidence of contagion, a pseudo-membranous angina with grave constitutional depression is not genuine diphtheria, though a remarkably good imitation of the real article. Grant only that there are diseases—call them what you will—which closely resemble the regulation nosological types, that people sometimes die of 6451
them, and that they are intimately associated with the eating, drinking, or breathing of filth-products, and I shall, for the present, leave the question of diagnosis to be begged by whosoever cares for it.

I. *Typhoid.*—Large country house with numerous "conveniences." Two "pan closets" on second floor; one in a small windowless hall-apartment, the other in a bath-room adjoining a bed-chamber; basin and bath-wastes led into trap of water-closet; leaden soil-pipe not continued above the line of fixtures, communicating directly with cesspool, and badly corroded at bends of closet-traps. Servants' pan-closet in basement with foul and leaky "retainer;" kitchen and laundry wastes on same horizontal branch, constantly liable to siphonage. Frequent illnesses of minor grade prevailed in this household until the whole plumbing system was reconstructed on a proper plan, since when the inmates have enjoyed excellent health.

II. *Typhoid.*—Small house in village street. Under the cellar runs the ill-covered channel of a former brook, which receives the sewage of several adjoining tenements. The house-refuse is discharged into this foul trench through an open untrapped conduit in the basement.

III. *Typhoid.*—Cottage of better class. No plumbing fixtures except kitchen sink, which discharges untrapped into an obstructed and very foul drain; leaching privy-pit on higher ground than the basement, which, with the foundation walls, is uncemented, affording ingress to ground-atmosphere.

IV. *Diphtheria.*—Elegant mansion, regarded by owner and "practical plumber" as a model of sanitary construction. Soil-pipe extended above roof, but without ventilation at its foot. Materials and workmanship good. On a lateral branch was a down-stairs water-closet into the trap of which the kitchen waste discharged, and into the dip of the running-trap of this horizontal soil-pipe, in the basement, and within a few feet of the furnace, was inserted a servants' hopper-closet without any flushing fixture; excremental matter being, of course, thus retained in the trap a great part of the time, and its decomposition favored by the admixture of hot water from the kitchen. When the water from the boiler was set running, the steam arose freely from this hopper.

V. *Diphtheria.*—Handsome country-seat. Plumbing work recently overhauled and declared perfect by the plumber. Three foul pan closets and numerous other "conveniences," all leading to unventilated cesspool. In the bedroom occupied by the patient the "safe-waste" from a stationary basin was carried into the soil-pipe, constituting a direct inlet from the cesspool.

VI. *Diphtheria.*—Presumably "first class" residence. Kitchen and laundry wastes carried from basement into privy-vault, which was filled to above the level of the pipes.

VII. *Typhoid?* (two irregular cases).—Cottage in good neighborhood. Bath and basin wastes discharging into trap of foul pan-closet with "putty-joints." Two inch tin pipe inserted, with leaky slip-joint, into bend of water closet trap, and carried with several angles to roof; no other ventilation of soil-pipe, which connects with leaching cesspool. Cellar riddled with rat-burrows (indicating probable connection with some old drain), and airbox of furnace made of loosely jointed boards, so as to convey the cellar air to upper part of house.

VIII. *Typhoid?* (continued fever)—Cottage on high ground. Offensive pan-closet on bedroom floor. Soil-pipe relieved by angular galvanized vent. But carried without other ventilation or trapping to cesspool on lower ground. Kitchen and laundry wastes untrapped and led to a row of buried barrels which were filled with a most malodorous mess, the water being allowed to soak into the soil as best it might.

IX. *Diphtheria.*—House without plumbing fixtures. Cellar loosely paved with bricks, and saturated with soakage from several privy-vaults on much higher ground and close in the rear; the fæcal-smelling semi-liquid filth actually oozing up between the bricks when they were stepped upon.

X. *Diphtheria.*—Cottage alleged by the owner, and innocently believed by the tenant, to be "one of the best plumbed houses in the county." Pan closet in a decadent and offensive condition, with untrapped bath waste and insufficiently trapped basin waste led into its seal. Short vent from bend of closet trap to outside of wall, with orifice closed during winter "to prevent water pipes from freezing;" soil-pipe thus without ventilation at top or bottom. Butler's pantry sink connected by tin pipe with earthenware drain, which was badly laid and composed of different sized pipes. Some distance beyond the junction of the soil pipe and wastes, this drain was tapped by a "ventilating" pipe carried into a chimney flue, with an occasional down-draught. Kitchen waste opening directly into an unventilated cesspool. All lead pipes of poorest quality.

XI. *Diphtheria.*—Country farm-house. No plumbing. Uncemented cellar; living room in wing built directly upon the earth. Overflowing privy-vault within twenty feet and on higher ground, the soakage and surface washing from which had permeated the soil around and under the building.

XII. *Diphtheria.*—Large and handsome house. Sanitary arrangements satisfactory to plumber. Pan-closet with insufficient flush. Two-inch tin vent from bend of soil-pipe carried with various angles into cold chimney flue. Running under the whole length of the basement was an eight inch earthenware drain receiving the soil-pipe and the wastes from different fixtures; its large caliber and slight grade precluded proper flushing, and it was thickly coated with refuse and chilled grease. Into its upper end was inserted the overflow from a tightly covered cistern, so that the only ventilation of the entire house-drainage system was through the rain-water leader, close to a "mansard" bedroom window.

XIII. *Typhoid?*—Two small houses of the poorer class, situated on a road at the foot of a steep declivity. No plumbing. Two privy-vaults, a pig-pen, and an indescribably filthy cow stable just behind and above them, from which the washings were traceable into their cellars.

I could extend the list by scores of illustrations of rural house-defects: soil-pipes disjointed from their outlet drains and discharging their sewage under basement floors; cesspools "backing-up" into kitchen sinks or laundry tubs, or pouring a reflux tide through "overflow" pipes into drinking water cisterns; ingenious devices of every sort to deprive the gases from pent-up filth of any escape, save into the dwelling. And these among the "wealthier residents," whose surroundings are commonly supposed to be above suspicion. As regards the unplumbed poor, their chances of inhaling filth-polluted air or imbibing filth contaminated water are often enhanced by inadequate cubic space and faulty construction within doors, and ignorant neglect of the very rudiments of hygiene in the environment; their cellars and wells being sunk in soil saturated with putrescent refuse. In the intermediate agricultural or mechanic class similar conditions frequently exist, their potency for evil depending chiefly upon the porous or retentive character of the soil; precautions to exclude the ground atmosphere from cellars or basements are seldom found; cesspools and privy-vaults are close at hand; and it is a common thing for a couple of adults and two or three children to sleep in a "stuffy" unventilated room with not more than 1,000 or 1,500 cubic feet among them.

From a sanitary point of view it matters little whether the gases from decomposing sewage escape from sodden soil or from a foul sewer; their nature is alike in either case, and the aggregate dose may be even larger in the former instance. But when, and why, and how, they, or any of them, exert their most deleterious influences, are questions which it is impossible to answer in the present state of our knowledge. It is an indisputable fact that people may for a long while be exposed to them without pronounced manifestations of "filth disease"—although such people, in my experience, are seldom thoroughly well, even if not specifically ill. But sooner or later an apparent qualitative change may take place, and an acute zymosis declare itself. I have elsewhere suggested the part that may be borne in this complicated problem by a "personal factor," or temporarily altered individual susceptibility;[7] but it seems necessary also to assume an alteration in the external conditions; and such alteration is explained by many etiologists on the hypothesis of the importation or evolution of specific pathogenic micro-organisms. That certain varieties of schizophytes are associated with some of the acute infections is beyond doubt; that in a few, such "microdemes" are the conveyers,[8] if not the causes, of the infection seems proved; but it must be remembered that in the diseases chiefly under consideration no characteristic bacteroidal forms have been defined. In typhoid fever, Klebs describes a bacillus where Letzerich finds only micrococci; according to Wood and Formad, the micrococcus of diphtheria is just like that of the ordinary buccal mucus; indeed, nearly all of the acutest infectious diseases are attributed to these ubiquitous micrococci, indistinguishable from each other in most instances, and divided into species solely on the score of their assumed physiological effects. Admitting all that the most ardent advocates of the germ theory can claim for it, there are at least three possible ways in which filth and fungi may be connected.

1. Taking the view of Naegeli and others as regards the mutability of the bacteria, it is conceivable that the common "scavenger" microphytes may acquire pathogenic properties by successive generations of development amid the products of certain decomposing substances. In favor of this conception may be cited the seemingly gradual intensification of "filth poisoning" in numerous instances; sore throats of a less septic type forerunning outbreaks of diphtheria; diarrhœal derangements preceding enteric fever; and, furthermore, Koch has found both bacillus-spores and micrococci in surface soils, the latter organisms preponderating where the earth is subjected to excremental soakage.

2. Or, accepting the specific classification of the schizomycetes, it may be supposed that some pathogenic germs obtain favorable intermediate conditions for their development and multiplication in these products of decomposition; a supposition almost necessary if the specific-germ theory be applied to enteric or choleraic discharges.

3. Finally, if it be conceded that desiccated spores may retain their specific vitality indefinitely, and be air-wafted almost unboundedly, the predisposing action of our filth emanations maybe imagined to be cumulative, slowly undermining the individual powers of resistance, or rendering certain cell groups an easier prey to the intruding organisms in the struggle for existence.

Which of these hypotheses, if either of them, will ultimately prevail is a question only to be decided by experimental investigations which are beset by a multitude of difficulties and sources of error.—*Med. Record*.

HORSE MEDICINE BIT.

Owing, no doubt, to the preponderance of horizontality over verticality in the construction of the horse, there results a considerable difficulty in administering medicine to that quadruped, and he frequently has to undergo what may be said to amount to cruelty in the endeavor to persuade him to swallow the unpalatable dose. It is therefore with satisfaction that we bring under our readers' notice a simple and effective invention which promises to do away with this difficulty, and from humanitarian motives we hope to see it widely adopted. It is the joint production of Mr. Philip Fonnereau, of Masons' Arms Yard, Maddox Street, and Mr. Willoughby Fielding, of Lisle Street, Leicester Square, London. The inventors have adopted the sensible and very obvious plan of utilizing that which the horse is trained to tolerate—viz., the bit. It will be seen from the annexed engravings that the invention consists essentially of a tubular bit, with a funnel attached, as shown at Fig. 1. The bit has a hole, which is close to the horse's tongue when in its mouth. The upper part of the apparatus is fitted with a rope, which is passed through a ring in the ceiling of the stable. By this rope the horse's head is gently elevated, so as to prevent the medicine from going in any other direction than down its throat. When it has been properly adjusted, as shown at Fig. 2, the medicine is poured into the funnel, and it immediately runs through the hole into the horse's mouth, and the animal cannot help swallowing it. The apparatus is then removed, and rinsed out for future use. Of course the invention is adapted to liquid medicine only, but we believe it is as easy to prepare medicine in a liquid form as in any other, and therefore there need be no difficulty on that account. We commend this invention to all having the care of horses as a practical means of obviating the perpetuation of a hitherto necessary but now unnecessary cruelty to animals.—*Iron.*

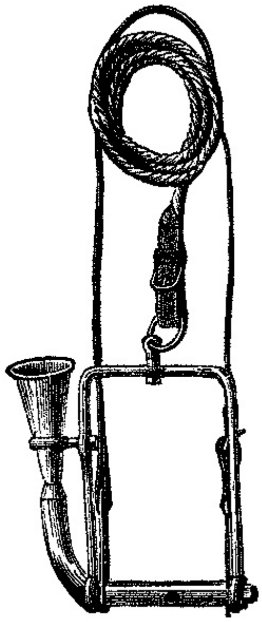


Fig. 1.

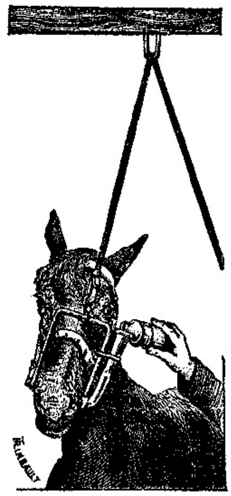


Fig. 2.

THE PHYSIOLOGY OF SLEEP.

As regards the vascular condition of the cerebrum during natural sleep, there seems to be at present a virtual agreement among physiologists. Whatever views may be held of the immediate or proximate cause, it is generally admitted that during sleep the brain is relatively anæmic. There are well-attested facts enough on record to substantiate this. The brain, denuded of a portion of its cranial covering, has been carefully watched during the waking state and in sleep, and it has been ascertained that, both in man and in the lower animals, the organ is comparatively bloodless during sleep, and its circulation more sluggish than at other times.

In the early part of this century Blumenthal first enunciated this theory, and supported it by the interesting case of a patient who had lost a portion of the right frontal bone; during sleep the brain was seen to be anæmic and in a collapsed condition. Dendy[9] relates a similar case, which was observed in 1821. But Durham's memoir on the physiology of sleep, which was published in the volume of "Guy's Hospital Reports" for 1860, was the first really thorough and scientific contribution to our knowledge of the vascular state of the encephalon during sleep, and the relation of that state to the phenomena of sleep. To Hammond also, many of whose experiments were made prior to Durham's publication, we are indebted for numerous original observations, and for the most exhaustive and conclusive exposition of the subject yet given to the world.[10]

We may see that during sleep all the encephalic blood-vessels are under a diminished pressure, as proved in fact by the manometer, and that this lessening of the active flow corresponds with a diminution of cerebral function. Even if no experiments had ever been made, inductive reasoning would have led irresistibly to this conclusion. During the intervals of digestion the gastric mucous membrane is relatively pale and bloodless; the submaxillary gland does not become turgid with blood until it begins to secrete saliva; a muscle in action becomes markedly hyperæmic. It is so with the organs in general. The performance of function is characterized by vascular activity and fullness. If in any part there is a call for work, there is a call for more blood. The nervous system forms no exception to this law, and there is the most intimate and absolute correlation between the evolution of nervous energy and the activity of the circulation. So true is this that it is everywhere admitted that the induction of functional work in any such apparatus as the digestive, the sexual, or the muscular produces a degree of hyperæmia of the apparatus called into action sufficient to prove a serious hinderance to the easy and satisfactory performance of any severe mental task.

Professor Mosso, of Turin, has lately made some interesting experiments on persons who had lost portions of the cranial bones, using Marey's ingenious hydro-sphygmograph. Noting, like others before him, that during sleep the brain diminished in volume, with shrinkage of its blood-vessels, and that the lively blush characterizing its surface during the waking state disappeared, he observed also that any sudden impression, if sufficient to rouse the brain to partial activity, was sure to be attended with an increase of its vascularity and its volume. He has proved, too, that every effort of the intellect is normally accompanied by a diminution of volume in the peripheral parts, the arm, for example, and that, on the contrary, when the cerebral activity is lessened the distant members are augmented in volume. Sleep is always accompanied by a dilatation of the vessels of the extremities, and particularly of the forearm, where this dilatation has repeatedly been measured by Mosso with his registering apparatus. Every excitation from without causes a contraction of the vessels of the forearm of the sleeping subject, and the augmented blood pressure at once produces a renewed afflux of blood to the brain. In this manner the fluctuations of cerebral activity can be followed: a sound, a touch, a ray of light falling on the closed lid of the sleeper, all give rise to modifications of the cerebral circulation—unperceived, doubtless, but possibly the source of dreams.[11]

The immediate cause of sleep is not simply the shutting off of a portion of the blood current from the brain. There are more important factors. Here Vulpian[12] is right. The lessening of the blood supply to the encephalon is rather the accompaniment than the cause of sleep. We cannot produce normal sleep in a person simply by exsanguinating his brain, or else we should have in an ice-cap and a hot foot-bath the speediest and most effective of hypnotics. The brain must first be in a certain condition. There must be in the constitution of the supreme nerve centers something that forbids further activity, and with that cessation of activity there will be a lessening of the blood-flow to the brain, in accordance with the physiological law before stated. What is the particular modification of the cortical cells which renders them less fit for the liberation of their special forces, and finally compels a suspension of action, with a diminution of the blood supply? Herbert Spencer has given a very plausible explanation, in accordance with the theory of evolution:

The waste of the nerve-centers having become such that the stimuli received from the external world no longer suffice to call forth from them adequate discharges, there results a diminished impulse to those internal organs which subserve nervous activity, including more especially the heart. Consequently, the nerve-centers, already working feebly, are supplied with less blood and begin to work more feebly, responding still less to impressions, and discharge still less to the heart. And so the two act and react until there is reached a state of profound unimpressibility and 6452
inactivity. Between this state and the waking state the essential distinction is great reduction of waste, which falls so low that the rate of repair exceeds it.... During the day the loss is greater than the gain, whereas during the night the gain is diminished by scarcely any loss. Hence results accumulation; there is restoration of nerve-tissue to its state of integrity.

According to Mr. Spencer, that rhythmical variation in nervous activity which we see in sleep and waking is the result of adaptation, due to survival of the fittest. "An animal so constituted that waste and repair were balanced from moment to moment throughout the twenty-four hours would, other things equal, be overcome by an enemy or competitor that could evolve greater energy during the hours when light facilitates action, at the expense of being less energetic during the hours of darkness and concealment."[13]

With some qualification, the foregoing statement is about as satisfactory as any that has yet been offered as to the proximate cause of sleep. During the waking hours the vaso-motor center in the medulla is doubtless under inhibition by the superior centers, and there is relative relaxation of the cerebral arterioles, with dilatation of the capillaries; when the cells of the hemispheres are exhausted, they are no longer able to exercise this inhibition—in common parlance, they no longer powerfully extract the blood—and the vaso-motor center "puts on the brakes"; the blood supply is then no longer sufficient for function, though enough for nutrition.

An ingenious theory has lately been proposed by Preyer, of Jena,[14] according to which, to use a homely illustration, the fire ceases to burn because the flues are clogged with cinders.

As Preyer puts it, the activity of the cerebrum is a sort of respiration, while its repose is a sort of asphyxia of this organ. It is certain that every psychical act, every thought, involves a certain consumption of oxygen by the nervous substance. During waking, this gas is furnished to the brain in the blood. If the blood supply fails, those forms of activity which we denominate consciousness, attention, volition, and thought cease. This is easily proved by compression of the carotids. It is known that in the waking hours the muscles, as well as the nerves and the nerve-centers, as a consequence of that activity, produce substances easily oxidizable, among which is lactic acid. Some have even attributed the sense of fatigue which we experience after prolonged exertion to the presence of this acid in the blood.[15] According to Preyer, after the work of the day is done, and the quiet of sleep is sought, the waste materials of which we have spoken, and which he proposes to call *ponogènes* (substances which cause fatigue), being accumulated in the tissues, little by little undergo decomposition, by taking oxygen from the blood. They thus divert a considerable quantity of this gas from the cerebrum, the cells of which, deprived of this element so indispensable to their activity, enter into a state of relative repose. These waste matters are, then, the physical cause of sleep, which will be the more profound and prolonged the more the blood is charged with the excrementitious products of function. Preyer has experimented on animals by injecting varying quantities of lactic acid into their blood, and has produced a deep somnolent condition which could not be distinguished from natural sleep. The use of lactate of sodium in the human subject has sometimes been attended with a like hypnotic effect. Further researches are needed before the question can be considered as settled.—*N. Y. Med. Jour.*

PREPARATION OF CHLORHYDRINES.

The usual methods of preparing chlorhydrines are in part inconvenient, in part unsatisfactory in yield. A. Ladenburg therefore proposes the following process, using ethylen-chlorhydrine as an example:

Glycol is heated in a distillery apparatus to 148° C., and a *slow* current of dry hydrochloric acid passed through it. The water formed and the glycol-chlorhydrine distill over and are collected in tubulated receivers. The temperature of the bath is gradually raised to 160° C., when all the glycol is completely decomposed, except a trifling residue. The distillate is mixed with two or three volumes of ether, and then freed from any hydrochloric acid present with potassium carbonate. The ethereal solution is drawn off, and completely dried over freshly fused potassium carbonate.—*Berl. Ber.*

A NEW METHOD FOR THE DETECTION OF SUGAR IN THE URINE.

At a recent meeting of the Clinical Society of London, Dr. Oliver gave a demonstration of the method he employs for the detection of sugar in the urine by means of test-papers. The test-papers were charged with the carmine of indigo and carbonate of soda. When one was dropped into an ordinary half inch test tube, and as much water poured in as just covered the upper end, and heat applied, a transparent and true blue solution, resembling Fehling's in appearance, was obtained. (A transparent solution could not, at the meeting, be produced from the London water. The characteristic reaction with grape sugar was, however, unimpaired).

If with the paper one drop of diabetic urine had been added, shortly after the first simmer, a beautiful series of color changes appeared; first violet, then purple, then red, and finally straw color; while, on the other hand, one drop of non-diabetic urine induced no alteration of color. The colors returned in the inverse order on shaking the tube, which allowed the air to mingle with the liquid. Reheating restored the colors again.

Confirmation of the presence of glucose was obtained by dropping in a mercuric chloride paper, while the solution was still quite hot, after the complete development of the indigo reaction. Then there was produced immediately a blackish green precipitate. No such precipitation occurred when a drop of non-saccharine urine was under examination by the indigo test; then the blue solution was merely turned into a transparent green one.

This test, as Dr. Oliver pointed out, discovers (*a*) the normal sugar; (*b*) the varying proportions of sugar which fill in the gap between the normal amount and that which characterizes diabetes mellitus, as in liver derangements and vaso-motor disturbances; (*c*) diabetic proportions.

It possesses the following advantages over Fehling's test:

1. It will detect sugar in any proportion in the presence of albumen, peptone, blood, pus, or bile, and as readily as in ordinary diabetic urine.

2. It gives no play of colors with uric acid.

3. It possesses portability, cleanliness, and stability.

Moore's, Trommer's, and Boettger's bismuth tests are all inferior in delicacy.—*British Medical Journal.*

CHEMICAL COMPOUNDS MADE BY COMPRESSION.

By M. W. Spring.

The author has previously shown the possibility of uniting the fragments of solid bodies by the sole action of pressure. He also established at the same time the possibility of forming chemical compounds by means of pressure. Thus he obtained cuprous sulphide by compressing a mixture of sulphur dust and copper; mercuric iodide, by compressing mercuric chloride with potassium iodide, etc. Finally, by compressing in the same manner mixtures of the filings of different metals, he formed alloys having for equal compositions the same melting points as those obtained by fusion.

The last mentioned facts certainly establish the possibility of causing bodies to enter into chemical reaction by the mere agency of a mechanical energy. This result is closely linked with another obtained during the course of the same investigation: the polymerization of certain simple bodies, *e. g.*, sulphur, by the action of pressure. The author had drawn a general conclusion from his experiments, and had announced that matter takes, below a given temperature, a state corresponding to the volume which it is compelled to occupy.

He has since undertaken a methodical study of the chemical reactions accomplished by the action of pressure. He had already shown the possibility of forming metallic arsenides by compressing mixtures of arsenic and of the filings of different metals (*Bulletin de l'Académie Royale de Belgique*, t. v., 1883), and he now communicates the results obtained by compressing mixtures of sulphur and of certain metals or non-metals. The results not merely confirm the author's former conclusions, but they throw a new light on the relations of organic and inorganic chemistry, and exhibit the so-called simple bodies as capable of assuming a peculiar constitution varying according to the conditions in which they are placed, and the actions to which they are submitted.

He used the metals in the state of fine filings immediately mixed with flowers of sulphur previously thoroughly washed. The mixtures were made in atomic proportions and were submitted to a preliminary pressure of 6,500 atmospheres. They then assumed the state of a hard compact mass, showing, on examination with the microscope, that the reaction of the sulphur and the metal had taken place wherever the elements were in contact. The mass obtained was then reduced into fine powder and compressed again from twice to eight times.

1. *Sulphur and Magnesium.*—After six compressions there was obtained a gray mass with a feebly metallic surface luster. It dissolves in water at 50° to 60° with a slow escape of hydrogen sulphide, the liquid becoming of a golden yellow. A drop of hydrochloric acid occasions immediately a very strong escape of hydrogen sulphide, while free sulphur is deposited. Hence magnesium and sulphur combine under the action of pressure, forming magnesium sulphide and possibly a polysulphide.

2. *Sulphur and Zinc.*—Three compressions yield a block deceptively similar to native blende with metallic luster. Dilute sulphuric acid dissolves the block slowly with an escape of hydrogen sulphide.

3. *Sulphur and Iron.*—After four compressions a block is obtained which the file scarcely touches. Dilute sulphuric acid dissolves it easily with continuous escape of hydrogen sulphide. If the product of compression is heated in a closed tube no luminous phenomenon is observed, the body entering into tranquil fusion. Hence the potential heat of the free sulphur and iron has been realized during the compression.

4. *Sulphur and Cadmium.*—Three compressions give a yellowish-gray homogeneous mass. The powder is yellow, but less pure than that of cadmium sulphide obtained by precipitation. Strong hydrochloric acid dissolves the mass with escape of hydrogen sulphide.

5. *Sulphur and Aluminum.*—Result incomplete. After five compressions a mass is obtained which, in contact with moist air, gives off an odor of hydrogen polysulphide.

6. *Sulphur and Bismuth.*—The combination takes place with great ease.

7. *Sulphur and Lead.*—The combination is still more easy.

8. *Sulphur and Silver.*—The action is slow; eight compressions are necessary.

9. *Sulphur and Copper.*—Three compressions complete the combination. When the product of the compression is heated, there is no development of heat or light.

10. *Sulphur and Tin.*—Three compressions give a block which yields a yellowish-gray powder, easily soluble in a hot solution of sodium sulphide. Stannic sulphide is therefore formed by the compression of sulphur and tin.

11. *Sulphur and Antimony.*—After two compressions we obtain a gray-black mass having the color and luster of stibine. When powdered it dissolves with ease in hot hydrochloric acid, giving off hydrogen sulphide.

12. *Sulphur and Red Phosphorus; Sulphur and Carbon.*—Result entirely *nil*; there is produced not the least trace of phosphorus sulphide nor of carbon sulphide.

CONCLUSIONS TO BE DRAWN FROM THESE FACTS.

The negative results just mentioned have an especial interest. It is established that red phosphorus has a higher specific gravity than white phosphorus, that of the former being 1.96, and that of the latter 1.82. The author's former researches (*Bulletins de l'Académie Royale de Belgique*, 49, p. 323, 1880) have shown that if sufficient pressure is applied to a body capable of assuming several allotropic states, it takes under pressure the state corresponding to its greatest density. It is consequently impossible to transform red phosphorus into white phosphorus by pressure. But we know, on the other hand, that red sulphur and red phosphorus may be mixed with impunity at common temperatures without combination ensuing; to produce combination the temperature must be raised to about 260°, the point of transformation of red phosphorus into white phosphorus.

It is thus established that red phosphorus must first be changed from its allotropic condition before entering into combination with sulphur. The pressure opposing this change renders also the act of combination impossible; red phosphorus appears to us like a body which has lost its chemical faculties.

Thus, the combination of an element with itself, *i. e.*, its polymerization, has really the effect of extinguishing its energy, rendering it incapable of fulfilling certain functions. The chemistry of red phosphorus, more simple than that of white phosphorus, may be considered as the chemistry of a deadened body. The phosphorus which is found in combination with sulphur is phosphorus sulphides, and that which enters into combinations of other kinds, is certainly not phosphorus in the red state; it is even possible, if not probable, that it is not even white phosphorus, but a substance still unknown in the free state.

We arrive at a similar but more complete conclusion as to the nature of carbon. It is known that the affinity of carbon for sulphur and even for oxygen only becomes manifest at a temperature bordering upon redness. Is not this tantamount to saying that, in order to enter into combination with another body, carbon, like red phosphorus, must first change its allotropic condition? This view is supported by the following considerations: The specific heat of amorphous carbon, and, *a fortiori*, that of graphite and diamond, form exceptions to the law of Dulong and Petit; they are too small by more than one-half. They would be normal if the atomic weight of carbon were greater than it really is; in other words, free carbon were a polymer of combined carbon. Rose has found that at a temperature of about 500° the specific heat of carbon agrees with the law of Dulong and Petit. At this temperature carbon undergoes a beginning of depolymerization, *i. e.*, its chemical affinities reappear, and it burns readily in oxygen. Do not these facts show a complete parallelism between the chemical history of phosphorus and that of carbon?

Crystalline carbon, and even free amorphous carbon, are without chemical activity at the ordinary temperature; but when, in consequence of a rise of temperature, they take another state, they are transformed into a new kind of carbon, constituting a fourth allotropic state, and endowed with a prodigious capacity of combination. If these conclusions are well founded, we may venture a step further and ask, if the carbon which enters into the composition, not of mere organic compounds, but of organized bodies, is not a carbon of still another allotropic state characterized by the appearance of new properties or forms of combination which find their expression in the vital phenomena.

In other words, a derivative of carbon, before forming part of a living body, must first undergo in its atoms a transformation similar to that which permits amorphous carbon to enter into the composition of organic compounds. In this order of ideas the carbon of organic chemistry would be merely a first deadened form of the carbon of biological chemistry, while free carbon is merely the defunct remains of the carbon of organic chemistry.—*Bulletin de la Société Chimique de Paris; Chem. News.*

COPPER ALLOYS AMONG THE ANCIENTS.

By Prof. E. Reyer, Ph.D., of Vienna.

The earth's crust consists in part of eruptive rocks, in part of sedimentary rocks. Both of them have served from time immemorial for building purposes; but at a very early period they were the only source from which weapons and tools could be made. Subsequently metals became known, and were employed for this purpose.

Metals are rarely met with in a pure state, but generally in combination with oxygen or sulphur. If we examine the original material of which the earth was composed, and which is frequently injected through crevices in the earth's crust, and the superjacent sediment as eruptive rock, we find it to be a mixture of different substances of a complex nature. It contains silicon, aluminum, iron, calcium, magnesium, potassium, and sodium. None of these are in a free state, but are combined with oxygen. Silicon, the lighter metals, and heavy iron do not exhibit their true metallic character, having all been changed into stone-like compounds, "calcified by contact with vital air," as the old chemists expressed it.

Of the heavy metals that are of such importance to civilization I have only mentioned iron, for this alone, in its compounds, takes any considerable part in the rock formations. Other heavy metals are met with in smaller quantities in the rocks. They are scarcely taken into account by geologists who consider the earth as a whole, but it is these rare guests that are of the greatest importance to civilization.

The metals are met with as silicates in the eruptive masses; they are also found as oxides or sulphides, scattered through different eruptive rocks in small granules.[16] Besides these, the "ores," which are workable metallic compounds, are here and there concentrated in crevices or fissures, which exist in eruptive as well as in sedimentary rocks.

Iron is met with as oxide in the eruptive rocks, in fissures, and finally in thick strata and deposits within the sediment; whole mountains consist of iron ore.

Tin occurs as oxide (tin stone), scattered through eruptive masses rich in quartz, also in fissures.

Copper, combined with sulphur, is found distributed through dark eruptive rocks, poor in silica, and also in fissures in those regions.

Gold and *silver* are mixed in smaller quantities with ores of other metals.

All these are continually exposed to atmospheric agencies toward which they act very differently. The oxidized ores of iron and tin do not change their character. The sulphur compounds, at least when near the surface, are oxidized, and hand in hand with this process goes the partial reduction of certain metals to the metallic state. Gold and silver, and to a less extent copper, are subject to this change; they are unmasked and are exposed to day light, not as stones, but as brilliant, malleable metals. Finally, the heavy ores and metallic particles are loosened from the rocks by the destructive action of water, floated off, elutriated, and washed. In undisturbed mountain ranges the mineral treasures lie in masses before our eyes.

The native shining and malleable metals (gold, silver, and copper) naturally first attracted the attention of man. They may have used the separate nuggets for ornaments as they found them, or after hammering them together into plates. This was surely the first step in the use of metals. It can scarcely be supposed that this use of soft native metals contributed much to the progress of mankind, and it is highly probable that in those early times the noble metal had but little value. The shining particles, as long as the natural supply lasted, seemed like worthless tinsel. Copper, which can be made into tools and vessels, as well as soft, poor weapons, was more highly prized. Such materials were not, indeed, suitable and able to take the place of stone tools and weapons; nevertheless, this working of metals served as preparation for the more complicated work of later times. Man learned to hammer and shape metals, and he found out that the operation was much facilitated by heating the metal. 6453

The discovery of iron meteorites may have had some value. In these the smith first became acquainted with the properties of a hard metal. But I would not attach too much importance to this. The art of working metals is not the possession of a people that have a few meteoric knives. In my opinion the metallurgical preparation of the hard metals from their ores is alone decisive on this point.

The volks' sagas frequently mention some god or hero, who discovered and taught metallurgy, yet there is scarcely any doubt that the "god," in most cases, was human ingenuity led by chance.

We have already seen that only certain metals are found native, while the hard metals under normal conditions remain in the form of oxide or mineral. They have a strong affinity for the oxygen of the air, and can only be separated and converted into metals by powerful chemical agents. There is *one* substance which has a still more powerful attraction for oxygen than those metals. This is ignited carbon, which, in its fight with the metallic oxides, robs them of their oxygen.

Carbon has been separated from the carbonic acid of the air by the life-giving force of the sun, and vegetable life dependent upon it. But the isolated element waits impatiently for the impulse that will enable it to unite with the vital air under flame and heat. Men that know how to utilize this process of nature possess the means of resurrecting those metallic treasures which, without its powerful assistance, would remain forever hidden from their eyes. But accident, as we have said, pointed out the way.

In numerous places visited by primeval man, as hunter and fisherman, and afterward as nomad, conflagrations broke out. Not unfrequently whole forests were burned, either intentionally or not. It could not be otherwise than that the earth's surface would get red hot in such places, and if a strong wind favored it, this would suffice to open these treasures. The glowing charcoal would rob the ores of their oxygen and leave the pure metal as melted drops or cakes.[17] Copper, tin, and iron ores could have been reduced in this way; mankind not only knew the result but also the method of reducing metals.

This process took place not once merely, but thousands of times in various parts of the earth, and thus, in my opinion, metallurgy may have become known to different races of people and at different times.

A simple trench in the ground, in which a heap of glowing coals and some pieces of ore could be subjected to a strong draught of air, suffices, under favorable circumstances, for the preparation of the metal; the oldest metallurgists had scarcely any more complete means at hand for their work.

In such primitive furnaces the well known and soft metals would naturally be worked first, and afterward copper, tin, and iron would be obtained from their ores. A variety of substances that occur together in nature would be smelted together in mixtures, and different metals would naturally be mixed and a great variety of products obtained.

CHARACTERISTICS OF COPPER ALLOYS.

The oldest civilized races used bronze for a long space of time as their chief useful metal, although some neighboring races understood the metallurgy of iron. These facts, which are in glaring contradiction to the present condition of things, require some explanation.

First it must be mentioned that *iron* frequently contains injurious contaminations, sulphur, phosphorus, etc., and that it must have been very difficult for these primitive metallurgists to remove these contaminations, and to introduce the proper quantity of carbon into the iron. We must also consider that even a good, pure steel would be a useless product unless it was worked by a skillful and experienced smith. Finally, iron is much more rapidly destroyed by oxidation than bronze. These negative considerations certainly favored the rule of bronze for a long time.

The following facts must be fixed in mind regarding the manufacture of bronze in olden times:

1. In many districts copper and tin ores are found near together (as in Cornwall), so that under these circumstances bronze could have been obtained by smelting both at once, and together.

2. In olden times only the upper horizon of copper deposits were worked in all districts. In these, as we know, the ores are mostly oxides (with native copper). Such ores are easily worked and yield largely.

3. In regard to the mixing of metals, the metallurgists everywhere must have soon learned by experience that the metal remained soft and red when too little tin was added, while too much tin made it light colored and lustrous, but, at the same time, very brittle. Hence, we find that among all peoples the alloys used for weapons contain from 6 to 16, or, more closely, 8 to 12 per cent. of tin. These mixtures have been found to do the best.

4. Bronzes, as we shall see below, by slight admixtures and certain treatment, can be made so tough and hard that they will compare with moderately hard steel.

So we see: The metal was useful, and there was an excess of rich and easily worked ores. Under such conditions, of course, the age of bronze would flourish a long time.

Zinc ores frequently occur on copper beds, and yet zinc is rarely found in quantity worth mentioning in the bronzes of the ancients. There are two reasons for this:

1. Near the surface of the earth zinc occurs as calamine (silicate of zinc), which is a gray, unattractive, earthy looking mineral, not heavy enough to be taken for a metallic ore, and would naturally be thrown away and not put in the furnace.

2. If some zinc ore did get into the furnace, part of it would be volatilized and part oxidized by subsequent smelting.

In later times, however, we find zinc ores used a good deal. We can distinguish three types of zinc alloys:

1. Copper with 10 to 20 per cent. zinc produces a red metal, red brass, which is similar to bronze that is poor in tin.

2. Copper with 20 or 30 (and even 40) per cent. of zinc, gives a yellow metal (yellow or ordinary brass), which has more of a golden color than bronze with much tin, but quite brittle.

3. Statuary metal, which is made of copper with quite a good deal of zinc and little tin (often lead) can be called brass containing tin.

All three types may be used for casting (ornaments, statues, and coin), but are not useful for tools or weapons, because they have not sufficient strength.

After discussing the natural association of ores, and the most important alloys of copper, we will turn to the analyses of antique alloys. I have found it necessary to divide them into two groups:

1. Alloys from which the weapons and tools were *forged*. These are pure and genuine bronzes. I shall designate them as malleable metals or weapon bronzes.

2. Alloys from which ornaments, vessels, statues, and coin were *cast*. Some of these contain lead, some zinc, and some are varieties of our brass. I shall designate these as cast metals or ornamental alloys. Those substances present in some quantity were evidently put in *intentionally*, and I have classed them as admixtures, while the unintentional ones in small quantities I have designated as impurities.

WEAPON BRONZES.

Country.		**Admixtures.**	**Impurities.**

	Essential constituents.		
Egypt	Copper + 6 to 14 tin	..	Iron.
Assyria	" +10 to 14 "	..	..
Greece	" +10 to 12 "	..	Fe. Ni. Co.
Italy	" +11 to 16 "	Lead and Tin.	Ni. Fe.
Gaul	" + 2 to 15 "	..	..
Britain	" + 7 to 14 "	1 to 3 per. ct. lead.	Iron
Alps	" + 8 to 12 "	Trace to 1 p. c. lead.	Fe. Ni.
Bohemia	" + 5 to 11 "	..	Fe. S.
N. Germany	" + 8 to 16 "	..	Nickel.
Denmark	" + 6 to 12 "	To 1 p. c. zinc.	Ni. Co.
Russia	" + 9 to 16 "	Lead	Ni.
II.—CAST METAL FOR ORNAMENTS.			
Country.	**Essential constituents.**	**Admixtures.**	**Impurities.**
Egypt	Copper + 4 to 11 tin	7 to 17 lead.	Traces
Assyria	" +10 to 14 "	..	Pb. Fe. Ni.
Greece	" + 6 to 12 "	Lead.	Fe. Ni.
Italy	" + 1 to 7 "	Zinc, lead.	Fe. Ni.
Gaul	" + 5 to 15 "	Lead	..
Britain	" + 5 to 15 "	2 p. c. lead.	Nickel.
Alps	" + 4 to 12 "	Zinc.	Pb. Fe. Ni.
Bohemia	" + 4 to 11 "	Lead.	..
N. Germany	" + 6 to 17 "	Pb. rarely zn.	Ni.
Denmark	" + 5 to 12 "	1 p. c. zn.	Fe. Ni. Co.
Russia	" + 7 to 16 "	Pb. zn.	Ni.

The following general statements are based upon these tables:

We see that the peoples named forged their weapons and tools from very different alloys; pure copper at one extreme, bronze with 20 per cent. tin at the other. Experience had everywhere taught them that copper and bronzes poor in tin are too soft, while bronzes with an excess of tin could not be used for weapons and tools on account of being too brittle.

They had also learned that lead and zinc considerably lessened the strength and tenacity of weapon bronze, while small quantities of iron, nickel, and cobalt are, at least, not injurious. So all races, although we can prove that they tried very different mixtures, finally adopted very simple and tolerably constant alloys. The bronze weapons of all countries frequently contain from 6 to 16 per cent. of tin, but usually between 8 and 12, with slight contamination of iron and nickel. Few nations have allowed lead to be used, fewer yet some zinc.

For casting, the oldest races used the same kind of bronze as for weapons and tools. In many cases a few per cent. of lead were added to make the casting easier. The Romans used zinc in addition to lead in large quantity as a constituent of their alloys, and they made old bronze, bronze-brass, and brass. Afterward many nations of middle Europe used zinc alloys.

Small quantities of iron, nickel, and cobalt are found for well known reasons in nearly all bronzes as harmless impurities.

Traces of *sulphur* are also found in them. This injures the quality of the alloy, and discloses the fact that such bronzes were not made from pure oxide ores, but from those containing sulphur pyrites. At the time when such bronzes were produced the mines had probably reached a considerable depth.

Some of the weapon bronzes made by the ancients contain traces of *phosphorus*, an element as important in hard bronze as carbon is in steel.

CASTING THE ALLOYS.

The Semito-Hamitic races made excellent castings at a very early date. The Phœnicians may be mentioned as particularly skillful. It is reported that there were two immense bronze pillars that stood before the temple of Gades in the 11th century before Christ. The Tyrian founders also made a pillar for Solomon's Temple, and a metallic basin 10 ells in diameter and 5 deep. Similar large basins have been dug up in Assyria.

The art of casting statues is no less ancient. Small statuettes were cast solid; larger ones consisted of several pieces which were riveted together. In the later Grecian and old Roman days the art reached a high stage of perfection. Many cities had thousands of bronzes; gigantic pieces were constructed. The Colossus of Rhodes was 30 meters high and stood with outstretched legs astride the entrance to the smaller harbor. Ships could pass through it with sails extended. A statue of Jupiter in Tarent was 20 meters high, and one of Nero was erected in Pliny's time, 30 meters high, costing a million dollars.[18]

These facts give us a good idea of the technical ability of the old founders of bronze.

Analyses of antique bronzes give us some idea of their art of mixing and coloring. We presume that they soon abandoned the use of copper and pure bronze; the former yields porous casts and of a poor color; the latter material was, in later times, too costly. Lead was probably used at first for its fusibility only, but afterward it was certainly introduced for economical reasons. This cheap material was often added in very considerable quantity until they learned that leaden bronzes did not have a fine color either while fresh and clean, or when old and covered with patina.

We have also seen that zinc, as well as lead, was often added. As the color of zinc alloys was red to light golden yellow (red metal, brass), they tried to dispense with tin entirely, as its price was higher than that of zinc (cadmia, as it was called). But they soon became convinced that for fine statues, at least, a small quantity of *tin was a necessity*. Generally a zinc-brass was used for statues.

To prevent the metallic constituents from separating during fusion, the mass was kept thick and pasty by putting in old scrap bronze that had been often melted and contained oxides. The smelters also knew that the metals, particularly the tin, grew smaller every time it was melted, in consequence of oxidation, slagging, and evaporation.[19] The Romans therefore added, besides the scrap bronze, an eighth part of "silver lead," *i. e.*, a mixture of tin and lead.

Finally, in regard to the color of the castings, the ancients collected valuable experiences. Cadmia (zinc ore) was used to impart a golden color to the bronze.[20] Alloys rich in tin were used for mirrors, and arsenic was employed to make them white.[21]

The moulds originally employed were very primitive. For simple objects a corresponding hole was dug in the sand or clay soil. Complicated figures had to be formed in clay, and the metal was cast in the clay mould. If the mould was to serve for several castings, it had to be made of baked clay, stone, brick, or other durable material. Organic substances were mixed with the clay to prevent uneven shrinkage and cracking.

Hollow casting is more difficult; first a core is formed corresponding to the hollow in the figure; over this the figure is formed, and over that the mantle, *i. e.*, the negative, or mould. The latter is taken off, the figure taken away from the core, the mantle replaced, and the metal poured into the space between the core and the mantle. In this case it is difficult to take off the mantle so clean and put it back so accurately that the parts will not be disturbed. To avoid this difficulty a wax model may be built on the core, and the mantle formed over this, and then when the mould is dry it can be heated and the wax melted out.

The Phœnicians and Egyptians must have used one or the other of these devices for their hollow castings.

The Greeks appear at first as pupils and imitators of the Phœnicians, but they soon surpassed their teachers in forms as well as skill. They knew how to make their moulds so perfect, and were able to place their cores so near the mantles, that the castings were as thin as cardboard. The master founders of to-day have not reached that perfection.

HARD BRONZES OF THE ANCIENTS.

We have already seen that only very pure bronze is suitable for weapons and tools. It must be well "cooked," and all sulphur, lead, and tin must be completely removed by oxidation. The best results are obtained with from 8 to 12 per cent. of tin. A bronze having this composition is tenacious and has a hardness of at least 4.

But the ancients were able to make much harder wrought bronzes, as proved by our collections of weapons and tools.

Unfortunately we have no record of the devices employed; but as we are able to make just such products and with simple means, we may assume that the ancients employed essentially the same methods. In our experience the following conditions are essential for the manufacture of hard bronze:

1. A particular treatment.

2. A small amount of phosphorus.

It is well known that normal weapon bronze, unlike iron, is softened by rapid cooling, but is hardened by hammering and rendered more compact.[22]

By repeating this process, the bronze gains in hardness and strength, and sheet bronze becomes lamellar by hammering or rolling, and hence acquires a certain elasticity.[23] Besides, a slight admixture of iron or nickel seems advantageous, but a slight amount of *phosphorus* is of the highest importance. The latter point may be somewhat enlarged on.

Ordinary bronze always contains *oxides* of copper and tin, the quantity increasing with the number of times it is recast. This oxide makes it pasty, so that the different constituents do not separate, and the casting is homogeneous.[24] This admixture of oxide does no harm for castings in which strength is not demanded; but is of importance for weapon bronze; the strength of which is considerably diminished by the presence of the oxide.

In this respect a slight amount of phosphorus is an advantage by preventing the formation of oxides, and consequently the mixture remains a thin fluid until it begins to solidify. On the other hand the metals are liable to separate. This evil can be avoided if the alloy is allowed to cool nearly to solidification *before casting*, and then cooled rapidly. Under these circumstances a homogeneous alloy is obtained that is nearly fifty per cent. stronger and about 200 per cent. more tenacious than bronze that contains oxides. The hardness and strength can be still further increased by chilling and hammering.

Besides the indirect influence of phosphorus, it also has the *direct* effect of hardening the bronze, because the compounds of phosphorus with copper and tin have a very considerable hardness. These facts, as well as the circumstance that we possess antique bronzes of extraordinary hardness, induced me, with the consent of Baron Sacken, to test the hardness of the bronze weapons in the Vienna Cabinet of Antiquities. Some hard pieces,[25] were sent to Prof. Ludwig, who followed the question with interest and agreed on the method of making the analyses. The results were satisfactory. The bronzes contained traces and up to one-fourth per cent. of phosphorus. Its presence had prevented the formation of oxides in these bronzes, and consequently the weapons were of extraordinary hardness. It now remains to ascertain how the 6454
ancients made these phosphorus-bronzes. It is evident that the phosphorus was not put directly into the metal, as is generally done at present. There is another method so simple that we can assume that the ancients employed it unintentionally. I refer to smelting the copper or bronze with charcoal and any salt of phosphorus. In this case the carbon would liberate phosphorus from the phosphoric acid, and it would be taken up by the melted metal.

The ancient metallurgists may have made use of the eruptive rocks that contain apatite, and with which copper ores are so often associated, for slag or flux, or the phosphates that occur in the gangue may have been smelted along with the ores; in both cases some phosphorus would get into the metal. Finally it is not impossible that the ancients did not put in phosphorus salts in some form. First of all I would mention certain vegetable and animal substances that are rich in phosphorus, especially *blood*,[26] which was a favorite with the old metallurgists and alchemists as having a powerful enchantment. In each of the cases referred to some phosphorus got into the metal, which thus acquired a considerable hardness that could be increased in the well known manner by chilling and hammering. Under certain circumstances weapons and tools were made almost as hard as steel.

We can easily comprehend how bronze with these excellent qualities could compete with steel at a time when rich ores were still abundant, and thus it checked and restrained the development of the iron industry.

SUMMARY OF ALLOYS USED BY THE ANCIENTS.

Egypt.—The wrought metal of the Egyptians is a pure bronze with 6 to 14 per cent. of tin; 22 per cent. is an exceptional case; 1 per cent. of iron is not rare.

The Egyptian cast metal is a plumbiferous bronze, with 4 to 11 per cent. tin, and 7 to 12 of lead; in one case 16 per cent. tin; rarely 2 or 3 per cent. of zinc.

Assyria.—The Assyrian bronze is very pure. It consists of copper, 10 to 14 per cent. of tin, and traces of iron and nickel; in one case 18 per cent. of tin.

Greece.—Their wrought bronze for tools and weapons contains 10 to 12 per cent. of tin and traces of nickel and cobalt; in one case 18 per cent. of tin.

The cast bronze has in part the same composition as wrought bronze. (Statues were rarely cast from pure copper.) A small quantity of lead was sometimes added, especially in later times, for statues and coin. The later coins contained 5 to 7 per cent. lead, even 20 per cent. in exceptional cases. Macedonian coins were of quite pure bronze.

Italy.—Roman weapons (found at Hallstadt) contain 11 to 16 per cent. of tin, in some cases some zinc or lead, also nickel and iron as impurities. Roman hatchets found in Gaul contain 20 or 25 per cent. of tin. We have too few analyses to give us a correct view of the matter, but on the contrary we have numerous analyses of Roman castings.

Ornamental Roman bronze for flexible articles contains less tin and lead. For less flexible objects bronze-brass with 1 to 7 per cent. of tin, and 5 to 12 per cent. of zinc, was employed; and for brittle but brilliant objects, like buckles and mountings, an almost pure brass was used, with 15 to 24 per cent. of zinc and little or no tin. Lead is found in all these alloys in small quantities, rarely more than 1 per cent.

The statues contain from 6 to 10 per cent. of tin, 0 to 3 per cent. zinc (in one case 14), and frequently from 10 to 12 per cent. of lead (once even 20), so that Roman statue bronze may be called lead-bronze with zinc in it.

Coin metal varied its composition at different times. In the days of the Republic a lead-bronze rich in tin (5 to 12 per cent.) was used. Under the early emperors brass or impure copper came into use. After the time of Marcus Aurelius an improvement is noticeable; the metal then in use can be called stanniferous brass (1 to 4 of tin). Under the Byzantines, coins were again struck from impure copper.

These are the most important alloys of the Romans. In general we may say that the zinc alloys held an important place among the Romans.

Gaul.—For weapons they employed a very pure bronze with 2 to 15 per cent. of tin. Traces of nickel were rare. Cast bronze contained a few per cent. of lead.

Britain.—The weapon bronze contained from 7 to 14 per cent. of tin. Cutting weapons not infrequently contain 1 to 3 per cent. of lead, and traces of iron. Ornament bronze does not differ from weapon bronze. Traces of sulphur are not rare, which points to the use of pyritical ores.

Alps.—Swiss weapon bronze contains 8 to 13 per cent. of tin (in one case even 16 per cent.), not infrequently 1 per cent. of lead and traces of silver, very often ½ to 1 per cent. of nickel and traces of iron (once as much as 3 per cent. of iron). The Swiss ornamental bronze has the same composition.

Bavaria.—Wrought bronze contains 8 to 12 per cent. of tin (in tools 17 and even 25 per cent.), and often as much as 1 per cent. of lead, traces of nickel and cobalt. Ornamental bronze has the same composition. A few per cent. of zinc is also found.

Bohemia.—The wrought metal contains 5 to 11 per cent. of tin and traces of iron and sulphur, from which we conclude that their ores contained pyrites. Their cast metal also contains lead.

North Germany.—The wrought metal contains 8 to 16 per cent. of tin, with frequently 1 per cent. of nickel. A sword contained only 5 per cent. of nickel, an ax 24 per cent. These are exceptions. The ornament bronzes contain also a few per cent. of lead; exceptionally, a considerable quantity of zinc. The ornamental metal in the Rhine region, Nassau, and Hesse contains 5 to 15 per cent. of zinc with the same of tin. At one time a rich bronze is used, at another quite pure brass, and then a bronze-like brass.

Denmark.—The Danes employed the same metal for weapons that they did for ornaments. It contained 5 to 12 per cent. of tin, and most of it 1 per cent. of zinc, but never lead; in one case only 2 per cent. of tin. Nickel and cobalt often occur, ½ per cent. of each; iron in traces.

Russia.—The Russian weapon bronze contains from 9 to 16 per cent. of tin, and traces of nickel. Arrows contain a little lead, up to 5 per cent. Ornament bronze frequently contains in addition a few per cent. of zinc.

The ornamental bronze of the Baltic provinces is a brass containing 15 to 20 per cent. of zinc, 3 to 4 per cent. of lead, and 1 to 2 per cent. of tin.

In Russia, as in other countries, the brass alloys belong to a later epoch; in older times real bronze was chiefly used for ornaments as well as other purposes.—*Translated from advanced sheets furnished by the author*.

THE BIG TREES OF CALIFORNIA.

We have previously spoken of the large *Sequoiæ* of California, which have justly a universal celebrity, and shall now render our remarks upon the subject completer.

If there is any sight that can throw us into mute contemplation and show us the littleness of our own nature, it is assuredly that of high mountains like Mont Blanc, or waterfalls like Niagara. But yet we do not at the first instant take in all the grandeur of these, but must make the tour of Mont Blanc, or pass under the falls of Niagara and study it at different points in order to obtain a just idea of such marvels. And so it is with regard to the vegetable curiosities of the Sierra Nevada, in California.

When points for comparison fail us, our eye, one of the most imperfect of instruments, never gives us an accurate idea of objects, and it is for this reason that we have placed upon the annexed figure a five-story Paris house, drawn to the same scale as the "Grizzly Giant," one of the most ancient *Sequoiæ* of the Mariposa Grove, in California. This true vegetable giant is 105 feet in diameter at the base, and 69 feet at 13 feet from the ground. It has, like many of the *Sequoiæ* that surround it, been struck by lightning, but, in spite of that, its total height is still more than 300 feet. Some of its branches are more than six feet in diameter. Those who have seen our old oaks in the forest of Fontainebleau will be able to compare the effect of time and lightning upon such venerable relics, these in California being possibly contemporaries of the Roman Empire. A few of the trees have been razed to the base, and serve as floors for dancing halls, while others, that have fallen, have been cut lengthwise and serve as bowling alleys. What especially distinguishes the wonderful region in which these *Sequoiæ* grow is the cleanness and beauty of the plains upon which they are found. In the virgin forests of South America, under the influence of a warm and damp atmosphere, the vegetation is so rank that, in order to open a passage, one is obliged to use an ax on the vines and thickets of interlaced plants. In California, on the contrary, the *Sequoiæ*, which are situated at an altitude of from 5,000 to 7,000 feet above the Pacific Ocean, are easily accessible. The routes are almost traced by nature, dangerous animals are rare, the summer temperature is delicious there, and hotels are everywhere being erected, as in Switzerland, to serve as a retreat and promenading place for tourists.—*La Nature.*

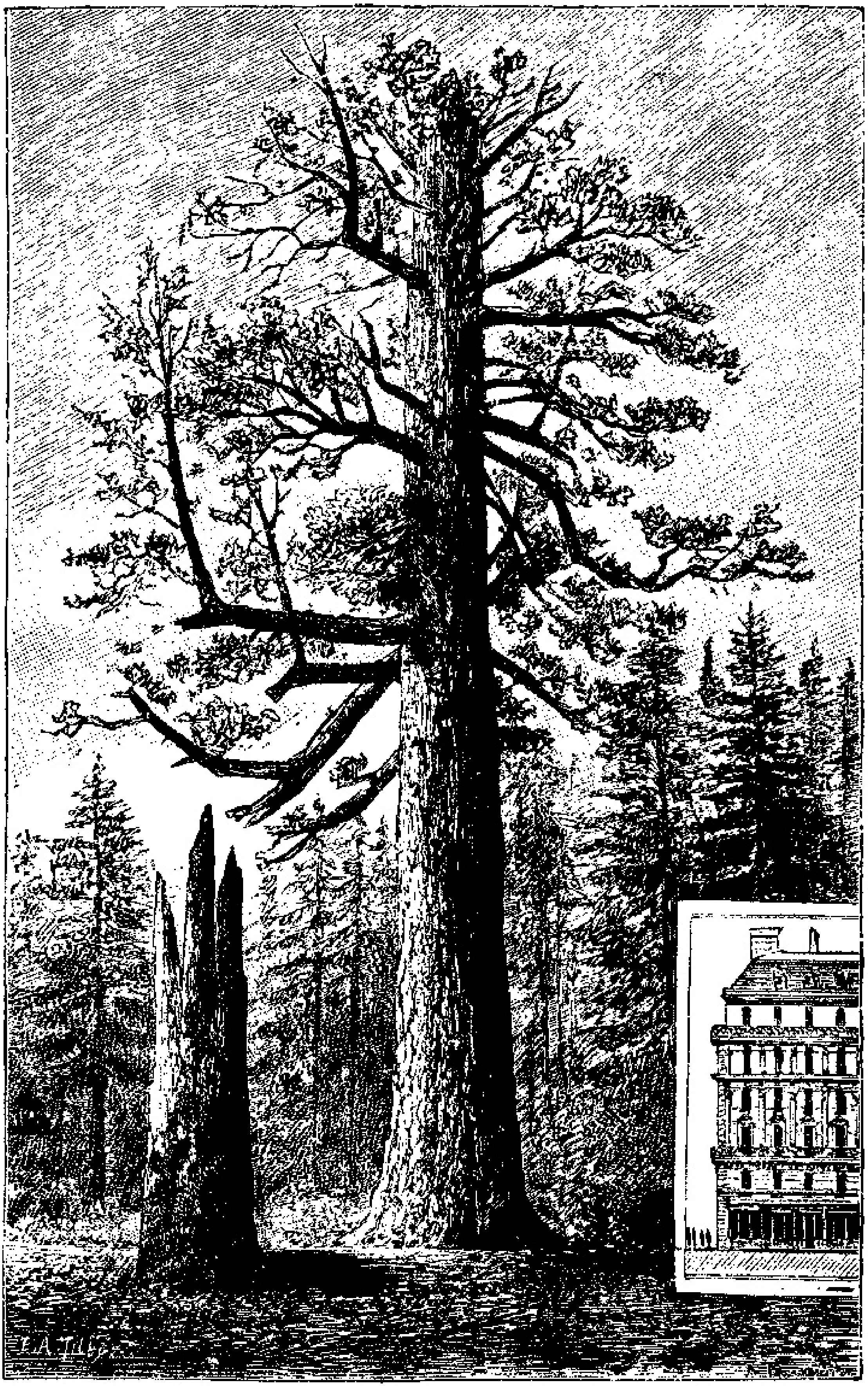


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TABLE OF CONTENTS.

FOOTNOTES:

1 Royal Institution of Great Britain.

2 *Comptes Rendus* of the French Academy of Sciences.

3 It is often desirable to make one of the apertures twice the diameter of the rest; it causes a greater intensity to be given to one image, and that facilitates the calculation of time, while it furnishes points for the comparison of the movements of the lower limbs with those of the arms.

4 Ang. Guerout, in *La Lumiere Electrique*.

5 Abbe Moigno, in his treatise on telegraphy, assigns the date of 1838 to this publication; but Mr. Zetsche (*d.c.*) gives it as 1811. We shall consider the latter as the true date; for, in 1838, there was no reason for publishing Soemmering's memoir, and especially for proposing improvements in his apparatus.

6 Abstract of a paper read before the New York Academy of Sciences.

7 Trans. Am. Med. Ass'n, 1880.

8 In fœtal syphilis it is assumed that the spermatozoa may be the carriers of the disease; but no microscropist has yet described a separate species of spermatozoon for such cases.

9 "The Philosophy of Mystery," London, 1841; cited by Hammond in his work on "Insanity."

10 See articles by Dr. Hammond in this journal for 1865 and in the "Journal of Psychological Medicine" for 1869, also his "Sleep and its Derangements," Philadelphia, 1872, and his "Treatise on Insanity," New York, 1883.

11 Yung, "Le sommeil normal et pathologique," Paris, 1883.

12 "Leçons sur l'appareil vaso-moteur," t. ii., p. 154.

13 "Principles of Psychology," vol. i., pp. 88, 89.

14 "Les causes du sommeil," "Revue scientifique," t. xix.

15 Yung, *op. cit.*

16 Magnetic iron and pyrites in basic rocks; tin stone in granite and porphyry.

17 Ancient authors report cases of this kind.

18 The largest bronze statue of modern times is the "Bavaria" in Munich, which is 20 meters high and weighs 80 tons. It consists of 12 pieces and cost about a quarter of a million dollars.

19 When a bronze is remelted six times the percentage of tin is reduced to half the original (Dumas). The evaporation of the metal can be shown by holding a cold plate on it while melted. Tin is immediately deposited on it.

20 They usually made a copper and zinc alloy, but it is possible that they also understood the art of embedding the casting in zinc ore (calamine) and heating strongly, whereby the surface of the metal was "cemented" and colored.

21 On examining a broken surface of an antique mirror, it will be seen that only the outside is white. It is probable that the finished mirror was embedded in some arsenical substance and heated, which cemented and colored the surface.

22 Uchatius makes his famous hard bronze by cooling and hydraulic pressure. Bronzes with 8 to 12 per cent. of tin are most benefited by this process. Bronzes with very little tin in them are but little affected by chilling and hammering (Riche). Alloys that are hard already, such as bronzes rich in tin and phosphorus, become too brittle and useless by repeated hammering.

23 When a cast sheet of inelastic bronze or brass is hammered or rolled, it "feathers."

24 The Romans preferred to put in some bronze that had been repeatedly cast.

25 One piece was scarcely scratched by feldspar, another by quartz. The Greek and Roman weapons in the Berlin Museum were tested as to hardness by Dr. Von Dechend at the suggestion of the Director-General, Von Schone. All of them were scratched by fluorspar; there were no hard bronzes among them. If the races of *classical* antiquity were not acquainted with hard bronze, it is easy to see why they soon began to use iron, in contrast with the Semitic-Hamitic races.

26 Excrements were also much used by the alchemists and pharmacists of the middle ages.

Transcriber's Note:

Inconsistent spelling and hyphenation are as in the original.