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## CORK AND ITS APPLICATIONS.

A CERTAIN number of trees, such as the cherry, birch, elm, plane, and maple, produce the subereous substance known as cork, but in layers so thin that the material cannot be worked. In Brazil, the bark of a tree of the order Bignoniaceæ, and the pith of the stalk of *Pourretia tuberculata*, of the order Bromeliaceæ, likewise yield a species of cork, as does also the *Euphorbia balsamifera* of the Canary Islands; but none of these substances is capable of being put to practical use.

Two species of oak, the cork oak* (*Quercus suber*), which grows in the basin of the Mediterranean, and the western oak (*Q. occidentalis*), which grows in Gascony, divide the monopoly of the production of cork in layers thick enough to be utilized. But the natural cork which they furnish, and which bears the name of "male" or "virgin cork," possesses, whatever be its thickness, but a very slight commercial value, and it is only after it has been improved by culture that we see it employed industrially. An object of cork—a stopper, for example—is therefore a product doubly industrial. First, as a substance whose qualities have been increased by improved processes of culture and gathering, and second, as an object manufactured, either by manual labor or machinery. An occasion, therefore, presents itself to study in this place, on the one hand, the processes of cultivating and gathering cork, and, on the other, the various industrial applications that are made of this substance. But, desirous of dwelling more especially upon such applications, we shall but briefly describe the processes of culture and treatment of the bark, that are designed to make a merchantable product of it, in order to more quickly come to the numerous transformations of which this wonderful material is capable and to an enumeration of the services that cork renders us in domestic life and in the industries. We must observe that these data are not to be found in any treatise, and have never been published. As we know, the bark of the cork oak consists of two distinct concentric layers, viz., first, an internal zone, which is the active part of the bark, corresponding to the liber of other trees, and which, under the name of tannin, is used for tanning skins; and, second, an external zone, thicker than the other, and composed of a spongy, light, and compressible material, which is but slightly permeable to liquids, and constitutes *cork*, properly so called.

Everywhere where the internal layer is destroyed on the trunk of the tree, there is no longer any formation of either bark or wood. A decortication of even, but slight, width entirely around the tree would infallibly cause it to perish. The second layer, on the contrary (the cork), is an inert envelope, and does not concur, like the preceding, in the active functions of vegetation. This explains how it is possible, without threatening the existence of the cork oak, to divest it of a portion of its subereous covering. Further, the internal zone (liber), left free, will, every year, form new layers of cork, to be removed in their turn when they have become thick enough, and will yield the cork of commerce, designated as "female." The question of the formation of new cork has been well explained by Mr. Mathieu in his Forestry Flora. The operation of removing the cork takes place in July and August, the season at which the movement of the sap permits the corky layer to be easily separated from the liber. It is necessary to avoid effecting the removal during the prevalence of a sirocco, which would dry the bark too rapidly. As for exposure to the sun, which is inevitable in this primitive process, that causes the death of two per cent. of the trees that are barked. Finally, the young bark which forms on contact with the air is subject to the attack of insects, and, owing to atmospheric influences, its crust becomes more or less fissured.

Struck by these disadvantages, a distinguished arboriculturist, Mr. Capgrand Mothes, has recently devised a process of protecting the cork oak, and which consists in restoring to the tree, for a certain length of time, the very bark that has just been removed from it. As the bark is removed in the form of two half cylinders, by means of slits made in the subereous layer, it is easy to hold it on the trunk by means of wire, and to cover the gap between the edges with a strip of cardboard. This jacket is allowed to remain on the tree three months at a maximum, and during this period the bark, thus replaced on the oak, dries much better than it would had it been arranged in piles, as is usually done with cork planks. As for the young layer of cork which forms under this covering, that is found, upon removing the latter, to have a very thin superficial crust, devoid of those fissures and insect punctures that are inevitable in the ordinary process. As the Capgrand Mothes process permits of utilizing all the subereous layer without waste, the new bark may be removed a year in advance of that of trees treated in the old way. And, moreover, it protects the oak that has been recently barked against the sirocco and insolation, whose disastrous results we have noted above. Before being delivered to commerce, the bark must be submitted to the operations of boiling, rasping, classifying, and putting up in bales. The object of boiling the cork planks, which is effected in large boilers filled with water and heated with waste bark, is to swell the cork in order to increase its elasticity. And, moreover, such bark as had up till then preserved a certain convexity comes from the boiler almost flat. The bark is next submitted to a rasping with iron tools, in order to remove the ligneous portion. This operation is likewise performed mechanically, through horizontal bobbins armed with iron points, and revolving at the rate of 900 revolutions per minute. Rasping, which causes a loss of 28 per cent. of bark, is rendered useless with cork cultivated by the Capgrand Mothes process. In England, these two first operations are replaced by singeing the bark, and afterward brushing it. The bark is classified according to five distinct thicknesses, and is then pressed into 150 or 170 lb. bales, which are strapped with bands of sheet iron. On reaching its destination, the bark is subjected to a new sorting, according to its quality and fineness.

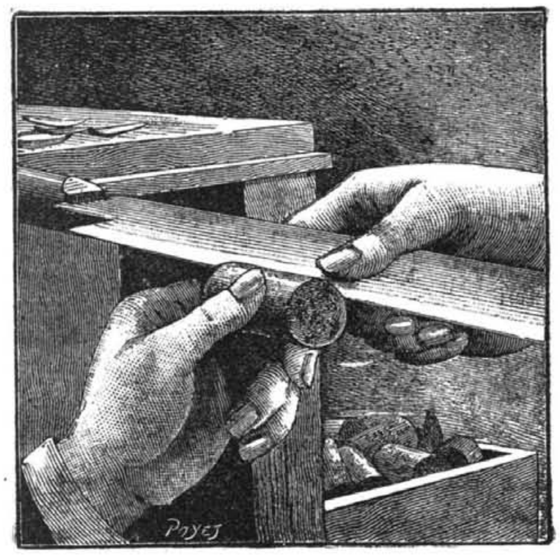


Fig. 1.—MANUFACTURE OF A CORK BY HAND.

Fig. 2.—MACHINE FOR CUTTING CORK INTO STRIPS.

Fig. 3.—MACHINE FOR CUTTING CORK INTO SQUARES.

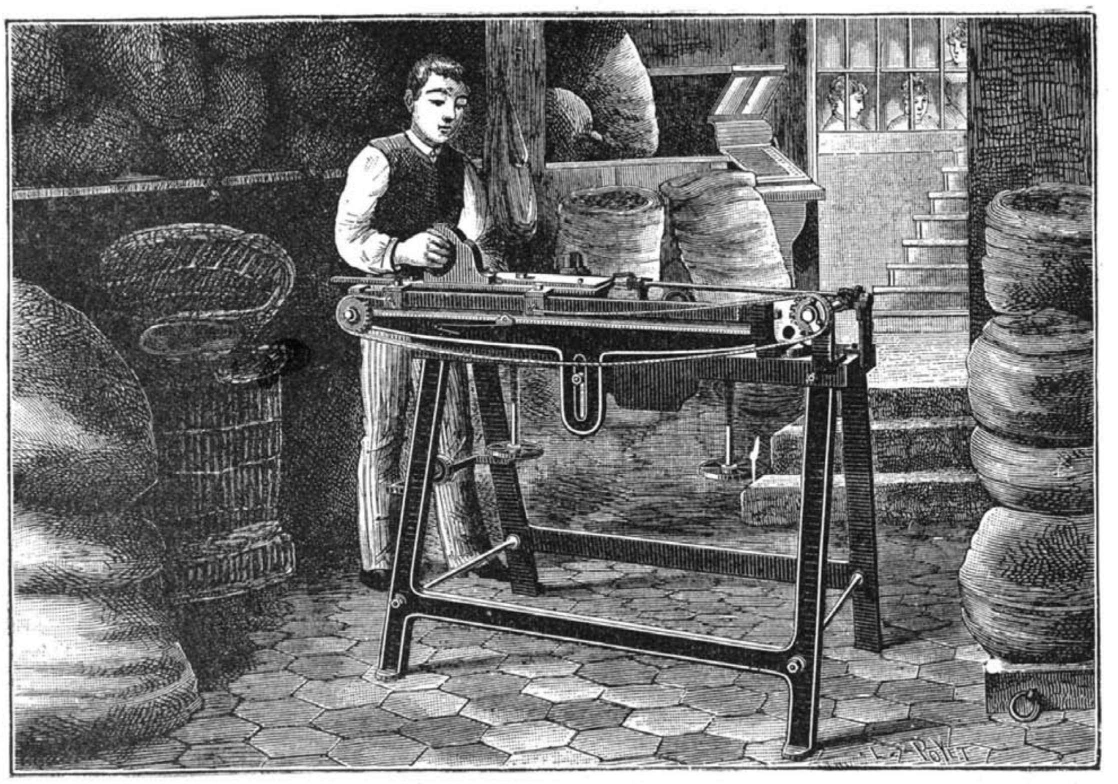


Fig. 4.—MACHINE FOR TURNING CORKS.

The following figures show the variation in price between the two extreme qualities: 100 lb. of superfine cork (for champagne bottles) are worth from $11 to $13, while the same weight of ordinary thin cork is scarcely worth more than from $1.40 to $2. These figures suffice to demonstrate the interest that the producer has in further and further improving the quality of his bark.

Mr. Lamey, the author of a study upon cork in Algeria, publishes some interesting tables in this work, regarding the annual increase and the mean thickness of cork. According to him, cork bark should not be removed before it has a thickness of eight-tenths of an inch. Commerce prefers a thickness of from 1 to 1¼ inch, and this can be obtained at the age of six years with thick, and nine years with ordinary cork.

The density of cork varies with its nature and age. Thus, under equal bulks, thin cork is heavier than cork of rapid growth, and, in cork barks of the same category, the density increases with age. According to Mr. Brisson, the density of cork is

* For illustration of the cork oak, see SUPPLEMENT, No. 167.

0·24; but this figure is rather a maximum than a mean. With ordinary cork ten years old, the density scarcely reaches 0·2. This extreme lightness of cork is accompanied with other valuable qualities, viz., it is a bad conductor of heat and sound, it is impermeable to gases and liquids, it is elastic, and it is but slightly combustible and nearly incorruptible, and its physical properties are daily finding new applications for it in the industries. It is not astonishing, then, that the consumption of it is daily increasing, and that, despite the enormous increase in the production of it since the exploitation of the forests of Algeria, the commercial value of the article has not depreciated.

Here, then, is a product whose culture, which is every day better understood, is destined to be one of the principal sources of richness for Algeria and our southern departments.

BOTTLE CORKS.

*Manufacture by Hand.*—The principal use made of cork, as we all know, is for the manufacture of stoppers of all kinds, the consumption of which has now reached formidable dimensions. The bark designed for such manufacture is piled up in a damp cellar, and then carried to the shop, where it passes into the hands of a workman who cuts it into strips of a width equal to the length of the future stopper. A second workman cut these strips into squares of a width equal to the diameter of the stopper to be formed. These squares are immersed in boiling water by means of large nets, so that they can be more easily worked, the cork having freely expanded in all directions. Having been put into a cool place and kept continually moist by sprinkling, the squares next pass into the hands of the cork cutter, who, giving them a rotary motion, presents them successively in front of a broad-bladed knife, taking care at the same time to give them a longitudinal motion. Thus manipulated by the skillful fingers of the workman, the little square is converted into a bottle cork. Such is the *modus operandi* in France and Algeria. In Russia, the square is laid upon a table and cut by the workman by means of a knife, to which he gives a downward motion. In Germany, the workman suspends a piece of cork in front of his breast, and against this cuts the squares, as is done in Russia upon a table. Fig. 1 shows the position of the blade and the cork in the French method. Whatever be the process employed, it is indispensable, in order to have solid corks, to take into account the direction of the grain. The rule is as follows: The axis of the cork must be parallel with the axis of the tree that furnished the bark, and the desired direction is easily recognizable by the colored striæ, due to the annual layers of subereous substance, that are observed upon a cork in the direction of its axis. Flat corks or bungs are the only ones that are cut out at right angles with the axis of the tree. Manufacture by hand is reserved for corks of superior quality. The form of these, which is not exactly cylindrical, but rather that of a square with rounded angles, offers, it seems, an advantage over the geometrically accurate form obtained with machines. This square form is especially remarkable in champagne corks, and the wedging of the four angles in the neck of the bottle is the only thing, it appears, that gives the perfection sought in difficult bottling. A good workman can make 2,000 corks per day by hand.

*Machine Manufacture.*—The accompanying figures represent three Demuth machines, that are remarkable by the simplicity of their operation, which permits of their being intrusted to any workman whatever, and even to a woman. The first (Fig. 2) cuts the bark into strips, and the second (Fig. 3) makes the squares. With this latter a child or a woman can cut 8,000 squares per day. These are sorted out automatically, according to their size, by the machine; and the knife, at every to and fro motion, sharpens itself against a little apparatus in front of which it passes. Next comes the machine for turning corks (Fig. 4), and with which 5,000 of them per day can be made. As in most machines of the kind, the square is held between two disks provided with points, and revolves with them in front of a blade that is maneuvered by hand, like a sort of plane. The to and fro motion of this knife controls (through a pitch chain) the rotary motion of the disks, which thus follow the velocity of the knife. The engraving is sufficiently clear to allow us to dispense with a prolix description of this ingenious machine, which permits of making corks of all sizes through varying the distance of the axis of the disks from the blade, and of turning them into a cylindrical or conical form, according as the said axis is parallel with the blade or makes an angle with it, variable at will.

Cylindricalstoppers are the ones that do the best corking, and these are the only ones used in corking mechanically. On the contrary, conical stoppers are the ones preferred for corking by hand.

We must mention two other systems of the mechanical manufacture of corks, the principle of which was curious, but which were not successful and were quickly abandoned. In the first of these the square was pressed against a sort of punch, consisting of a tube having a cutting edge, and which cut out the cork precisely as a punch would have done. In the second, the squares were worn away by friction against emery wheels. The inventor, M. Moreau, made corks with heads in profile in this way, and hoped to see every large wine house adopt fancy corks carrying the silhouette of its head member. But these two processes had to be discarded. A cork, in fact, must be sharply cut in order to have the polish required by the consumer.

Finally, a machine has recently been constructed in which the blade is replaced by a disk with a cutting edge, having a rapid rotary motion, and in front of which the squares revolve. It is easy to sharpen this disk without the necessity of stopping the apparatus. This machine, which is also used for dividing cork into thin sheets, seems to give good results in the manufacture of bottle corks.

When the corks come from the hands of the workman, or from the machine, they are washed in water containing oxalic acid or chloride of tin, and are then submitted to the action of sulphurous acid. This gives them the beautiful tint that we are familiar with, and they have now become velvety and soft to the touch. After this they are screened to separate the different sizes, sorted out according to quality, and counted out by hand or by special machines, and then packed in bags containing 15,000 or 30,000.

The quality looked for in a good cork is, before everything else, impermeability to gases and liquids. It can be tested before manufacture by means of an apparatus invented by Mr. Salleron, who has made some interesting researches upon cork. In this apparatus the bark to be experimented with is submitted to the pressure of a liquid, which is compressed by means of a small hydraulic press. If the cork is good, it ought not to have absorbed any liquid after having undergone a pressure of several atmospheres.

The wastage in the manufacture of corks is 60 per cent., 100 lb. of bark giving but 40 lb. of corks. We shall find the scraps used as a crude material in three important industries, that of cork powder, linoleum, and agglomerates.

A large number of methods of corking other than by stoppers of cork oak bark have been experimented with. Glass and rubber stoppers are even preferred to cork in certain cases, but none of the other systems has been able to prove a very dangerous competitor, as may be judged from the following figures:

England uses, for herself and her colonies, more than two million corks per day; Europe consumes more than a thousand million per year; and in France, we may estimate that the mean annual consumption is 20 cents per inhabitant. If we are supprised at this figure, we have only to remember that our country contains 400,000 wine merchants and 150,000 grocers, and that the average consumption of corks by these two classes of merchants is $10 per year. We have, then, for these two businesses alone a mean of $5,400,000 worth of corks per year. Let us add to these figures what is used by brewers, perfumers, ink manufacturers, and pharmacists, and we shall readily understand the importance of the cork making industry to the departments of Lot-et-Garonne, Landes, and Pyrenees-Orientales, where is almost exclusively located the manufacture of such corks as are used in France.—*A. Good, in La Nature.*

## THE MANUFACTURE OF HORSE-SHOE NAILS.

UNTIL within about fifteen years, all nails used in shoeing horses were made by hand, although of course the common cut nail is much older. As might have been expected, when machine-made nails were first introduced, the blacksmiths eyed them with great distrust, but now they have almost entirely superseded hand-made nails, in this country at least. In England, the making of hand-nails was a regular manufacture, and I believe is still carried on in a few factories there. Some of the scattered nailers, who lived in the smaller towns, used to practice what seemed to be a very curious paradox. The blacksmiths would bring to a nailer a certain weight of iron, in the shape of rods. The nailer would return the same weight of nails, charging nothing for the work except the iron that was left over! The secret was that they kept a box of sand into which they thrust the white-hot rod, and so worked in the slag thus formed that at the end the nails weighed more than the iron from which they were made. Another curious process was used. Beside the anvil was a small circular bellows, about a foot in diameter and fifteen inches high. A handle and weight were fastened to the top board, and from the bottom board extended a tube, with a small nozzle like a blowpipe, which was directed to the spot on the anvil where the nail was hammered. The top of the bellows was raised, and then the glowing rod was removed from the fire to the anvil, where the jet of air was blowing. The air, instead of cooling off the rod, as we should naturally expect, caused a rapid combustion of the iron, thus keeping the rod hot for some time, and enabling the nailer to make several nails with one heating of the rod.

A good horse nail must be solid, so that it will not split, and it must be stiff enough not to bend more than the proper degree when being driven through the hoof, and yet be capable of being clinched on the outside without breaking. The iron at the neck must be tough and strong, so that it can withstand the constant jarring to which it is subjected by the horse. For this reason the head is given the peculiar shape which distinguishes it from the common nail, and prevents our upsetting the head like an ordinary nail. The end of the nail is beveled on one side, so that although it is driven into the bottom of the hoof parallel to the side, it will bend inside the hoof and come out at the side about an inch above the bottom, and it is then cut off and clinched.

Machine-made nails may be divided into two classes: those which are cut from a flat bar, generally cold, in a more or less finished state, and those which are forged hot on the end of a rod. In the manufacture of cut nails the proper thickness is given to the head and body by rolling the bars with ridges, and their outline is determined by the shape of the dies. The nails are cut either transversely across the grain of the iron or longitudinally; the latter being far preferable. Sometimes short stubs are cut, and then these passed through rollers, in which cavities are formed to give the required shape.

The trouble with all cut nails is that the shearing injures the iron, rendering it liable to split and break, so that although cheaper than forged nails, they are not so much used as the latter. In forging nails the end of the hot rod is shaped either by rapidly reciprocating dies or by a combination of dies and a small rapidly moving roller. A machine of the latter kind was invented by one Mills (?), and used in the Saranac Horse-nail Factory at Plattsburg. It may be described as follows: "A rectangular frame, about 2½ ft. square, is supported by four legs about 2¼ ft. high. At either side of the frame a little forward of the center are two uprights, about a foot high, carrying bearings at their upper ends, in which runs the main spindle. This is driven by a belt pulley at its outer end, and carries at its center a 'roll stock,' in which is held a roll about one inch in diameter. The roll revolves in a circle nine inches in diameter. Below the main spindle, and at right angles to it, is another shaft, the center lines being about eight inches apart. This is driven by suitable gearing from the main spindle, the velocity ratio being 1 to 11. This lower shaft carries a drum or head directly under the revolving roll, and in this head are set a series of anvils or dies, so shaped that the roll in passing over them will give the proper thickness to the head and body of the nail; both the roll and anvils are of chilled cast iron. The side blows are given by steel dies held in two hammers which are revolving on centers below the lower shaft. These hammers receive their motion through pitmen with ball-and-socket joints, from two eccentrics on the main spindle. A 'gripe' at the front part of the frame holds the rod while it is being hammered, and the rod is also guided by a funnel-shaped 'nose piece' immediately in front of the anvils and dies. The gripe is raised for a short time during every revolution of the lower shafting, to enable the rod to be inserted and pushed forward. Beside each machine is a small furnace, burning hard coal, in which about a dozen rods can be heated at a time. The hot rods are taken from the furnace, and with a quick movement of the hand are thrust through the nose piece until they strike a gauge or stop on the revolving anvil head, and then under the raised gripe. After being hammered as above by the rolls and dies, the 'blank' is cut off by cutters working on the lower or anvil shaft, and then drops into a pan below the machine. Five or six nails are made from a rod before it is taken out of the machine and reheated. The blanks are made at the rate of about 64 per minute, and it takes 11 revolutions of the main spindle to each blank. These 'blanks' are now assorted by boys, and must then be finished. They are covered with scales of black oxide, and are soft and have square points. They are first put into a cast-iron tumbling barrel with sawdust, and in about three or four hours they are taken out bright and polished. Then they are taken to the finishing machines or 'pointers.' Here they are fed by small boys into notches cut in the edge of a horizontal iron ring, about 18 inches in diameter. This ring receives an intermittent rotary motion by means of a ratchet and pawl, and carries the nails first before a reciprocating roller, which rolls them out slightly and gives them the requisite stiffness; then they are nicked by a very blunt punch or chisel to form the bevel at the point, and then the top or point is formed by suitable dies which shear off the sides. The nail is then released and placed in a wooden tumbling barrel to remove any slight burn or 'wire edge' left by the shears. The nails are again assorted, this time by nimble-fingered girls, and are then ready to be packed into boxes, holding 25 pounds."

The factory is a very noisy place; conversation can be carried on only with great difficulty, and on a still day I have heard the rattle of the machines over a mile away.

It is also very hot in summer, standing before the furnaces. I have seen the thermometer hung on the neck of one of the nailers register 140°. But to offset this they are well paid. They work by the pound, and often make $3 and even more per day. Eighteen machines make 200 pounds of nails per day each. The iron used was at first forge iron made in the Catalan forge, near Plattsburg, but afterward Swedish or Norway iron, Star and Crescent brand, was used. It cost $80 per gross ton delivered in Plattsburg. About 15 per cent. of the iron is wasted during the various processes. The finished nails vary in price from 26 cents per pound for the smallest to 18 cents for the largest size, with a discount of 30 per cent.

There are extensive horse nail factories in Keeseville, N. Y., Vergennes, Vt., Chicago, and also, I believe, in Montreal.—*C. H. Veeder, Jour. Engineering Society.*

## NATURAL GAS.

A LECTURE on the subject of natural gas was delivered at the Franklin Institute, Philadelphia, on Dec. 18 last, by Mr. Charles A. Ashburner, geologist in charge of the Pennsylvania State Geological Survey. The lecturer stated that natural gas was by no means a recent discovery. Even its utilization for the purposes of the mechanic arts had been successfully attempted in China, where, by pipes of bamboo, it had been conveyed from natural wells to suitable furnaces, where, by means of terra cotta burners, it was consumed. In the confines of Persia, in the south of France, and in our own Western States, burning springs had long been known. When Lafayette visited this country in 1821, the inn in the town of Fredonia, New York, was illuminated in his honor by gas procured from a neighboring well. It is, however, only within recent years that natural gas has arisen to any importance in its bearing on the mechanic arts. At present the great iron and glass works of Pittsburg and of other places are supplied with natural gas as their only fuel, and millions of cubic feet are yearly consumed in Pittsburg and similarly situated cities.

Of the origin of natural gas there seems to be no reasonable doubt. It arises from the decomposition of forms of animal or vegetable life embedded in the rocks in suitable situations. The gas is not believed to be generated continuously, but merely to be stored in porous or cavernous rocks overlaid by impervious strata. When these collections are tapped the gas is set free, but a new supply is not being formed to take its place. The position at which the gas is found is very variable, depending upon the force of gravity and upon the position of the porous layer in which the gas is confined. The lecturer entered into an accurate description of the localities in which the gas was found, and gave the reasons why it was hopeless, from geological grounds, to look for natural gas east of the Alleghenies. The region in which the gas is found is practically embraced in that portion of Pennsylvania west of the Allegheny Mountains, and extending a very short distance into Ohio, New York, and West Virginia, and it is also stated to have been found in a very limited extent in Illinois and Kansas.

The most important economic locality is that in the immediate vicinity of Pittsburg, which supplies that city with the fuel for the vast iron and glass works and for numerous private dwellings. There are 6 natural gas companies in that city, managing 107 wells and supplying the gas through over 500 miles of pipe, of which 232 miles are situated in the city proper. The total area of pipe leading into Pittsburg is given as 1,346,608 square inches, and the total capacity of the lines is estimated at over 250,000,000 cubic feet of gas per day. The largest company is the Philadelphia Natural Gas Company, which supplies over 400 manufactories and over 7,000 dwellings with the entire amount of fuel consumed. The composition of natural gas varies greatly, both in specimens from different wells and in those from the same well at different times. In general terms it can be described as a mixture of hydrogen, nitrogen, and marsh gas, with occasionally higher carbon compounds. It burns with a

nearly colorless flame, and gives off no odor or deleterious matter.

In speaking of the use of natural gas for domestic purposes, Mr. Ashburner pointed out the great advantages which a gaseous fuel has over a solid one like coal, and stated his belief that the greatest of the advantages of the discovery of natural gas was that it had proved the great economy and practical utility of such fuel. A thousand cubic feet of gas was calculated to equal in heating capacity 55 lb. of coal. He stated that the use of natural gas for domestic purposes would not have been possible without the inventions of Mr. Westinghouse, of Pittsburg, two of whose inventions the lecturer illustrated. One of these inventions was intended to prevent leakage from gas pipes, and to locate leaks accurately when they occurred. The leaking gas is conveyed to the nearest lamp post and there consumed. Another invention was a most ingenious pressure regulator, which not only regulates the pressure at which the gas is supplied to the burners, regardless of the pressure in the mains, but in the event of the pressure in the mains dropping to zero, automatically shuts off all gas from the house; nor is it possible to turn the gas on again without violence to the regulator until every source of escape of gas larger than a pin-hole leak has first been corrected. A model of the regulator was exhibited. The lecture was illustrated by drawings and maps and by a small working model of a well-boring apparatus.

In answer to inquiries, the lecturer stated that the source of natural gas was certainly capable of exhaustion, but that he did not think there was any imminent danger of such a calamity. The sources of supply would certainly last many years, and he believed that before they would give out a method of producing an artificial gas would be invented which would perfectly supplant the present natural gas. The cost of natural gas could not be compared with our coal gas, for the reason that the natural gas was not sold by meter. The consumer makes a yearly contract with the company to supply him with light or fuel, or both, at certain rates. A house containing twelve rooms costs, to heat and light, from $70 to $90 a year. The use of the gas is most satisfactory, for by means of an automatic regulator every room of a house may be kept at a temperature not varying two degrees, regardless of the condition of the outside temperature or the pressure on the mains. Defects and troubles were met with from lack of understanding how to properly regulate the supply or the combustion.

## PHOTOGRAPHY BY PHOSPHORESCENCE.

By Dr. JNO. VANSANT.

ON the 6th of August last, I discovered what was, so far as I could ascertain, a new fact in physics, and one that may be of practical importance, viz., that *the radiation from phosphorescent bodies can affect a photographically sensitive surface, and that pictures can be made by that means.*

Quite unknown to me, M. Ch. V. Zengler, it now appears from a paper communicated by him to the Academy of Sciences, Paris, Aug. 30, 1886, had previously made the same discovery, though he had not published it. I did not immediately make publication of the new fact either, as I wished first to prosecute further my researches. But, though the discoveries of M. Zengler and myself are almost identical, they are not entirely so, as the following brief account of some of my experiments and their results, taken from notes made at the time, will show.

About 3 P. M., Aug. 6, 1886, I exposed to the sun's rays for two minutes a piece of paper, coated on one side with a phosphorescent sulphide of calcium paint, and covered on the same side with a thin sheet of bronze metal having several letters, 1½ inches long, cut, stencil like, through it, to show the calcium sulphide. I then immediately transferred the phosphorescing paper, with the sheet metal attached, to a closet illuminated only by a feeble orange light used for photography, and covered the letters with a piece of "Eastman's bromide paper (A)." This sensitive paper was then covered with several layers of thick brown paper, and the whole was lightly pressed together by my hand for about one minute. I then removed the sensitive bromide paper, and proceeded to try to develop an image of the phosphorescent letters.

The ordinary oxalate of iron developer was used, and in about three minutes I had the satisfaction of seeing the letters come out strongly in black on the white ground of the paper. This picture was impressed by the phosphorescent rays alone, all other light having been rigorously excluded.

It is, therefore, evidently possible to expose a sheet of phosphorescent material to light beneath an ordinary photographic negative on glass or paper, *or originally in the camera*, and then, some time afterward, to print from this dimly radiant material on sensitized silver surfaces.

Aug. 7, 1886.—In connection with my memorandum of yesterday, I have to add that, last night, I succeeded in obtaining, after five minutes' contact with a more sensitive gelatino-bromide paper, a good impression of the same object experimented with in the afternoon (*i. e.*, the phosphorescent letters), *upward of seven hours after the calcium sulphide had been exposed to sunlight*, it having been shut up meanwhile in a perfectly light-tight box.

Aug. 8, 1886.—Referring to my memoranda of Aug. 6 and 7, I have to record the following experiment which I made to-day, and which shows that the phosphorescent radiation from calcium sulphide, in the dark, will pass through a piece of greenish tinted window glass and impress a positive picture of an ordinary photographic negative on silver sensitized paper or gelatin films.

About noon, I exposed a piece of glass, painted on one side with a luminous paint of calcium sulphide, to the sun for several minutes, the calcium side to the sun. I then conveyed it to a photographic dark room, and after a few minutes laid the phosphorescent plate, calcium side up, on the table, and placed thereon a photographic negative, on glass of the usual greenish hue of common window glass, the gelatin side of the negative being uppermost. On this I put a piece of "Eastman's bromide paper (A)," with the sensitive side down next to the negative. Over this was placed a pad of several thicknesses of brown paper, and on top of all a small weight. I allowed this to remain five minutes. The sensitive paper was then removed, and I examined it for a moment in the weak orange light of the closet. No change was perceptible. This paper was then treated with solution of oxalate of iron, as usual, for developing a picture on such paper after exposure to ordinary light. In about ten minutes a good *positive picture* of the photographic negative was developed, and it was subsequently fixed in the usual way with sodium hyposulphite.

After those memoranda were written, I made, in August and September last, numerous other experiments (of which I have the records) with phosphorescent radiation, instead of ordinary light, for photographic printing, and obtained some excellent pictures in that way, just as good, I may say, as I can make by lamp or daylight.

I have found that it is not necessary to expose the phosphori always to daylight to render them fit for use in printing through negatives, but that a *few seconds'* exposure to any brilliant artificial light, as that from gas, magnesium, or electricity, will answer. And I have also found that numerous prints can be made, on very sensitive films, after a single exposure of the phosphorescent substance to light.

I deduce from my experiments that glass of the color, kind, and thickness generally used for gelatino-bromide dry plates intercepts fully two-thirds of the chemical radiations that would fall on a sensitive surface in direct contact with the phosphorescent substance (calcium sulphide).

The interposition of paper (like that used for negatives) rendered translucent between the phosphori and sensitive films prevents the passage of fully three-quarters of the actinic rays.

Therefore, when such paper and glass are interposed together, not more than one-twelfth of the phosphorescent rays reach the sensitive film.

Nevertheless, when using a glass negative and "Eastman's bromide paper (A)," a few minutes' (three or four) exposure to a card covered with paint of calcium sulphide will make a good impression, if the card has been only a short time away from a bright light.

A translucent paper negative, on "Eastman's *negative paper*," requires about the same exposure (three minutes) to produce a good *positive* on the same kind of very sensitive "negative paper."

Positive pictures on glass (transparencies) can also be well printed by phosphorescent radiation.

Negatives on glass can have the phosphorescent substance, whether calcium, strontium, or barium sulphide, spread directly on the glass side if desired.

U. S. Marine Hospital, St. Louis, Mo., Nov. 13, 1886.

## UNBOILED EMULSIONS.*

By Professor SPENCER B. NEWBURY, Cornell University.

LAST April I contributed to *Anthony's Photographic Bulletin* an article entitled "Notes on Emulsions," in which an effort was made to give a simple and certain method of preparing photographic plates of any grade of sensitiveness, together with the results of many experiments made to show the effect of different conditions of time, temperature, and proportion of ingredients on the rapidity and character of the resulting emulsion. The only new suggestion of any importance which the paper contained was the method of securing a fine precipitate of silver bromide (in my experience the chief stumbling block in emulsion making), which was accomplished by adding first the silver nitrate and then the bromide, both in crystals, to a warm solution of gelatine containing alcohol. I have had several very gratifying letters from friends who have used this formula, all reporting complete success in working it and great satisfaction with the resulting plates. There are, however, some interesting results to be obtained by using this emulsion in an unboiled condition, of which my original paper contained no mention.

All writers on emulsion making insist that the emulsion shall be "red by transmitted light." This is a condition which implies great fineness in the precipitated silver bromide, and is very easily obtained by the method given above. In my earlier experiments, using other methods of emulsifying, I used often to obtain an emulsion of which a drop spread on glass and held against the light showed a reddish tinge, and supposed that the condition demanded had been secured; but never, until I hit upon this method of mixing, did I see an emulsion which was "red by transmitted light," in the extreme sense of the phrase. The fineness of the precipitate obtained as I have described is such that a drop of the emulsion spread on glass shows a bright orange-red color; a drop of emulsion mixed with a beaker of pure water imparts to it a pale blue opalescence, like that of some specimens of refined kerosene; an opalescence which does not disappear by subsidence even after standing for weeks. On boiling the emulsion, the particles increase in size, as is well known, and these peculiar qualities disappear. It occurred to me to try the use of this emulsion in an unboiled condition, principally in the hope of obtaining a fine plate, free from granularity, suitable for fine lantern slide work.

The operation of washing and making up an emulsion of this kind is the same as in the case of rapid, boiled emulsion. The coated plates, however, present, after drying, a very different appearance. Even though quite a heavy coating of emulsion be used, the film, after drying, is so transparent as to permit the shape of a gas flame to be seen through the plate with ease. The film is extremely glossy, and when held against white light shows the peculiar orange color of the freshly prepared emulsion. All who have worked with wet plates will remember that they show nearly the same color by transmitted light.

These plates are very slow, probably about as rapid as wet plates. They show a Warnerke sensitometer of 2 to 3, and in my hands require for an open view with Dallmeyer's rapid rectilinear lens, smallest stop, about ten seconds' exposure; whereas a rapid Stanley plate, showing 24 on the sensitometer, required an exposure of only one-half second. The resulting negative is, however, a very interesting and peculiar thing. The shadows are represented by absolutely clear glass as in a wet collodion plate, while the lights show every grade of transparent brown color of increasing depth, like dark brown glass. These qualities, especially the perfect clearness, good color, great density, and yet extraordinary range of half tones, and freedom from grain of any description, make the plate an almost perfect one for lantern slide work. For this purpose oxalate developer gives, I think, the finest results, although I have made beautiful slides with the pyro-potash developer. The color of the slide is in either case a dark olive-brown, totally different from the cold gray tone which is always obtained with a rapid plate. The color can be changed to a deep purple by a very slight intensification with mercury and sodium sulphite, but I do not think that this is any improvement in most cases. I have used many commercial lantern slide plates, and though some of them are excellent, I have never found any that were in any respect superior to the plates made in the simple manner that I have described. The operation of preparing them is so easy that I have been able to train one of our students at Cornell to prepare the emulsion, coat the plates, and make slides from engravings or photographs, and he is now turning out three or four hundred slides a month for use in the various departments of the University.

### FORMULA.

The following simple formula is an outline of our method of working. The quantities given are for 20 ounces of finished emulsion, sufficient for four dozen 8 x 10 plates.

| | | |
|---|---|---|
| Nelson's No. 1 gelatine.. | 8 grms. | (123 grains) |
| Water.... | 300 c. c. | (10 ounces) |
| 1 per cent. solution of hydrochloric acid..... | 4 " | (1 drachm) |
| Alcohol.... | 50 " | (1 ounce 6 drms.) |

Allow the gelatine to soak in the water in a beaker for ten minutes, then place the beaker in hot water until the gelatine dissolves. Add the acid and alcohol, and transfer to a twenty ounce bottle. In the dark room add 32·5 grms. (500 grains) nitrate of silver, in crystals, to the gelatine solution, and shake until dissolved. Then add in the same manner 25 grms. (385 grains) potassium bromide, and shake again until complete solution is effected. Allow to stand ten or fifteen minutes and decant into a beaker containing 10 grms. (154 grains) of Simeon's hard gelatine, previously soaked in water, drained, and melted.

Place the beaker of emulsion in ice water to set. In an hour it will be quite hard, and may then be squeezed through coarse embroidery canvas and washed, as usual. This need not take more than two hours. The emulsion is transferred to a beaker and melted; 10 grms. (154 grains) Simeon's hard gelatine (previously soaked and drained) and 50 c. c. (1 oz. 6 dr.) alcohol are added, and the bulk of the emulsion made up to 20 ounces by the addition of water, if necessary. It may be used at once, as there is no apparent gain in sensitiveness or density on keeping, in the case of unboiled emulsions.

This formula is the same as that given in the article referred to above (*Anthony's Photo. Bulletin*, 1886, p. 232), except for the omission of the boiling and the use of a smaller proportion of potassium bromide.

As a general rule, it is probably better for the amateur or professional photographer to content himself with the plates which are to be obtained in the market, and not to encounter the many perplexities of emulsion making. But the operations of making these slow plates are so simple, and the results so certain and so gratifying, that I heartily recommend any one who has become interested in lantern slides to try the experiment of making some of these plates for himself. And after this task has been mastered and the manipulations learned, a very slight change in the proportion of bromide used, and half an hour's boiling of the emulsion, will give a plate as rapid as any in the market. I shall be very happy to give any further information that may be desired to any one who thinks of taking up this last accomplishment of photography, and can safely say that the pleasure of using the best commercial plates is far less than that of exposing and developing plates prepared by one's own hands.

The fineness of the precipitate of bromide of silver in the emulsion I have described depends solely on the method of emulsifying, and the amount of excess of soluble bromide present appears to have no effect on the character of these slow plates. But if the emulsion is boiled, the proportion of bromide has a great effect. Using 32·5 grms. of silver nitrate, I find that with 28 grms. of potassium bromide and half an hour's boiling, a very rapid plate is obtained (23-24 on the sensitometer), which has about the quality of the best commercial plates. With 25 grms. of bromide, however, the plates are much less sensitive (15 on the sensitometer), but present almost exactly the qualities of the lantern slide plates, *i. e.*, the same peculiar brown color and fineness of the deposit. Plates so prepared are those which I prefer for landscape work.

I have made some interesting experiments with these lantern slide plates made with unboiled emulsion. In the first place, it has been stated that the medium in which the silver bromide is suspended has a great influence on its sensitiveness, and that it is partly for this reason that gelatine plates are more sensitive than collodion. To test this matter, I tried the experiment of soaking these lantern slide plates in weak nitrate of silver solution, exposing them wet, and developing with an ordinary wet plate developer, consisting of a solution of ferrous sulphate made strongly acid with acetic acid. The experiments were successful; the plates developed quickly and without fog or stain, giving a result much like a wet plate, but with a more reddish deposit. The sensitiveness was about the same as an average wet plate. Hence it appears that the bromide of silver in an unboiled condition is no more sensitive when suspended in gelatine than in collodion.

Secondly, it has been stated that the sensitiveness of gelatine plates over wet collodion plates is in part due to the fact that, since the former contain no free silver nitrate, it is posssibe to use alkaline or neutral developers, *i. e.*, pyrogallol and ferrous oxalate, which were said to be more powerful than acid ferrous sulplate. I find, however, that if two of the plates be given equal exposure, and one moistened with nitrate of silver solution and developed with wet plate developer, the other developed directly with ferrous oxalate or pyro, the latter appears considerably underexposed, showing that the mechanical development is more energetic than the chemical.

It is well known that a rapid plate cannot be moistened with nitrate of silver solution and developed with wet plate developer without the appearance of fog and stain. The fact that slow plates, made from un-

* Read before the Society of Amateur Photographers of New York.

boiled emulsion, may be so developed shows that the cause of this fog is to be found in the decomposition of the gelatine during the operation of boiling. I find, in fact, that plates made from unboiled emulsion may be successfuly intensified with pyro and silver, in the same manner as negatives made on wet collodion plates.

[CONTINUED FROM SUPPLEMENT, No. 579, page 9246.]

## PHOTOGRAPHY OF MOVING OBJECTS, AND THE STUDY OF ANIMAL MOVEMENT BY CHRONO-PHOTOGRAPHY.*

By E. J. MAREY.

WITHOUT entering into the dry details incident to the analysis of chrono-photographic images of the gaits of man, I will endeavor to describe its practical applications.

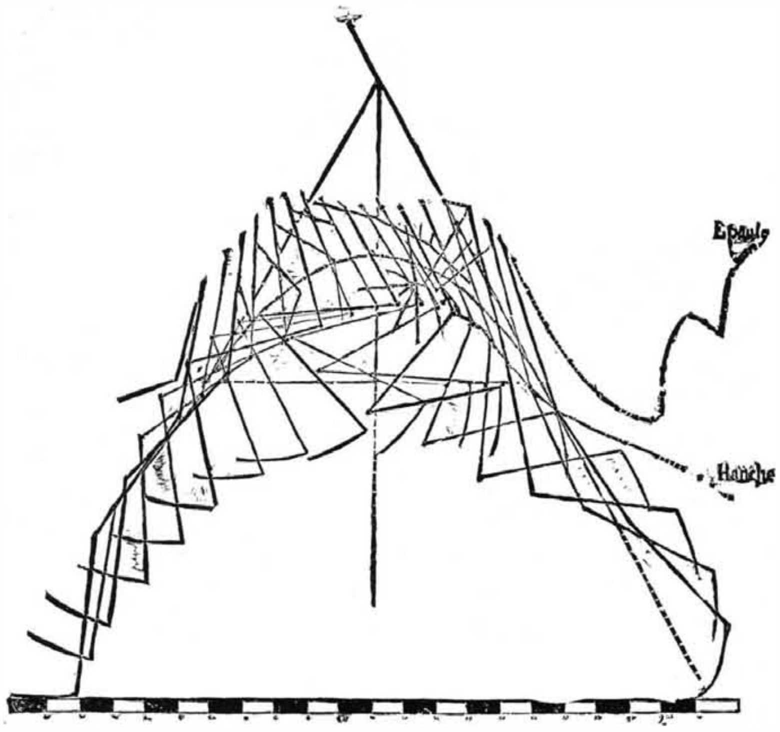



FIG. 18.—Successive attitudes of the body in a high jump. The parabolic curve shows the successive positions of the center of gravity.

Just as machines are driven so as to obtain a useful effect at the smallest expenditure of power, so a man can govern his movements so as to produce the wished for effects with the least waste of work, and consequently with the least possible fatigue. Of two gaits which carry us over a given space in a definite time, that one should be preferred which costs the least possible fatigue. Up to the present time, it has been impossible to compare the work expended in two kinds of movement, for all the elements of the problem were not known, such as the mass of individual organs and the velocity of movement affecting each one. As we have seen, chrono-photography gives exactly the velocity of the different parts of the body; by the balance we can determine the masses in movement. Thus with absolute precision we can determine the work expended in the different acts of movement. From these comparisons important conclusions can be drawn, as, for example, the following. In walking, the most favorable gait is one where step succeeds step at the rate of about one hundred and twenty a minute. For running, the number of steps should be nearly two hundred and forty a minute.

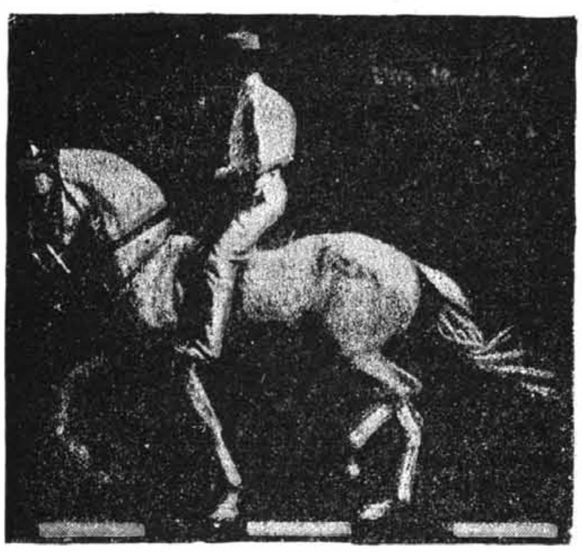


FIG. 19.—Trotting horse; the instant shown corresponds to the middle of the phase of support upon a diagonal base.

FIG. 20.—First phase of the gallop; support upon one posterior member only.

Fewer or more numerous steps will give less effect at a greater expenditure of work. The applications are therefore obvious; they enable us to fix the rate of steps of soldiers, to economize as much as possible their strength, in the severe trials to which it is subjected. To make these studies practically applicable, they should be followed out at great length, under varying conditions and using a great number of subjects; but the method has been found, and experiment has confirmed that which the laws of mechanics alone could not foretell, when the dynamic conditions of the work of man were incompletely known.

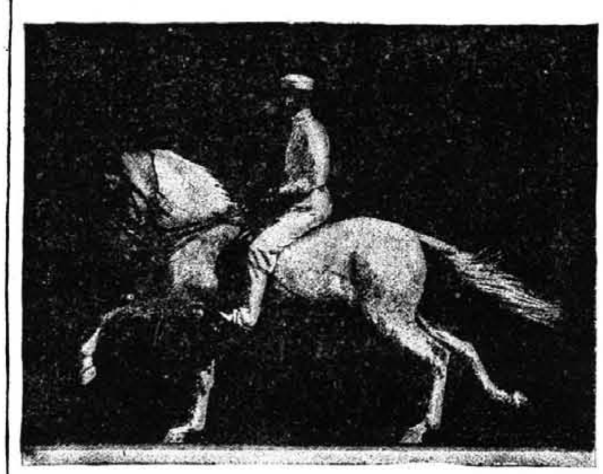


FIG. 21.—Second phase of the gallop; support upon a diagonal base.

The example we next present is well suited to show how the movements of animated beings are rigorously governed by the laws of mechanics. The theory of ballistics proves that the internal forces developed in a moving body do not change the trajectory of its center of gravity, so that if a bombshell bursts in the midst of its parabolic course, the common center of gravity of the fragments scattered in all directions follows its trajectory in the prolongation of the original curve. Now, when a man jumps over an obstacle, as soon as he leaves the ground his center of gravity follows, like that of a projectile, a parabolic trajectory. If by muscular action he displaces his arms and legs in his aerial course, the center of gravity of his body will remain in the parabolic curve. By analyzing a chrono-photographic curve of a jump, Fig. 18, M. Demeny, my assistant at the physiological station, has traced the position of the center of gravity of a body previously determined for all the attitudes taken by the jumper while in the air. He thus found that the trajectory of the center of gravity followed precisely the parabolic curve, and consequently that, if the jumper raises his legs at the instant he is passing the obstacle, his head drops the necessary quantity to mantain his center of gravity on the trajectory. The lowering of the head at the apex of the curve is very marked in the figure; it is not produced when the jumper, having no obstacle to go over, leaves his legs extended.

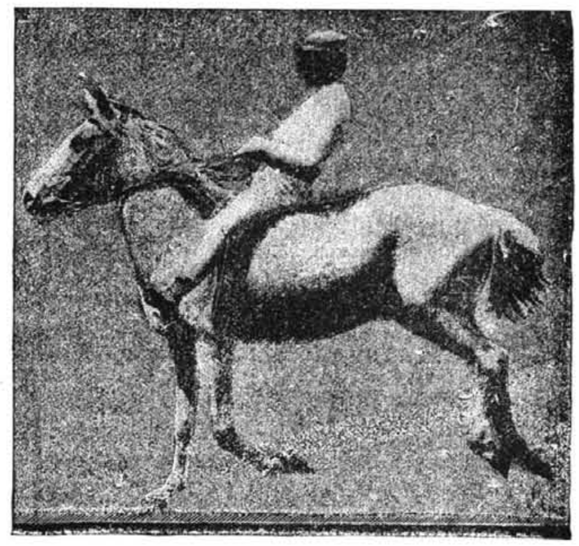


FIG. 22.—Third phase of the gallop; support upon one fore foot only.

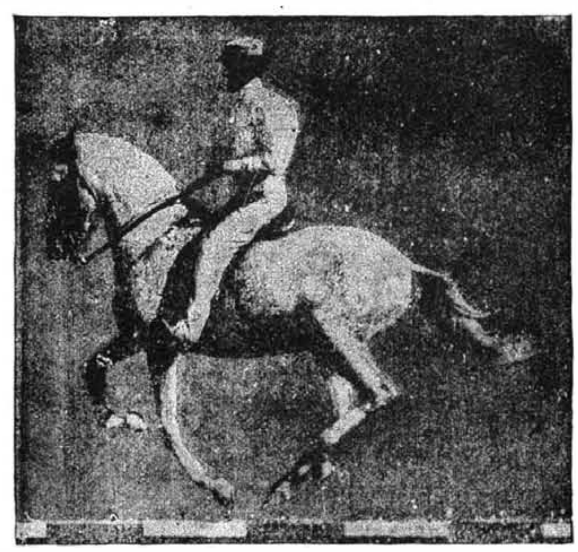


FIG. 23.—Fourth phase of the gallop; suspension.

These elucidations will allow us to describe very summarily the applications made to the study of the movement of animals. The most interesting type among quadrupeds is the horse. Up to date, it is the only one whose various gaits have been carefully studied.

We see here some isolated attitudes taken at the most characteristic periods of the trot or the gallop. These figures, thanks to the extreme sensitiveness of the new photographic plates and to the short time of exposure, have a hitherto unattained vigor and sharpness.

FIG. 24.—Oscillation of the fore leg in walking. Interval between exposures one-tenth second.

Fig. 19 represents the trot; the instant chosen is the middle period of support on a diagonal base. Figs 20, 21, 22, 23, correspond to the gallop, and show respectively the first, second, and third periods, and finally the suspension, or the instant when the horse is in the air just before one of his posterior feet touches the ground.

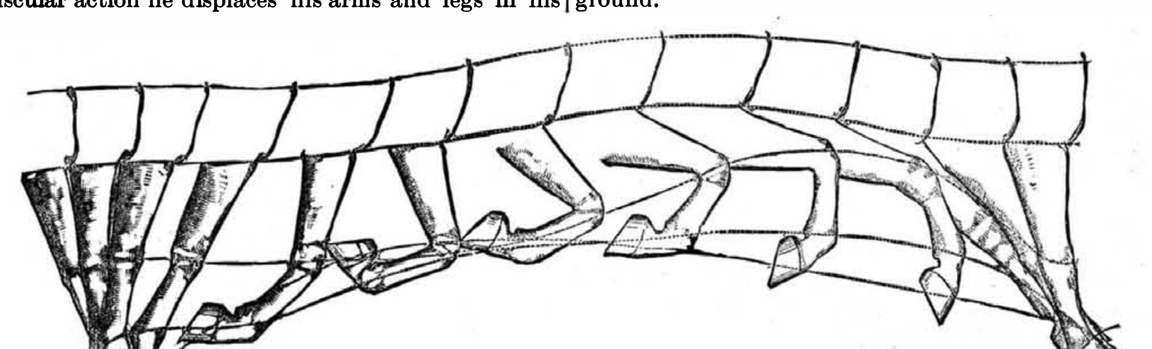


FIG. 25.—Oscillation of the fore leg in a gallop. Interval between exposures one twenty-fifth of a second.

* A paper read before the French Association for the Advancement of Science, at Nancy (1886).

If it is desired to photograph a series of images, one soon encounters the same difficulties described with reference to human movements. The great length of the horse's body causes the images, even if of comparative infrequency, to cover each other and cause confusion. By blackening three of the legs of a white

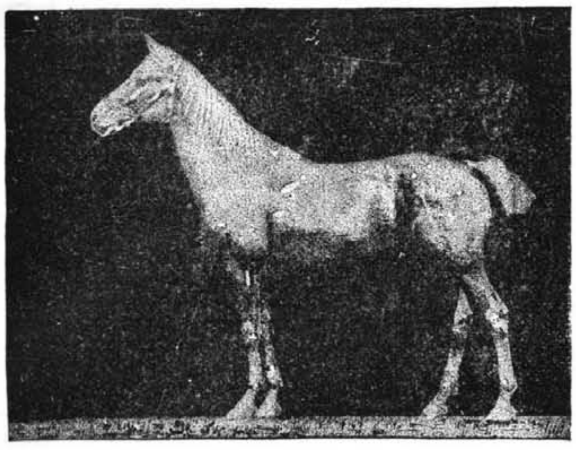


FIG. 26.—Black horse having on all his joints pieces of paper of different forms, so as to give the chronophotographic trajectory of each joint.

horse, partial chrono-photographs are obtained that in a satisfactory manner reveal the motions of the visible member. Thus Fig. 24 shows the swinging motions of a walking horse's fore leg, and the trajectory followed by the articulations of the bones between two points of rest of the foot. Fig. 25 shows the same in the gallop.

To further carry out the analysis of the movements, the horse cannot be clothed in black velvet with white lines, as was described for a man. So the difficulty is thus obviated: A black horse is selected, who is still further blackened with lamp-black, because the luster of the hair reflects light, and produces the effect of a white horse, as in Fig. 26. Next, after carefully determining the centers of movement of the different joints, we glue on each of them a little piece of white paper of particular form; a round one in one place, in another a triangle, or a square, or cross, etc. When the animal has passed before the dark space and the plate has been exposed as before, the chrono-photograph presents a mass of little marks, disseminated apparently at random. The image enlarged is projected on a sheet of paper, by noting the base marks, that is to say, the marks which, for each fifth exposure, are more strongly marked. Nothing remains to be done but to join by lines the marks which belong to the same image, and a figure is obtained quite comparable to that corresponding to the running man just described, and which gives the different attitudes of the limbs and body. Figs. 27 and 28 contain all data requisite for determining the movements of the fore legs of a horse at different gaits.

The analysis of the flight of birds presents special difficulties. Not only the extreme rapidity of the movements of the wings at certain phases of their revolution requires an extremely short exposure, but the direction, often capricious, of the flight of the bird, the length of path, which must be followed to include on a sensitized plate sufficiently sharp images, add to the difficulty. Several repetitions of the same experiment are required generally before success.

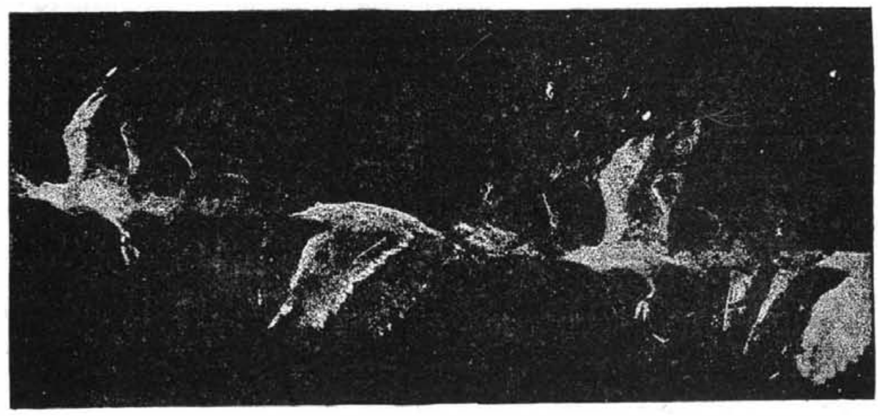


FIG. 31.—Successive and very frequent images of a flying gull.

We see first a series of attitudes of a gull. Figs. 29 and 30 show the bird with his wings at their upper limit then half concealed under his wings, whose carpal joint is bent, and whose separated feathers show, through their intervals, the wing on the other side. These images are spaced well apart, in order to avoid the confusion that is produced when a great quantity are taken (Fig. 31), but the number is insufficient to enable us to follow the series of movements constituting a beat of the wing. Nevertheless, a beat of the wing occupies, sensibly, the interval between two base images. It fills, therefore, the time of one turn of the disk, showing that the bird gives nearly five strokes of his wing per second. These first data would be a valuable guide for recognizing to what phase of the stroke of the wing belongs each of the isolated attitudes of the bird obtained in the complete photograph. As for the partial photographs by reduction to bright lines, I have been unable to attain any result. Meanwhile I have endeavored, from the images gathered in series, to determine the order in which the different positions of the wing succeed each other in the complete stroke.

By taking a position farther from the black screen, so as to follow the flight of the bird for a longer distance, and taking ten exposures a second, we see, what was to be anticipated, that the wing is represented alternately raised and lowered. But these attitudes are not, if I may so express myself, diametrically opposed. This proves that the strokes of the wing of the gull, at least during the first instants of its flight, do not last exactly the fifth of a second, but a slightly shorter period, so that successive images of the raised wing correspond to a phase more and more advanced of its elevation, while the depressed wing appears at a phase more and more advanced of its recovery.

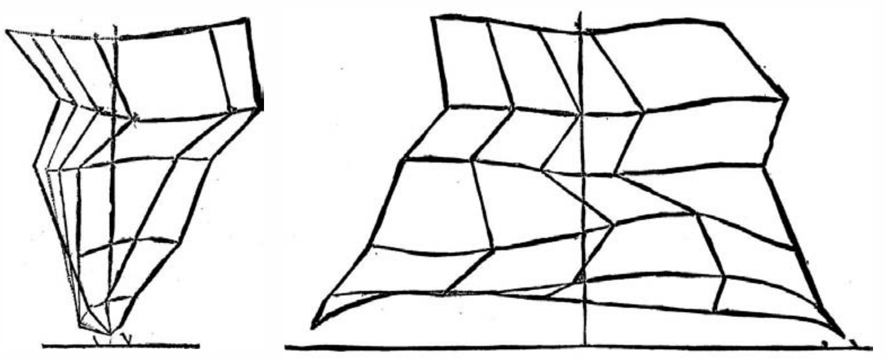


FIG. 27.—Successive positions of different segments of a horse's fore leg while trotting; the left portion corresponds to support, the right to motion through the air.

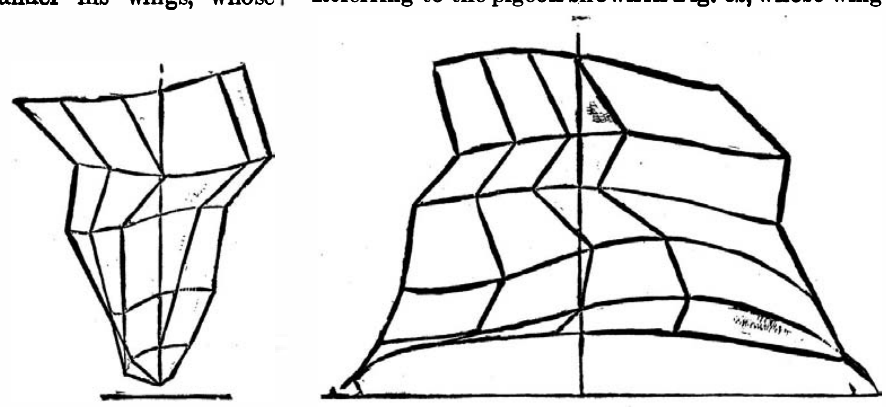


FIG. 28.—Successive positions of the hind legs of a horse galloping; the left portion the phase of support, the right portion the phase of motion.

Referring to the pigeon shown in Fig. 32, whose wing made about eight strokes per second, the wing, in the series of successive images, does not present the alternations of elevation and depression which we have just seen in the gull; but, starting from full depression, it is seen successively less and less lowered and finally completely raised.

This manner of determining the order of succession of movement of wing beats by the difference of phase existing between the turns of the shutter disk and the wing strokes is analogous in principle to the stroboscope, used by physicists to analyze optically periodic movements. It enables us to arrange in their natural order images corresponding to a long series of attitudes. This I have attempted to do (Fig. 33) by tracing one after another on a sheet of paper eleven images expressing the succession of movements in one wing beat. Taking as the point of departure the instant when the bird has its wing at its highest elevation, it appears that this wing in descending comes more and more forward, so that its point or tip, at first situated vertically above its tail, finds itself at the end of the down stroke vertically below the head. From this moment the carpal joint bends and the pinions rotate on their axis by a mechanism yet to be studied, but which is apparently explained by anatomy (Fig. 34). This bend of the carpal joint persists until the wing is nearly at its highest elevation. At this instant it straightens out, and the wing completely spread is ready for another descent.

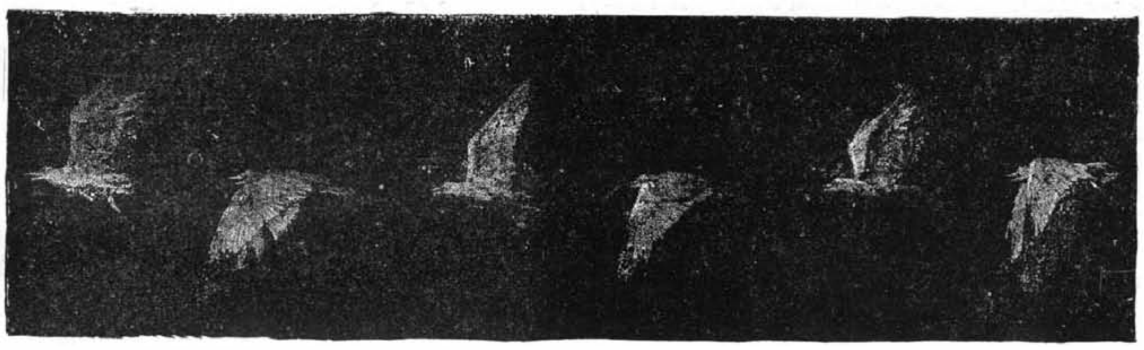


FIG. 29.—Successive views of a gull flying at one-tenth second interval.

The analysis of chrono-photographs shows also mechanical effects of the strokes of wings, that is to say, the reactions impressed by them on the body of the bird; an acceleration of speed and a slight elevation of the body accompanies the down stroke; a retardation and lowering of the trajectory can be observed in the phase of up stroke. Finally, the resistance of the air is shown clearly in its effects by the bending of pinions at the instant of quickest descent of the wing

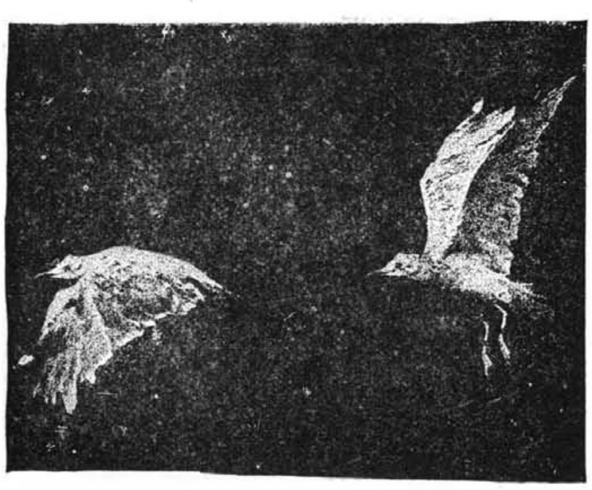


FIG. 30.—Two successive images of a flying gull.

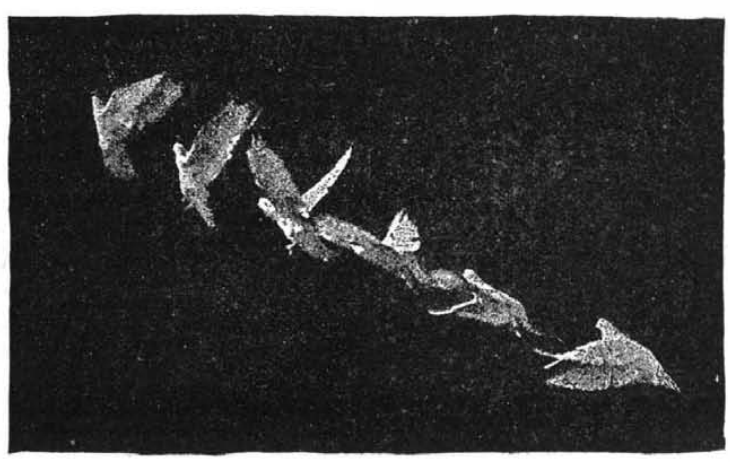


FIG. 32.—Pigeon rising in flight. The successive images correspond to less and less advanced phases of the wing's revolution.

(third image of Fig. 34); at this instant the velocity of the carpal joint is about seven meters (23 feet nearly) per second.

The analysis of the chrono-photographs of the bird reveals many curious details. But I must stop. By confining your attention for so long a period to the different applications of chrono-photography, I have wished to make you the judges of the scope of this method and the promise of its future.

Science only exists by precision; it has perpetual need of exact measurements. These measurements have attained a high degree of perfection in all that refers to the geometric properties of bodies; with great exactitude also are determined the static value of the forces of nature, such as weight, electric state, and temperature. Certain dynamic phenomena are also susceptible of exact measurements, when they have attained a uniform dimension; it is thus with the velocity of a stream of water, the intensity of an electric current, the work absorbed by a machine, etc. In all these cases, a common character pervades the methods—the dimension to be measured is compared with another of known value.

FIG. 33.—Eleven successive attitudes of a flying gull. In this series of images, traced from the originals, the distances representing the positions of the bird in space are exaggerated to avoid confusion.

But when the dimension to be measured is subject to ceaseless change, when the velocity and complexity of its variations defy the most attentive observation, science is brought to a halt. Then a free scope is given to hypotheses; opinions come in conflict, and endless discussions prevail. The imprudent being who risks building his calculations on uncertain grounds obtains absurd results. But when a new method appears which enables us to measure rigorously that which escapes the observation of our senses, science resumes her certain march and progress.

The invention of registering apparatus has made appreciable the variations of all forces that can move a stylus making a trace upon a rotating cylinder. The applications of this graphic method have given an extreme degree of precision to certain branches of physics and of physiology.

But if the body whose rapid changes of position or of form we wish to know is inaccessible to us, its movements cannot be mechanically traced. The physiologist who studies the complex acts of man's or of animals' locomotion should, like the astronomer, determine exactly the position of bodies which he observes at perfectly measured intervals of time. Like him he should determine trajectories, velocities, accelerations, but under the special difficulty that these determinations should be made at extremely short intervals of time.

FIG. 34.—Successive images of a flying gull, showing the flexure of the carpal joint as the wing rises.

You have seen that chrono-photography answers to all needs. If some improvements in apparatus are effected, and if some additional efforts are made to extend the application of the method, the knowledge of motion in the physical world, and in the world of animated beings, will, I hope, attain all desired perfection.

## ON THE PURIFICATION OF WATER BY AGITATION WITH IRON AND BY SAND FILTRATION.*

By W. ANDERSON, M. Inst. C. E.

THE fact that iron possesses the property of removing from impure waters coloring matter and organic contamination has been known for these thirty years. In 1857, Dr. Medlock took out a patent, according to which water was to be purified by suspending iron in the tanks containing it; but no practical results followed till some eighteen years ago, when Professor G. Bischof took the matter up, and contrived the domestic filter, which now enjoys a deservedly high reputation. In these filters, the water, after a rough preliminary filtration, passes through a layer of iron in a coarsely granular condition, then through a stratum of native peroxide of manganese, and finally through a layer of filtering stand.

In applying iron to the purification of water upon a large scale, Professor Bischof adopts a different arrangement. The water first passes through a layer of ordinary filter sand, by which the mechanical impurities are separated, then through a layer composed of a mixture of three parts, by measure, of coarse gravel to one part of the granular iron, and, finally, the water is made to flow through an ordinary sand filter. In the layer of gravel and iron a chemical reaction takes place. The iron is slowly dissolved by the water through the combined agency of the free oxygen and carbonic acid which are always present, in variable quantities, in natural waters. The carbonate of iron and low hydrated oxides of the metal which are formed afterward pass into a higher state of oxidation at the expense of the free oxygen in the water, or of that taken up from the air after the passage of the water through the iron and gravel mixture. I will not attempt to determine the precise nature of the purifying action, but the fact remains that iron is first dissolved in the water to the extent of about one-tenth of a grain to the gallon, and that during this process and the subsequent deposition a powerful effect is produced on organic matters held in solution.

Professor Bischof's system was for some time in operation on a large scale at the Antwerp Water Works, and left nothing to be desired so far as the cleansing effect on the water was concerned. But the river Nethe, from which the supply is taken, is a greatly polluted stream. The iron, therefore, had an abnormal amount of work to do, and in consequence the upper layers of the iron and gravel mixture got choked comparatively quickly with the dissolved impurities separated from the water.

It was curious to note the appearance of the iron filters. All that could be seen from above, when the water had been drawn off, was the ordinary surface of a sand filter, which had to be cleaned in the usual way about every fortnight. On digging through the sand no change could be detected till the spade arrived within a couple of inches of the iron mixture, when discoloration became apparent, and this continued to increase till the layer of iron was reached. For six or eight inches the gravel and iron particles were thickly coated and mixed with a reddish, slimy substance, the product of the chemical action of the iron.

Deeper down the mixture was of an intense black, and had apparently remained unchanged during the four years that the filters had worked. The upper six inches of the iron mixture had to be removed and washed about every six months, but no difficulty was experienced from any concreting together of the mass. There is very little doubt but that, with purer water, the inconvenience and expense caused by the great deposition of slimy matter would have been less severely felt, and I believe that, in the case of domestic supplies and moderate sized installations, Professor Bischof's system is the best yet introduced. The behavior of the filters at Antwerp demonstrates conclusively that a true chemical action takes place, because the water, before it reached the iron, had undergone twelve hours' subsidence and ordinary filtration through two feet deep of sand, and must, therefore, have been deprived of all mechanically suspended impurities which sand was capable of taking from it; and yet the remaining impurities, when acted on by the iron, were sufficient to cause the clogging up of a very open mixture of gravel and iron, much too coarse to act as a filter, and which, as a matter of fact, permitted the water to issue on to the sand filters in the muddy condition which it must have acquired in passing through.

The rate of filtration was not nearly so rapid as was expected from preliminary experiments. It was thought that the water could be purified at the rate of 150 gallons per square foot per twenty-four hours In reality, however, the rate did not exceed half that amount. For small installations and with fairly clean water it would be safe, I think, to make the iron and sand filters each have an area of such extent as to filter at the rate of eighty gallons per square foot per twenty-four hours.

The water, as it comes from the iron filters, should be allowed to fall in a shallow cascade or a balloon jet into the sand filter, so as to bring as large a surface as possible into contact with the air. With some kinds of water it is very difficult to remove a faint marshy taste and smell. In such cases, the blowing of a considerable volume of air through the water after treatment with iron, by means of perforated pipes, has been found beneficial, and the same method is efficacious in hastening the deposit of iron where there is not sufficient space to allow time for natural aeration. The depth over the sand should be such as to allow about four hours before the inflowing water reaches the sand. Thus, if the filtration be at the rate of 6 inches deep per hour, or 74½ gallons per square foot per twenty-four hours, the water over the sand should not be less than two feet deep.

Over the filters the water assumes a reddish hue, and a slimy deposit is left on the surface of the sand. This has to be removed from time to time in the usual manner, the frequency depending on the purity of the water to be treated, and generally also on the season of the year. When a filter begins to run sluggishly, its life may be increased by about per 25 cent. by trailing a light chain over the surface of the sand, and by that means breaking up the slimy deposit.

After four years' working, the demand for water by the city of Antwerp had increased to an extent which rendered it imperative that the means of purification should be extended. To double the existing arrangements would have involved the employment of 900 tons more iron and extension of space which would have led to immense expenditure. Under these circumstances, I determined to try a suggestion first made to me by Sir Frederick Abel, of treating the water by agitation with iron instead of by filtration through it. Sir Frederick had pointed out that the action of the iron was of a chemical nature, and that it was desirable to present it continually to the water in the cleanest condition possible, and at the same time to cause the clean metal surfaces to come into contact with fresh quantities of the water under treatment; and that these conditions could be best secured by causing the iron particles to tumble about in a cylinder through which the water was caused to flow very slowly. The difficulty in the way of adopting Sir Frederick Abel's suggestion arose from the idea which prevailed, though not with him, that very prolonged contact, as much as three-quarters of an hour, between the water and the iron was indispensable. Hence the scheme seemed almost impracticable for large volumes of water. Notwithstanding this prejudice, however, an experimental revolving cylinder was at last made, and it was very soon proved that even the impure waters of the Nethe could be perfectly dealt with by agitation with clean iron, with a contact of 3½ minutes only. In working out this process, I have been greatly indebted to Mr. G. H. Ogston, who had been associated with me from the first, who had made all the analyses, and who had previously tested and condemned many other plans for attaining the object in view. The "revolver," as the purifying apparatus is called, consists of an iron cylinder arranged to revolve on its long axis on hollow trunnions secured to each end. The trunnions are fitted with pipes, connected to them by means of ordinary stuffing boxes and glands, so that the pipes remain stationary while the trunnions revolve watertight round them.

The trunnions are supported on ordinary pedestals, and a slow rotatory motion is given to the cylinder by means of a spurring secured round one end and driven by a pinion actuated by a suitable train of wheelwork. The inlet pipe opens into the cylinder against a disk which forces the water to spread evenly in a radial direction, and the outlet pipe commences in the cylinder in the form of an inverted funnel, up which the water streams so slowly that none but the finest particles of iron are carried away. The inside of the revolver is fitted with curved shelves or ledges arranged in sets to hit and miss each other; these serve to scoop up the iron and shower it down again almost continuously through the water. One-tenth of the volume of the cylinder is filled with coarsely subdivided iron, either Professor Bischof's granular, so called, spongy material, or iron cast into small bullets, or iron granulated by being poured into water, or by ordinary coarse cast iron turnings or borings from engineers' shops. The last form of iron is found, so far, to be the most efficient. The motion of the cylinders is very slow. The Antwerp revolvers, which are 5 feet diameter and 15 feet long, with 10 inch inlet and outlet pipes, capable of purifying 500 gallons a minute, revolve once a minute, and require about ⅙ horse power to drive them.

In March, 1885, three of these revolvers were started at Antwerp, and the original iron and gravel beds were converted into ordinary sand filters; by this change the capacity of the works was at once doubled. The total weight of iron in use at one time was reduced from 900 tons to 3½ tons, and all the expenses connected with digging over and washing the purifying materials were done away with.

When pure water is passed through a revolver, a certain amount of iron is dissolved, and then the water flows out a light gray color. After two or three hours, the color changes to a reddish brown, and a deposit of rust takes place at the bottom of the vessel. If filtered at once, on escaping from the revolver, the liquid will generally be clear at first, but after a time it will sometimes get cloudy and the deposit of rust will take place, showing that the iron existed in the first instance in solution, and was afterward precipitated by the action of atmospheric oxygen. If the water be impure, colored and charged with dissolved organic matter, it will issue from the revolver of a dark gray color, and this will increase to an inky black in the case of very bad water. So that it is possible to judge of the quality of the water by the color assumed during its treatment. If the impurities are not more than the iron can deal with, the liquid, on standing for some three or four hours, becomes lighter and lighter in color, a black precipitate forms, and sinks very slowly to the bottom, the color becomes a dirty gray, and then the water will filter quite clear and bright. If the impurities overpower the iron, or are of a nature which the iron cannot effectually attack, a purplish color remains, and the liquid will not filter colorless. As in the case of the Bischof filter, the time of repose and exposure to the air before filtration is obtained by providing a sufficient depth of water over the sand of the filter beds.

In addition to its chemical action, iron possesses the property of causing the very finely divided particles of matter, which cause opalescence and cloudiness, to coagulate to such an extent that they can be removed by filtration. The waters of the Nile, for example, which will not subside clear in any reasonable time, and which cannot be filtered bright by sand filters, yield a beautiful clear water if agitated with iron before filtration through sand.

From the nature of the case, the system described is absolutely permanent and constant in its action. The surfaces of the particles of iron are necessarily preserved bright and effective, and the slow waste being made good by periodic additions of fresh iron, the revolver, once set to work, will go on acting in the same manner for an indefinite time.

In a recent paper, read before the Institution of Civil Engineers, Dr. Percy Frankland* described certain results which he had obtained by agitation of water with various finely divided solid substances, including the so-called spongy iron of Professor Bischof, and his results led him to the conclusion that the simple process of agitation could accomplish "a most remarkable purification," but that its efficiency "cannot at present be relied upon, owing to the uncertainty of its success."

This conclusion may be correct with respect to such materials as chalk, charcoal, and coke, with which Dr. Frankland experimented, and which might have the effect of removing organized matter "by mere contact," to which he appears mainly to ascribe the results obtained by him, and the uncertain success of the treatment. But it is impossible to understand how the classification of finely divided iron with these materials, "in regard to the dependence of its efficiency upon mere contact, and, therefore, to the uncertainty of success of an agitating process in which finely divided iron is the agent used," can be reconciled by the author with his statement of results obtained by him in the employment of iron as a filtering agent. Dr. Percy Frankland justly considered it of great interest to ascertain the character of the purifying results obtained by Clark's process upon the large scale. It is therefore to be regretted that he did not also examine into results which the treatment—by agitation of water with finely divided iron—was furnishing upon a large scale, and thus eliminate the uncertain, and the consequently

* A recent lecture before the Society of Arts, London.

* Proceedings of the Institution of Civil Engineers, session 1885-86. Vol. 85.

fallacious, nature of the results of his small-scale laboratory experiments in this direction.

The effects of the treatment of water by iron may be classed under three heads:

1. The invariable result is that the organic matter is altered in its chemical nature, and the albuminoid ammonia is reduced to from one-half to one-fifth of its original amount.

2. A reaction analogous to that in Clark's softening process appears in many cases to go on. The iron oxide which is produced by combining with some of the carbonic acid which holds the carbonates of lime and magnesia in solution in the water, causes some precipitation of these to take place, and hence an appreciable amount of softening generally results. Thus, at Antwerp, the boilers of the pumping station were originally fed with untreated water; a hard scale was consequently formed in them; but when the arrangements were altered, and the treated and filtered water was supplied, the scale was greatly reduced in quantity, and became of a very open, friable character, which does not adhere to the boiler plates. In the same way, when water contains much iron in solution, the treatment with iron causes a deposition of the metal, on account of the removal of the free carbonic acid, so that the waters of the Nethe have less iron in them after treatment than before. It is very remarkable how completely the iron is deposited from solution in this process; the merest trace only remains, an amount not greater than the Kent Company's water, for example, contains. An idea prevails that, because iron is used in purification, the water resulting must necessarily be unfit for many purposes, such as washing linen, paper making, and so on. I have not been able to find any grounds for this prejudice. Fish live and thrive in the water; it is used exclusively by the famous Zoological Gardens at Antwerp; aquaria are supplied with it; and no complaints about its injurious effect on linen have ever been received.

3. Treatment with iron appears to destroy or remove much of the infusorial life. According to Dr. Frankland, Bischof, Voelcker, G. H. Ogston, and others, who have experimented in the laboratory, the treatment with iron prevents the development of that kind of microscopic life which is the cause of putrefaction of animal substances; and Mr. Ogston's experiments with sterilized infusions placed in sterilized chambers, and also with Dr. Koch's method, prove that the microbes causing fermentation and putrefaction are destroyed or removed.

At Antwerp, during the autumn of last year, the unusual drought, coupled with the great influx of visitors in consequence of the International Exhibition, made so severe a demand upon the purifying arrangements of the water company that it proved impossible to remove entirely the marshy taste in the water. This caused considerable alarm, because the cholera was raging in Spain, and great fears were entertained lest it should travel eastward; the town council, therefore, appointed a commission of five distinguished Belgian chemists to report on the condition of the water. The commission made a very exhaustive examination, and reported that there was nothing deleterious in the water, that it was absolutely sterile to Koch's gelatine test, although life was developed by cultivation on potato slices. I do not venture to pronounce any opinion as to whether it is desirable or not to remove all infusorial life from water. There is no proof whatever, as yet, that it would be any advantage to do so, while there is evidence that microscopic life has the effect of naturally purifying water; and analogy would lead us to suspect that, just as small birds keep down insect pests, so some kinds of microbes, harmless in themselves, may be of great use in destroying dangerous germs.

It is well known that iron is inimical to vegetable and animal life. The presence of salts of iron in the soil produces sterility. Iron must not be used in the construction of aquaria, or of the pipes and pumps connected with them, for even creatures as hardy as eel fry show such strong repugnance to the water as it issues from the revolvers that they make the most persevering efforts to crawl out of it, even up the vertical sides of the iron tank in which the water flows. It is not surprising, therefore, that it should prove inimical to microscopic life. It has been suggested that the presence of iron deprives the water of its free oxygen, and thus smothers animal life, and again it is thought that the slimy precipitate which is formed carries down and entangles the infusoria, and prevents them getting through the sand filters. However that may be, this property of iron is undoubtedly established, and would lead to the inference that, supposing dangerous as well as harmless germs to be destroyed, the worst water treated by iron is safer for dietetic purposes than the best natural supplies, because protection from contamination of water artificially purified is under the complete control of the establishment supplying it, for it can be kept in covered reservoirs and pipes beyond all risk of pollution. Whereas, the best natural supplies, used in their natural condition, those from deep wells not excepted, are more or less open to contamination. Witness the number of wells that have had to be abandoned in the outskirts of London, and the obvious ways in which springs and water courses can be defiled.

The adoption of iron purification by water works deriving their supplies from rivers liable to periodic muddiness and discoloration from floods would obviate the necessity of having large intake reservoirs for the purpose of storing up water when the source is in a good condition, for use when it is too discolored and polluted to be drawn upon. Not only would such a course save a vast amount of valuable space, but it would remove the danger which must accompany the exposure of a vast surface of water to the contaminating influence of the atmosphere of large towns, and who can tell how fatal this may be on the outbreak of epidemic disease? The practice adopted largely in London, for example, is to convert running streams into stagnant ponds situated in the midst of a dense population and surrounded by factories, and make such ponds the real source of supply.

The system which I have had the honor of bringing before you is now in operation on the large scale at Antwerp, at Gouda, and Dordrecht, in Holland, and at the great iron works of Messrs. Cail & Co., in Paris, where the waters of the Seine, considerably polluted by sewage and by the floating wash houses, are taken from opposite the factory on the Quai Grenelle, and purified for the supply of the factory and the workmen's cottages. In addition, experimental apparatus of large size is in operation in Berlin and at Ostende. In the case of the latter town, the object is to determine whether an abundant supply of good water, which the town stands much in need of, can be obtained at Jabbeke from a canal, the water in which, usually about the same quality as that of the Nethe, from which the Antwerp supply is derived, is subject to periodical pollution by the Espierre, a stream which drains a large manufacturing district. The apparatus has been at work since last spring, and has given very satisfactory results, the purified canal water being superior to any at present in use in the town.

A table of analysis, showing the degree of purification attained, is appended:

EFFECT OF PURIFICATION BY IRON.

| | Organic matter. | | Ammonia. | | | |
|---|---|---|---|---|---|---|
| | | | Albuminoid. | | Free. | |
| | Before. | After. | Before. | After. | Before. | After. |
| Antwerp | 77 | 31 | 0·27 | 0·08 | 0·40 | — |
| Dordrecht | 34 | 14 | 0·14 | 0·05 | 0·12 | — |
| Gouda | 151 | 85 | 0·41 | 0·23 | 0·05 | 0·03 |
| Ostende (single purification) | 135 | 76 | 0·58 | 0 22 | 1·30 | 0·12 |
| Ostende (double purification) | — | 40 | — | 0·19 | — | 0·23 |
| Paris | 51 | 25 | 0·16 | 0·06 | 0·40 | — |

The distinguished Antwerp chemist, Mr. Kemna, has found that in the case of bad waters a double purification is possible, the water being twice passed through the revolver and twice sand-filtered. The results, in the case of Ostende, are given in the table. In his capacity as consulting chemist to the Antwerp Water Works, Mr. Kemna has devoted much time and research to the process, and to him as well as to Mr. Devonshire, the resident engineer, I am much indebted for many useful investigations and suggestions.

I will conclude this paper by exhibiting a laboratory apparatus, wherein the process which I have been describing is in actual operation.

The revolver before you is made of cast iron, and has a capacity of 1½ liters. It is charged with one-tenth of its volume, or 150 c. c., of coarse cast iron borings, and is caused to revolve by means of a train of wheelwork driven through the agency of a band by a small electric motor, the power required being about 2½ watts. The water to be purified is placed in the glass vessel, above the revolver, and is siphoned over into it through the hollow trunnions by means of a glass tube and India rubber pipe fitted with a pinch cock. The water is delivered from the revolver into a series of four tall jars connected together by glass siphons, so arranged that the contents of one jar are drawn from its bottom into the top of the next in the series. This arrangement is adopted merely to avoid the inconvenience of a single jar four feet deep. The last jar delivers, by means of a siphon, into a sand filter, arranged in a large glass beaker, the filtered water being siphoned over into a Winchester quart bottle. Beside this filter is a second one, in which, by way of contrast, the water being purified is filtered direct without the intervention of the iron treatment.

The fluid being operated on consists of Kent Company's water, contaminated by the addition of 4 per cent. of a strong infusion of leather cuttings, which give it a strong yellow color, and the like amount of house sewage of a very pronounced odor.

The apparatus was started three hours before this meeting commenced, and was stopped as soon as the glass jars were full, in order to give the time necessary for the chemical action to take place, and restarted when the meeting commenced. You will, probably, be able to notice the difference in shade of each succeeding jar, the black deposit at the bottom of each, and the same on the surface of the sand in the filter. The dirty yellow water you see has been changed into a colorless fluid, while the same water, merely filtered through sand, retains nearly all its color, though it has become somewhat clearer.

I place in beakers a sample of the water supplied by the water company to this house, a sample of the water you have seen purified, and another of the same water unpurified, but filtered through sand only. I add to each beaker an equal quantity of a weak solution of permanganate of potash, and you will see, in a few moments, that the purified water does not yield much in color to the water company's supply, while the original water has hardly changed color at all, the permanganate having been reduced by the impurities.

The cost of applying this method of purification depends, of course, upon local circumstances, and the quality of the water to be treated. But the capital outlay, where filters exist already, may be taken as £1,000 per million gallons per 24 hours, while the working expenses are merely nominal, the revolvers running without any attention beyond regular oiling and the addition, once a week, of a fresh supply of iron. The cost of the water at Antwerp, delivered into the town main under a pressure of 280 feet, does not exceed three-quarters of a penny per thousand gallons in working expenses of all kinds. Where filter beds exist, as at Dordrecht, and Gouda, in Holland, the revolving purifiers can be added without any substantial alteration, and the filter beds can generally be worked at a greater rate than when the untreated water is to be made reasonably fit for use.*

CEROID.—According to the *Moniteur Scientifique Quesneville*, the fatty matter extracted from wool may be transformed into a substance, to which the above name has been given, possessing the consistency and several properties of wax.

* Further information may be obtained by reference to the "Proceedings of the Institution of Civil Engineers," vol. lxxii., p. 24, vol. lxxxi., pp. 279 and 287. "Journal of the Royal Agricultural Society," vol. xx., part ii., 1884, p. 681. "Rapport sur la qualité de l'eau de la ville d'Anvers pendant l'été de 1885." In the library of Institution of Civil Engineers.

## STANDARD PIPE AND PIPE THREADS.

THE adoption, or rather the readoption, by the wrought iron pipe manufacturers of the United States of the Briggs standard of gauges insures the important feature of a general conformity, and it practically solves the problem of interchangeability of pipe and pipe threads.

Of course, it is important that the several manufacturers shall be certain that every gauge to which they work accurately represents the Briggs standard. The taper in the Briggs standard is 1 in 32 each side, or ¾ inch per foot in diameter, up to and including 8 inch pipe. The length of that part of the thread which is perfect at top and bottom (the angle of thread being 60 degrees), and which is termed the "complete thread," is expressed generally by the formula—

Complete thread = $(4{\cdot}8 + 0{\cdot}8\,D)\,P$, D being the outside diameter of the pipe, and P the pitch of thread, equal to $\frac{1}{N}$, N being the number of threads per inch.

The length of perfect thread expressed by the formula is followed by two threads imperfect at the top, the bottom only being complete, and finally the remaining four threads, which are imperfect at both top and bottom, vanish at the surface of the pipe at this point.

The following table gives the values of complete thread deduced from the above formula, with length of the additional two threads:

| Nominal size of pipe. | Actual inside diameter. | Actual outside diameter. | Length of complete thread. | Length of complete thread plus 2 threads. | Pitch of Thread $= \frac{1}{N}$. |
|---|---|---|---|---|---|
| Inches. | Inches. | Inches. | Inches. | Inches. | Inches. |
| ⅛ | 0·270 | 0·405 | 0·19 | 0·264 | 27 |
| ¼ | 0·364 | 0·540 | 0·29 | 0·402 | 18 |
| ⅜ | 0·494 | 0·675 | 0·30 | 0·408 | 18 |
| ½ | 0·623 | 0·840 | 0·39 | 0·534 | 14 |
| ¾ | 0·824 | 1·050 | 0·40 | 0·546 | 14 |
| 1 | 1 048 | 1·315 | 0·51 | 0·683 | 11½ |
| 1¼ | 1·380 | 1·660 | 0·54 | 0·707 | 11½ |
| 1½ | 1·611 | 1·900 | 0·55 | 0·724 | 11½ |
| 2 | 2·067 | 2·375 | 0·58 | 0·757 | 11½ |
| 2½ | 2·468 | 2·875 | 0·89 | 1·138 | 8 |
| 3 | 3·067 | 3·500 | 0·95 | 1.200 | 8 |
| 3½ | 3·548 | 4·000 | 1·00 | 1·250 | 8 |
| 4 | 4·026 | 4·500 | 1·05 | 1·300 | 8 |
| 4¼ | 4 508 | 5·000 | 1·10 | 1·350 | 8 |
| 5 | 5 045 | 5·563 | 1·16 | 1·406 | 8 |
| 6 | 6·065 | 6·625 | 1·26 | 1·513 | 8 |

## SCOURING AND BLEACHING PROCESSES.

### MARION'S PROCESS.

C. MARION immerses the textile, whether cotton or flax, for two hours in a boiling solution of the caustic soda of commerce, having a specific gravity of 1·060. Lifted from the vat the fiber is set to drain, then transferred to the hydro-extractor, and the alkaline solution which is driven out collected. Water is then freely showered like rain upon the rotating textile, until the discharged liquid is neutral to test paper.

In order to avoid waste of the soda used, by rendering it again fit for employment in scouring, the collected alkaline liquors containing the extracted substances are evaporated in an iron boiler and the residue heated to fusion to burn out the organic matter.

During the operation of scouring, any fibers gummed or otherwise united together become detached. The quantity of solution used should be six times that of the textile acted on.

When the fiber is to be bleached, it—upon being removed from the hydro-extractor—is thrown into acidulated water, containing, say, a half of one per cent. of acid, and allowed to remain for one hour. It is now returned to the hydro-extractor and washed as before until the rinsings are neutral.

In a wooden vat, having a capacity of 2,000 liters, make a solution of 1,200 liters hypochlorite of soda at 12° B., heat to 45° C., enter 700 kilos textile, and let it soak for an hour and a half. On being lifted, it will be found perfectly white. Drain, rinse as before, and return to hydro-extractor, and remove the last traces of soap by passing into a cold bath slightly acidulated with hydrochloric acid.

The bath for mordanting is prepared with:

| | |
|---|---|
| Water | 2,000 liters. |
| Acetic acid | 10 " |
| Tannic acid | 2 kilos. |

Enter 200 kilos of fiber, and work for six hours. Without rinsing dry in the centrifugal, and collect the drainings for subsequent addition to the tannic solution. The solution may serve many times, if, for every 100 kilos of the textile, 200 grammes gallotannic acid be added.

Remove fiber from the centrifugal, and enter in bath containing:

| | |
|---|---|
| Water | 2,000 liters. |
| Acetate of alumina, free from iron, | 1 kilo. |
| Glycerin | 2 kilos. |
| Tartar emetic | 1 kilo. |

Soak textile for an hour, drain off liquid in centrifugal, preventing waste by collecting the draining, and without rinsing, dry.

### TAPPAN'S PROCESS.

The compound for bleaching consists, in certain proportions, of one or more of the products of petroleum, preferably paraffin, a sulphur oil, that of mustard, and an alkali. The latter is used in order to furnish a soapy matter. The compound is dissolved in water, and the matter to be bleached is put in a bleaching vat containing the solution. Heat is applied, the temperature raised to ebullition, and maintained at that point for two or three hours. The stronger the solution, the less the time necessary to finish this stage of the process. After the boiling, the textile is lifted and clean water forced through it. When thoroughly rinsed, it is transferred to a solution of chlorinated lime, and the bleaching completed.—*Textile Record.*

## ON ERECTING THE SUPERSTRUCTURE OF THE TAY BRIDGE.*

By Mr. ANDREW S. BIGGART, C.E.

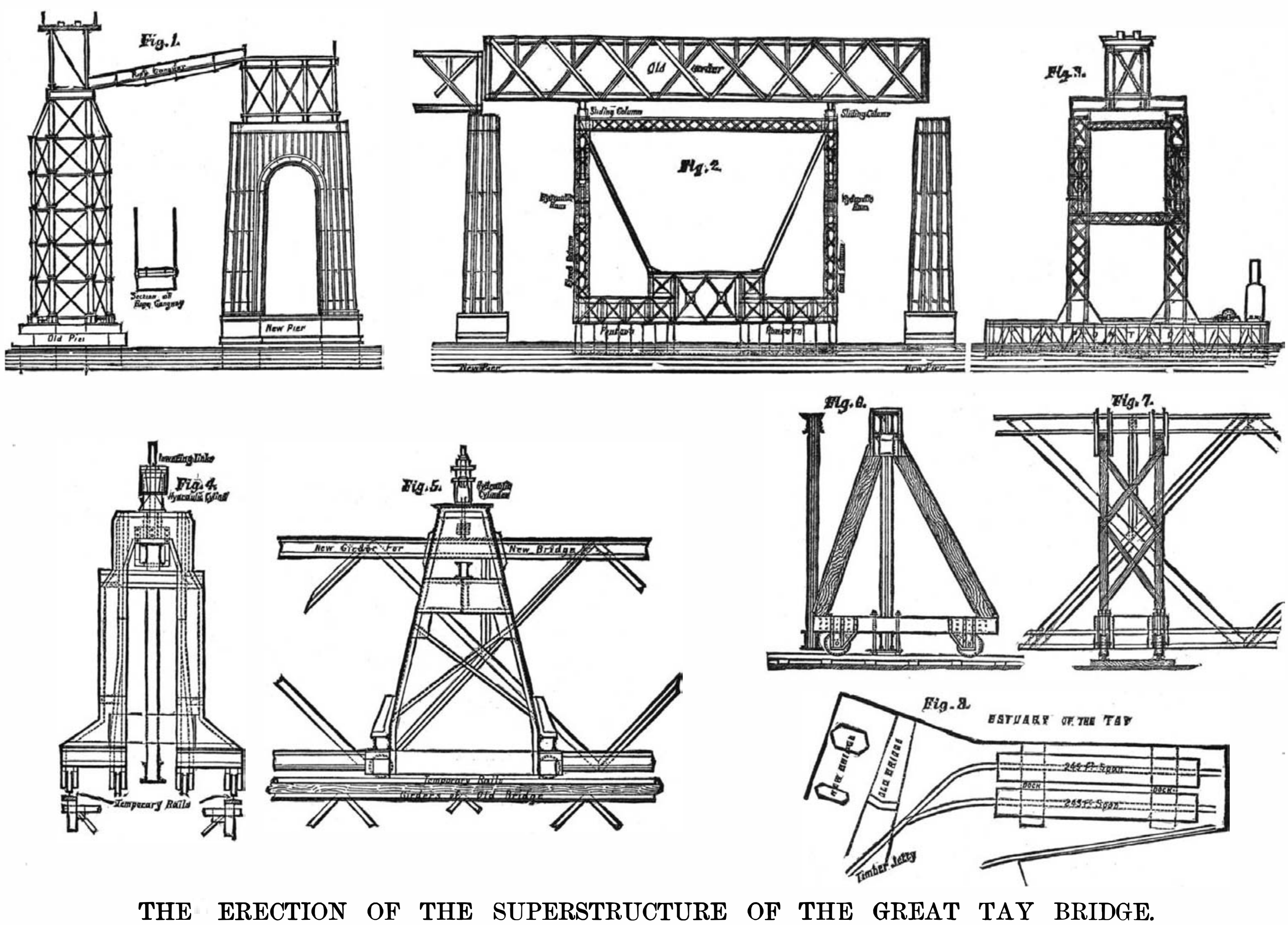
Two sessions ago I had the honor of laying before this Society a paper dealing shortly with the mode of sinking and building the substructure of the new Tay Viaduct, and noticing the many original devices adopted by Mr. Arrol for the carrying out of that work.†

To-night I will confine myself to the superstructure, and at once turn to it, merely premising that it will be found that the methods adopted vary as much from the ordinary modes of erection as did those which were employed in the preliminary parts of the undertaking.

As the mode of erection employed at the south end of the viaduct necessarily varied considerably from that at the north end, and still more that at the center of the river from either of the former, I shall deal with the erection of each of these three parts separately, thus endeavoring to bring all the salient points under your notice.

In the paper already referred to, the description left off at that part of the piers where the iron base was securely fixed to the brickwork by means of strong bolts built well down into the same.

This base is composed principally of channels, the upper ones being of an octagonal shape, and suitably formed to receive the wrought-iron superstructure, which is securely riveted to it. About 8 ft. above high water the two bases over each pier are joined to one another by other channels, which form part of the connecting piece, they being built into it. All the bases are similar in design, although they vary much in size.



THE ERECTION OF THE SUPERSTRUCTURE OF THE GREAT TAY BRIDGE.

*The South End of Viaduct.*—Here the wrought-iron piers (see Fig. 1) have an exceedingly graceful form. From each of the channel bases two octagonal columns spring, which become united as they near the top. This connection is easily effected by curving the three inner sides of each octagonal column till the two columns meet and form an arch immediately over, though high above, the connecting piece of the piers; the two adjoining sides of each column being meanwhile widened on the flat till they also meet each other, in a common plane. The three remaining, or outer, sides of the columns are carried to the full height, and thus leave the pier, at the top, an irregular though eight-sided figure. The sides and ends of the pier batter toward one another as they near the top.

The whole of the pier is plated, the thickness of the plate varying from 7-16 in. to ½ in. At each of the corners two splayed channels form the outside connection, while inside they are connected by an obtuse angle. Both outside and inside tees cover and stiffen the vertical joints of the plates, while horizontal diaphragms are introduced, at regular intervals, to stiffen the whole pier. Near the top of each pier four short girders are securely riveted, to carry the bedplates of the main or roadway girders.

On the premises at Glasgow, where all the work preparatory to erection was executed, the whole of the piers were put together before being dispatched, and at this stage a large part of the riveting was done. They were then taken down and forwarded to Dundee for final erection. To facilitate this re-erection, care was taken that the joints of all the angles, plates, channels, etc., were, while giving ample strength, so arranged as to allow the piers being taken down in large sections.

To provide a steady working platform, from off which the work of erection might proceed, one of the pontoons, which had previously been employed in sinking the cylinders of the bridge, was floated alongside the pier, and, in the manner formerly described, carried above the influence of the tide, by its supporting columns. On this platform a derrick crane was placed, of a height sufficient, and so fixed, as to command the entire pier until completion. The various parts of the pier were, as required, brought alongside the pontoon in boats. Under these conditions the erection was carried on so expeditiously that an entire pier could easily be built in six days. After erection, the unfinished riveting was completed. This was done by hand, the men working from off a rising platform, composed of two light lattice girders running along each face of the pier, the platform being meanwhile suspended from four small winding drums, fixed to two portable frames resting on the top of the pier.

Communication is established between the old bridge and these piers (see Fig. 1) by means of small rope gangways, consisting of two curved or carrying ropes, a few vertical standards, with crossbars for carrying a timber footway, and two upper ropes, used principally as handrails. The ends of the ropes are securely fixed to the old and new bridges, and are tightened by means of simple union screws.

As soon as the first pier was completed, the girders required for the southernmost span (the whole four of which are new) were built on a projecting platform, secured to the old bridge, and from it slid to their final position in the new bridge on beams stretching from the old to the new structure.

After several piers were completed, arrangements were made to have the roadway girders of the old bridge removed intact, so as to form part of the new. This was most successfully accomplished, and with perfect ease and safety.

Two large pontoons (see Figs. 2 and 3), each 80 ft. by 27 ft. 6 in. by 8 ft. 6 in., designed for this purpose and the subsequent floating out of the large 245 ft. span center girders, were employed, with certain special appliances. These pontoons were securely bound together, at a parallel distance of 20 ft. from each other, by heavy cross-girders. The arrangement was as follows: Firmly fixed to the outer edge of each pontoon, and securely braced to one another, were two wrought-iron columns rising to a great height. In each of these columns was placed another or telescopic column, so fitted as to be easily raised or lowered by a hydraulic ram when required. This hydraulic ram was secured to the fixed column, and had a stroke of about 7 ft., but by arranging different points of attachment to the sliding column, a lift of 13 ft. could be obtained. To secure temporarily the sliding column to the fixed, and thus make the two as one for the time being, a series of equally pitched pinholes were provided in both columns in line and opposite to one another, through which pins might be passed when desired. On the top of each pair of columns a strong girder extended from the one to the other. These girders formed the support for the roadway girders while the spans of the old bridge were being transferred to the new structure. If these two pontoons, and their various parts, be looked upon as one complete pontoon, then the size would be 80 ft. by 75 ft.—dimensions sufficiently large to at once impress your mind with certainty as to the absolute safety, so far as stability was concerned. Each section of this pontoon was supplied with steam boiler, winch, capstan, bollards, and all other appliances necessary for mooring and handling such a craft. Hydraulic pumps were also on board, to supply the power required to work the rams used in raising and lowering the columns and their load. The full load the pontoon was designed to carry safely was 600 tons.

Thus equipped, this pontoon could in less than half an hour lift from the old bridge, and transfer and place on the new, a complete span, consisting of two roadway girders and the bracing between them.

The plan adopted in the removal was as follows: Near the time of low water, the pontoon was placed immediately beneath the girders to be removed. If the difference between the height at which they were and that to be occupied by them was great, then the hydraulic rams within the columns were put out well-nigh their full stroke; with this, and the variable height to which the sliding columns could be telescoped, it was so arranged that a space of a few feet was left between the roadway girders and those on the top of the lifting columns. Hardwood packing was now placed on these cross girders, immediately underneath the four points where the two roadway girders would take their bearings. But a short time now elapsed till the rise of the tide enabled the pontoon to lift the whole span from off its resting place, and thus leave both free to be slowly carried along by the current, as the mooring ropes were slackened away, till the load was adjusted over its new seat. This being accomplished, the whole four sliding columns were simultaneously lowered. Thus the girders of the little used roadway of the former Tay Bridge are made to form a part of the new, although this first position is not their final one. It is determined by the use to which they are now put, viz., to form a roadway on which to run out the new or additional center girders, and from off which they are to be lowered into position. These new center girders, required to form a double line of rails on the new bridge, were built, and riveted almost complete, on the high ground taken up by the railway slidings, immediately to the south of the bridge. Full advantage was taken of the numerous lines of rails for carrying the material to the place of building, and also for traveling the cranes along, during the building and riveting operations.

The girders were built parallel to the lines of rails, care being taken to have them in the same relative position to each other as they would ultimately occupy on the bridge. The riveting was done by hydraulic machines. These were hung from a light crane, temporarily placed on a railway truck, running on any convenient line of rails commanding the entire girder. The whole of the girders were riveted up singly, and were in all cases at a considerable distance to the side of the line of rails leading directly to the bridge. This consequently entailed, when built, their being moved sideways till in direct line. For this purpose a special traveler was designed (see Fig. 3), being so constructed as to be capable of being moved forward as well as sideways, so that after having moved the girders to a convenient position, it might run them out on to the bridge. After a trial of this method, however, it was

* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

† A full description of the new Tay Bridge will be found in SUPPLEMENTS, 503 and 513, and descriptions of the original Tay Bridge, which was blown down Dec. 28, 1879, are given in SUPPLEMENTS, 214, 215, 216.

found more convenient to move the girders sideways by a traveler designed for this purpose only (see Figs. 6 and 7), and then run them on to the bridge by the one just mentioned, and from it lower them into position.

The traveler used for the side movement was of the simplest form. It consisted of two box girders placed at right angles to and immediately over the bottom boom of the girder to be moved, each box girder being provided with two running wheels. Against a bracket on the outer ends of the box girders there butted movable wooden struts lying at an inclination to one another, and carrying overhead a short crossbeam capable of supporting the top boom of the girder. These struts were braced to each other, and in this fashion combined the whole into a strong though temporary carriage. Two of these carriages were used for transporting a girder, each of which was placed about one-third of the span from its respective end. As soon as the box girders were in place, two crossheads were at each carriage passed under the bottom boom of the girder to be moved, and through these and the box girders bolts were inserted, which, on being tightened up, raised the girder from the ground and transferred it meanwhile to the carriages. These were now traveled over temporary rails till in position with the line leading directly to the bridge. Here the girder was lowered, and the carriages employed thus far removed to make way for the other carriages which were to run on to the bridge. These were the carriages referred to (see Figs. 4 and 5), and were of a form somewhat similar to those already described, though made wholly of iron, and in every way of much more substantial build. Each carriage was provided with eight wheels, four to each box girder. The inner wheels were set to the ordinary 4 ft. 8½ in. gauge, while the outer ones were pitched to the gauge of the girders of the old bridge, by this time transferred to the new structure. On these old girders temporary rails had been laid to form the necessary roadway. Fixed to the crosshead of each of these carriages was a hydraulic cylinder provided with links for lowering the girder into its final position on the piers. These hydraulic cylinders and links were those formerly used for lowering the foundation cylinders, and were fully described in the paper I have already referred to. As soon as these carriages were in place, an engine was attached, which slowly moved forward over the then completed portion of the new bridge until it arrived at the point where only the girders of the old bridge formed the roadway. At this point the second set of wheels came into play to the relief of the first. If more than one span had to be gone over, then the carriages were drawn forward into position by the engine moving backward, while attached to tackle extending beyond the furthermost point to which the girder had to be drawn. After arrival at this point special pipes were attached to the hydraulic cylinder, and then the girder, in a similar manner to that employed in the case of the foundation cylinders, was lowered on timber blocks previously placed on the top of the piers. In the case of the first lowered it was moved a little across the piers to allow the second new girder to be placed alongside in a similar way to the first. After this had been accomplished, the whole four girders (two old and two new) were separated until they rested immediately over their final position on the top of the piers. They were meanwhile carried by temporary end posts and plates (put in position before being brought out), to allow of the flanges and webs, which formed them into continuous girders, being riveted up in the places where necessary. While this was proceeding, the floor plates and the bracings connecting the girders to one another were put in place and riveted, so that when these several parts were completed, the bed-plates on the piers could be at once placed in position and the four continuous spans finally lowered thereon. This last lowering was accomplished by means of a hydraulic ram acting on the end of a long lever which was inserted between the two bed-plates on the piers.

The work on the south side is rapidly approaching completion, being a repetition, in its various stages, of the work just described.

*North End of Viaduct.*—On the north, or Dundee, side of the Tay, little difficulty was experienced in placing the work in position, this being specially the case where that work was on land. The whole of the piers and girders, out to the skew arches, were new, and were erected by means of a steam crane traveling along the old bridge. From the second span beyond that point the outside girders in the new bridge were those transferred from the old.

In several cases, the iron piers are simply plated boxes resting on the channel bases already mentioned. These boxes are flat-sided, the sides and ends having a varying batter similar to that of the piers already described. The remainder on to the center piers may be said to be those of the south end in miniature. Like them, they were also made in sections of a convenient size for handling during erection.

The erection at this point was accomplished by means of a crane, fitted on board a small steamer, which also served to carry out the material to the pier. A single pier could be completed in the working part of four tides, which represents about sixteen hours' work. After erection, any riveting requiring to be done was completed, and then the old girders spanning the opposite space in the old bridge were removed to their position in the new structure. In effecting this removal in a considerable number of the spans, near the north end, a different method from those formerly mentioned was employed. At the one end of the girder to be transferred (that end being the one next the center of the river) a strong trussed timber was securely fastened to the pier and stretched across to the corresponding pier in the new structure. As soon as the bracings between the girders were cut away, the end of one of them was gradually slid, by means of a crane stationed on the old bridge, along the beam, the other end meanwhile being moved by means of a crane in a boat, and slowly moved by it toward its new position.

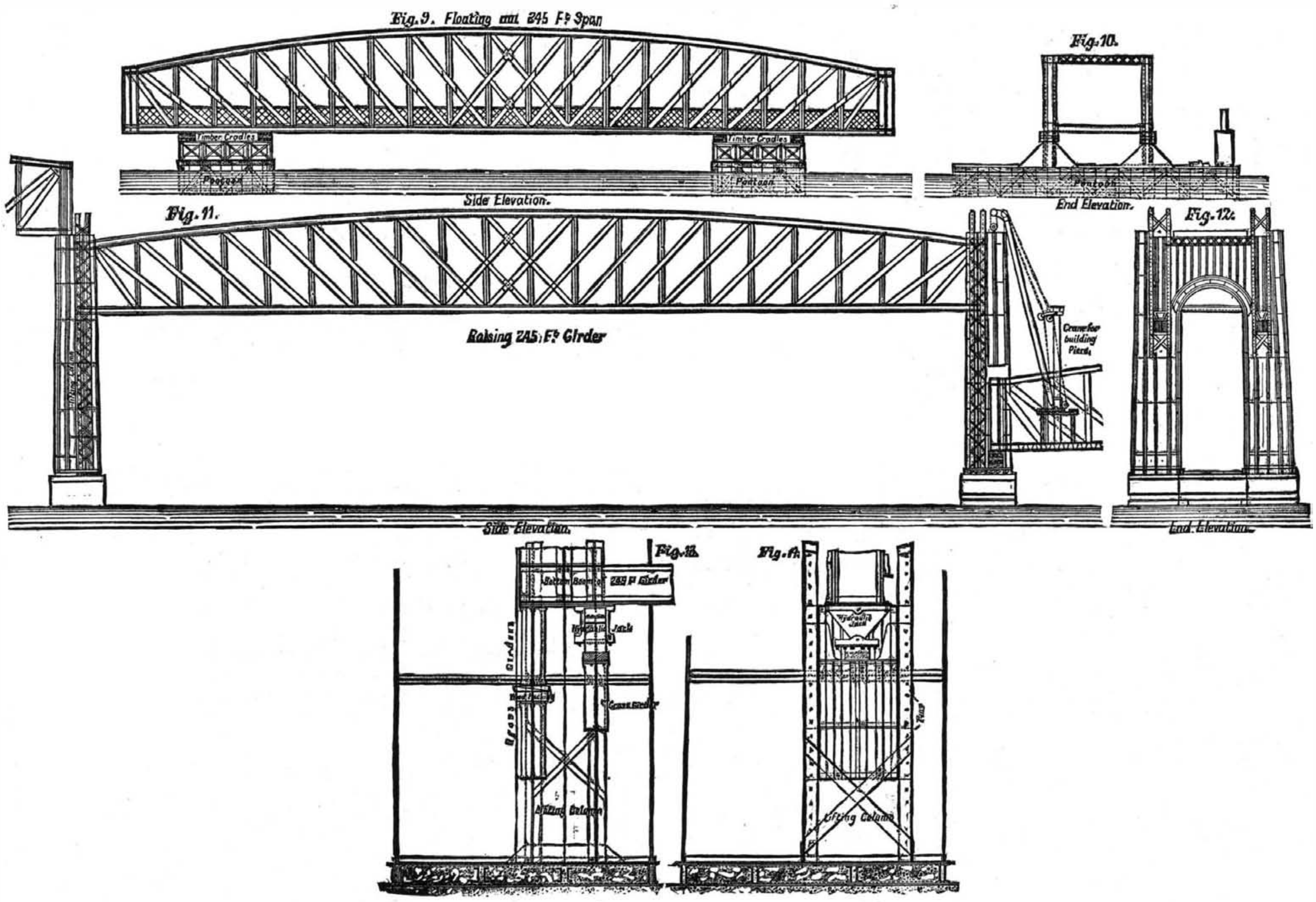
After being conveyed thus, the end supported by the boat crane was transferred to one on the new bridge, the other end remaining as before. The gradual sliding was continued till the whole safely rested on the new bridge. When a girder had been thus removed, the companion girder was similarly shifted to its new position, although in neither case the final one, because they had now to serve as the roadway on which the new or additional girders required were to be run out and lowered into place. So soon as the pontoon could be conveniently employed, the girders were removed by it, and the remaining work completed in a manner similar, and with the same appliances as were used at the other end of the bridge.

*Center.*—A different mode of erection than those just described had to be adopted for the central or large spans of the bridge. These spans are opposite to that part of the old structure which fell on that eventful night in December, now almost seven years ago. Unlike the smaller spans, the girders here are not continuous. In overtaking this section of the work, each span was finished on land, floated out to the piers, and laid in position on them while at a low level, and afterward raised to the full height by hydraulic appliances.

The girders, floors, and bracing, comprising the span, were built on a specially constructed timber jetty (see Fig. 8) placed at a point convenient for handling the material, and afterward floating the whole span off by means of pontoons. The jetty was provided with two docks, of a size sufficient to admit the pontoons, and into which they could be floated at right angles to the girders. During the time the girders were being built, these docks were temporarily covered over so as to form a continuous platform on which the building and riveting might proceed.

The girders were built and riveted by hydraulic power, in a manner somewhat similar to those already described. In this case, however, the trough-shaped floor, resting on the bottom booms of the girders, and the bracing connecting the two girders, were riveted while in position, thus completing the span. Two spans were simultaneously built and completed alongside each other. So soon as any two spans were finished, preparations were made to float them out (one span at a time) to their respective piers. These preparations consisted in placing on each pier, upon which the girders were to rest, timber blocking, to carry them to the proper height, and also the fixing of chains and other tackle to assist in bringing the girders into true position. At the jetty, the timber covering over the docks was removed to allow the two pontoons to be floated underneath the first of the spans. This was done at the ebb tide, immediately previous to the flow, during which it was taken out. The pontoons (see Figs. 9 and 10) were those which had been employed in transferring the girders of the old bridge to the new, but were necessarily stripped of the upright columns. In their stead, however, timber cradles were placed at the four points where the span took its bearings. After having been floated into the docks, and the necessary tackle attached, nothing further had to be done but await the rise of the tide.

During this interval, the whole system had to be carefully watched, in order to make certain that the girders were taking their proper seat. After this had occurred but a short time elapsed to effect the transference of the full weight of the span from off the jetty on to the two pontoons. When sufficient clearance was had, the pontoons, with their complete span, were then gradually pulled clear of the jetty by means of the steam winch on board each pontoon. This was generally about an hour before high water. Hawsers from four steam tugs, lying close by, were now attached, and a start made to tow all well out into the river. As the jetty was on the east side of and close to the old bridge, the tendency of the tide was to carry the pontoons toward it, and in towing the aim kept in view was to go well down as well as out into the river, and while there turn the span broadside toward the bridge, opposite to the space which it was to occupy when in place there. The tide would then gradually carry it to its position, being in its course guided by the tugs. Several times




## THE ERECTION OF THE SUPERSTRUCTURE OF THE GREAT TAY BRIDGE.

two of the tugs had to be transferred to the upper side of the span, to overcome the effect of a head wind, too strong for the current caused by the tide. In all cases the spans were soon brought between the piers of the old bridge, and at once tackle extending from the old piers, as well as the new, was attached to the pontoons, to assist in guiding the spans to their position, over the timber blocking, on which they rested on the piers. On this being attained, screw chains, from the ends of each girder to the opposite sides of the pier, were now brought into play to accurately adjust the span at each end. At the same time, and indeed until the tide was at its full height, additional timber was added to that already on the piers, to keep under the space between the girders and the blocking. When the tide began to recede, the girders very soon took their bearings; this being hastened by the opening of the valves, and admitting about 18 in. of water in each pontoon. So soon as the weight was wholly transferred to the piers, the pontoons floated away, and were immediately towed to the jetty, to be in readiness for similar duty during the following tide.

On the material and plant being brought forward, a start was made to build the piers around and above the ends of the girders just placed. This was done by a crane placed on a trestle resting on the floor of the girders, and able to command the whole pier. It was built in large sections in a manner similar to that employed on the south side. Here, however, owing to the ends of the girders passing through the sides of the pier, large portions were, for the present, left unbuilt. The part of the pier immediately over the top of the girders, however, was built complete; and this, with the additional strutting put in under the arch, served to stiffen the incomplete pier, and insure the safety of the succeeding work and the safe lifting of the whole span to its final position. Several sets of lifting columns, hydraulic jacks, and cross girders were employed (see Figs. 13 and 14). While lifting any but the end spans of these center girders, four columns were used at each pier. This gave one column to each end of the girders. In order to increase the rigidity of the two columns on either side of each pier, they were braced to each other and the pier. To make the description clearer, I will confine myself to a single column, and the work performed at it. Each column rested on a sole plate directly over the channel base of the pier. It consisted of eight steel angles (8 in. by 4½ in. by ⅞ in.) placed in pairs, in the form of a rectangle. The deep member of these angles was at right angles to the main girder, while the 4½ in. member was placed to the outside, to receive more freely the bracings running parallel with the girder. Other bracings above and below the girder, but at right angles to it, were secured to the deep members by bolts passing through the large pinholes in these members, drilled for the primary purpose of securing the cross girders to the columns during the after raising operations. During the lifting there were required underneath each end of the main girder three cross girders and one hydraulic jack. The cross girders were formed of strong steel plates with stiffening angles.

The plates extended to and passed through between the deep members of the angles of the columns, and were secured by means of steel pins passing through them and the angles. The hydraulic jack was fastened to the under side of the main girder, on the center line of one side of the column. Underneath and to it was secured one of the cross girders. The other two cross girders were placed in the other half of the lifting column, the upper one being fixed to the main girder. Upon the latter would rest one quarter of the weight of the span, on the timber being removed from under the end of the main girder, thus allowing the load to be transferred to the cross girder.

The lifting of the span was carried out by raising each end alternately; the power being supplied by a set of hydraulic pumps placed on the floor of the span they were raising. At first only a little water was admitted, until the ram took up one quarter of the weight of the span, and relieved the upper of the two cross girders. The pins inserted through this girder were then withdrawn. Water being again admitted, the girder began to rise, taking with it the hydraulic cylinder and the upper cross girder. Between the upper and lower cross girders, hardwood packing was constantly inserted as the girder rose, in order to prevent any lengthened drop should anything give way. The span having been raised 7½ in., the pin-holes in the upper cross girders, and in the columns, were again in line. At once the pins were inserted, and the main girder allowed to take its bearing again on the cross girder. The pins passing through the other two cross girders were now withdrawn, and these girders raised the same height as the main girder. The girder next the hydraulic jack was raised by it, while the other was lifted by means of a simple screw.

As a rule, two of these lifts of 7½ in. were made at one end of the span before it was raised at the other. The lifting is so continued till the span has reached its full height. During the lifting much time is taken up in removing the plates, etc., of the pier, immediately over the girders, to make a passage, and in placing in position and riveting those underneath. To fix the lifting columns to the piers, and afterward replace the bracings of the columns, is also a work of considerable time. The raising accomplished, the ends of the main girders are carried over the top of the piers, by a girder passing between the columns, till they are removed, upon which the remaining permanent cross girders and bedplates are placed in position, and the main girders lowered by means of a hydraulic jack thereon. On removal the columns are transferred to the next span about to be lifted; there to repeat similar work to that already performed. Two spans are usually raised at the same time, although each may be at a different stage. When raised to the full height, and lowered on to the pier, these large spans are practically ready to receive the permanent way, for, as we have seen, the whole was riveted up complete before being floated out.

At the three different sections of the bridge, the work is thus being rapidly pushed to completion, and now we are within a measurable distance of the time when communication by rail over the estuary of the Tay will be re-established; this time over a structure the graceful and scientific design of which will be a lasting monument to Messrs. Barlow & Son, the engineers of the undertaking, and in the execution of which the genius of Mr. William Arrol has shone with such luster.

As regards the quality of material and workmanship, nothing is left to be desired. Add to this the fact that a wind pressure of 55 lb. per square foot has been provided against, and that each foundation has been satisfactorily tested to one-third more than the greatest possible load which could be put upon it, and we may, with every confidence, assert there is not the remotest possibility of the fate of the first Tay bridge being that of the second.—*Engineering.*

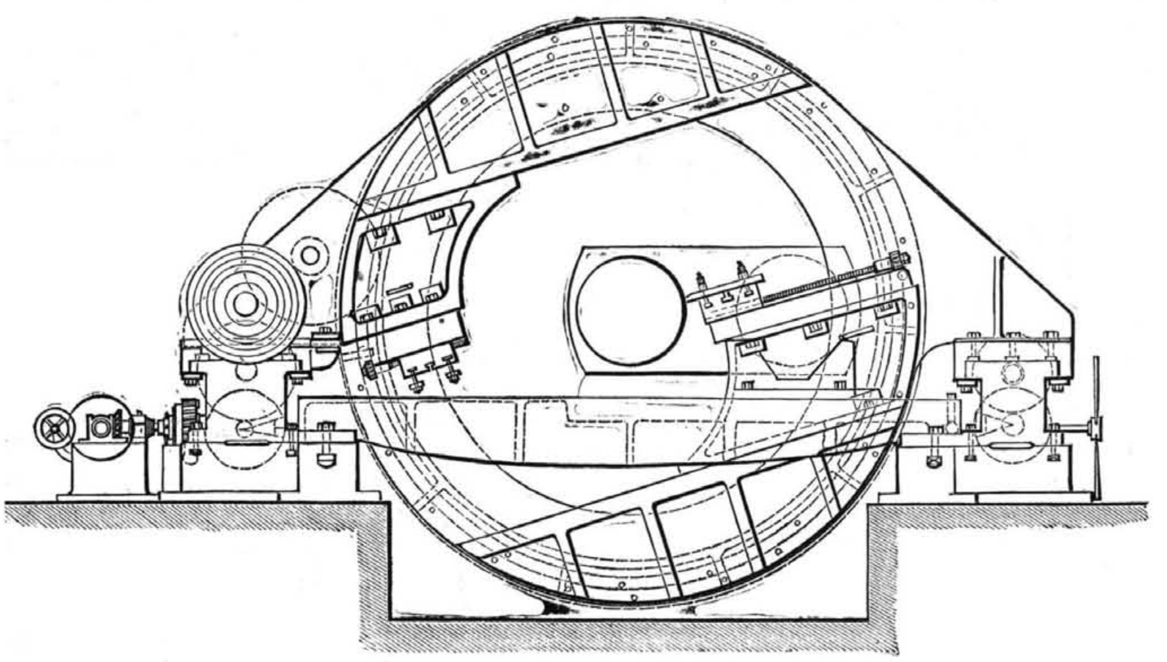
## CRANK PIN LATHE.

At the establishment of the Liverpool Forge Company, the crank pins for large steamers are turned in a hollow lathe, made specially for the company by Messrs. Craven Brothers, of Manchester, which does away with the necessity for making a heavy shaft revolve eccentrically, with a counterweight for balancing the body and causing such vibration as greatly to interfere with an accurate turning of the pin.

With this machine, shown by the illustration, the shaft is clamped down in two V-shaped blocks supported on cross girders, two on each side of the revolving ring carrying the tool rests or boxes. The outside V blocks, adjustable by screws, are kept in line, and parallel with the center line of the machine and of the crank. Setting the crank parallel with the center line, and a distance horizontally of half the throw on one side of it, brings the pin into the center of the ring. For facing up the inside of the webs the tool is fed inward by an endless screw, worm, and worm wheel, star wheel, and fixed kicker; while for turning the pin, the ring is made to traverse longitudinally by hand or by an endless screw. With two tools cutting at once, the roughly forged pin may be reduced as much as six inches in one traverse, each tool making a 1½ in. cut. The internal diameter of the ring, which revolves in bearings, adjustable to compensate wear, is 9 ft.; and the rests or boxes, which are made deep, but as narrow as possible, so as to clear, may be changed to suit any crank. The machine, which is very substantial, is capable of finishing cranks up to 27 in. diameter and 3 ft. throw.

As the size of engines, and therefore of crank shafts, is continually increasing, it becomes more and more necessary to build them up, instead of making them in one piece. This is not so much on account of difficulty in forging a solid crank of the requisite size, but owing to the greater delay which must occur, in the event of breakdown, in making a new solid crank shaft. For a given strength, the built crank, which consists of two journals, two webs, and a crank pin, weighs about 25 per cent. more than the solid shaft; but the cost of both is about the same. The webs of the built crank are first planed to the required thickness, and then bored together, the body end being finished to size, and the pin end rough-bored to ¼ in. less than the finished size. They are then slotted to size on the outside, and shrunk on to the pieces for the journals, rough-turned to finished size. The two webs with their journals are then set and truly clamped together in the bed of a boring machine to have the holes for the crank pin bored out together. The bed is removed from the machine, and a wood fire is made round the webs to expand them. The finished crank pin, with the ends turned 1·64 in. in diameter larger than the holes when cold, is then inserted, and the webs left to cool gradually, thus insuring even contraction and absolute accuracy. The crank, weighing nineteen tons, for the City of Berlin was built up in this manner.

All work is finished ready to be put in place. The brass liners of propeller shafts are shrunk on and turned to fit their lignum-vitæ bearings in the stern tube. This is facilitated by the excellent machines made by Craven Brothers, including two lathes of 6 ft. 6 in. centers, one 60 ft. and the other 70 ft. long, and a planing machine by Collier, of Manchester, with divided table, the halves of which can work separately or together, being capable of planing 10 ft. square and up to 25 ft. long.—*The Engineer.*



HOLLOW LATHE FOR TURNING CRANK PINS.

## WATER PIPES.

At a recent meeting of the Engineers' Club of Philadelphia, the secretary presented, for Mr. A. H. Howland, a paper upon the general subject of water pipes.

As to cast iron pipes, after considering at length the various questions and conditions affecting their proper thickness, the author says: "In relation to the strength of pipes, it is a simple matter to calculate the resistance of a perfect cylinder, made of a certain quality of material, against an internal pressure; but, until you are willing to pay a fair price and insist upon good material and good workmanship, we must pay for an excess of material sufficient to insure us against the poor quality of the material and the carelessness of the workman. Just what percentage to add to the minimum thickness of pipe for all these things is a little uncertain, but, from a careful examination and study of all the data obtainable from 500 different works in the United States and Canada, I have concluded that —for all we have to guard against, either in quality of material, carelessness in manufacture, carelessness in handling or laying, or against water hammer—a factor of safety of five is ample, and this only on the larger pipes.

"At the present time it is perfectly feasible to obtain pipes made of material having a tensile strength of 18,000 lb. to the square inch, and, with such material, the minimum thicknesses of various sizes of pipe, together with their weights and ultimate strength, are as follows:

| Internal Diameter. | Minimum Thickness. | Weight per Foot of Cylinder. | Weight per Foot of Pipe Laid, Including Bells. | Weight per Length to Lay 12 Feet, Including Bells. | Ultimate Strength if Made of 18,000 lb. Iron. | One-fifth of the Ultimate Strength. |
|---|---|---|---|---|---|---|
| 4 | 0·32 | 13·57 | 14·67 | 176 | 2,880 | 576 |
| 6 | 0·35 | 21·82 | 23 83 | 286 | 2,100 | 420 |
| 8 | 0·37 | 30·43 | 33·00 | 396 | 1,665 | 333 |
| 10 | 0·40 | 40 83 | 44·33 | 532 | 1,440 | 288 |
| 12 | 0·45 | 55·00 | 59·83 | 718 | 1,350 | 270 |
| 14 | 0·47 | 66·76 | 72·75 | 875 | 1,210 | 242 |
| 16 | 0·50 | 80·99 | 88·42 | 1,061 | 1,125 | 225 |
| 18 | 0·52 | 94·54 | 102·25 | 1 227 | 1,046 | 208 |
| 20 | 0·55 | 110·95 | 117·92 | 1,435 | 990 | 198 |
| 24 | 0·60 | 114·89 | 156·50 | 1,875 | 900 | 180 |
| 30 | 0·70 | 210·97 | 227·00 | 2,724 | 840 | 168 |
| 36 | 0·80 | 289·04 | 310·75 | 3,729 | 800 | 160 |
| 40 | 0·85 | 340 87 | 369 25 | 4,431 | 765 | 153 |
| 42 | 0·90 | 379·03 | 410·58 | 4,927 | 770 | 154 |
| 48 | 1·00 | 481·02 | 521·08 | 6,253 | 750 | 150 |

After discussion of the above figures and of the facility with which he considers a 6 in. pipe of but $\frac{3}{10}$ in. in thickness can be successfully tapped for service connections, the author proceeds: "In the reports from 38 different places using 24 in. pipes under various pressures, I find one place using pipe weighing as light as 182 lb. to the foot, which would be about $\frac{7}{10}$ of an inch in thickness; while another works, under the same pressure and probable circumstances, uses pipes weighing 3′6 lb. to the foot, or about 66 per cent. in excess of the lighter. I do not know that I have strength of conviction enough to advocate the use of 24 in. pipe only $\frac{6}{10}$ of an inch in thickness, for any works where there is any pressure at all, although my estimates and figures show that it would be perfectly safe; but it is so radically different from custom that I have, to a certain extent, given way to custom and prejudice, and have adopted as standard weights for all pipes used in works, contracted for by myself, as follows:

| Internal Diameter. | Thickness, Inches. | Weight per Foot of Cylinder. | Weight per Foot of Pipe Laid, Including Bells. | Weight per Length of Pipe to Lay 12 Feet. | Ultimate Strength when Made of Iron Having Tensile Strength of 18,000 lb. | One-fifth of the Ultimate Strength. |
|---|---|---|---|---|---|---|
| 4 | 0·40 | 17·27 | 18·75 | 225 | 3,600 | 720 |
| 6 | 0 42 | 26·46 | 28·92 | 347 | 2,515 | 503 |
| 8 | 0·45 | 37·33 | 40·50 | 486 | 2,025 | 405 |
| 10 | 0·50 | 51·54 | 56·17 | 673 | 1,800 | 360 |
| 12 | 0·55 | 67·76 | 73·75 | 885 | 1,650 | 330 |
| 14 | 0·58 | 83·02 | 90 67 | 1,088 | 1,490 | 298 |
| 16 | 0·60 | 97·78 | 106·78 | 1,281 | 1,350 | 270 |
| 18 | 0 64 | 117·11 | 126·67 | 1,520 | 1,280 | 256 |
| 20 | 0·70 | 142·25 | 153·43 | 1,841 | 1,260 | 252 |
| 24 | 0·80 | 194·77 | 210·33 | 2,524 | 1,200 | 240 |
| 30 | 0 90 | 273·00 | 285·33 | 3,524 | 1,080 | 216 |
| 36 | 1·00 | 363·22 | 390·50 | 4,686 | 1,000 | 200 |
| 40 | 1·10 | 443·82 | 480·83 | 5,770 | 990 | 198 |
| 42 | 1·16 | 491·49 | 532·42 | 6,389 | 995 | 199 |
| 48 | 1·30 | 629·16 | 681·58 | 8,179 | 975 | 195 |

Cement lined pipes, so called, are next discussed. Their mileage is given as next to that of cast iron, and

the attractive feature of their cheapness in first cost noted. As to the results of their use the author says:

"Three years ago I sent personal letters to every department whose address I could obtain, throughout the United States and Canada, that had ever used wrought iron cement lined pipe, and received a very large number of replies. From a careful study of these replies, I find that the average life of the cement pipe, as usually made, was eight years, and that no place, with two exceptions only, that had had these pipes in use for a longer period than eight years recommended them.

"The objection to this class of pipe is: first, cement mortar, composed of one-half sand and one-half cement, is not an impervious material, and water, under ordinary pressure, is forced, to a greater or less extent, through it, and so comes in contact with the shell, which it eats until it has no strength left, when the pipe is destroyed. In examining many miles of this pipe which has been taken out and replaced with cast iron, I have noticed that wherever a joint was made and covered with neat cement, the iron has been in almost as good condition as the day the pipe was laid, and this gives rise to the belief that a wrought iron shell, lined and coated with neat cement, would have greater durability and life than one lined and coated with cement mortar. Whether such a pipe can be perfectly made or not is a serious question, and is the only question which prevents a much larger and more general use of this kind of pipe. The many manipulations necessary before the pipe is complete in the trench, and the fact that both the lining and coating depends, for its efficiency, upon the manipulation of mechanics, allows too many possible mistakes or errors to creep in and so render the pipe imperfect."

Wrought iron coated pipes are next considered, with their advantages, and the objections thereto on the score of durability, with the various processes which have been devised for their preservation. The author says: "It is my opinion that wrought iron pipes treated in some one of the methods indicated, or in some method yet to be discovered, will soon supersede, in most cases, all other kinds of pipe."

Wooden, earthenware, composition, and glass pipes are noted in concluding the paper. All but the latter the author treats as of little general importance. As to glass pipes, he says: "Glass pipes of large diameter have not been successfully produced, but it has been predicted by several large glass manufacturers that it will not be long before some method of casting these pipes successfully and cheaply will be devised.

"Made in form similar to our present cast iron pipes, with some suitable device for a joint, and of a malleable glass, they would form a water pipe to which there could scarcely be an objection—strong, tough, smooth, and indestructible, and made of a material that is found almost everywhere. It is not without the range of probability that whenever a large quantity of pipe is to be used in any one locality, a furnace will be erected and the pipes made where they are to be used."

## WHEEL MOULDING MACHINE.

WHEEL moulding by machinery is no novelty, and among those who have largely contributed to the practical success of the system is the firm of Messrs. William Whitaker & Sons, of the Sun Iron Works, Oldham. An improved wheel moulding machine of this firm we now illustrate. It is self-contained, and all the parts are arranged so as always to maintain their relative positions with respect to themselves and to the work. The wheels are moulded in a box, which is placed on a revolving table. Through the center of the table is a shaft, which acts as a center from which the moulds are struck, preparatory to receiving the teeth. The shaft also serves as a guide for the moulding box, which is bored at the center to fit it, and is also prepared to receive a relieving screw under the table, so that the table may revolve with ease whatever the weight upon it. To the under side of the table is keyed an accurately cut division wheel, into which is geared a worm. This wheel and worm are well protected by the table and the upper part of the circular base. Motion is given to the table from the handle through the change wheels. On the side of the circular base is attached the extension slide. This slide is provided to extend the radius between the center spindle and the pillar, so as to admit of large as well as small wheels. By means of this slide, wheels may be moulded with facility, from three inches to eight feet diameter. To this slide is fitted a socket, which is bored throughout to receive the pillar for supporting the horizontal slide. At the longer end of the vertical slide is the socket for carrying the block or pattern to be moulded from. The pillar is made so as to be raised or lowered through the socket by means of the rack and pinion, so as to dispense with unnecessary length in the vertical slide. By this means the machine is more rigid, and the weight to be lifted every time the pattern is withdrawn from the mould is reduced. The radius of wheel is obtained by moving the arm to or from the center of the machine, using the pillar as a center, kept in position by the set screws in socket. The vertical slide is used for lowering or raising the pattern to or from the mould by means of the hand wheel rack and pinion attached to the slide.—*Iron.*

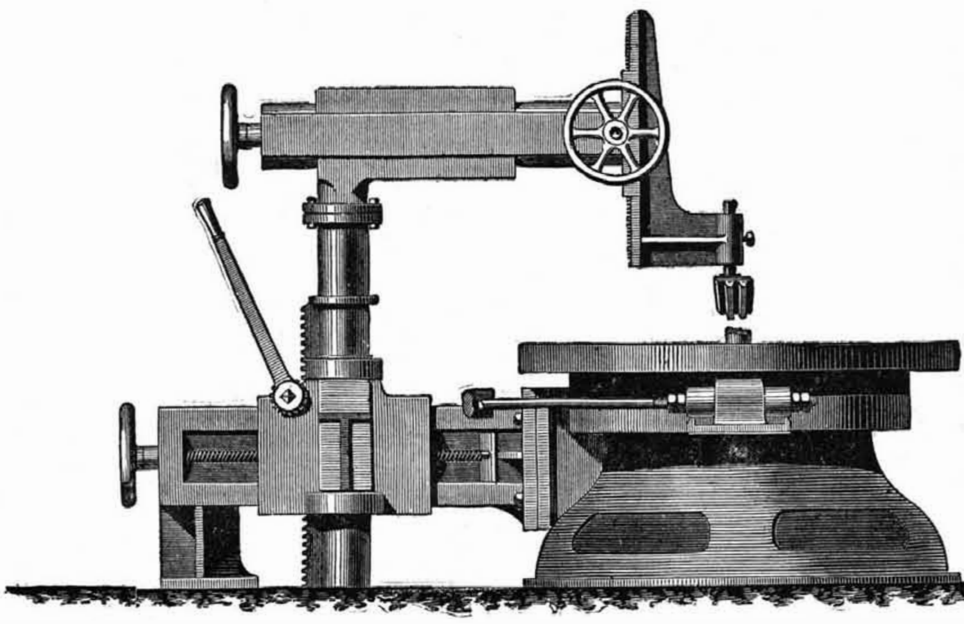


FIG. 1.

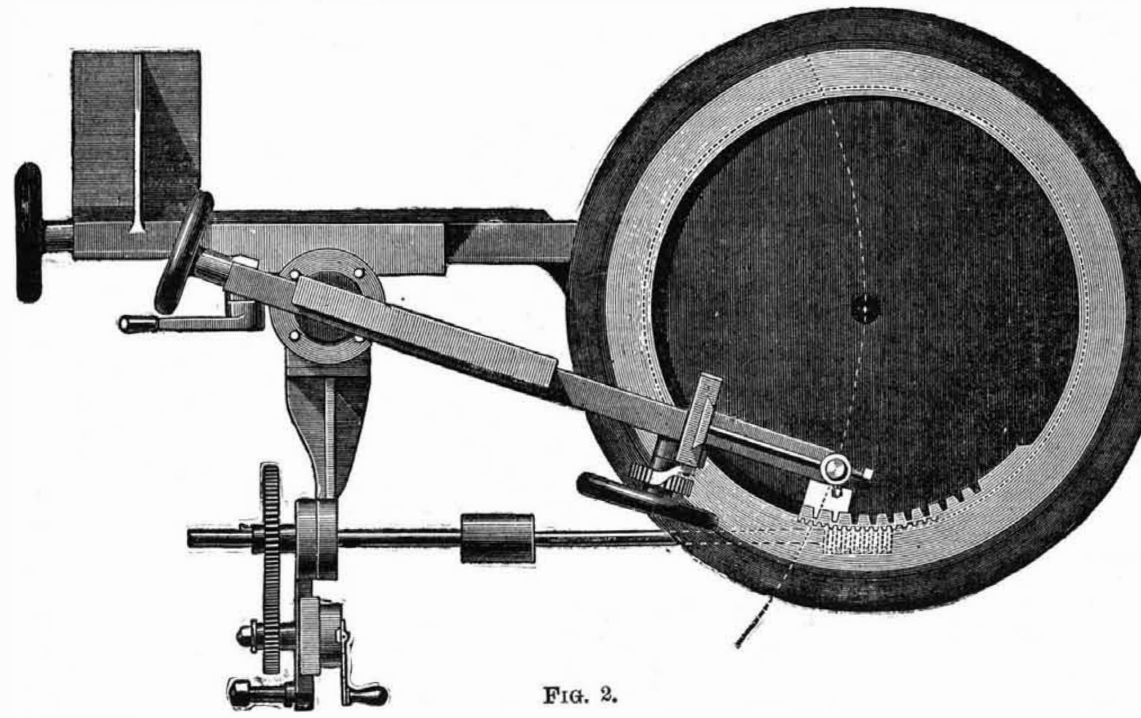


FIG. 2.

WHEEL MOULDING MACHINE

ISAAC LEA, LL.D., the American naturalist, who earned world-wide fame for his extensive scientific researches, died Tuesday morning, December 7, at his residence in Philadelphia, in the ninety-fifth year of his age. Dr. Lea was a member of the Zoological Society of London, the Linnæan Society of Bordeaux, the Imperial Society of Natural History of Moscow, and an honorary member of the Asiatic Society of Bengal; and at the time of his death he was an honorary member of nearly all the scientific, philosophic, and historical societies of the world. He was president of the Academy of Natural Sciences of Philadelphia from 1853 to 1858.

## ELEMENTARY EDUCATION ON THE CONTINENT.

MR. MATTHEW ARNOLD has but lately resigned the office of her Majesty's inspector of schools, a position which he has filled for many years with credit to himself, and with great benefit, we are sure, not only to such schools as have come under his immediate supervision, but also to English educational interests in general. One of his last official duties of any importance was to visit Germany, Switzerland, and France, and to write an official report on certain specified points connected with elementary education in those countries. Some portions of that report were used by Mr. Arnold in his address before the University of Pennsylvania, which was printed afterward in the *Century* magazine. But the entire report is of the liveliest interest of American educators; for several of the points investigated by Mr. Arnold are those to which no little attention is being paid in this country, and all the information gathered by him is part of the material to be used by the comparative method in studying educational institutions and methods.

By the terms of Mr. Arnold's instructions, his attention was to be more particularly directed to Germany and Switzerland, and the points he was to study were four in number: 1. Free education. 2. Quality of education. 3. Status, training, and pensioning of teachers. 4. Compulsory attendance, and release from school. Only fourteen weeks were given to the inquiry; and of these, five were spent in Prussia, two in Saxony, two in Bavaria, two in Switzerland, and three in France. Mr. Arnold's latest mission, as he expressly states, differed from those of 1859 and 1865 in that he did not go now to study systems of education, but only to report on the four above mentioned points. These points Mr. Arnold takes up in order.

Under the head of free education, he was instructed to ascertain whether gratuitous education is confined to elementary schools, or extends to other schools or colleges; what reasons induced the state to establish the gratuitous system; in what way (directly or indirectly) the lower classes of society are made to feel the weight of the expenditure on education; in what way the dirty and neglected children in large towns are dealt with, and especially whether all descriptions of children are mixed in the same schoolroom; whether there is a legal prohibition against charging fees in public schools, even if parents and children are willing to pay; whether the attendance of children has increased or diminished since the establishment of free schools. Mr. Arnold answers these questions first with the information gained by him in Prussia. In the Prussian constitution of 1850 is this provision: *In der offentlichen volksschule wird der unterricht unentgeltlich ertheilt.* But this provision has generally remained inoperative, because the popular school is to be maintained by the *Gemeinde*, or commune, and the communers have not in general found themselves able to forego the income from school fees. And, on the other hand, the state has not been able or willing to provide gratuitous instruction in the communes. Some few communes, however, have been able to throw their popular schools open to all classes of the population, free of all charge. Dusseldorf has done so; so has Berlin. The Berlin schools have been free since 1870, and last year it cost more than 6,000,000 marks to support them. At the time of the introduction of free schooling, the municipality had 49 communal schools, with 31,752 scholars; in 1885 it had 146 such schools, with 132,889 scholars. These communal schools are the only body of schools in Berlin, or throughout Prussia, in which school fees are not paid. Herr Von Gossler, minister of education, was found by Mr. Arnold to favor making the communal schools free everywhere, and Prince Bismarck is said to agree with him. But among the public generally, including the teachers themselves and the government officials, the weight of opinion is against such a course. Even where school fees are charged, they meet but a small portion of the total expense. On an average for the whole of Prussia, school fees furnish 20·58 per cent. of the cost of teaching in the popular schools; endowments, 12·02 per cent.; the communes, 55·26 per cent.; and the state, 12·14 per cent. In some towns, Cologne for example, where the popular schools are not free, provision has been made for giving free instruction to poor children in schools by themselves. But in Berlin the children of the working and middle classes all attend school together. The only distinction made on the ground of poverty at Berlin is that school books and school material are supplied gratuitously whenever the teacher finds that the child cannot afford to buy them.

But throughout Germany, payment is the rule, free schooling the exception. The popular school is a municipal thing, and is paid for out of municipal taxes. No special school tax is levied.

In Switzerland there is also a constitutional provision determining free schooling. Article 27 of the Federal constitution of May 29, 1874, says, "Primary instruction is obligatory, and in the public schools gratuitous." So jealous are the cantons of their local independence, that there is no national department of education. Yet each canton has complied with the above article of the constitution. Mr. Arnold takes as examples canton Zurich, which is Protestant and industrial, and canton Lucerne, which is a mountain canton, and Catholic. In Lucerne the child must come to school at seven years old, and may come at six; his day school course lasts until he is fourteen; and he has then, unless he goes to some higher school, to attend a *fortbildungsschule* for two years more. In Zurich the child must come to school at six years old; his day school course lasts until he is twelve; and he must then spend three years at an *erganzungschule*, besides an hour a week at a singing school. All these schools are free, and in canton Lucerne the higher schools are free also. Religious instruction is given in the popular schools in the several cantons according to the faith of the majority. Catholic instruction is given in Lucerne, Protestant in Zurich. There is, according to Mr. Arnold, no unfair dealing, no proselytizing, no complaint. In Switzerland there is no separate provision for dirty and neglected children, because there is no such class. Fifteen years ago there were 1,500 pupils attending the great town school of Lucerne; now there are 3,300. "I regard free schooling, however," says Mr. Arnold, "rather as a part and sign of the movement of advance in popular education than as itself the cause of the movement."

In France, Mr. Arnold found that the payment of fees in public primary schools was abolished in 1881, and that attendance at school is obligatory for children of both sexes between the ages of six and thirteen. This is ascribed to no constitutional provision, as in Germany and Switzerland, but to *l'idee democratique*, a moving cause at which Mr. Arnold sneers a little. No religious instruction is allowed in these schools, for democracy in France is at war with clericalism. The result is that there is much complaint, and rival schools, established by private effort, are numerous. The Catholics alone have raised for their schools in Paris over 15,000,000 francs in the last six years, and at the present time educate in their schools one-third of all the school children of Paris. As to how these public primary schools are supported, the report summarizes thus: "The communes had formerly to maintain their primary schools out of their own resources, supplemented, if necessary, by an addition of four centimes to the four direct taxes for the commune; further supplemented, if still necessary, by an addition of four centimes to the four direct taxes for the department; supplemented finally, if still necessary, by a grant from the state. These eight centimes for the commune and department have now been made regular and fixed taxes paid to the state. Since 1882 the state has relieved of all further charge for their primary schools those communes which could not meet such charge out of their own resources. Only the five chief cities of France have undertaken so to meet it, Paris, Lyons, Marseilles, Bordeaux, Lille. In all the other communes of France the cost of primary instruction is met out of the public taxes by the state. When, therefore, it is asked how the lower classes feel the weight of the expenditure on education, the answer must be, so far as they feel their share in the general taxation of the country to be increased by it. And this probably they do not feel at all."

Mr. Arnold found a very large increase, both in the outlay for primary schools and in the number of children attending them, since he last saw them in 1859. At present the state bears nine-tenths of the annual expense of primary instruction, and spends over 80,000,000 francs on it. The municipality of Paris had, in 1884, 361 primary schools, with accommodations for 121,798 scholars.

The second subject of inquiry related to the quality of the education given; and Mr. Arnold speedily found that the suggestion of his official instructions, that he determine this by having the teachers set papers in arithmetic and dictation on the model of those set in England, could not be carried out, because the whole spirit and course of teaching was opposed to setting in school hours a number of sums, and leaving the children to do them by themselves. So Mr. Arnold determined to secure an answer to this question by seeing and hearing what the scholars did; and the popular schools of the free city of Hamburg he chose for the test. He concludes that in German schools, as a rule, the programme is fuller, the course longer, and the instruction better, than in England. The methods of teaching seemed more gradual, more natural, more rational, on the Continent than in England. He wrote again and again in his notes, '*The children human.*' As to the school course at Hamburg, we read: "The fixed matters of the course are religion, German language, English language, object lessons, history, geography, natural history, arithmetic and algebra, geometry, writing, drawing, singing, and gymnastics. English must be taught in the popular schools from the thrid class upward, and French comes in as an optional matter (the only one), and to take it the consent of the *oberschulbehorde* is required. The two lower classes have each of them 26 hours of schooling a week, the class next above them has 28, the four higher classes have 32 each. Some of the popular schools in Hamburg, like those in Berlin, meet once a day only. In summer the schools meet at 8 in the morning, and the different classes go on till 12, 1 or 2, on different days in the week, so that each class shall make its proper number of weekly hours. In winter they meet at 9 and go on an hour latter. No week day is a holiday, like the Saturday with us and the Thursday with the French. Other schools have two daily meetings, from 8 to 11 or 12, and from 2 to 4, the proper number of hours for each class being again always made. Local convenience determines whether the school shall have two daily meetings or one. The pressure which the long attendance from 8 to 2 or from 9 to 3 would seem likely to exercise is remedied by an arrangement which I found general in German countries, and which works very well. At the end of each hour the class disperses to the corridors and playground, and the teachers to the teachers' meeting room. In ten minutes a bell rings, and the classes and teachers reassemble refreshed. How much the work of a long morning is lightened by this simple plan may be observed by any one of school experience who will pass a morning in a German or Swiss school."

In German grammar the children learn the declension of nouns, comparison of adjectives, and conjugation of verbs. In history, where the prescribed aim is to make the pupil acquainted with the prominent persons and points in the development of mankind in general, and of the German nation in particular, biographical notices form the principal subject matter. In religion, parables and hymns are learned and said by heart, and instruction is given in the literary history and translation of the Bible. Everywhere in Germany Mr. Arnold thought the text-books used good. The following passage merits quotation in full: "In the specially formative and humanizing parts of the school work, I found in foreign schools a performance which surprised me, which would be pronounced good anywhere, and which I could not find in corresponding schools at home. I am thinking of literature and poetry and the lives of the poets, of recitation and reading, of history, of foreign languages. Sometimes in our schools one comes across a child with a gift, and a gift is always something unique and admirable. But in general in our elementary schools when one says that the reading is good, or the French, or the history, or the acquaintance with poetry, one makes the mental reservation, 'good, considering the class from which children and teachers are drawn.' But in the foreign schools lately visited by me I have found in all these matters a performance which would be pronounced good anywhere, and a performance, not of individuals, but of classes. At Trachenberg, near Dresden, I went with the inspector into a schoolroom where the head class were reading a ballad of Goethe, 'Der Sanger.' The inspector took the book, asked the children questions about the life of Goethe, made them read the poem, asked them to compare it with a ballad of Schiller in the same volume, 'Der Graf von Habsburg,' drew from them the differences between the two ballads, what their charm was, where lay the interest of the middle age for us, and of chivalry, and so on. The performance was not a solo by a clever inspector; the part in it taken by the children was active and intelligent, such as would be called good if coming from children in an altogether higher class of school, and such as proved under what capable teaching they must have been. In Hamburg, again, in English, and at Zurich, in French, I heard children read and translate a foreign language with a power and a pronunciation such as I have never found in an elementary school at home, and which I should call good if I found it in some high class school for young ladies. At Zurich, I remember, we passed from reading and translating to grammar, and the children were questioned about the place of pronominal objects in a French sentence. Imagine a child in one of our popular schools knowing, or being asked, why we say *on me le rend*, but *on le lui rend*, and what is the rule on the subject!"

And the instruction is better in foreign schools, because the schools are better organized, and the teachers better trained, than those in England. This brings us to the third general subject treated in the report, the status, training, and pensioning of teachers.

To begin with, it may be safely said that teachers in Germany, France, and Switzerland come from the same class of society as do teachers in England. For mention of all that is interesting and valuable in Mr. Arnold's report about the training of teachers, we have no space; but we give an abstract of the training in a typical instance, in Saxony.

The training school course there lasts six years. But a youth enters at the age of about 14, with the attainments required for passing an examination for the *entlassungs-zeugniss*, or certificate of discharge, from a *mittlere volksschule*, or popular school of the second grade, a school which in Saxony must be organized in at least four classes, with a two years' course for each. In the training school, instruction and lodging are free; a small sum is paid for board, but a certain number of free boarders, "gifted poor children," are admitted. To the training school is attached a practicing school, organized as a *mittlere schule*, a middle school with four classes and 155 scholars. In this school the students see and learn the practice of teaching. Their own instruction they receive in small classes which may not have more than 25 scholars. Their hours in class may not exceed 36 a week, not counting the time given to music. The matters of instruction are religion, German language and literature, Latin, geography, history, natural science both descriptive and theoretical, arithmetic, geometry, pedagogy including psychology and logic, music, writing, drawing, and gymnastics. All of these matters are obligatory, but after the first year students of proved incapacity for music are no longer taught it. One-third of the teaching staff of the training school may be distinguished elementary teachers without university training, but this proportion is never to be exceeded. Each teacher, exclusive of the director, is bound to give 26 hours of teaching in the week. There are half yearly examinations; the six years' term may be lengthened by one year for a student who is deemed not ripe for the leaving examination, which comes at the conclusion of the course. At the end of the course, when the student is about 20 years old, he undergoes the *schulamtskandidaten-prufung*, or examination for office. The examination is both oral and in writing, and turns upon the work of the student's course in the training school. The examining commission is composed of the minister's commissary, a church commissary, and the whole staff of the training college. The staff conduct the examination, the minister's commissary presides and superintends. If the student passes, he receives his *reifezeugniss*, or certificate of ripeness, and is now qualified to serve as assistant in a public popular school, or as a private teacher where his work has not to go beyond the limits of popular school instruction. After two years of service as assistant, at the age of about 22, the young teacher returns to the training school and presents himself for the *wahlfahigkeits-prufung*, or examination for definitive posting. For this examination the commission is composed of the minister's commissary, a church commissary, the director of the *seminar*, and either two of its upper teachers, or else other approved schoolmen named by the minister. This examination again is both written and oral. Mr. Arnold attended the oral part on two days, and heard and saw candidates examined in religion, music, German language and literature, the history of education, pedagogy, psychology, logic, and school law.

Training schools for women are much less numerous in Germany than those for men, because women are much less used in teaching than men; the presumption being that women cannot teach satisfactorily certain matters of instruction in the upper classes of a popular school. The result is that in Prussia there are 115 training schools for men, and 10 for women; in Saxony, 16 for men, 2 for women.

As to teachers' salaries and pensions, custom and law vary greatly. In Prussia in 1878 the average salary of a schoolmaster was £51 12s. per annum. In Berlin the average salary was £103 3s. In France the primary school teachers must rise through a series of grades, to each of which a fixed salary is attached, varying from £36 to £48 for a man, and from £28 to £36 for a woman. If a school mistress marries in Germany, she loses her situation. In all the countries visited by Mr. Arnold, teachers have retiring pensions, to establish which a deduction is made from their salary.

In respect to the fourth and last subject of inquiry, that as to compulsory attendance, Mr. Arnold quotes Saxon law as representative for all the countries visited by him. It is thus: "Every child has to attend, for eight years uninterruptedly, the common popular school in the school district where it resides; as a rule, from the completion of the sixth year of its age to the completion of its fourteenth. Children who by the end of their eighth school year do not attain due proficiency in the principal matters of instruction, that is to say, in religion, the German language, reading, writing, and arithmetic, have to attend school a year longer. The holidays for the popular schools in Saxony are fixed by law, and amount to 44 days in the year. In general the school meets for a minimum of three hours in the morning and of two hours in the afternoon. 'Parents and guardians are bound,' says the law, 'to keep children of school age to a regular attendance in school hours. As a general rule, only illness of the child, or serious illness in the child's family, is ground of excuse for its missing school.' Absences, with their causes, are entered daily by the teacher in the school registers. At the end of every month he hands a list of them to the managers, whose chairman has to bring, within eight days after the end of the month, all punishable absences to the notice of the magistrate, if he has not previously brought the parents to their duty by an admonition, or had the child taken to school by the school beadle, to whom a small fee is due from the parent for his trouble. If, however, the matter goes before the magistrate, this functionary inflicts a fine, which may go as high as 30s., and if the fine is not paid the penalty is changed to one of imprisonment. In Saxony the law prescribes that the number of scholars in a class shall not exceed 60, and that the number of scholars to one teacher shall not exceed 120. In schools with from 60 to 120 children, therefore, if the commune is not rich enough to do more in the way of providing teachers than the law actually requires, two classes are formed, and a reduction of school time takes place for each, in order to allow the one master to conduct them separately."

The rural population greatly prefer the half day school, as it is called, because they thus have the older children at their disposal for half the day.

Mr. Arnold concludes his valuable paper with three comments: 1. The retention of school fees is not a very important matter; something can be said for and against it, but the weight is in favor of their retention. 2. Keep improving our schools and studying the systems of other countries. 3. Organize the secondary instruction not only in the interest of that instruction itself, but in the interest of popular instruction. This last remark applies with peculiar force to education in the United States.

Mr. Arnold's report is free from official dryness, and reads more like an essay than a government document. —*Nature.*

## USE OF OIL AT SEA.*

THE following memorandum, dated June 16 last, on the use of oil at sea for modifying the effect of breaking waves, has recently been printed and circulated by the British Admiralty:

"Many further practical experiments at sea have been made since the report by Capt. Chetwynd, R.N., to the Royal National Lifeboat Institution, dated September 30, 1884, on the use of oil for smoothing broken or troubled waters, which report was communicated to commanders in chief in Admiralty circular letter of December 1, 1884, N.S. $\frac{3206}{8305}$.

"As these further experiences go to show that the use of oil, under different circumstances, is of very extended and simple application, my Lords Commissioners of the Admiralty consider it desirable, in order that the facts may be generally known, to reissue the report above mentioned, together with such other information as may serve for the guidance of officers, whose attention is hereby called to the fact that a very small quantity of oil skillfully applied may prevent much damage both to ships (especially the smaller classes) and to boats by modifying the action of breaking seas.

"The principal facts as to the use of oil are as follows:

"On free waves, *i. e.*, waves in deep water, the effect is greatest.

"In a surf, or waves breaking on a bar, where a mass of liquid is in actual motion in shallow water, the effect of the oil is uncertain, as nothing can prevent the larger waves from breaking under such circumstances; but even here it is of some service.

"The heaviest and thickest oils are the most effectual: refined kerosene is of little use; crude petroleum is serviceable when nothing else is obtainable; but all animal and vegetable oils, such as waste oil from the engines, have great effect.

"A small quantity of oil suffices, if applied in such a manner as to spread to windward.

"It is useful in a ship or boat, both when running, or lying to, or in wearing.

"No experiences are related of its use when hoisting a boat up in a seaway at sea, but it is highly probable that much time and injury to the boat would be saved by its application on such occasions.

"In cold water, the oil being thickened by the lower temperature, and not being able to spread freely, will have its effect much reduced. This will vary with the description of oil used.

"The best method of application in a ship at sea appears to be hanging over the side, in such a manner as to be in the water, small canvas bags capable of holding from one to two gallons of oil, such bags being pricked with a sail needle to facilitate leakage of the oil.

"The position of these bags should vary with the circumstances. Running before the wind, they should be hung on either bow, *e. g.*, from the cathead, and allowed to tow in the water.

"With the wind on the quarter, the effect seems to be less than in any other position, as the oil goes astern, while the waves come up on the quarter.

"Lying to, the weather bow and another position farther aft seem the best places from which to hang the bags, with a sufficient length of line to permit them to draw to windward while the ship drifts.

"Crossing a bar with a flood tide, oil poured overboard and allowed to float in ahead of the boat, which would follow with a bag towing astern, would appear to be the best plan. As before remarked, under these circumstances the effect cannot be so much trusted.

"On a bar with the ebb tide, it would seem to be useless to try oil for the purpose of entering.

"For boarding a wreck, it is recommended to pour oil overboard to windward of her before going alongside. The effect in this case must greatly depend upon the set of the current and the circumstances of the depth of water.

* From the *Board of Trade Journal.*

"For a boat riding in bad weather from a sea anchor, it is recommended to fasten the bag to an endless line rove through a block on the sea anchor, by which means the oil is diffused well ahead of the boat, and the bag can be readily hauled on board for refilling if necessary."

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[NATURE.]

## ON THE NATURE OF SOLUTION.*

IN connection with the discussion on the "Nature of Solution," in Section B, at the Birmingham meeting of the British Association, the following paper was read by Spencer Umfreville Pickering, professor of chemistry at Bedford College:

The "hydrate" theory attributes dissolution to the existence, in a stable or partially dissociated condition, of definite liquid compounds (generally unknown in the solid form) of the substance dissolved and its solvent, and the mixing of these compounds with excess of the solvent.

In certain special instances we have direct evidence of the reality of such compounds,† but it is on general grounds rather than on any special experiments that I would seek to establish their existence.

There is, in the first place, a strong *prima facie* improbability that substances such as copper sulphate, potassium hydrate, etc., which possess such an intense affinity for water, should be capable of existing in the anhydrous condition in the presence of an unlimited amount of water.

We know, moreover, that in a great number of cases—where a dehydrated salt is placed in water—hydration does undeniably precede dissolution,‡ and in such cases the salt can only exist in the liquid in the uncombined state if the continued action of the solvent is to decompose the hydrate which it has just formed. The only two forces by which such a decomposition might be supposed to be effected are (1) the attraction of the bulk of the water present for the few molecules of water combined with the salt; (2) the attraction of this same bulk of water for the (anhydrous) salt molecules. On the one hand, however, it is absurd to imagine that the mass of water molecules possess such a strong attraction for the few contained in the hydrate as to decompose this latter, or, even if they did, that they would ever have given them up to the salt in the first instance. And, on the other hand, it is equally absurd to urge the intensity of the attraction of the salt molecules for the water molecules as a reason for these two parting company.

Another general fact, which lends considerable support to the view that the dissolution of a salt is due to the formation of a hydrate, is, that those salts which *combine* with water always *dissolve* in that liquid, and, as a rule, the greater the energy with which they do combine with it, the greater is their solubility.

The thermal phenomena attending the act of dissolution point incontestably to the same conclusion. When a dehydrated salt (say $MgSO_4$) is dissolved in water, a considerable evolution of heat occurs; and by the simplest experiment it can be established, beyond any possibility of doubt, that all or the greater portion of this heat is due to the hydration of the salt. If the salt be taken in the hydrated condition, less heat is evolved, and, without a single known exception, this evolution diminishes continuously as the salt taken is more and more highly hydrated. But even when taken in its most highly hydrated condition, the evolution of heat is in many cases still very considerable.§ Now, unless we can reconcile ourselves to attribute the heat evolution in this latter case to a cause entirely different from that which exists in the other cases—unless we are content to shut our eyes to the proportionality between the heat evolved and the degree of hydration of the salt taken—we must admit that even with a fully hydrated solid salt the heat evolved is due to further hydration. That not only do hydrates exist in solution, but that they are often of a higher order than the highest known in the solid condition.

Coming now to the other side of the question, we find many general considerations, as well as special results, brought forward against the hydrate theory of solution. The latter, however, are for the most part, I consider, urged on mistaken notions, and prove nothing *pro* or *con*.

Thus Dr. Nicol's study of the molecular volumes of salts in solution shows that their volumes are entirely uninfluenced by the presence or absence of water of crystallization in the solid salt. That if any water is still combined with the salt when dissolved it acts in the same way, and is quite indistinguishable from the rest of the solvent present. In so far as his conclusion that these molecular volumes afford no evidence in support of the existence of combined water, I entirely agree with Dr. Nicol. But in concluding that therefore no water is combined, he has pushed his conclusions far beyond legitimate limits. The same reasoning that leads to the belief that the water and the salt bear no chemical relationship toward each other in solution would hold equally good with reference to the radicals of which the salts themselves are constituted, as Favre and Valson indicated in 1875 (*Comptes Rendus*, lxxv., 1,000). Each radical possesses its own specific volume entirely uninfluenced by the nature of the other radical with which it is combined. The radicals behave independently, and as if there were no combination between them.

Nor is it only from the study of the volumes of salts in the dissolved state that such results are obtained. Numerous determinations of the extent to which the vapor pressure, the freezing point, and the temperature of maximum density of water is influenced by the presence of various salts in it, have been made by Wullner, Blagden, Dufour, Depretz, Rudorff, and De Coppet,* with the general results that certain hydrates of the salt are in some cases present, and in others the salt is anhydrous; but these conclusions, which would tell more against the hydrate theory than for it, are eminently unsatisfactory. The whole question, however, has been reopened by Raoult (*Ann. Chim. Phys.* (5), 28, 123; (6), 2, 66, 4, 401); and by an exhaustive extension of the work, and by including solvents other than water, and solids other than salts, he has thrown a new light on the subject. Not only does the salt, in its influence on the freezing point, show no signs of the presence of combined water, but it shows no signs of itself being a single compound; each of the radicals contained in it acts independently of the other, and in precisely the same manner as a *molecule* of a non-saline substance (see especially *loc. cit.* 4, 426). Precisely similar conclusions as to the apparent non-combined state of radicals in a dissolved salt were arrived at by Valson in his work on capillarity (*ibid.*, 1870) and by Hugo and Vrie (*ibid.*, 1883) in their examination of the effect of membranes on salt solutions. Other instances of a similar nature, physical and thermo-chemical, might be quoted.

That atoms or molecules, which are undoubtedly united, may retain their individuality so far as to act toward certain agents as if they were free, is surely not surprising; and from such methods as would lead us to conclude that the very radicals composing a salt are uncombined, it would be useless to look for evidence of the more feeble combination of the salt with its water, and inconsistent to argue, from the absence of such evidence, that no combined water is present.

Although I am not inclined to attribute any weight to these special experiments brought forward against the hydrate theory, it is otherwise with more general considerations.

The formation of hydrates cannot explain the absorption of heat, which in many cases accompanies dissolution. The phenomena of solution are too universal to permit of imagining the existence of some definite compound of the dissolved substance with the solvent in every case. There is a continuous influence exerted by the salt on its solvent too extensive to be accounted for by the effect of mass on partially dissociated hydrates; there is a continuity between the fused and dissolved states in many cases, and a regularity in the variation of solubility with change of temperature, etc., which cannot be thoroughly explained on the hydrate theory.

However undeniable the existence of these compounds may be in many cases, they do not give an adequate explanation of all the facts of dissolution.

The hydrate theory can be neither rejected nor accepted.

The explanation of this contradiction is not, I think, very difficult to find. We are talking about molecules of solids and liquids, not as they exist, but as they do *not* exist. Our chemical formulæ for them represent but the results of analysis, or, at the most, the constitution of the substance in that transitory state of simplification which immediately precedes entire decomposition; what their composition may be when in the free state, and removed from all decomposing forces, we know not; all we do know or believe about them is, that they are then far more complex than chemical formulæ represent.

Crystalline form alone would show that a number, probably a very great number, of our so-called molecules combine together, bear certain definite relations and hold certain definite positions toward each other, producing a molecular aggregate or physical unit, which alone should receive the name of molecule.†

Just as a number of similar particles unite to form an aggregate or true molecule of any simple substance, so will dissimilar particles unite to form aggregates of a more complex nature.

It is but natural that our prejudices in favor of the "laws" of chemical combination and atomic valency, to which we owe so much, should lead us to attribute the variable composition of certain substances to our imperfect means of investigation rather than to the nonconformity of these substances to our laws. Whether we be right or not in our explanation, we must acknowledge that apparent inconstancy in composition is one of the most marked features of immense classes of substances which cannot be termed other than chemical compounds.

The varied composition of minerals is said to receive an explanation in the statement that isomorphous substances may displace each other in definite proportions, but to an indefinite extent. This is undoubtedly true, but it does not obviate the necessity of recognizing the existence of some form of attraction between these isomorphous substances. No purely mechanical or physical cause can explain this phenomenon; mere similarity of crystalline form has been proved to be incompetent to produce such results. A selective power is exhibited by the substances which thus unite‡ as well defined as that selective power which in the case of simpler substances has received the name of chemical affinity, and the resulting compounds are characterized by the same uniformity in composition and physical properties,§ which is the attribute of acknowledged chemical compounds.

Nor is it with minerals and artificial crystals only that we find ourselves in what would appear to be a wide borderland between chemical compounds and mixtures. Whether we study the formation of alloys, the occlusion of gases by solids, ranging from the most mechanical action by insensible gradations to the formation of a substance having every appearance of a definite compound, or the decomposition of some of the firmest chemical bodies by so-called mechanical means (filtration), or the constant change in the composition of many basic salts, with change in the circumstances of their formation, we are forced to admit that the definiteness which characterizes the combination of atoms may be absent from, or at any rate unrecognizable in, the combination of our so-called molecules to form complex aggregates.

When we examine the constituents of these apparently indefinite compounds, it becomes clear that it is only substances which resemble each other which can combine in this manner; and one of the most striking features of dissolution offers such a strict parallel to this, that its meaning can scarcely be mistaken.

A certain degree of similarity in nature between the solvent and the substance dissolved is the invariable accompaniment of dissolution.

Dissolution, I believe, is but one of the many results of apparently indefinite chemical combination.

We cannot obtain a satisfactory explanation of the composition of minerals by admitting the existence of *definite* double salts only, nor can we explain the phenomena of dissolution by confining our attention to *definite* hydrates only. These may, and in all probability do, exist in solution, but they are only small circles within the larger ones; their successive formation and decomposition would give rise to irregularities and effects such as those which are observed in some cases; but these irregularities would form but ripples on the more regular changes which would accompany the variations in the molecular aggregates—variations which, as in the case of minerals, would be so dependent on physical conditions as to obliterate their chemical nature when examined from many points of view.

The evolution of heat accompanying dissolution will still be attributable, as on the ordinary hydrate theory, to the formation of chemical compounds, but the far greater complexity, and, consequently, instability, of these, than of atomic hydrates, if I may so call them, will remove all difficulty in comprehending the continuous effect of the mass of the solvent upon them, even when the latter exceeds that of the salt many hundredfold. Where heat is evolved, therefore, the evolution will be increased, though at a diminishing rate, by dilution.

The rapid increase in the heat of dissolution, produced by a rise of temperature, is but a necessary consequence of the formation of a chemical compound possessing a specific heat less than the sum of those of its components, and would of itself go far to prove that a solution did in reality contain such a compound. But a rise of temperature would also undoubtedly have another and opposing effect, for, being inimical to the complexity of these hydrates, they would be more dissociated at higher than at lower temperatures, and hence the heat of dissolution would not be so great as it should be according to the various specific heats. This is precisely what Dr. Tilden has proved to be the case (*Proc. Roy. Soc.*, 1885, 401).

There is, however, another action which I believe accompanies every act of dissolution resulting in the *absorption* of heat.

The heat absorbed by a large number of salts in dissolving cannot be freely accounted for by the mere physical change of the solid into the liquid salt. Thus, the heat of dissolution of potassium nitrate is —8,500 cal., and that of sodium nitrate —5,000 cal., whereas the heat of fusion of these salts at the same temperature is but —1,300 and —2,300 cal. respectively. There must be some other heat-absorbing action besides the fusion of the salt. The amount of heat thus absorbed increases also with the dilution of the liquid. Moreover, we cannot, I think, account for the manner in which heat is evolved in one case and absorbed in another, or the way in which an absorption of heat sometimes gives place to an evolution, as the temperature or other conditions are changed, but by admitting the constant co-existence of two actions producing opposite thermal effects, and being influenced to different extents by an alteration of circumstances.*

On the theory which I am here advocating, this absorption of heat receives a ready explanation. Whatever be the complexity of the molecular aggregates of a liquid, those of a solid will be still more complex. Fusion would, therefore, entail their simplification: it would be but a chemical decomposition absorbing heat; this simplification would be pushed much further, however, when the salt is dissolved instead of being merely fused, for the particles of the liquid act chemically (*ex hyp.*) on those of the solid, and combine with them themselves; the cold absorbed on dissolution would exceed that absorbed on fusion, and would, moreover, be increased by increasing the amount of the solvent. This accords fully with the facts observed.

All the phenomena attending dissolution are, therefore, I contend, accounted for by a full recognition of the real complexity of the units of matter, and by taking the more liberal view of chemical combination which is inculcated by a study of minerals and other substances. Every act of dissolution involves two actions, the chemical decomposition of the more complex aggregates of the solid into a simpler form, absorbing heat, and a chemical combination of these with the liquid, evolving heat. The only quantity which we can at present measure is the algebraic sum of these two.

Mr. Durham next gave a short statement of his own theory of solution:

When, for example, common salt (NaCl) is placed in water, all the atoms act upon each other. The sodium of the salt acts upon the oxygen of the water, and the chlorine of the salt upon the hydrogen of the water; and the result is a definite compound, which we call a solution. The heat of formation of the acid is neutralized by the heat of formation of the oxide. If they be not equal, the difference is the heat of the solution; if they be equal, the heat is of course *nil*. If the former be the greater, the heat of the solution is negative; if the latter, it is positive. Solution arises from chemical affinity, and takes place inversely as the attraction between the positive element and the oxygen—and the negative element and the hydrogen—of water. But chemical affinity is itself physical; the atoms are physical, and all forces which act upon them must be physical forces. In a chemical mixture every atom

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* See SUPPLEMENT No. 574, page 9,173, for commencement of this discussion.

† See especially Berthelot, *Ann. Chim. Phys.* (5), 4, 445 to 537.

‡ Dr. Nicol (*Phil. Mag.* 1885, i., 453, and ii., 295) quotes experiments with sodium sulphate in opposition to this view. He shows that the dehydrated salt may dissolve in water under certain circumstances without any signs of previous hydration. When it does so, however, it forms a supersaturated solution, which is certainly very different from a normal solution, being, according to Dr. Nicol's determination of the solubility, due to the extension at lower temperatures of conditions which exist naturally only above 33°; but when it dissolves to form a *normal* solution, it is with evident signs of hydration. Whatever this may prove as to the supersaturated solution, it certainly does not prove that the normal solution contains the anhydrous salt—rather the opposite.

§ Thus the "true" heat of dissolution of $MgSO_47H_2O$ is +7,000 cal., and even this number is probably 1,000 to 3,000 cal. too low, as it contains no allowance for the heat of fusion of the $MgSO_4$ molecule. (See *Chem. Soc. Trans.*, 1886, 279.)

* For a general summary and discussion of the results from the point of view of these physicists, see De Coppet, *Ann. Chim. Phys.* (4), 23, 366; 25, 502; and 26, 98.

† In a paper read before this section last year (Report, p. 989), I argued that our formulæ adequately represented the molecules of solids and liquids with which chemical reactions deal, although I fully recognized the existence of far more complex aggregates. My opinions have so far altered that at present I consider these aggregates to be recognizable in many operations which must be termed chemical, although in the great bulk of ordinary reactions the simpler or ultimate molecules need alone be considered.

‡ A power or "affinity" so strong that it will sometimes induce a salt to separate out in a crystalline form and with a proportion of water foreign to its nature, as well as from a solution too weak to yield it of its own accord (Aston and Pickering, "Multiple Sulphates," *Chem. Soc. Trans.*, 1886).

§ J. M. Thomson, on the "Double Sulphates of Nickel and Cobalt" (*Brit. Assoc. Rep.*, 1877, 209).

* A study of the thermal results attending the dilution of salt solutions, established by Thomsen ("Thermo-chem," iii., especially plate iv., and also the curves given by formic and acetic acids and by potassium and sodium hydrates), impresses very forcibly the co-existence of these two actions, although Thomsen himself does not seem to have noticed it.

is acting upon every other atom, but such action can be nothing else than physical; and we are therefore led to the conclusion that there is really no difference between chemical and physical action, and, consequently, that the alternative between the two does not exist.

In the course of the discussion, and preceding the reading of Mr. Pickering's paper, the following remarks were made:

Dr. Armstrong said that, from the summary given by Prof. Tilden, it appeared that the two important questions for discussion were: (1) Does water of crystallization exist in solution combined with the salt as it did prior to dissolution? and (2) What distinction is to be drawn between chemical combination and mechanical association or adhesion? In short, are the phenomena of dissolution of a chemical or of a mechanical character? But Prof. Tilden had made an important omission, inasmuch as he had not discussed the possible simplification of the molecules on dissolution. In discussing the evidence afforded by the various phenomena, everything turned upon the question whether the crystal molecules are of the composition represented by our ordinary formulæ, or are more or less complex.

As regards the first question, Prof. Tilden appeared to differ from Dr. Nicol, and to think that water of crystallization did exist in solution. (Prof. Tilden, interposing, desired to explain that what he had said was that it was impossible, in the case of any solution, to say that one portion of the water is in combination with the salt and that another is not; all the phenomena of dissolution and dilution being continuous, no point can be found at which such a distinction can be set up. He believed that the salt was attached to all the water present without exception.)

Dr. Armstrong, resuming, said that much of the evidence appeared, he thought, to favor the conclusion that in certain cases water of crystallization did exist in solution; *e. g.*, the difference in color between many hydrated and dehydrated salts taken in conjunction with the color of their solutions. Again, many dehydrated salts dissolved much less readily than the corresponding hydrated salts. Instances of this kind were not common among inorganic salts, but were often met with among organic salts, and the speaker cited calcium butyrate and certain naphthalene and naphthol sulphonates as examples. Dextrose, again, ordinarily crystallizes with two molecules of water, but if dehydrated and carefully dissolved in water at a low temperature, it may be crystallized out from the solution in the anhydrous state. T. Thomsen's recent experiments, however, appeared to show that when two substances were dissolved in water they appropriated the water in the proportions in which they were present, thus favoring a purely mechanical interpretation of the phenomena of dissolution; but, on the other hand, it was to be noted that in the case of citric and sulphuric acids, for example, Thomsen's results were in accord with this conclusion only when it was assumed that the citric acid was present as the dihydrate, and sulphuric acid as the monohydrate, $H_2SO_4.OH_2$. In fine, the speaker was of opinion that while the question could not be regarded as settled, yet there was a considerable amount of evidence that the water was not evenly distributed, but was, in some cases at least, in part directly combined with the dissolved substance. Dr. Nicol had deduced an ingenious argument from J. Thomsen's observations on heats of neutralization. As a criticism of Dr. Nicol's argument from the existence of neutralization constants he would venture to say "Put not your faith in constants." If the views which he held—views which probably were at present peculiar to himself—were correct, the quantities in question ought to have a constant value. According to Helmholtz, all atoms hold a positive or negative electrical charge, a single charge being associated with a monad, two with a dyad, and so on. If when combination takes place these charges exactly neutralized each other, all compounds would be neutral and saturated; but actually this is not the case. In point of fact, there is no such thing as a saturated compound. Helmholtz seems to think that the charges may be held by different atoms with different degrees of force, but the speaker took a somewhat different view, and thought that probably when two atoms combined, in consequence perhaps of peculiarities of structure, their charges were not completely used up. The resulting molecules therefore possessed a certain residual charge or affinity, and were consequently in a position to enter into combination with other molecules. Thus water, he thought, was not a saturated compound. Its oxygen atom was still possessed of residual affinity. The same was true of sulphuric acid. Consequently the two could combine together to form a hydrate. On neutralizing a dilute solution of alkali by a dilute solution of acid, a stable condition is finally attained, and it is to be assumed that the affinities are fully satisfied, or very nearly so—that the charges practically neutralize each other; hence it may be expected that the heat of neutralization will have nearly a constant value, provided there be no disturbance such as the separation of a precipitate would produce. But the value of each of the several processes which go to make up the heat of neutralization are entirely unknown to us, and in the absence of such knowledge it is impossible to place much confidence in arguments based upon the study of such complex phenomena.

As regards the question of chemical *versus* mechanical action, the speaker could only imagine one form of mechanical action attending dissolution, viz., that of the water molecules bombarding the surfaces of the solid, and as it were chipping off particles. All other actions, in so far as they could be regarded as involving the attraction of the molecules of the dissolved substance by those of the solvent, he was inclined to class as chemical. Nothing was more certain than that dissolution depended on the nature both of the solvent and of the substance dissolved. Like dissolves like—water is *the* solvent for bodies containing oxygen; sulphur compounds are dissolved by carbon bisulphide; phosphorus compounds by chloride of phosphorus; shale spirit, which is rich in olefines, and especially resin spirit, which is rich in acetylenes and benzenes, were far better solvents of hydrocarbons and resinous bodies than petroleum, which consisted of saturated inert hydrocarbons, and was the worst of solvents. Facts such as these spoke strongly in favor of the conclusion that the phenomena of dissolution are largely of a chemical character.

Prof. W. N. Hartley was understood to base the argument in favor of the hydration theory chiefly on the changes of color observed in the solution of certain salts in various proportions of water. The chlorides, bromides, and iodides of cobalt, nickel, and copper exhibit these phenomena most plainly. Thus the iodide of cobalt in the anhydrous state is black, its dihydrate is green, the hexhydrate a reddish brown. If this last be dissolved in water, a pink solution is formed, which probably contains a richer hydrate. The brown saturated solution of the hexhydrate is a very dense liquid, of specific gravity about 3, and when water is added to it the formation of the pink liquid is attended by a large evolution of heat, and this affords evidence that the hydrate exists in the solution. Again, hydrated cupric chloride contains two molecules of water, and when quite dry is of a pale blue color. Its solution in water has the same color unless it be heated, and then it turns green. Nickel salts behave similarly. So that the evidence, on the whole, warrants the belief that when a hydrated salt is dissolved in water, the water of crystallization remains a constituent part of the molecule.

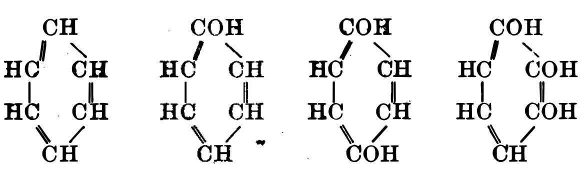
Dr. Gladstone commenced his remarks by a discussion of the question, What is a salt in solution? Is the solution of a salt in water a process analogous in any degree to the decomposition which takes place when one salt is mixed with another? Take, for instance, chloride of sodium and water. Many years ago the speaker had endeavored to determine whether any chemical decomposition of the salt by the water occurred, so as to give rise to sodium hydrate and hydrochloric acid, but he had come to the conclusion that this decomposition took place, if at all, only to a very small extent. Many salts, as had already been stated, combine with water to form colored hydrates, and the hydrate is of a color different from that of anhydrous salt. But a colored hydrate, when dissolved in a sufficient quantity of water, is never changed by further dilution. The speaker had endeavored to ascertain whether the specific refraction of substances was altered by solution. He had found that no alteration could be detected, and this result was afterward confirmed by the experiments of other chemists. The refraction equivalent of a solution is equal to the sum of the refraction equivalents of the salt and the water present. In an alum solution, the water of crystallization supposed to be in combination with the salt is not distinguishable by its refractive power from the water of solution outside it. It seems impossible, however, to arrive at a conclusion with regard to the constituents of a solution. The idea of reciprocal decomposition is not supported by experimental evidence, save in some exceptional cases, and the condition of a dissolved salt seems beyond expression by formulæ.—*Chem. News.*

## PYROGALLOL.*

By SPENCER B. NEWBERRY, Cornell University.

THOUGH pyrogallol, or pyrogallic acid, is one of the most familiar substances with which photographers have to deal, yet but little is generally known concerning its chemical nature. In view of the great usefulness of the substance, and the beautiful results which it can be made to yield, it may be that a brief sketch of the origin, mode of manufacture, and chemical properties of pyro will not prove uninteresting to this society of students of the science as well as the art of photography.

Pyrogallol is a derivative of benzole, and is closely related to phenol, or carbolic acid, and also to hydrokinone. The relations in which these substances stand to each other is shown by their graphic formulas:



Benzole. Phenol or Carbolic Acid. Hydrokinone. Pyrogallol.

It will be seen from this diagram that phenol consists of benzole in which one atom of hydrogen attached to a carbon atom is replaced by the group "hydroxyl," or OH; in hydrokinone two atoms of hydrogen, and in pyrogallol three atoms, are replaced in the same way. It is not, however, from benzole that pyrogallol can most conveniently be prepared. An abundant source of supply is found in nature in the gall nuts or rounded swellings produced by the sting of an insect on the twigs of the *Quercus infectoria*, a species of oak common in Syria and Asia Minor. These gall nuts are collected and exported in great quantities from Smyrna and Aleppo to all parts of the world, principally for use in the manufacture of writing ink. They contain a large percentage of tannic acid, or digallic acid, which on boiling with dilute acids splits up into two molecules of gallic acid. Finally, gallic acid, when gently heated, melts and gives off carbonic acid, forming pyrogallol, according to the equation

$$C_6H_2(OH)_3COOH = CO_2 + C_6H_3(OH)_3.$$

Pyrogallol forms white crystalline leaflets and tufts; melts a little above the boiling point of water; and when heated is volatilized and deposited again in feathery masses in the cooler parts of the vessel. This operation is termed sublimation, and is a valuable method of purification of volatile solids, since in passing into the state of vapor the impurities are left behind. Hence the purest pyrogallol is termed "resublimed."

Pyrogallol is not an acid, for the slightest addition of an alkali renders it distinctly alkaline. Rosing states that it does not decompose carbonates, and forms no salts with the alkalies. It is therefore evident that the common name, pyrogallic acid, gives a false idea of the nature of the substance, and that it is no affectation to say "pyrogallol," as all modern chemical writers do.

Pyrogallol—or "pyro," to use a convenient and well-established abbreviation—owes its efficiency as a developer to the great ease with which it may be oxidized and decomposed. In a dry state it remains unaltered in the air, but in solution in water it quickly absorbs oxygen, and is converted into carbonic acid, acetic acid, and brown products of decomposition. Reducing agents prevent this; sulphurous acid, for example, is a well-known preservative of pyro solutions. Salts of gold, silver, and mercury are readily reduced to metal on the addition of pyro to their aqueous solutions. In the case of silver compounds, this action is greatly retarded by the presence of large quantities of acids, and on the other hand is rendered much more energetic if the pyro be made alkaline with caustic ammonia, potash, or soda, or the carbonates of these alkalies. In fact, alkaline pyro will reduce to metal not only the soluble salts of silver, but also the bromide, chloride, and iodide, which are not affected by acid pyro solutions. In the old wet collodion process, the development consisted in the reduction of the free nitrate of silver which was present in excess, and the deposition of the metallic silver which resulted upon the parts of the film upon which the light had acted. For this purpose, if pyro was employed, it was necessary to use a highly acid solution, in order that the deposition of silver should take place gradually; neutral or alkaline pyro would give dense fog at once. In dry plates, however, there is no silver nitrate present, and the development consists in the direct reduction to metal of the bromide and iodide of silver composing the film. To effect this the most powerful developing agents which chemistry can furnish—as, for example, alkaline pyro—may with safety be employed.

Of the various alkalies which have been suggested for use with pyro, ammonium hydrate and the carbonates of soda and potash are most often employed. Sodium sulphite is generally added to the pyro solution to preserve it from decomposition, and to prevent the staining of the negatives which results from the action of oxidized pyro on the gelatine of the film. The preservative effect is also much aided by the addition of a little sulphuric acid to the solution of pyro and sulphite, thus causing the liberation of a small amount of sulphurous acid. Even with all these precautions, solutions of pyro are very liable to deterioration by absorption of oxygen from the air, giving stained negatives, and by far the best plan is, as is well known, to prepare the solutions only in small quantities, and to renew them frequently.

In the hands of the writer the sulpho-pyro-potash developer (suggested, I believe, by your president) has yielded results superior to those obtained by any other formula. There is an exquisite crispness and beauty about the pyro-potash negatives which seems to me to be lacking in those produced by the aid of either soda or ammonia.

Other substances resembling pyrogallol in chemical character, and, like pyro, belonging to the group of polyvalent phenols, are known to have strong reducing properties, and may be used as developers. One of these, hydrokinone, of which the formula is before you, is stated by Captain Abney to be more efficient than pyro, and to give results of equal beauty. Its high price has, however, been an obstacle to its general use. Two "isomers" of pyrogallol (that is, substances having the same composition, but differing in the arrangement of the atoms in the molecule), namely, phloroglucin and oxy-hydrokinone, are stated by Dr. Eder to be less powerful developers than pyrogallol. These differ from pyro only in the fact that the three hydrogen groups are attached to different carbon atoms in the closed chain. Another substance, tetraoxybenzine, which has four hydroxyl groups, and which may yield interesting results, appears not yet to have been tested photographically.

All these compounds act as developers by virtue of the readiness with which they absorb oxygen. It is probable that the developer acts indirectly upon the bromide and iodide of silver, by decomposing water with absorption of oxygen, setting hydrogen free, which in turn takes the bromide from the silver compound, forming hydrobromic acid, and leaving metallic silver. The influence of the alkali may be explained by the supposition that it neutralizes this acid as fast as it is formed. In the action of the developer, however, there is much that is only very imperfectly understood, for we know nothing positive as yet as to the nature of the mysterious, invisible, latent image produced upon the plate by light, which gives the first impulse to the development and determines the chemical reactions which result in the visible picture. Until we know more of these things, we may say that in many points chemists find themselves as much in darkness as other people when they enter the dark room.

* Read before the Society of Amateur Photographers of New York, 1886.

## DECOMPOSITION OF GLASS.

Two years ago, Bunsen published the results of some experiments which he had made on the condensation of carbon dioxide gas upon the surface of glass (*Ann. Phys. Chem.*, xx., 545). His results showed that in three years 5·135 c. c. of this gas were condensed upon each square meter. Kayser subsequently repeated the experiment in a different form and obtained different results, whereupon Bunsen re-examined the subject and showed that his glass fibers were not perfectly dry, and that a part of the observed absorption was due to this capillary water layer. On taking the apparatus down, Bunsen analyzed the glass fibers on which the action had taken place. Under ordinary conditions carbon dioxide does not attack glass, but it is quite possible that so concentrated a solution of carbonic acid as existed in these capillary layers might have some action. The analysis showed not only that the glass had been acted on, but that this action had been unexpectedly great. A weight of 49·543 grms. of glass fiber gave to cold water sufficient sodium carbonate to yield, on the addition of hydrochloric acid and evaporation, 0·8645 gramme sodium chloride. From the composition of this glass, determined before the experiment, it appears that during the course of the observations—109 days—5·83 per cent. of the entire weight of the glass must have been thus decomposed. The suggestion is an obvious one that possibly all the absorption which Bunsen observed might have been due to the formation in this way of sodium carbonate. But he shows that of the total volume of gas absorbed by the entire mass of glass, 236·9 cubic millimeters are set free again on heating. If combined as hydrosodium carbonate, the quantity of sodium found on analysis would require only 165·2 cubic millimeters, leaving 71·7 cubic millimeters to be otherwise disposed of. In view of the fact that pure water may also be expected to act on the substance of the glass, it is evident that glass is not a suitable material for experiments on capillary absorption.—*Ann. Phys. Chem.; Ber. Berl. Chem. Ges.; Amer. Jour.*

## THE NEW CHEMICAL LABORATORIES OF THE ZURICH POLYTECHNIC SCHOOL.

THE month of October, 1886, saw the opening for use of what is undoubtedly the largest and most perfect institute for teaching pure and applied chemistry as yet erected. The celebrated Federal Polytechnic School of Zurich has for a long time attracted a large number of chemical students, and the laboratory, erected in 1856, and at that time considered a very good one, had long been filled to overflowing every term by students, attracted by such men as Wislicenus and Victor Meyer in the chair of pure chemistry, and Bolley, E. Kopp, and Lunge in that of chemical technology. Both the space and the fittings of the old laboratory have proved wholly inadequate, and the Federal Parliament in 1883 voted a sum of about £70,000 for a new building. This has just been finished and fitted up, so that the winter term can be opened in it. The plan of the building has been designed by Messrs. Bluntschli and Lasins, Professors of Architecture in the Polytechnic School, in accordance with the programme submitted by Professors Victor Meyer and Lunge; but the internal fittings have been devised by Professor Lunge alone, with the help of the architects; his colleague, Victor Meyer, having been prevented from co-operation by illness, and later on by his removal to Gottingen. Previous to designing the building and fittings, the four above named professors were enabled, by a grant of the

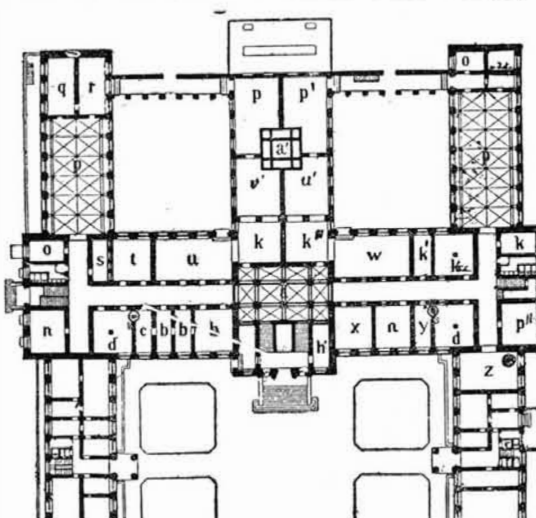


FIG. 1.

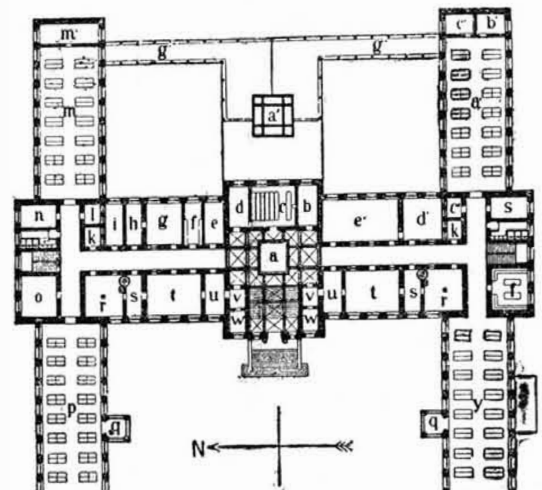


FIG. 2.

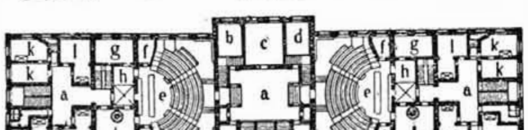


FIG. 3.

THE ZURICH CHEMICAL LABORATORIES.

Federal Council, to personally inspect all the chemical laboratories recently erected in Germany, Austria, and Hungary. Those at the Owens College, at Paris, and in some other places, were also studied, with the object of selecting the best features of each of them—the generous programme of the Swiss Federal Council having been to waste no money on mere outward show, but to spare nothing either in the solidity or the completeness of the building and fittings, so that the new institute might hold a first place for a long time to come. Accommodation was to be provided for about two hundred students, but in reality a good many more might find places in the present institute. The fees paid by the students, are very moderate, viz., £4 per annum for matriculated students, and £9 per annum for outsiders, with the right of working eight hours every day; the greater part of the expenses is defrayed by a vote from the federal funds. The ground floor of the west wings, that is, about one-sixth of the building, is occupied by the Federal Assay Laboratory for Agriculture and the Federal Institute for the Control of Seeds. The remainder of the building is devoted to the chemical laboratories of the Polytechnic School. The northern half is taken up by the "Analytical Laboratory," with the exception of the rooms marked *b b b c*, on the ground floor (Fig. 1), which contain the laboratory for assaying gold and silver, under the care of the professor of technical chemistry. The latter has also charge of the whole of the south half of the building; but this half contains, as we shall see, rooms for pharmaceutical chemistry, and for photography, along with those for technical chemistry proper.

The "Analytical Laboratory" has to serve, first, for the practice of ordinary qualitative, quantitative, and organic analysis (for which purpose it is regularly frequented by the students in their first terms); secondly, for the research work of advanced students. The "Technical Laboratory" is frequented by the students in the second, and partly by those in the third year of their study; the work pursued here is not exactly of a "technical" character, but consists in making preparations, starting from simple inorganic compounds and finishing with the most complicated organic substances. Special attention is paid to educating the students by repeating the preparation of substances newly discovered and described in the chemical periodicals or in patent specifications. Along with this kind of work, technical analysis and gas analysis are also practiced, and the advanced students have the same opportunity of pursuing research work as in the analytical laboratory. Facilities are also afforded for working in special subjects pertaining to chemical technology, as dyeing, calico printing, metallurgy, etc.

Referring now to the plans published herewith, Fig. 1 shows the ground floor, Fig. 2 the first floor, and Fig. 3 the second floor, above which there is a technological museum, forming the top of the building. On entering by the principal doors, a visitor finds himself in a large hall marked *a* (Fig. 2). Immediately in front is a small lecture theater, *c*, provided with seats for fifty students, and with all appliances for experimental work, including a preparation room, *b*. This theater is used for the classes on pharmacy, and those given by the "Privat docenten;" *d* is a private room for the professor of pharmacy; *e'* the pharmaceutical laboratory for twenty students, and *d'* a pharmaceutical museum, used also for microscopical practice in this department. A lobby, *v*, communicates between the entrance and the chief professor's consulting room, marked *u*; *w* is the assistant professor's room, *t* the professor's private laboratory, *s* a balance room, and *r* the principal storeroom, communicating by means of a staircase with a similar room, *d*, on the ground floor (Fig. 1). This arrangement is repeated in the block on the north side of the main entrance, which is devoted to analytical chemistry, *e* and *i* being special storerooms, *f* the library, *g* a chemico-physical laboratory, *h* the organic balance room, and *l* and *k* two dark rooms for optical purposes.

Still keeping on this side, *o* is the analytical balance room, *n* a special room for high temperature operations under pressure, while *m* and *p* are the large working rooms, with fourteen and sixteen double benches respectively; *m'* is a combustion room, *q* a veranda, and *g'* a gallery leading to a covered space for outdoor work. The same arrangement as in the analytical laboratory is carried out in *y* and *a'*, with benches for about one hundred students; *b'* is an optical room, and *c'* a combustion room. On the ground floor (Fig. 1), *z* is a room for practicing photography, connected with a set of rooms underground by means of a spiral stair case; *p''* is a laboratory for night work; *k* contains steam apparatus for distilling ether, benzene, or other very inflammable liquids, no gas or fire being allowed in this room; *p* is a large operating room, with stone benches along the sides and center; *o* is a gas analysis room, and that next to it forms a special laboratory for advanced students; *d* is a storeroom, *y* a private laboratory; *n* and *x* rooms for experiments in dyeing and tissue printing; *h'* a porter's lodge; *k'* a room for electro-chemistry, containing a large dynamo driven by shafting from the room, *w*, in which are a number of grinding and other machines. In *k''* is a battery of twelve steam evaporating pans, and a large steam oven; *u'* contains a large number of crucible furnaces, which send their smoke and gases into the main chimney shaft, *a'*. Below *p* and *p'* are the steam boilers. Turning now to the analytical side, *b b b c* are gold and silver assay rooms, *s* the magazine, *t* a room kept apart from the others for legal analyses, *u* a room containing steam baths, *o* a gas analysis room, and *n* a room for special night work; *p* is a large operating room, while *q* and *r* are at present not utilized for any special purpose. From *r* an arched gallery leads into *p* and *v'*, the pyrotechnical rooms, and back through *k* into the hall, *a*.

On the second story (Fig. 3), the large lecture theaters, *e e*, are entered, either from the vestibule, *a* (which is the students' entrance), or from the preparation rooms, *h h*. The latter communicate with the rooms, *g g*, containing a collection of chemicals, and the rooms, *i i*, for apparatus. The other rooms at each end are demonstrators' living rooms. The last part of this laboratory consists of analytical collection rooms, *b c d*, accessible from the theater, *c*, and from the hall, *a*.

Special notice should be taken of the details and fittings. Each beginner's place on the working benches, in the large rooms as well as in the smaller laboratories, is provided with two gas taps, one water tap, and one vacuum tap. Over and above this, each double bench has at either side a water basin, with a special water tap and waste pipe. The benches are provided with a number of closets and drawers of different kinds, and a special flap, with a lead-lined receptacle below for solid refuse.

In every window niche there is a draught place, with a slate bench, gas, water, vacuum, and waste pipe. These evaporating niches are over 3 ft. wide, and therefore large enough to take good sized apparatus. They can be divided into two compartments by means of a central sliding window. The draught is produced, first, by double chimneys passing through every one of the window piers; secondly, by pressure in the rooms; thirdly, in case of need, by a special gas jet lighted in the exit hole. There are two end holes on each side of the niche, one close to the top and another near the bottom of the niche, the second hole being intended for introducing any pipes conveying noxious gases.

The common places in the operation rooms on the ground floor, *p p*, are fitted up with slate benches, water, gas, vacuum, draught hoods, and so forth, and in addition with steam taps and compressed air taps in every window niche. Here operations on a somewhat larger scale are to be carried out, such as need the use of charcoal furnaces. The vacuum and compression are produced by continuously working pumps, exhausting or compressing the air in large regulating vessels, from which a network of pipes and taps spreads through the whole building. Special attention has been paid to the question of heating and ventilation, and it is believed that no more perfect system for the special, object in view has ever been carried out. We have already mentioned the steam boilers. These are of 55 horse power, and furnish the steam necessary for heating the rooms, for supplying the numerous steam-heated laboratory apparatus, and for a 12 horse power engine, whose principal work is to set a large fan blast in motion. This fan blast aspirates air from without, which can be filtered and artificially cooled by a spray of water as may be required, and forces it on through a complicated system of flues, communicating with every single room in the building through one or more louver openings. In certain parts of these flues there are systems of pipes through which the exhaust steam of the engine, and in case of need steam direct from the boilers, can be passed, in order to heat the ventilation air up to the intended temperature.

This heating of the air suffices for autumn and spring; while for the proper winter heating, special steam heating apparatus, supplied direct from the boilers, are provided in each room, and are worked on the circulation principle. The air forced into the rooms enters at a height of about 7 ft., and finds its way out, partly by special louver openings near the ceiling, and in all the rooms provided with draught places (evaporating niches), partly through the latter. It must be remembered that all the window piers are perforated from top to bottom with upright shafts, which end over the flat roof in hooded terra cotta pipes. Thus the fresh air introduced in one or more places (according to the size of the room), and producing a slight over-pressure within the rooms, must make its way out either in a great many places all over the room, or, if desired, exclusively through the draught places, so that the noxious gases there generated cannot by any possibility flow back into the room. The upper parts of all the windows are hung on horizontal swivels, and can be opened from below in a moment by pulling a cord, if at any time an unusually large amount of noxious gas should be evolved outside the draught places.

There is also in every one of the larger rooms a large sink, covered with a draught hood, for emptying liquids which woud cause a smell in the rooms. The arrangements are altogether worked out so completely that no special "stink room" is required, since *all* rooms are adapted for carrying on all sorts of work without nuisance.—*Industries.*

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VOLCANIC GLASS CHANGED TO PUMICE.—In a paper on Marekanite, pearly glassy balls of volcanic origin (*Geol. Mag.*, June, 1886), Professor J. W. Judd shows that the amount of volatile matter present is large enough to convert the glass, when heated to whiteness, into cauliflower-like masses which are true pumice. The same author in a later paper, "On the Volcanic Rocks of the Northeast of Fife, Scotland," states that a dacite-glass, when carefully dried at 110° C. and then weighed, was found, on ignition, to have lost 8·90 p. c. of its weight; and when fragments were heated in a flame urged by a powerful blast, they swelled up into cauliflower-like excrescences, eight to ten times the original bulk. The obsidian of Krakatoa (a porphyritic enstatite-dacite glass) acted in the same way, yielding a dirty-white pumice, "almost undistinguishable from the natural pumice which was ejected from that volcano during the great eruption of August, 1883." The latter paper is in *Q. J. G. S.*, Aug., 1886.

[NATURE.]

## VOLCANIC ERUPTION IN NIUA-FU, FRIENDLY ISLANDS.

SIR J. H. LEFROY has forwarded to me a small packet of volcanic dust, together with an extract from a letter written by Mr. Coutts Trotter, F.R.G.S., and has requested me to examine the former and append my remarks upon it to the more important parts of Mr. Trotter's letter. This document is dated on Sept. 24, 1886, "on board the steamship Suva, a few miles south of the island of Niua-foou" (or Niua-fu, one of the Friendly Islands). After speaking of an expedition to Fiji, Mr. Trotter proceeds:

"Meanwhile I got into a little steamer to visit the windward island of the group, and was persuaded to come on in her to Tonga. There I found that news had just come of an awful volcanic eruption in the island of Niua-foou above mentioned, and my steamer was chartered to go and make inquiries and give relief. . . . We started at once, and arrived off the island before dark yesterday. No trace of fire or smoke, and I was much chaffed for my 'disappointment.' But on landing this morning we found the damage done was substantial enough, an eruption of dust and stones and water having gone on for eighteen days, and two-thirds of the island smothered or greatly injured.

"The island is some forty or fifty miles round, all volcanic, no beach anywhere, and landing difficult, and a lake of brackish, bitter water occupying perhaps a fourth or more of its extent. There are at all events three small islands in the lake, one with a lake in its center. I suspect this lake is the remains of the crater and eruption to which the existence of the island is due, later eruptions being cause for the small island craters. The present eruption began apparently near one end of the lake. I saw three or four craters there, one covered with a green, sulphurous scum, and another, just beyond it, which I could not in the time I had actually visit, very deep, and full (a friend tells me) of mud and water.

"Near it is a little rounded mountain of 'earth,' some 200 feet high, formed by the present eruption, and projecting far into the lake. At the other end of the lake is a fresh accumulation, as I was told, of pumice, but it looked to me from where I stood more like an accumulation of black sand. The whole island has been in a disturbed state for some three months and a half, the dates of the principal disturbances coinciding remarkably with those which are going on in other parts of the world—earthquakes on June 8 and 11, which, I think, are the dates of the first New Zealand outbreaks,* again on August 12, ditto.

"This, of course, is not wonderful, but the final catastrophe here took place on August 31, which we understand was the exact date of the recent American earthquake.† It was preceded for twenty-four hours by earthquakes, . . . and went on for ten days, I am told, without intermission, then two days quiet interval, then going on again for nearly a week, terrific thunder and lightning for twenty-four hours incessantly. The column of steam rose, they say, several thousand feet, anyhow immensely higher than a hill 7,600 feet high, which I ascended, and whence I had a bird's-eye view of the lake and crater. Showers of stone accompanied it. These fortunately fell straight, or nearly straight, back.

"They were red-hot, with masses of dust attached, and as they fell left the dust behind, which produced the effect of a fiery tail. The great mischief was done by the dust, which, as the wind shifted, carried destruction in every direction. In one village which I entered, the shower only lasted an hour and a half, but the ground was deeply covered, the blades of grass even now only beginning to peep through, and every cocoa-palm ruined for the present, the branches hanging withered and almost perpendicular, and the young central shoot sticking out by itself. If they get rain, the trees will recover and bear again in three years, but otherwise are likely to die.

"But in other districts the houses are buried, and along the coast large extents of forest, scrub, or bush, and, what is more immediately serious, the yam beds. They have just been planted, and any that were above ground will be killed, even if the latest planted may push through and flourish. Wonderful to say, no one was killed, although many very old people have died since from fear and exhaustion. They all betook themselves to the upper parts of the island for safety, and perhaps with reason, for the last two volcanic outbursts both took place on the coast country, near the shore.

"These (respectively nineteen and forty years ago) were both lava eruptions. I saw the craters and the lava streams from them down to the sea on the west coast as we steamed along to-day, the lava of the earliest being hardly invaded yet by vegetation, not a blade of green on the later, which runs far out into the sea, like the rough substratum for a big embankment or breakwater. According to native tradition, the last eruption of a kind similar to the present took place from very nearly the same spot in the lake seventy-two years ago, the old people having childish recollections yet.

"The lake is a great depth, so that this hill of 200 feet or more rising from the bottom represents a vast amount of solid matter, to say nothing of the thick deposits of dust all over the island. The lake was still bubbling in places, and things are by no means settled down yet. At Vavau, where we touched two days ago, they had just had a very severe earthquake, and shocks are still going on at Niua-foou (vertical, *I was told*, but my informant's wits were much shaken by recent events) daily on the level ground near our landing place, from which it is inferred that the danger is not over. Strong gases too are perceptible rising from the ground near the coast, which is always where they apprehend most danger, and an outburst of lava. I suppose the solid matter coming up through the deep lake is pulverized into the (to life) comparatively harmless dust.

"During the earthquake of August 12, the captain of a ship at anchor found that, whereas he had paid out twenty fathoms of chain overnight, he had only eight fathoms under him in the morning. I never saw such big cocoanuts anywhere, though the trees are not exceptionally big, indeed there seem to be no very fine or old trees of any kind on the island, which favors the theory of a modern origin, for the soil is very fertile. The name means New Niua, the Old Niua being probably the neighboring Keppel Island or Niua-tobu-dabu. I wish I could give you a better or fuller and more interesting account of the whole affair, but the visit was a very hurried one, and, in fact, I had not more than two hours on shore. Still it may interest you, as it is written on the very spot. No other account is likely to reach England. I send a pinch of 'sand' from the crater. C. T."

This "sand" or "dust" is a very dark brown, almost black, color. When examined with a lens it seems composed mainly of fragments of glass, and has a slightly speckled aspect, owing to the mixture of lighter and darker fragments. One or two glassy white fragments may also be noted. When some of the dust is placed under the microscope, it is seen to consist almost wholly of fragments—some rudely polygonal in shape, others flattish chips—of a brown glass, the former being the commoner. The majority of the bits vary from about 0·01 inch to 0·03 inch in diameter, and the latter measurement is but rarely exceeded. Minute chips are also present, but they do not form at all an important constituent in the mass.

A conspicuous characteristic is the (apparently) entire absence of the tiny pellets of "cindery" scoria, so frequent a constituent of volcanic dust, and of the fine pulverulent material, the presence of which commonly makes it needful to mount the dust on a slide before it can be properly studied. I have found no difficulty in examining this Niua-fu dust, and even the finer chips, often less than 0·001 inch in diameter, by simply spreading it over a sheet of glass. The glass fragments, even when very minute, have a tinge of brown. When about 0·01 inch in thickness, they are fairly translucent, and a rich olive brown in color, but as they approach 0·03 inch in thickness they become opaque, light only passing through the thinner edges. Small cavities, spherical or egg shaped, are not infrequent, but the glass is remarkably free from microlithic inclosures.

No granulation of the coloring matter is perceptible, as a rule, with a magnification of 150 diameters. Opacite dust and trichites (especially the latter) are very rare, and of other microlithic inclosures I have only seen an occasional lath-shaped crystallite (? feldspar). I have not identified among the fragments either biotite, augite, or hornblende, so that if any of these minerals are present they must be very rare. The clear glassy fragments mentioned above are feldspar, probably labradorite. They do not in number exceed about 2 or 3 per cent. of the whole. Many of the flatter brown glass fragments exhibit ropy folds or the remains of a cellular structure, evidencing that they are due to the destruction of a very vesicular glass, while the more solid polygonal fragments may be the detritus of the thicker parts of the same or of a more uniform glass. The strong brown color of the fragments reminds me of specimens of the more glassy lavas of the Sandwich Islands in my collection, and, like them, I should, from microscopic examination, consider the rock a basalt glass (tachylyte) with a silica percentage, which was probably above rather than below 50. This view accords, I find, with Cohen's statement concerning the lava of Niua-fu, which, judging from his description, is very similar to that above described (*Neues Jahrb. fur Min.*, 1880, vol. ii., pp. 36 and 41). He says that it is almost identical in composition with the "basalt-obsidians" (*i. e.* tachylytes) of the Sandwich Islands. It contains 50·74 of silica. Their analyses show from 50·82 to 53·81.

While the above was passing through the press, I received from my friend Dr. S. Rideal a determination of the specific gravity of the volcanic material (powdered to get rid of cavities). The specific gravity is 2·726. As the feldspar is included, and it is slightly the lighter, the specific gravity of the glass itself must be a little higher, about 2·73. Hence we need not hesitate to call it a tachylyte. The average of six Sandwich Island glasses is 2·71 (see Judd, *Q. J. G. S.*, xxxix., 444).

T. G. BONNEY.

* The first outbreak was early on the morning of June 10. See *Nature*, vol. xxxiv. p. 301.

† The principal shock was on Tuesday night, August 31. See *Nature*, vol. xxxiv., p. 470, and vol. xxxv., p. 31.

## FAMILY TAINT.

THERE was a painful scene in the Baltimore Criminal Court, May 26, when William E. Stone was acquitted of the murder of his wife. His daughter Clara, a fine-looking girl, but pale as death from excitement, arose in the witness-box and, pointing at the weeping man, said:

"Yes; you ought to cry! You ought to cry! You ought to have been hung!"

Ella, another daughter, rushed to the released prisoner, and throwing her arms around his neck, kissed him.

Epilepsy runs in the Stone family, and it was shown during the trial that the prisoner had always been a kind husband and tender father. He suffered from epilepsy. One day he came home from work, shot and killed his wife, then tried to kill himself, and after falling bleeding to the floor, dragged himself over to where his dead wife lay, and threw his arms lovingly about her. He called his little three-year-old boy to come and kiss him, and told the police that he had committed the crime for his children's sake. Some of the neighbors said it was jealousy, but members of the family declared he was crazy.

It was brought out in evidence that Stone had attempted to kill himself three times. He had on several occasions had differences with his wife. About four years ago she left him at Selina, Pa., and they were separated for some time.

Mrs. Eliza Jane McGuire, of St. Louis, an elder sister of Stone, was the important witness for the defense. She cried bitterly as she told her story, and had the jury and the crowd of spectators in tears. She said her husband was a blind basket maker in St. Louis, and she stripped the house of everything that both she and her husband possessed to raise money to come here to try and save her poor brother. Her father, she said, was an epileptic. She has seen him have several fits. Her father had once tried to cut his throat with a razor. He was very eccentric, and imagined he was called to preach the Gospel. One time he went out in his stable, placed a rope around his neck, and said to them that he was going to heaven, but they cut him down. In describing the condition of her mother's family she said they were all more or less crazy. One of her sisters was an idiot.

Mrs. King, another sister of the prisoner, was seized with an epileptic fit as she was about to give her testimony.

Charles Stone, a brother of the prisoner, who had spent two years in an insane asylum, testified to the mental condition of the prisoner, and exhibited on the witness stand pitiable evidences of his own affliction.

Mrs. McGuire said that she also was subject to epileptic fits. She had one in court yesterday. Some years ago, while living in Baltimore, she tried to throw her baby out of the third story window.

The whole family of epileptics testified in their brother's behalf, and their disconnected talk and occasional spasms in court made the trial a remarkable one.

This case shows the need of legally interdicting the marriage of epileptics, and exhibits the different views held of crime caused by disease, even by members of the same family. While one would extenuate, the other sets down all to malice.—*Alienist.*

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