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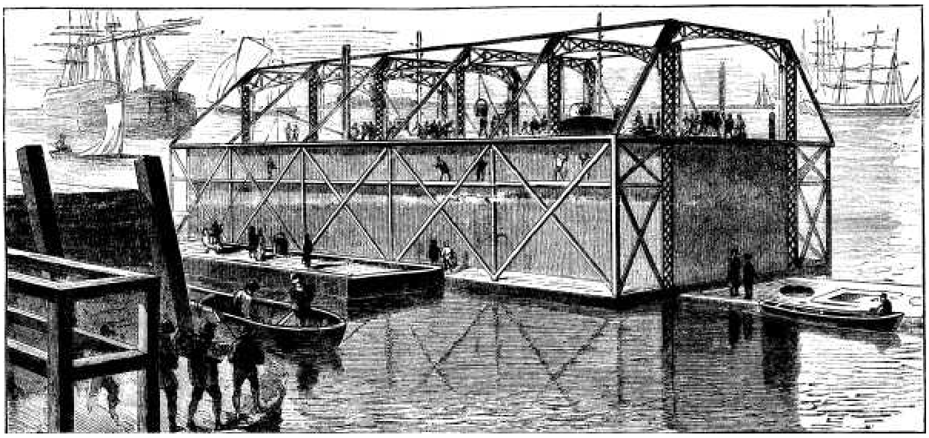
IMPROVEMENTS IN THE HARBOR OF ANTWERP.

The harbor of Antwerp, which, excepting those of London and Liverpool, is the largest in Europe, has been improved wonderfully during the last decade. Before 1870 it was inferior to the harbor at Havre, but now it far surpasses the same. The river Scheldt, which is about 1,500 ft. wide, was badgered out up to the vertical walls of the basin, so that the largest ships can land at the docks. The river was deepened by the use of caissons, in the lower parts of which the workmen operated in compressed air. The annexed cut shows that part of one of the caissons which projects above the surface of the water. The depth of the river at low tide is about 26 ft., and at high tide about 39 ft. Some of the old sluices, channels, basins, etc., which were rendered useless by the improvements made in the river Scheldt have been filled up, and thereby the city has been enriched by several handsome and elegant squares.--*Illustrirte Zeitung*.

PROGRESS OF ANTWERP.

Antwerp is now the chief port on the Continent. Since 1873 the progress has continued, and made very rapid advances. In 1883 the tonnage of the port reached 3,734,428 registered tons. This marvelous development is partly due to the position of Antwerp as the embarking point from the Continent of Europe to America, and partly also to the recent additions and changes which have been carried out there, and which, now nearly completed, have made this cosmopolitan port one of the best organized in the world. This is so well known that vessels bound for Switzerland with a cargo of corn from Russia pass Marseilles and go two thousand miles out of their way for the purpose of unloading at Antwerp. No other port, in fact, offers the same facilities. There is not another place in the world where fifty vessels of 3,000 tons can come alongside as easily as the penny boats on the Thames run into the landing.



CAISSONS FOR DEEPENING THE RIVER AT ANTWERP.

Since the opening of the St. Gothard Tunnel nearly all the alimentary provisions that Italy sends to the British Isles pass through Antwerp. In 1882 82,000,000 eggs and 30,000 pounds of fruit were shipped there for England. The greater part of these came from Italy. Antwerp has become also an important port for emigrants; 35,125 embarked in 1882, out of which number 3,055 were bound for New York. The city was always destined, from its topographical position, to be at the head of a very considerable traffic; political reasons alone for many years prevented this being the case. These have happily now disappeared, and, since 1863, when the "Scheldt was liberated," the progress of commerce has been more rapid than even the most ardent Antwerp patriot dared hope. At that date the toll of 1s. 11d. on all vessels going up the river, and of 7½d. on vessels going down, was abolished, and reforms were introduced among the taxes on the general navigation; the tax on tonnage in the port itself was abolished, and the pilot tax was lowered. The results of these measures became immediately apparent. Traffic increased with such rapidity that in 1876 the crowding on the quays was such that the relation of the tonnage to the length of the quay was about 270 tons per yard, which is four times as great as at Liverpool.

A few words now, briefly, as to the nature of the important works[1] completed at Antwerp. They were commenced in 1877, and have opened for the port an era of prosperity such as was never experienced even during the sixteenth century, the zenith of her splendor. These works have cost £4,000,000, and have necessitated the employment of 12,000 tons of wrought iron, of 490,000 cubic yards of brickwork and concrete, of 32,000 cubic yards of masonry, and of more than 3,300,000 cubic yards of earthwork in filling and dredging, etc. The quay walls run the whole length of the town, a distance of rather more than two miles. It rests on a foundation laid without timber footings, and giving a depth of twenty-six feet at low water, sufficient drawing for the largest ships afloat. Beyond this wall are the real quays, which consists of first a line of rails reserved for hydraulic cranes serving to unload vessels and deposit their cargo railway trucks; secondly, a second line of rails parallel with the first, on which these trucks are stationed; thirdly, sheds extending toward the town for a width of one hundred and fifty feet, and covered with galvanized iron sheetings. A third line of rails parallel with the two others runs from end to end of these sheds, and a number of lines placed transversely with this one connect it by means of spring bridges with, fourthly, four more lines also parallel with the quays, whence the goods start for the different stations, and thence to their destinations. The total width of these immense constructions is about three hundred and twenty feet. Such is their magnitude that about six hundred houses had to be pulled down to make place for them. A railing running along their entire length cuts them off from the town.

[Transcribers note 1: changed from 'words']

During the course of last year 4,379 vessels entered the port of Antwerp, gauging a total of 3,734,428 tons, which places Antwerp, as I have already stated, at the head of European ports. In 1882 the tonnage of Havre was only 2,200,000, that of Genoa 2,250,000, and of Bilboa 315,000, owing to its iron ore exports. Among the English ports a few only exceed Antwerp. London is still the first port in the world, with a tonnage of 10,421,000 tons, and Liverpool the second, with 7,351,000 tons; Newcastle follows with 6,000,000 tons, also in excess of Antwerp, but both Hull and Glasgow are below, with respectively 1,875,000 and 2,110,000 tons.--*Pall Mall Gazette*.

BICYCLES AND TRICYCLES.

[Footnote: A recent lecture before the Society of Arts, London.]

By C.V. BOYS.

The subject of this paper is one of such wide interest, and of such great importance, that it is quite unnecessary for me to make any apology for bringing it to your notice. Exactly two months ago, I had the honor of dealing with the same subject at the Royal Institution. On that occasion I considered main principles only, and avoided anything in which none but riders were likely to take an interest, or which was in any way a matter of dispute. As it may be assumed that the audience here consists largely of riders, and of those who are following those matters of detail, the elaboration, simplification, and perfection of which have brought the art of constructing cycles to its present state of perfection, I purpose treating the subject from a totally different point of view. I do not intend, in general, to describe anything, assuming that the audience is familiar with the construction of the leading types of machines, but rather to consider the pros and cons of the various methods by which manufacturers have striven to attain perfection. As a discussion on the subject of this paper will doubtless follow--and I hope makers or riders of every class of machine will freely express their opinion, for by so doing they will lend an interest which I alone could not hope to awaken--I shall not consider it necessary to assume an absolutely neutral position, which might be expected of me if there were no discussion, but shall explain my own views without reserve.

The great variety of cycles may be grouped under the following heads:

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  1. The Bicycle unmodified.
  2. The Safety bicycle, a modification of 1.
  3. The Center-cycle.
  4. The Tricycle, which includes five general types:
  (a.) Rear steerer of any sort.
  (b.) Coventry rotary.
  (c.) Front steerer of any sort (except e).
  (d.) Humber pattern.
  (e.) The Oarsman.
  5. Double machines: sociables and tandems.
  6. The Otto.
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It is perfectly obvious that not one machine is superior to all others in every respect, for if that were the case, the rest would rapidly become extinct. Not one shows any signs of becoming extinct, and, therefore, it may be assumed that each one possesses some points in which it is superior to others, the value of which is considered by its riders to far outweigh any points in which it may be inferior. The widely varying conditions under which, and purposes for which, machines are used and the very different degrees of importance which differently constituted minds attach to the peculiarities of various machines, will, probably, prevent any from becoming extinct. Nevertheless, the very great advantages which some of these possess over others will, no doubt, in time become evident by the preponderance of the better class of machines.

The bicycle, which surpasses all other machines in simplicity, lightness, and speed, will probably, for these reasons, always remain a favorite with a large class. The fact that it requires only one track places it at a great advantage with respect to other machines, for it is common for a road which is unpleasant from mud or stones to have a hard, smooth edge, a kind of path, where the bicyclist can travel in peace, but which is of little advantage to other machines. Again, the bicycle can be wheeled through narrow gates or door ways, and so kept in places which are inaccessible to tricycles. One peculiarity of the bicycle, and to a certain extent of the center-cycle, is that the plane of the machine always lies in the direction of the resultant force, that the machine leans over to an amount depending on the velocity and the sharpness of the curve described. For this reason all lateral strain on the parts is abolished, and if we except the slipping away of the wheel from under the rider, which can hardly occur on a country road, an upset from taking a curve too quickly is impossible. This leaning to either side by the machine and rider gives rise to that delightful gliding which none but the bicyclist or the skater can experience. In this respect the bicycle has an enormous advantage over any machine, tricycle or Otto, which must at all times remain upright, and which must, therefore, at a high speed, be taken round a curve with discretion.

The perfect and instantaneous steering of the bicycle, combined with its narrowness, counteract, to a great extent, the advantage which the tricyclist has of being able to stop so much more quickly, for the bicyclist can "dodge" past a thing for which the rider of the three-wheeler must pull up. In one other respect the bicyclist has an advantage which, though of no real importance, has great weight with many people. The bicycle well ridden presents a picture of such perfect elegance that no one on anything else need expect to appear to advantage in comparison.

The chief disadvantage of the bicycle is the fact that a rider cannot stop for any purpose, or go back a little, without dismounting. For town riding, where a stoppage is frequently necessitated by the traffic, this perpetual mounting and dismounting is not only tiresome, but wearying, so much so that few bicyclists care to ride daily in town.

The position of the rider on a bicycle, with respect to the treadles, is by no means good, for if he is placed sufficiently far forward to be able to employ his weight to advantage without bending himself double, he will be in so critical a position that a mere touch will send him over the handles. He has, therefore, to balance stability and safety against comfort and power; the more forward he is, the more furiously he can drive his machine, and the less does he suffer from friction and the shaking of the little wheel; the more backward he is, the less is he likely to come to grief riding down hill, or over unseen stones. The bicyclist is no better off than the rider of any other machine with a little wheel, the vibration from which may weary him nearly as much as the work he does. The little wheel as a mud-throwing machine engine is still more effective on the bicycle than it is on any tricycle, for in general it is run at a higher speed.

I now come to the usual complaint about the bicycle. There is a fashion just now to call it dangerous and the tricycle safe. But the difference in safety has been much exaggerated. The bicyclist is more likely to suffer from striking a stone than his friend on three wheels, but then he should not strike one where the tricyclist would strike a dozen. Properly ridden, neither class of machine can be considered dangerous; an accident should never happen except it be due to the action of others. People, carts, cattle, and dogs on the road are liable to such unexpected movements, that the real danger of the cyclist comes from the outside; to danger from absolute collapse, due to a hidden flaw in the materials employed, every one is liable, but, the bicyclist more remotely than the tricyclist, owing to the greater simplicity of his machine. The bicyclist, though he has further to fall in case of an accident from any of these causes, is in a better position than the tricyclist, for he is outside instead of inside his machine; he can in an instant get clear.

It would appear that many tricyclists consider accidents of the kind next to impossible, for in several machines the rider is so involved that an instantaneous dismount without a moment's notice, at any speed, is absolutely impossible. There remains one objection, which, however, should be of next to no importance--the difficulty of learning the bicycle prevents many from taking to the light and fast machine, because they are afraid of a little preliminary trouble.

The chief objections to the bicycle, then, are the liability of the rider to go over the handles, the impossibility of stopping very quickly, and the inability to remain at rest or go backward, and the difficulty of learning.

The first two of these are, to a large extent, overcome in the safety bicycles, but not without the introduction of what is in comparison a certain degree of complication, or without the loss of the whole of the grace or elegance of the bicycle. On almost all of these safety bicycles the rider is better placed than on the unmodified bicycle, but though safer, I do not think bicyclists find them complete in speed, though, no doubt, they are superior in that respect to the tricycle. Though they do not allow the rider to stop without dismounting, the fatigue resulting from this cause is less than it is with a bicycle, owing to the fact that with the small machines the rider has so small a distance to climb. Of these machines, the Extraordinary leaves the rider high up in the air on a full-sized wheel, but places him further back and more over the pedals. The motion of these is peculiar, being not circular, but oval, a form which has certain advantages.

In the Sun and Planet and Kangaroo bicycles a small wheel is "geared up," that is, is made to turn faster than the pedals, so as to avoid the very rapid pedaling which is necessary to obtain an ordinary amount of speed out of a small wheel. In each of these the pedals move in a circular path, and their appearance is in consequence less peculiar than that of the Facile, which, in this respect, does not compare favorably with any good machine. The pedal motion on the Facile is merely reciprocating. Riders of machines where circular motion is employed, among them myself, do not believe that this reciprocating motion can be so good as circular, but I understand that this view is not held by those who are used to it. Of course, the harmonic motion of the Facile pedal is superior to the equable reciprocating motion employed in some machines where speed is an object, especially with small wheels.

If I have overlooked anything typical in the modified bicycle class, I hope some one will afterward supply the omission, and point out any peculiarities or advantages.

That very peculiar machine, the center-cycle, seems to combine many of the advantages of the bicycle and tricycle. On it the rider can remain at rest, or can move backward; he can travel at any speed round curves without an upset being possible; he can ride over brickbats, or obstructions, not only without being upset, but, if going slowly, without even touching them. As this machine is very little known, a few words of explanation may be interesting.

In the first place, the rider is placed over the main wheel, as in the bicycle, but much further forward. There are around him, on or near the ground, four little wheels, two before and two behind, supported in a manner the ingenuity of which calls for the utmost admiration. Turning the steering handle not only causes the front and rear pairs to turn opposite ways, but owing to their swiveling about an inward pointing axis, the machine is compelled to lean over toward the inside of the curve; not only is this the case, but each pair rises and falls with every inequality of the road, if the rider chooses that they run on the ground; but he can, if he pleases, arrange that in general they ride in the air, any one touching at such times as are necessary to keep him on the top of the one wheel, on which alone he is practically riding. He can, if he likes, at any time lift the main wheel off the ground and run along on the others only. The very few machines of the kind which I have seen have been provided with foot straps, to enable the rider to pull as well as push, which is a great advantage when climbing a hill, but this is on every machine except the Otto, of which I shall speak later, considered a dangerous practice.

Some of the objections to the bicycle to which I have referred were sufficient to prevent many, especially elderly men, from dreaming of becoming cyclists. So long as the tricycle was a crude and clumsy machine, there was no chance of cycling becoming a part, as it almost is and certainly soon will be, of our national life. The tricycle has been brought to such a state of perfection that it is difficult to imagine where further progress can be made.

Perhaps it will be well to mention what is necessary in order that a three-wheeled machine may be made to roll freely in a straight line, and also round curves. At all times each wheel must be able to travel in its own plane in spite of the united action of the other two. To run straight, the axes of all the wheels must obviously be parallel. To run round a curve, the axis of each must, if continued, pass through the center of curvature of the curve. If two wheels have a common axis, the intersection of the two lines forming the axes can only meet in one point. To steer such a combination, therefore, the plane of the third wheel only need be turned. If the axis of no two are common, then the planes of two of the wheels must be turned in order that the three axes may meet in a point.

Not only does free rolling depend on the suitable direction of the planes of the wheels, each wheel must be able to run at a speed proportional to its distance from the point of intersection of the three axes, i.e., from the ever-shifting center of curvature.

The most obvious way, then, of contriving a three wheeler is to drive one wheel, steer with another, and leave the third, which must be opposite the driver, idle. The next in simplicity is to drive with one wheel, and steer with the other two, having one in front and the other behind. So far then, the single driving rear-steerer and the Coventry rotary pattern are easily understood. The evils of single driving, minimized, it is true, to a large extent, in the Coventry rotary, have led to the contrivance of means by which a wheel on each side may be driven without interfering with their differential motion in turning a corner.

Three methods are commonly used, but as only two are employed on tricycles, I shall leave the third till I come to the special machine for which it is necessary. The most easy to understand is the clutch, a model of which I have on the table. If each main wheel is driven by means of one of these, though compelled to go forward by the crankshaft, it is yet free to go faster without restraint. By this means "double driving" is effected in several forms of tricycle.

Differential gear, which is well understood, and of which there are several mechanically equivalent forms, divides the applied driving power, whether forward or backward, between the main wheels, equally if the gear is perfect, unequally if imperfect. To understand the effect of the two systems of driving, and of single driving, let us place on grooves a block which offers resistance to a moving force. If we wish to move it, and apply our force at the end of one side, it will tend to turn round as well as move forward, and much friction will be spent on the guides by their keeping it straight.

This is the single driver. If, instead of applying force at one side, we push the block bodily forward by a beam moving parallel to itself, then so long as the guides are straight no strain will be put upon them, even though one side of the block is resisted more than the other; if, however, the guides compelled the block to travel round a curve, then the power, instead of being divided between the two sides in such proportion as is necessary to relieve the guides of all strain, is suddenly applied only to the inside, and the effect is that of a single driver only. This is the clutch. Lastly, if the last-mentioned beam, instead of being pushed along parallel to itself, were pivoted in the middle, and that pivot only pushed, the same power would be applied to each side of the block, and no strain would be thrown on the guides, whether straight or curved, so long as the resistance opposed to the block on the two sides were equal; if, however, one side met with more resistance than the other, then the guides would have to keep the block straight. This is the differential gear.

I have assumed that in the last case the force was applied to the middle of the beam;

this corresponds to every evenly-balanced gear. In the gear employed by Singer, which is not evenly balanced, but which derives its good qualities from its simplicity, the same effect is produced as if the beam were pivoted on one side of the center instead of on the center. Thus, though both sides are driven, one is driven more than the other. On the whole, there is no doubt that the balanced gear gives a superior action to the clutch, for except when the two sides of the machine meet with very different resistance, and then only when running straight, the clutch will not compare with the other. The clutch also gives rise to what is considered by most riders a grave defect, the inability to back treadle, while the free pedal, which is an immediate consequence, is considered by others a luxury.

On the other hand, this same free pedal can be obtained on differentially driven machines to which speed and power gear have been applied.

Of the relative merits of different forms of differential gear there is little to be said. Perhaps it will not be thought I am unduly thrusting myself forward, if I refer to a scheme of my own, in which no toothed wheels are employed, but in which two conical surfaces are driven by a series of balls lying in the groove between them, and jambed against them by a recessed ring.

I have here a large wooden diagrammatic model, and a small working model in steel, which shows that the new principle employed is correct, namely, that a ball while jambed is free to turn, or if turning is able to jamb. All Humbers, and most front steerers, employ differential gearing; in some front steerers the clutch of necessity is used.

Neglecting for the present the different modes of transmitting power from the pedals to the main wheels, it is possible now to consider the four typical builds of tricycle. The only advantage that a rider can find in a rear-steerer is the open front, so that in case of accident he can more easily clear himself of his machine; as I have already remarked, this power of instantly escaping seems to be considered by many as of no importance.

In a rear-steerer which has not an open front, whether driven by a clutch or by differential gear, I fail to discover any good quality. The steering of a rear-steerer is so very uncertain, that such machines cannot safely be driven at anything like a high speed, because any wheel meeting with an obstruction will, by checking the machine, diminish the weight on the steering wheel just at the time when a greater weight than usual should be applied. It is for the corresponding reason that the steering of a front-steerer is so excellent; the more the machine is checked by obstruction, by back treading, or by the brake, the greater is the weight on the front wheel.

For shooting hills, or for pulling up suddenly, no machine of any kind will compare with a good front-steerer. In all respects it is superior to the rear-steerer if we except the open front, but against this may be set the fact that on many the rider can mount from behind, or can dismount in the same manner while the machine is in motion. Experience shows that the front-steerer is for general excellence, safety, easy management, and light-running, the best all-round tricycle that is to be had.

The Humber build, which departs less from the ordinary bicycle than any othar, is far superior to all others for speed; it is, however, somewhat difficult to manage, for the steering is not only delicate, but critical, requiring constant care lest a stone or other obstruction should take the rider unawares, and steer the machine for him.

The control which a skillful rider of the Humber has over his machine is wonderful; the elegance of the machine among tricycles is unequaled. So great a favorite is this form, especially among the better class of riders, that almost every firm have brought out their own Humber, each with a distinguishing name.

The only improvement or change, whichever it may be, that has been made by others with which I am acquainted, is the triple steering, in which the hind wheel moves the opposite way to the others. The corresponding change in the bicycle was soon discarded; I do not know what advantage can result from the increased delicacy of steering here. I should have thought it delicate enough already.

One noticeable change in the front-steering tricycle, which has been largely made, lately, is the substitution of central for side gearing, in consequence of which bicycle cranks can be employed, instead of the cranked axle, with its fixed throw. This gives an appearance of lightness which the older types of machine do not possess.

I now come to that very difficult and all-important subject, the method of transmitting power from the body of the rider to the main axle. Next to the structural arrangement, this is most important in distinguishing one type of machine from another.

The first to which I shall refer is the direct action employed on the National and the

Monarch tricycles. It is obvious that by having no separate crank shaft, much greater simplicity and cheapness and less friction are attained than can be possible when the extra bearings and gear generally used are employed. In this respect the direct action machines undoubtedly have an advantage, but an advantage of any kind may be too dearly bought, as it certainly is here.

In the first place, the direct action can only be applied to a rear-steering, clutch-driven machine, or single driver, for if the wheels were not free to run ahead, it would be impossible to go round a curve. In the second place, the rider must be placed at such a height for his feet to work on the axle that the machine, of necessity, is very unstable, and is likely to upset if ridden without great caution round a curve. Thirdly, to diminish as far as possible this last objection, miserable little wheels must be employed, which cannot be geared up, that is, made to travel faster than the treadles, and so be equivalent to larger wheels. Therefore, though it is likely that at such low speeds only as it is safe to run such a machine it may move more easily than a machine of a recognized type, and though direct action would undoubtedly be advantageous if it did not entail defects of a most serious order of magnitude, we may dismiss this at once from our consideration. It is true that in the Monarch a few inches of height are gained by the hanging pedals, but I question very much whether one machine is much better than the other.

The chain which is used on almost every make of machine cannot be considered perfect; it is, on the whole, a dirty and noisy contrivance, giving rise to friction where the links take and leave the teeth of the pulleys; stretching, or rather lengthening, by wear, and, finally, allowing back lash, which is most unpleasant. In spite of all this, it affords a convenient and reliable means of transmitting power, which is applicable to every type of tricycle, except one.

Instead of a chain, an intermediate or idle wheel has been tried, but this has not been found advantageous. The intermediate wheel has been removed, and the crank and wheel pulley allowed to gear directly together, making reverse motion of the feet necessary, and possibly reducing friction.

The crank and connecting rod are employed in some machines. If there are two only, they must not be placed in opposite positions, but be fixed at an angle, so that there are times when each rod is under compression, a strain which delicate rods cannot stand. In the three-throw crank, employed in the Matchless tricycle, this objection is obviated, for one, at least, is at all times in such a position as to be in tension. The objection to the crank is the fact that it weakens the shaft, and that it can only be used with a clutch, not with a differential gear.

The most silent, neatest, and cleanest driver, the one of which the working friction is least, is the endless steel band, so well known in connection with the Otto bicycle. This is not, as far as I am aware, employed on any tricycle, makers probably fearing lest it should slip. The Otto shows that it can safely be employed.

I have devised a scheme, of which I now show a model, which seems to me to be free from the objections which may be urged against other methods; but I, of course, cannot be considered in this respect a judge. Eccentrics are well known as equivalent to cranks, but if used in the same way, with a connecting rod, either fatal friction or enormous ball-bearings would be necessary. Instead of these, I connect two pair of equal eccentrics by an endless band embracing each, so that the band acts like a connecting rod without friction, and, at the same time, acts by its turning power as on the Otto, thus making two eccentrics sufficient instead of three, and carrying them over the dead points.

There is one more system of transmitting power employed on a few machines. In these, a band or line passes over the circumference of a sector or wheel, and the power is directly applied to it. The motion of the feet in the omnicycle, and of the hands and body in the Oarsman, is therefore uniform. There would be no harm in this if it were not for the starting and the stopping, which cannot be gradual and at the same time effective in machines of this type. For this reason, a high speed cannot be obtained; nevertheless, these machines are better able to climb hills than are tricycles with the usual rotary motion, for, at all parts of the stroke--which may be of any length that the rider chooses--his driving power on the wheels is equal. The ingenious expanding drums on the omnicycle make this machine exceptionally good in this respect, for increased leverage is effected without increased friction, which is the result of "putting on the power" in some of the two-speed contrivances.

Having spoken of the Oarsman tricycle, I must express regret that I have not been able to find an opportunity to ride on or with the machine, so that I cannot from observation form an opinion of its going qualities. There can be no doubt that the enormous amount of work that can be got from the body in each stroke on a sliding seat in a boat must, applied in the same manner on the Oarsman tricycle, make it shoot away in a surprising manner; whether such motion, when continued for hours, is more tiring than the ordinary leg motion only, I cannot say for certain, but I should imagine that it would be. The method by which the steering is effected by the feet, and can with one foot be locked to a rigidly straight course, is especially to be admired.

There is much difference of opinion with respect to the most suitable size for the wheels of machines. Except with certain machines, this has nothing to do with the speed at which the machine will travel at a given rate of pedaling, for the wheels may be geared up or down to any extent, that is made to turn more quickly or slowly than the cranks. Thus the most suitable speeding is a separate question, and must be treated by itself.

Large wheels are far superior to small wheels in allowing comfortable, easy motion, a matter of considerable importance in a long journey. They are also far better than small for running over loose or muddy ground, for with a given weight upon them they sink in less, from the longer bearing they present, and this, combined with their less curvature, makes the everlasting ascent which the mud presents to them far less than with a smaller wheel. On the other hand, the large wheel is heavier, and suffers more from air resistance than the small wheel. For racing purposes a little wheel, geared up of course, is certainly better than a high wheel; for comfortable traveling, and in general, the high wheel is preferable. Though this is certainly the case, it does not follow that large wheels are worth having on a machine when there is already one little wheel. If the rider is to be worried with the evils of a little wheel at all, it is possible that any advantage which large wheels would give him would be swamped by the vibration and mud-sticking properties of the small steering wheel. One firm, in their endeavors to minimize these evils, have designed machines without any very small wheels; all three wheels are large, and a steadier and more comfortable motion no doubt results.

High and low gearing are the natural sequel to high and low wheels. Of course the lower the gearing the greater is the mechanical advantage in favor of the rider when meeting with much resistance, whether from wind, mud, or steepness of slope. In spite of this, for some reason which I cannot divine, the machines with excessively low gear do not seem to obtain so great an advantage in climbing hills as might be expected. To make such a machine travel at a moderate speed only, excessively rapid pedaling is necessary, and the rider is made tired more by the motion of his legs than by any work he is doing. The slow, steady stroke by which a rider propels a high-geared machine is far more graceful and less wearying than the furious motion which is necessary on a low-geared machine. The height up to which the driving-wheels are usually geared may be taken as an indication of the ease with which any class of machines runs. A rider on a low-geared machine can start his machine much more quickly than an equal man on one that has high gearing, and therefore in a race he has an advantage at first, which he speedily loses as his rapid pedaling begins to tell. For ordinary riding the slight loss of time at starting is a matter of no importance whatever.

There are several devices which enable us to obtain the advantages of high and low gearing on the same machine, which at the same time give the rider the benefit of a free pedal whenever he wishes. On some single driving rear-steering tricycles the connection on one side is for speed, and that on the other for power, either being in action at the wish of the rider, or both speed and power combinations are applied on the same side. To drive with a power gear a single wheel only seems to me to be the height of folly; in my opinion no arrangement of this type is worthy of serious attention. Among the better class of machines there are three methods by which this change is effected--first, that employed on the omnicycle, to which I have already referred; secondly, an epicyclic combination of wheelwork which moves as one piece when set for speed, thus adding nothing to the working friction except by its weight, but which works internally when set for power, thus reducing to a small extent, by the additional friction, the gain of power which the rider desires; thirdly, a double set of chains and pulleys, each set always in movement, so that, whether set for speed or power, there is rather more friction than there would be if there were no additional chains, but these are free from that increased friction due to toothed wheel gearing, from which the epicyclic contrivances suffer only when set for power. There is much difference of opinion whether any of these arrangements are worth carrying, for perhaps nine miles, for the sake of any advantage that may be obtained in the tenth. It is on this account that the drums on the omnicycle are so excellent; whether expanded or not, there is, on their account, no loss of work whatever, for there is no additional friction. The subject of these two speed gears will, I hope, be discussed; it is one which, though not new, is coming more to the front, and about which much may be said.

Having now dealt with the means by which tricycles are made to climb hills more easily, I wish to leave the subject of bicycles and tricycles altogether for a few minutes, to say a few words which may specially interest those who are fond of trying their power in riding up our best known hills. The difficulty of getting up depends to a large extent on the surface and on the wind, but chiefly on the steepness. The vague manner in which one hill is compared with another, and the wild ideas that many hold who have not made any measurements, induces me to describe a method which I have found specially applicable for the measurement of steepness of any hill on which a cyclist may find himself, and also a scheme for the complete representation of the steepness and elevation of every part of a hill on a map so as to be taken in at a glance. The force required to move the thing up a slope is directly proportional not to the angle, but to the trigonometrical sine of that angle. To measure this, place the tricycle, or Otto--a bicycle will not stand square to the road, and therefore cannot be used--pointing in direction at right angles to the slope of the hill, so that it will not tend to move. Clip on the top of the wheel a level, and mark that part of the road which is in the line of sight. Take a string made up of pieces alternately black and white, each exactly as long as the wheel is high, and stretch it between the mark and the top of the wheel. If there are n pieces of string included, the slope is 1 in n, for by similar triangles the diameter of the wheel is to the length of the string as the vertical rise is to the distance on the road. This gives the average steepness of a piece sufficiently long to be worth testing, because an incline only a few feet in length, of almost any steepness, can be mounted by the aid of momentum.

There is only one process, with which I am acquainted, which supplies a method of representing on a map the steepness of a road at every part. Contours, of course, show how far one has to go to rise 50 or 100 feet, but as to whether the ascent is made uniformly or in an irregular manner, with steep and level places, they tell us nothing. Let the course of a road be indicated by a single line where it is level, and by a pair of lines where inclined. Let the distance between the lines be everywhere proportional to the steepness, then the greatest width will show the steepest part, and an intermediate width will show places of intermediate steepness; the crossing of the lines, which must be distinguishable from one another, will show where the direction of the slope changes. Further, the size of the figure bounded by the two lines will show the total rise; a great height being reached only by great steepness or by great length, a large figure being formed only by great width or by great length. Those who are mathematically inclined will recognize here that I have differentiated the curve representing the slope of the bill, and laid the differential curve down in plan.

Having wandered off my subject, I must return to more mechanical things, and give the results of some experiments which I have made on the balls of ball bearings. There is no necessity to argue the case of ball vs. plain bearings, the balls have so clearly won their case, that it would be waste of time to show why. Of the wear of the twelve balls forming one set belonging to the bearings of the wheels of my Otto, I have on a previous occasion spoken; I may, however, repeat that in running 1,000 miles, the twelve balls lost in weight only 1/20.8 grain, or each ball lost only 1/250 grain. The wear of the surface amounted to only 1/158000 inch; at the same rate of wear, the loss in traveling from here to the moon would amount to only 1/34.3 of their weight. I examined each ball every 200 miles, and was surprised to find that on the whole the wear of each, during each journey, varied very little. The balls experimented on were a new set obtained from Mr. Bown. I also had from him one ball of each of each of the following sizes 3, 4, 5, 6, and 7 16ths of an inch in diameter, as I was curious to know what weight they would suppport without crushing. As as preliminary experiment, I placed a spare 5/16 ball between the crushing faces of the new testing machine at South Kensington, and applied a gradually increasing force up to 7 tons 9½ cwt., at which it showed no signs of distress. On removing it I found that it had buried itself over an angle of about 60° in the hard steel faces, faces so hard that a file would not touch them. Those marks will be a permanent record of the stuff of which the ball was made. The ball itself is sealed in a tube, so that any one who is curious to see it can do so. Finding that the crushing faces were not sufficiently hard, I made two anvils of the best tool steel, and very carefully hardened them. These, though they were impressed slightly, were sufficiently good for the purpose. In the following table are the results of the crushing experiments:

3/16 ball at 2 tons 13 cwt. did not break, but crushed on removing part of the weight.

¼ ball at 3 tons 15 cwt. did not break, but crushed on removing part of the weight.

5/16 ball at 4 tons 9 cwt. broke.

3/8 ball at 8 tons 6 cwt. did not break, crushed under another 120 lb.

7/16 ball crushed before 3 tons, with which I was starting, had been applied. Examination showed that the steel bar of which it was made had been laminated.

These experiments do not tell much of importance; they are curious, and perhaps of sufficient interest to bring before your notice. The fragments are all preserved in tubes, and labeled, so that any one who likes to see them can do so.

Of the advantage which a machine which will collapse or fold up when desired, but retain its form on the road, offers in convenience, it is unnecessary for me to speak.

Of double machines, the Rucker tandem bicycle seems to me to be in every respect the best, but I should add that I speak only from imagination and not from experience. The independent steering, the impossibility of capsizing forward or sideways, the position of the rider over his work, the absence of any little wheel with its mud throwing and vibrating tendencies, combine to make a machine which ought to be superior in almost every desirable quality to any other; what it may be in practice I hope to hear in the discussion.

Of double tricycles, the Sociable has been tried by many, and is practically a failure in so far as traveling quickly and easily is concerned. The Tandem, though it presents so objectionable an appearance, seems likely to become a favorite, for it surpasses any single tricycle, and rivals the bicycle in speed. How it may compare in comfort or in safety with the single machine, perhaps those few who are well acquainted with them will say; at any rate, in the case of the Humber, greater stability is given to the steering, owing to the weight of the front rider.

Time will not allow me to say more of these machines, or to attack the subject of steam, electric, or magic tricycles, which I had hoped to do. With steam and electricity we are well acquainted; by magic tricycles, I mean those driven by a motor which, without any expense, will drive one twenty miles an hour, up or down hill, with perfect safety. Highway regulations, and certain reasons not well understood, have at present prevented these contrivances from making a revolution.

There remains one machine which must be considered separately, for it cannot be classed with any other. This is the Otto bicycle. My opinion of this machine is so pronounced that I do not care to state it fully. I shall merely give the reasons why I prefer it to anything else, and in so doing I shall be taking the first step in the discussion, in which it will be interesting to hear from riders of other machines the reasons for their preference.

In the first place, the evils of a third or little wheel, the cause of trouble in all tricycles, are avoided. There is none of the vibration which makes all other machines almost unbearable to Ottoists, vibration which tricyclists have learnt to consider a necessary accompaniment of cycling, but which has, no doubt, been diminished by the use of the spring support of the front steering Humber. It would be presumptuous in me to make any remarks on the effect of this vibration on the human system; we shall all be anxious to hear what our Chairman has to say on this point. By having only two wheels, we have only two tracks, so that we can travel at a fair speed along those places in the country called roads, which consist of alternate lines of ruts and stones, where a three-track machine could not be driven, and where, from the quantity of loose limestone in the ruts, a little wheel of a two-track tricycle would be likely to suffer. By having no little wheel, we can ride in dirty weather without having the rest of our machine pelted with mud, so that cleaning takes less time than it does with anything else. As I have already remarked, the small wheel is the culprit which makes the bicycle and tricycle drive so heavily on a soft road. The ease with which the Otto can therefore be run through the mud astonishes every one. Having no little wheel, we can obtain the full advantage of the high 56 inch wheel, which almost every one prefers. As I have ridden all combinations, from a 50 inch geared up to 60 inch, to a 60 inch geared level, I can speak from experience of the increased comfort to be derived from these large wheels, though for speed only they do not compare with the smaller and lighter wheels geared up. A further point gained by the use of two wheels only is the fact that the whole weight of machine and rider is on the driving-wheel, as it is also on the steering-wheel, so that by no possibility can the wheels be made to slip in the driving, or to fail in steering from want of pressure upon them.

The most important consequence, however, is the absence of any fixed frame. In all machines, bicycles and tricycles, with the usual fixed frame, a position is found for the saddle which is, on the whole, most suitable. For some particular gradient it will be perfect; on a steeper gradient the treadles will be further in advance, but with a steeper gradient the rider should be more over the front of the treadles. To get his weight further to the front, he has to double up in the middle, and assume a position in which he cannot possibly work to advantage. The swinging frame of the Otto carries the treadles, of necessity, further back, so that the Ottoist, when working at his hardest, is still upright, with his hands in the line between his shoulders, and his feet and his arms straight, so that he can hold himself down, and employ his strength in a perfectly natural position. On going down a slope, the fixed frame of a bicycle or tricycle leans forward, and places the rider in such a position that extra weight is thrown on his arms and his shoulders, whereas the swing frame of the Otto goes back, and the rider of necessity assumes that position in which his arms are relieved of all strain. In so far as the general position taken by the automatic Otto frame is concerned, nearly the same effect can be obtained by using the swing frame of the Devon tricycle, which can be shifted and locked in any position which the rider wishes, or by the sliding saddle, which can be slid backward or forward and locked so as to place the rider in one of three positions. Though the rider can by these devices assume nearly that position with respect to the treadles which is most advantageous, he cannot obtain that curious fore and aft oscillation made use of by the Ottoist in climbing hills, which, as the model on the table shows, enables him to get past the dead points without even moving, and which, therefore, makes the Otto by far the best hill-climbing machine there is, if account is taken of the high speeding with which all Ottoists ride. This is a proposition which none who knows the machine will question for one moment.

The freedom of motion resulting from the swing of the frame of the Otto gives a pleasurable sensation, which those who have only experienced the constrained motion of a three-wheeler cannot even understand.

The very peculiar method of driving and steering, which seems so puzzling to the novice, especially if he is a good rider of other machines--for in that case he is far worse off than one who has never ridden anything--give the rider, when he is familiar with them, a control over the machine which is still surprising to me. In the first place, the machine will run along straight, backward or forward, so long as the handles are let alone. This automatic straight running is a luxury, for until a deviation has to be made, the steering handles need not be touched, and the rider may, if sufficiently confident, travel with his arms folded or his hands in his pockets. The rigid connection between the cranks and the wheels does away with all the backlash, which is so unpleasant with chain or toothed wheel gearing. There is no differential gear or clutch, but the machine possesses the advantage of the clutch over the differential gear when meeting with unequal resistance on a straight course, for each wheel must travel at the same speed; but, in turning a corner, instead of driving the inner wheel only, which is done by the clutch or both wheels equally, which is the case with differential gear, each wheel is driven, but the outer one more than the inner. At high speeds, the steering of the Otto has this advantage, that whereas, with a given action on a tricyle, the same deviation will be effected in the same *space* at high as at low speeds, the same action on the Otto will, at high speeds, produce the same deviation in the same *time* as it does at low speeds; and so instead of becoming more sensitive at high speeds, as is the case with the tricyle, the steering of the Otto remains the same. This is because the steering of the tricycle depends on a kinematical, that of the Otto on a dynamical principle.

In another respect, no machine can approach the Otto; at almost any speed the rider can, if there is reason, instantly dismount, by which action he puts on the brakes, and the machine will save him from falling, stopping with him almost instantly. As is well known, we can move backward and forward, we can twist around and around in our own width, or can ride over bricks with impunity.

One objection to the machine is the difficulty of learning, which is considerable, but which presents no danger. This difficulty has been much exaggerated, for before the present powerful brake was applied it did require considerable skill to ride it down a steep hill. The way to do this must still be learnt, but it is now comparatively easy. For going down steep hills, the front steering tricycle is without a rival; I do not know what other machine will do this better than the Otto. Lastly, the foot straps, which would be a great advantage on any machine, if only they were safe, are not--though none but riders will believe it--in any way a source of danger on the Otto. Having ridden this machine for close upon 10,000 miles, I can speak with more authority on this point than can those who are not able to sit upon it for a moment.

The only disadvantage which the machine presents is the fact that it is impossible to remove the feet from the pedals while running, without dismounting; but though they must at all times follow the pedals, the Ottoist is not, as is generally thought, working when descending a hill.

The enthusiastic terms in which every one who has mastered the peculiarities of the Otto speaks of it would be considered as evidence in its favor, if we were not all considered by other cyclists to be in various stages of lunacy.

THE CANAL IRON WORKS, LONDON.

Some interest is awakened in engineering circles in London, just now, by the approaching close of the old engineering works so well known as the "Canal Ironworks," at the entrance to the Isle of Dogs, London, E. This notable establishment stands second in priority in London--that of Messrs. Maudslay, Sons & Field being the oldest--for the manufacture of marine engines. It was founded by the late Messrs. Seawards, above sixty years ago. Here was originated Seaward's hoisting "sheers" with the traveling back leg, a modern example of which, 100 feet high, in iron, stands on the wharf. An interesting tool, also, is the large vertical boring machine for largest size cylinders; Seaward spent £5,000 upon this, and it is certainly an admirable tool. There is also the large vertical slotting machine, with a stroke up to 5 feet 2 inches, a wonderfully powerful and compact machine. The extensive collection of screwing tackle is, perhaps, unsurpassed, and extends up to 8 inches diameter. There is a peculiar erecting shop roof, which will still repay examination.

MARINONI'S ROTARY PRINTING PRESS.

The greatest progress that has been made in recent years in the art of printing is in the invention of the high speed press provided with continuous paper.

Three French constructors, Messrs. Marinoni, Alauzet, and Derriey, have brought this kind of apparatus to such a degree of perfection that the majority of foreign journals having a large circulation buy their presses in France. We reproduce in Fig. 1 a perspective view of the Marinoni press, and in Fig. 2 a diagram showing the parts of the same. In order to give a complete description of it, we cannot do better than to reproduce the very interesting study that has been made of it by Mr. Monet, a civil engineer.

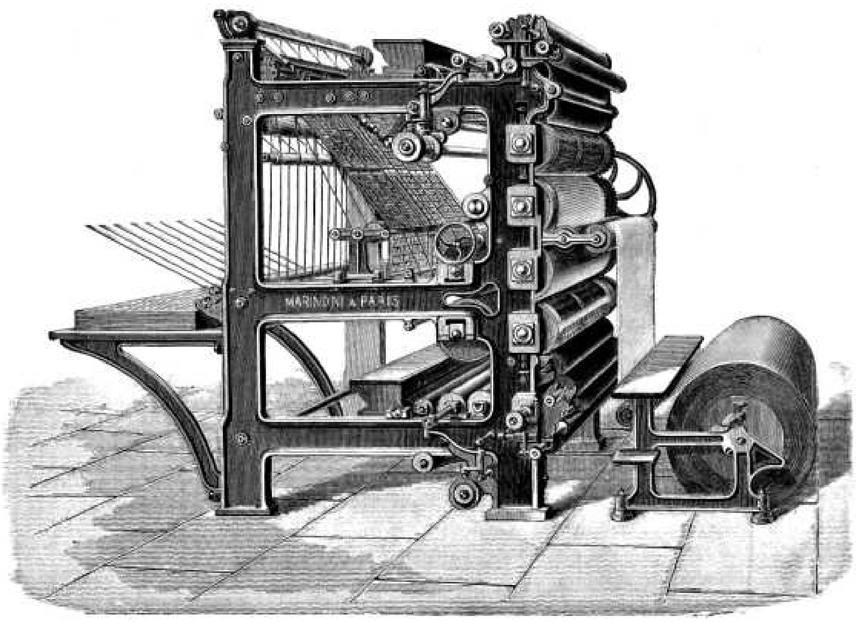


FIG. 1.--MARINONI'S ROTARY PRINTING PRESS.

The roller, J (Fig. 2), is placed in the machine in the state in which it is received from the paper manufactory. The paper unwinds, runs over the rollers, e and e', which serve only for tautening it, and then passes between the two cylinders, A and B. The cylinder, A, carries the form, and B carries the blanket, and the paper thus receives its first impression. It afterward passes between the cylinders, A' and B', and receives an impression on the other side, the cylinder, A', carrying the form, and B' the blanket. Being now printed on both sides, it passes between the cylinders, KK', which cut it off and allow the sheet to slide between the cords of the rollers. These latter lead the sheets over the rollers, g h, on which they wind, one over the other, when the rollers, a a', are in the position shown by unbroken lines in the cut.

The part of the machine that holds the rollers, g h, and the different cords that wind over them, is the *accumulator*, and it is in this part of the press that the sheets accumulate, one over the other, to any number desired.

The size of the rollers, g h, and their distance apart are so regulated that when the sheet reaches the accumulator, it falls exactly on those that have preceded it. When the proper number of sheets is in the accumulator (4 or 5 being the number most employed for afterward facilitating the separation into packets on the receiving table), the two small rollers, a a', advance over the rack, N, and the sheets, instead of continuing to roll over into the accumulator, fall on the rack and are deposited by it upon the receiving table, O.

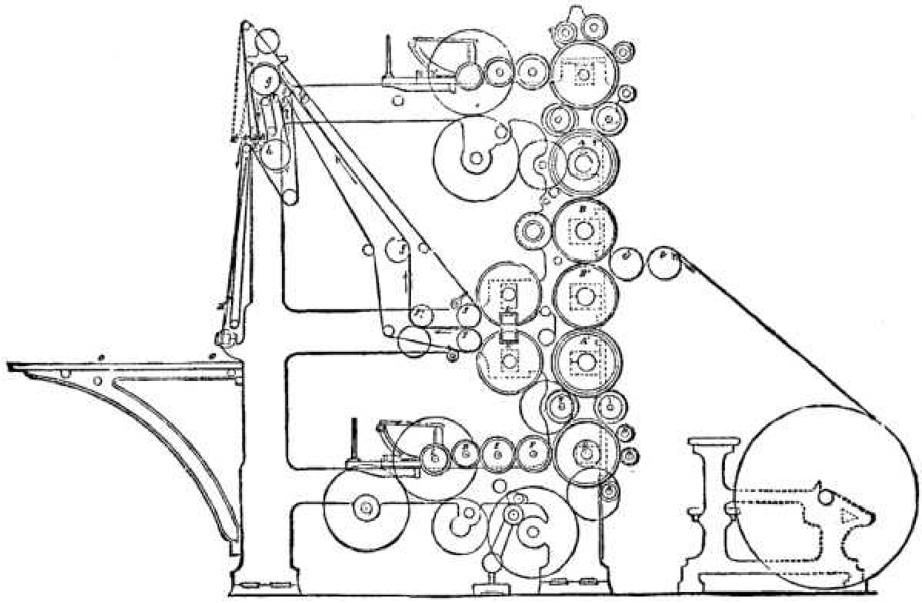


FIG. 2.--MARINONI'S PRESS.

The rack having fallen twenty times, and deposited five sheets each time, or one hundred in all, the table moves in such a way as to prevent the sheets subsequently deposited from getting mixed with them. When the rack has fallen twenty times, the table returns to its initial position.

The distributing rollers, D, come in contact with the inking rollers, I, once during each revolution of the printing cylinders, and are mounted on racking levers provided with regulating screws that permit of easily regulating the amount of ink taken up. The supports of the inking rollers are movable and can be made to approach or recede from the distributing rollers, so as to still further vary the amount of ink taken up by them.

The distributing rollers supply the ink to a roller, E, of large diameter, which, having a backward and forward motion, begins to distribute the ink and to transmit it to a second roller, F, of the same diameter. This latter then spreads it over a metallic cylinder, G, which is of the same diameter as the printing cylinders, and against which revolve three distributing rollers, H, that have a backward and forward motion.

Between the cylindrical inking table, G, and the type cylinder, there are situated inking cylinders, T, of large diameter, that constantly take up ink from the inking table and distribute it over the types.

The machine here described, when designed for printing large sized journals, has cylinders whose circumference corresponds to the size of paper for two widths of pages, and whose length is sufficient to allow it to receive two forms. Each cylinder, then, carries four forms, or eight in all, and prints two complete copies at each revolution.

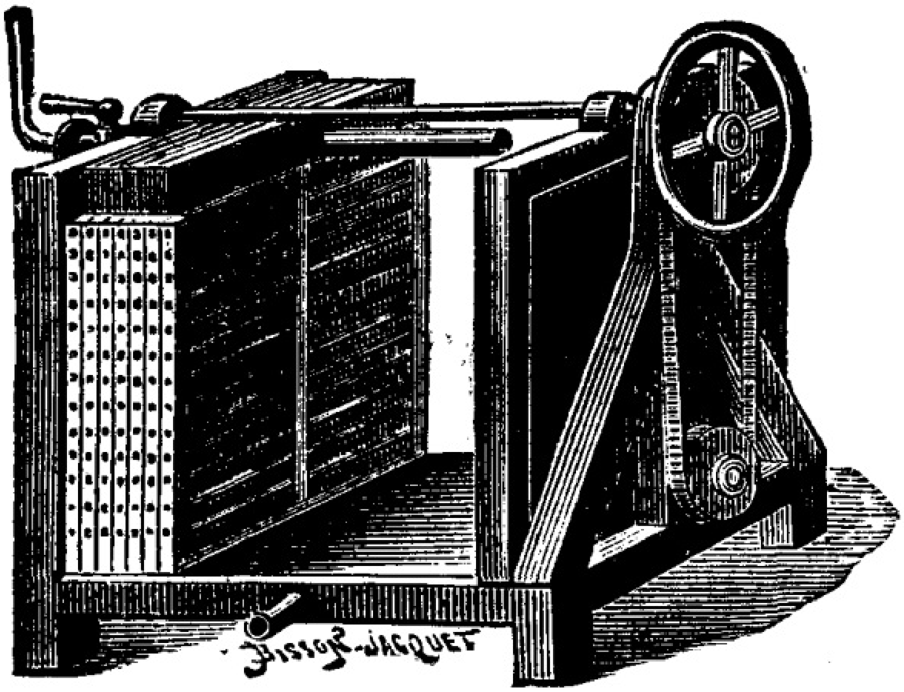
The large sheet cut off by the cylinders, K K', contains, then, two copies; and this sheet, on passing under the roller, f is again cut in two by a disk which separates it in a direction perpendicular to the cylinders.

To this press there may be added a mechanical folder of Mr. Marinoni's invention, capable of folding a journal five times.--*Annales Industrielles*.

CHENOT'S ECONOMIC FILTER PRESS.

Mr. E. Chenot, who is occupied in the manufacture of wine from dry grapes, has been led to devise a new style of filter, which by reason of its mode of action and its construction, he calls the "Economic Filter Press."

The apparatus, which is shown in the accompanying cut, consists of flat bags whose mouth may be at the top, as usual, or at the side. Through this orifice there is introduced a flat piece of wood or metal, which, like the bag, has an aperture through the center. The whole is suspended from a distributing pipe that is fixed at one end to the frame and is free at the other. This pipe is slotted beneath, and the pieces of wood or metal contain, opposite the slot, a number of small apertures that put the distributer in communication with the interior of the bags. Between these latter there are placed wire cloth frames which hold them in position and facilitate the flow of the filtered liquid. The cut shows the filter provided with a portion of its bags and frames. When all the frames are in place they are locked by causing the movable plate to move forward by means of two screws connected with an endless chain and actuated by a hand wheel. The pressure of this plate closes up the bags hermetically. Then, the feed cock being opened, the liquid flows into all the bags, deposits therein what it holds in suspension, and the clarified product flows to the inclined bottom of the filter and from thence to the exterior.



CHENOT'S ECONOMIC FILTER PRESS.

The apparatus may be supplied either through an upper reservoir, a juice elevator, or a pump. The discharge is proportional to the square root of the pressure. When the bags are full of residuum, the feed cock is closed, the filter is unscrewed, and the bags and frames are taken out. With fresh bags and the same frames, it is possible to at once set the apparatus in operation again.

Before the filter is taken apart, the residuum may be exhausted by washing it either with water or steam, or by pressure. To effect the operation by pressure, the pieces of wood or metal are removed, the mouths are closed by making a fold in the top of the bags, and the latter are then put back into the apparatus or into an ordinary press and submitted to another squeezing.

To render the maneuvering of it easier, the apparatus has been given a horizontal position.--*Revue Industrielle*.

[American Engineer]

STEEL CHAINS WITHOUT WELDING.

We take the following description, together with the illustrations, of a method and machine for making steel chain without welding, from our valued contemporary, *Le Genie Civil*, of Paris:

When we regard an ordinary oval-linked chain endwise, it presents itself in the form of a metal cross, and it was this that gave the cue to M. Oury, of the Government Arsenals, to construct chain without welding. By a series of matrices and punches, etc., he contrives, with small loss of metal, to model a chain out of cross-shaped steel bar.

Steel is the better material for such usage, from its homogeneity, both as to composition and strength.

Referring to the plate below, Figs. 1 to 10 explain the successive steps from the bar to the finished chain.

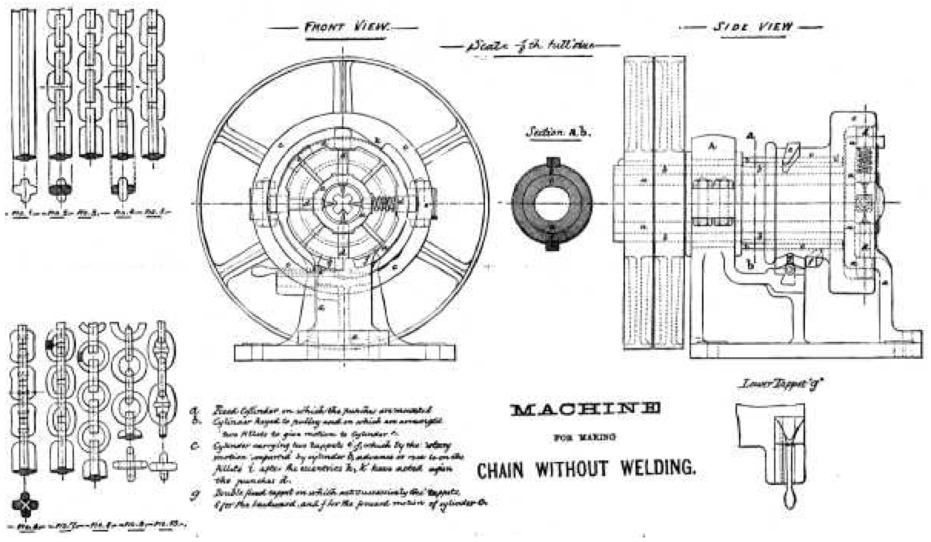
Fig. 1 shows in plan and section the steel bar, whose length may be some 40 feet, and which would make a chain say 50 feet long. The shape of the bar presents no difficulties in the way of rolling.

Figs. 2 and 3 give, in side elevations of the two faces and sections, the first rough form of the links. These first begin to take the exterior shape with the rounding of the angles.

The operations following, represented by Figs. 4 and 5, is the piercing of the center of the links, which can later be furnished with a stay for such chains as require special strength. The point now is to detach the links, which is accomplished by oblique piercings, as shown in Fig. 6. In the operation represented by Fig. 7, the oval shape is imparted to the link, and the operation finishes as shown in Fig. 8.

Actually, the links are circular and separate. This separation is retarded as much as possible, for it is plain that it is easier to operate a rigid bar than a chain, above all when the operation necessitates its being pushed forward.

By means of a good system of heating, analogous to that employed on the large parts entering into ship construction, it is hoped to perform a major part of the operations, of which we have given but an idea, at a single heat.



MACHINE FOR MAKING CHAIN WITHOUT WELDING.

These operations require work on both faces alternately--this presents no difficulties; but what appears to us most difficult to realize is *continuous work*, the bar passing through several machines which successively impress upon it the steps of progress toward the finished chain. If the machines are end on to each other in a direct line, there will necessarily be a fixed place for each tool; the rough cut chain must accurately reach the point where another tool is ready to continue the modeling. This appears to us practically impossible, the more so as the elongation which the bar takes at each stamp varies with its initial diameter.

What is more admissible is that with one heat and in the same machine an operation could be performed on the two faces perpendicularly. The bar could then be taken from one furnace and put in another immediately, to pass at once to another machine to again undergo the operations following. The work could then be done rapidly, submitting the bar to several heats.

A few words on the tools as they exist.

The most important principle to note, and on which the different machines employed are designed, is this: The punches or matrices acting on the chain at its different points of progress are put in motion by spiral springs worked by means of tappets or cams distributed over the circumference of a cylinder, having a rotary movement imparted to it by pulleys and belts.

The figures on our plate show with sufficient clearness the working of one of these machines. It will be seen that the bar traverses through and through the machine for stamping, and that it can be disengaged for a reheating before passing to subsequent operations.

The bog peat of Mexico is now being used on a considerable scale as fuel for locomotives, stationary engines, smelting purposes, smiths' fires, and househould use. The peat is mixed with a proper proportion of bitumen, and is said not only to burn freely, and without smoke in much quantity, but to give a higher dynamic equivalent of heat than the same amount of wood.

THE BITTER SUBSTANCE OF HOPS.

[Footnote: *The Brewers' Guardian*, from the *Zeit. f. d. gesammte Brauwesen*.]

By DR. H. BUNGENER.

Little that is definite is known of the substance or substances to which the hop owes its bitterness. Lermer has succeeded, it is true, in separating from hops a crystallized colorless substance, insoluble in water, an alkaline solution of which has a marked bitter flavor, and which easily changes on exposure to the air, assuming a resinous form. According to Lermer, the formula of this substance is $C_{32}H_{50}O_7$; it possesses the properties of a weak acid and forms a characteristic copper salt, which is soluble in ether. This hop bitter is, however, produced from the hop by a very roundabout process, by treatment of the extract with alkalies; it is not therefore regarded by many as present in this form in the hop, and they hold that it is only produced by the action of the alkalies. On the other hand, however, Etti, by a complicated extracting process, but without using an alkali, succeeded in producing a bitter substance from hops, which is, however, soluble in water.

Several experiments convinced me that there really existed in hops a crystallizable substance, insoluble in water, the alcoholic and alkaline solution of which had a bitter flavor, in short, which possessed all the properties of Lermer's hop bitter acid. Petroleum ether is the best practical solvent in use for its isolation, as it does not dissolve the majority of the remaining constituents of the hop, especially the hop-resin, which they contain in considerable quantity. Still, the extraction of hop-bitter acid from hops is a troublesome and thankless job, the petroleum ether taking up certain substances which add greatly to the difficulty of purifying the crystals. On the other hand, we can readily and quickly attain our object, if we employ for our original material fresh lupuline from unsulphured hops.

The following process has furnished me the best results:

The lupuline is first freed from gross impurities (hop-seed leaves, etc.), and then covered with petroleum ether boiling at a low temperature (40° to 70°) in stoppered flasks. The mixture is shaken up from time to time. After twenty-four hours, by means of a Zullowsky filter immersed in the mass, and with the aid of a suction-pump, the dark brown solution is drawn off; then fresh ether is poured on to the lupuline, and it is allowed to stand for another twenty-four hours. After this process has been three times repeated, nearly everything the petroleum will dissolve has probably been extracted. The solutions are put together, and the petroleum ether distilled off *in vacuo* at a low temperature, until there remains in the flask a dark brown sirup, which on cooling solidifies into a crystalline mass. This is pulverized and turned on to a filter composed of a large funnel, in which a smaller funnel covered with muslin is inserted. With the aid of a suction-pump, the greater portion of the thick, crude solution can be filtered through. There remains on the filter a highly colored crystalline "cake," which should be pulverized with a small quantity of petroleum ether and again filtered. After this operation has been repeated three or four times, we obtain an almost colorless mass, consisting of hop-bitter acid, contaminated by small quantities of a fatty substance, and a substance which I could not isolate, and which I had at first great trouble in separating from the hop-bitter acid.

If we do not wish to utilize this crude substance at once, it will be necessary to melt it in the water bath and pour it into a bottle under close seal, where it will at once crystallize and solidify. If it remains exposed to the atmosphere, it will soon become sticky and turn partly into resin. Six kilos of lupuline, which included a large proportion of sand, furnished 400 grammes of crude hop-bitter acid. The first experiments in crystallization with petroleum ether gave poor results; it is difficult to produce the acid pure in large quantities by this process, as a small quantity of the above substance obstinately clings to it, and it readily assumes a non-crystallizable form. Our object is more readily attained if we crystallize it once from alcohol, for which purpose we dissolve it in a little lukewarm alcohol, then quickly cool the solution; flakes of a fatty substance will be separated, which are removed by filtration with the aid of a suction-pump. Then we throw a few small crystals of the acid into the solution, and after a short time crystallization commences. As soon as it appears to be ended, the mother solution is removed with the aid of a platinum cone, and the crystals washed with a little cold alcohol. The alcoholic mother solution, which still contains the chief part of the bitter acid, must be quickly evaporated, and the residue consigned to a flask. The acid crystallized from the alcohol is then recrystallized several times from petroleum-ether. In order to quickly dissolve the bitter substance, it should be carefully melted in a flask, and double its volume of ether gradually added; on its cooling, we obtain beautiful prismatic crystals, which attain a length of 1 cm., and become perfectly pure after four or five crystallizations. The mother solutions must be speedily evaporated if we still wish to obtain crystals; after a time they will only furnish a resinous residue.

The hop-bitter acid melts at 92° to 93°. It is easily soluble in alcohol, ether, benzol, chloroform, sulphide of carbon, and vinegar; to a lesser extent in cold petroleum ether, and not at all in water.

In the analysis I obtained figures which correspond best with those calculated from the formula $C_{25}H_{35}O_4$.

	Calculated.	Obtained.					
		2. Crystal.	3. Crystal.	5. Crystal.		6. Crystal.	
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
C	75.19	74.79	74.83	74.9	75.04	75.05	75.07
H	8.77	8.97	8.90	8.85	8.87	8.83	8.80
O	16.04						

If we shake up the ether solution of bitter substance with an aqueous solution of acetate of copper, the ether will assume a green color, and gradually deposits a green crystalline powder, a cupreous combination of the bitter acid. It is difficult to obtain in a pure state, as the solutions are readily subject to slight decomposition, accompanied by a small deposit of copper oxide. This combination is readily soluble in alcohol, to a lesser extent in ether, and is insoluble in water.

In the course of analysis, I obtained the following figures:

C	69.4 per cent.	69.3 per cent.
H	7.95 "	7.98 "
Cu	7.20 "	7.18 "

If we suppose that the copper combines with two molecules of hop-bitter acid, by the decomposition of one of its atoms, H, we obtain the formula $C_{50}H_{68}O_8Cu$. This combination will contain 69.87 per cent. C, 7.91 per cent. H, and 7.33 per cent. Cu. The figures obtained do not perfectly coincide with those calculated; it is nevertheless probable that the formula is correct, and the combined substance analyzed was not perfectly true.

I have already referred to the fact that solutions of hop-bitter acid, if left standing too long, assume a yellow color, and on evaporation leave only a yellow resinous residue. This, as its reaction shows, evinces a complete analogy with the crystallized acid. The dark-colored mother solution, from which the crystalline cakes of bitter acid are obtained, contains a large proportion of this resinous compound, which can be isolated by treatment with a weak soda-lye; this substance, like the crystallized acid, is soluble in alkalies, and can be precipitated from an alkaline solution by an acid. Old hops furnish far less crystallizable acid than new hops; from some samples I have been able to obtain only a few crystals; the remainder had been transformed into the resinous modification.

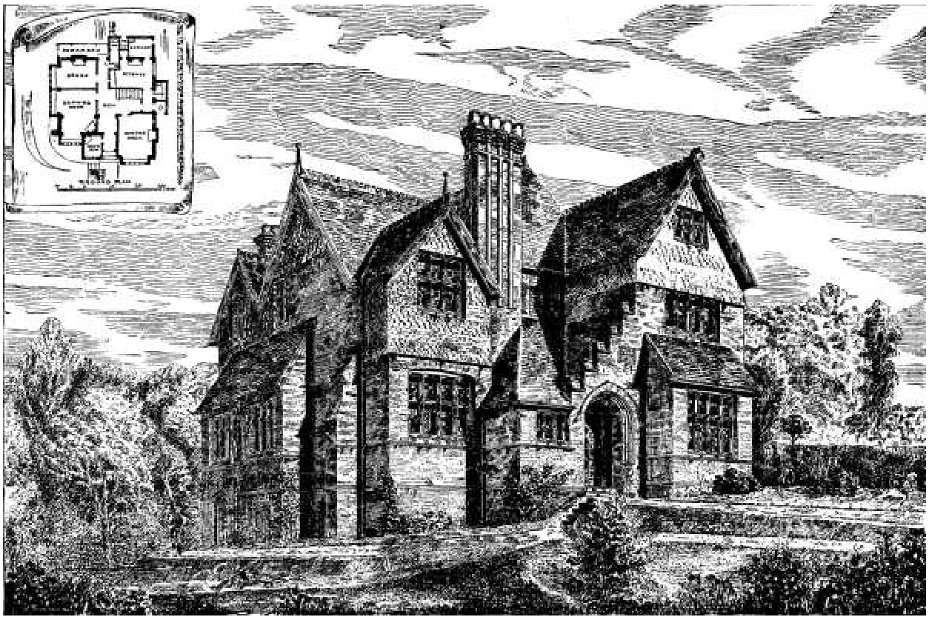
If pure hop-bitter acid be pulverized and exposed to the atmosphere, it soon turns yellow and the surface assumes a resinous consistency. At the same time, a more pronounced odor of fatty acids and aldehydes is apparent. Still more rapidly will this oxidation occur if a thin layer of an alcoholic solution of the acid is allowed to evaporate in the air. On the other hand, we can allow hop-oil to stand for days without its odor being perceptibly changed; it appears to me more than probable that the peculiar smell of old hops is due far more to the oxidation of the bitter substance than to the oxidation of oil.

Hop-bitter acid appears to possess the character of an aldehyde and of a weak acid; for the present I am not in a position to state its constitution more clearly. Most of the oxidizing processes have an energetic effect on it, forming also considerable quantities of valerianic acid.

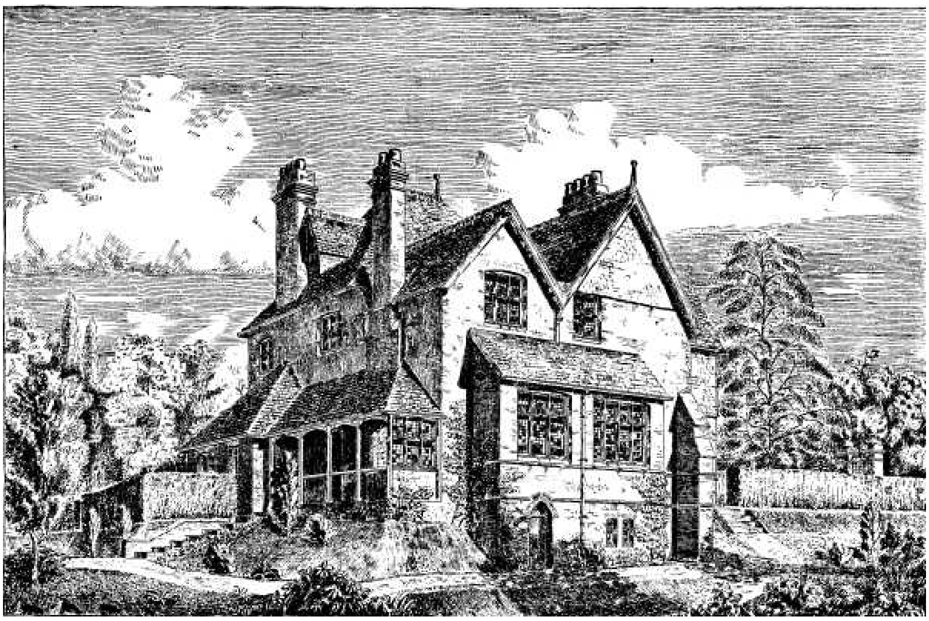
The question as to whether the hop owes chiefly to this acid and its resinous modifications the property of imparting a pronounced bitter flavor to a solution, I must for the present leave unanswered. The acid and its isomer are both insoluble in water; they are, on the other hand, very readily dissolved in hop oil; they also furnish a tolerably bitter solution, if boiled for a long time in water, probably on their account of their gradual decomposition. I will not for the present go further into the subject, as I hope soon to be in a position to give more definite information.

ST. PAUL'S VICARAGE, FOREST HILL, KENT.

This vicarage, for the Rev. Frank Jones, has recently been completed from the designs of Mr. E.W. Mountford, A.R.I.B.A.; of 22 Buckingham Street, Strand, W. C., and Mr. H. D. Appleton, A.R.I.B.A., of the Wool Exchange, Coleman Street, E. C., who were the joint architects. The builder was Mr. William Robinson, of Lower Tooting, S. W. The walls are of yellow stock bricks, with red brick arches, quoins, etc., the gables being hung with Kentish tiles and the roofs covered with Broseley tiles. The internal joinery is of pitch pine.



ST. PAUL'S VICARAGE, FOREST HILL.--VIEW FROM ROAD.



ST. PAUL'S VICARAGE, FOREST HILL.--VIEW FROM GARDEN.

The illustrations are from drawings by Mr. J. Stonier.--*The Architect*.

SOME ECONOMICAL PROCESSES CONNECTED WITH THE CLOTHWORKING INDUSTRY.

[Footnote: Read before the Society of Arts, London, May, 1884.]

By Dr. WILLIAM RAMSAY, Professor of Chemistry at University College, Bristol.

In this present age of scientific and technical activity, there is one branch which has, I think, been the subject of an article in the *Quarterly Journal of Science*. It is one which deserves attention. It was there termed "The Investigation of Residual Phenomena," and I can conceive no better title to express the idea. The investigator who first explores an unknown region is content if he can in some measure delineate its grand features--its rivers, its mountain chains, its plains; if he be a geologist, he attempts no more than broadly to observe its most important rock formations; if a botanist, its more striking forms of vegetation. So with the scientific investigator. The chemist or physicist who discovers a new law seldom succeeds in doing more than testing its general accuracy by experiments; it is reserved for his successors to note the divergence between his broad and sweeping generalization and particular instances which do not quite accord with it. So it was with Boyle's law that the volume of a gas varies in inverse ratio to the pressure to which it is exposed; so it is with the Darwinian theory, inasmuch as deterioration and degeneration play a part which was, perhaps, at first overlooked; and similar instances may be found in almost all pure sciences.

I conceive that the parallel from the technical point of view is a double one. For just as every technical process cannot be considered to be beyond improvement, there is always scope for technical investigation; but the true residual phenomena of which I would speak to-night are waste products. There is, I imagine, no manufacture in which every substance produced meets with a market. Some products are always allowed to run to waste, yet it is evident that every effort consistent with economy should be made to prevent such waste; and it has been frequently found that an attempt in this direction, though at first unsuccessful, has finally been worked into such a form as to remunerate the manufacturer.

It is my purpose to-night to bring under your notice methods by which saving can be effected in the cloth industry. I am aware that these methods have not much claim to novelty; but I also know that there are, unfortunately, few works where they are practiced.

The first of these relates to the saving and utilization of the soap used in wool scouring and milling. It is, perhaps, hardly necessary to explain that woolen goods are scoured by being run between rollers, after passing through a bath of soap, and this is continued for several hours, the cloth being repeatedly moistened with the lye, and repeatedly wrung out by the rollers. The process is analogous to ordinary washing; the soap dissolves the greasy film adhering to the fibers, and the "dirt" mechanically retained is thus loosened, and washed away. Now, in order to dissolve this greasy matter, a considerable amount of soap must be employed; and in the course of purification of the fabric, not merely what may be characterized as "dirt" is removed, but also short fibers, and various dye-stuffs with which the fabric has been dyed, many of which are partially soluble in alkaline water; moreover, it invariably happens that some dye does not combine with the fiber and mordant, thus becoming fixed, but merely incrusts the fiber; hence this portion is washed off when the retaining film of grease is removed from the fiber. The suds, therefore, after fulfilling this purpose, are no longer a pure solution of soap, but contain many foreign matters; and the problem is so to treat these suds as to recover the fat in some condition available for re-conversion into soap.

For this purpose wooden runnels are placed beneath the rollers, through which the cloth passes in the scouring machine, so as to collect the suds after they have been spent. These runnels lead to a wooden pipe or runnel, which receives the spent suds from all the scouring machines, and the whole of the waste, instead of being let off into the stream, polluting it, delivers into a tank or trough, which may also be constructed of wood, but, as it has to withstand the action of acid, is better lined with lead. This tank is necessarily proportioned in size to the number of scouring machines and the quantity of spent suds to be treated. When a sufficient quantity has collected, oil of vitriol, diluted with twice its bulk of water, is added, one workman pouring it in gradually while another stirs the contents of the tank vigorously. At short intervals, the liquid is tested by means of litmus paper, and when it shows a faint acid reaction, by turning the blue paper red, the addition of acid is stopped. The acid has then combined with the alkali of the soap, while the fatty acids formerly in combination with the alkali are liberated, and float to the surface of the liquid, carrying with them the impurities in the shape of short fibers and dye stuffs; the sand and heavier impurity, should any be present, sinks to the bottom.

After standing for some hours, the separation is complete. In order to separate the two layers, the tank is provided with an exit in the side, near the bottom, closed by a sluice or valve. This valve is opened, and the watery portion is allowed to escape into a sand filter bed.

The filter serves to retain any solid impurities which may still remain suspended in the water; but it will be found that the escaping water is nearly pure.

The dark brown fatty acid is mixed with a large amount of impurity, such as short wool fibers, burrs, sand, and dye stuffs washed from the wool. To remove water more completely, the semi-fluid mass is pumped from the tank, and delivered into hair-cloth filters; the liquid which drains from these bags finds its ways to the sand filters joining the drainage which formerly passed out from the tank through the sluice. After being turned over in the filter several times, the residue is transferred to canvas sacks. These sacks are placed in a filter press, where they are exposed to pressure while heated to a temperature sufficient to melt the fat. The solid impurities remain in the bags, while the fatty acids escape, and are received in a barrel or tank for the purpose. The fatty acids, when cold, are of a deep brown color, and of the consistency of butter. The residue is kept, and the method of treating it for the recovery of indigo will afterward be described.

The fatty acids are now ready for conversion into soap. It may here be remarked that, on distillation, they yield a nearly white fatty mass, which, when treated with soda-lye, is capable of yielding a perfectly white soap. But, for the clothworker's purpose, this purification is unnecessary.

The conversion into soap is a very simple matter. As the fats are acids--a mixture of palmitic, oleic, and stearic acids--and not the glycerine salts of these acids, like ordinary fats, soap is made by causing them directly to unite with caustic soda. The fats are melted in a copper, by means of a steam-jacket, or coil of steam-pipe in the copper, and the soda-lye is run in until complete union has taken place. The exact point of neutralization can easily be found by taking out a small sample after stirring, and dissolving it in some methylated spirits. A few drops of alcoholic tincture of phenol-phthalein are then added, and as soon as a faint red color appears, addition of soda is stopped. This shows that the fatty acids have been over-saturated. Addition of a little more fat renders them perfectly neutral, and the soap is then ladled out into wooden moulds, lined with loose sheets of zinc.

The resulting soap is of a brown color, but is perfectly adapted for the purpose of wool-scouring. It should here be mentioned that, in practice, the soap is always made somewhat alkaline; in point of fact, it contains about 2 per cent. of free alkali. This is found to assist in scouring; I presume that the free alkali forms a soap with the oil added to the wool during spinning, and if no free alkali be present, this oil would not be so thoroughly removed.

It will be noticed that in this simple method of soap-making, there is no salting out to separate the true soap from the watery solution of glycerine, for no glycerine is present. The apparatus may be of the simplest nature, and on any required scale, proportionate to the size of the mill. It is a process which requires no specially skilled labor; in any works some hand may be told off to conduct the process as occasion requires; and as a very large proportion of the fatty matter is recovered, the soap-bill is reduced to a very small fraction of the amount which would be paid were recovery not practiced. And lastly, the streams are not polluted; the only waste is a little sulphate of soda, which can hardly be regarded as a nuisance, inasmuch as it is a not unfrequent constituent of many natural waters.

Let us now return to the solid matter from which the fatty acids have been removed by pressure. This brown, earthly-looking cake consists of vegetable impurity washed off from the cloth, of short fibers, and of various dye stuffs. It is divided into two lots: That which contains indigo, and that which contains none, or which contains too small a quantity for profitable extraction. And it may here be remarked, that it is advisable to collect the suds from cloth dyed with indigo separate from that to dye which no indigo has been employed. The residue from indigo-dyed cloth has always a more or less blue shade, and if much indigo is present, the well-known copper-color is evident. Of course, the amount of indigo must greatly vary, but it may rise to 8 or 10 per cent. of the total weight of the refuse.

To recover the indigo from this refuse, the somewhat hard cakes are broken up, placed in a tank, and allowed to steep in water. When quite disintegrated, they are transferred to another tank--a barrel may be used for small quantities--and thus this refuse is exposed to the reducing action of copperas and lime. The indigo is converted into indigo-white, and is rendered soluble, and it oxidizes on the surface, forming a layer of blue froth on the top of the liquid, while the remainder of the impurities sinks. This process of reduction may last for twenty-four hours, and is helped by frequent stirring.

The indigo scum is preserved, and placed in filter cloths, where it is thoroughly washed with water two or three times. The residue which has sunk to the bottom is removed, dried, and forms a valuable manure, owing to the amount of the nitrogen which it contains. Its value may be increased by addition of weak vitriol, which exercises a decomposing action on the nitrogenous matter, forming with it sulphate of ammonia. The original residue from the filter-press, if it does not contain indigo, may be at once put to similar use.

In large works, which dye their own goods, it is well known that the "fermentation vat" is in general use for indigo-dyeing. But this vat requires constant superintendence, and must be kept in continual action; besides, it is successful only on a comparatively large scale. And, moreover, it requires skilled labor. Small works, or works in which dyeing is only occasionally practiced, find it more convenient to use Schützenberger and Lalande's process. Although this process is well known, a short description of it may not here be out of place.

The process depends on the reduction of indigo to indigo-white, or soluble indigo, by means of hyposulphite, or, as it is generally termed to avoid confusion with antichlore, rightly named thiosulphate of soda, hydrosulphite of soda. The formula of this substance is $NaHSO_2$, as distinguished from what is commonly known as hyposulphite of soda, $Na_2S_2O_3$. It is produced by the action of zinc-dust on the acid sulphite of soda. The zinc may be supposed to remove oxygen from the acid sulphite,

$NaHSO_3$, giving hyposulphite, $NaHSO_2$. The reduction of the acid sulphite is best performed in a cask, which can be closed at the top, so as to avoid entrance of air. The acid sulphite of soda, at a strength of 50 or 60 Twaddell (specific gravity 1.26 to 1.3), is placed in the cask, and zinc-dust is added, with frequent stirring. The liquid is then mixed with milk of lime, and after again thoroughly stirring, the liquid is allowed to settle, and the clear is decanted into the dyeing-copper. The indigo, in the frothy state in which it is skimmed from the purifying barrels or tanks, is then added, with sufficient lime to dissolve it when it has been reduced. It is heated gently by a steam coil, to about 90° Fahr., and the goods are dyed in it. The colors obtained by means of this indigo are light in shade, and the goods must be dipped several times if dark shades are required. But it is found better in practice not to attempt to dye dark shades by this process; the ordinary indigo-vat is better adapted for such work. The object of not wasting indigo is sufficiently attained by employing it for the purpose to which it is best adapted. Of course the recovered indigo may be used in the ordinary manner. I merely mention the most convenient way of disposing of it in works where only a small quantity is recovered, and which do not practice dyeing on an extensive scale.

I have now to ask you to turn to a different subject, namely, the scouring of wool, not by the usual agent, water, but by a liquid, bisulphide of carbon, made by the action of sulphur vapor on red hot coke or charcoal.

This, again, is not wholly a new process, for various attempts have been made to dissolve out the yolk, or *suint*, or greasy matter from unwashed wool, as it comes from the back of the sheep. Fusel oil has been patented for this purpose. Carbon disulphide has also been patented, but, as will afterward be shown, the old method of removing it from the wool injured the color and quality of the fiber, so as to make the application of this scouring agent a failure.

Wool in its unwashed state contains a considerable proportion of what is termed *suint*. This consists of the fatty matter exuded as perspiration from the sheep, along with, or in some form of combination with, potash derived from the grass on which the sheep feed. *Suint* was first investigated by Vauquelin. He obtained it by evaporating, after filtration, the water in which raw fleeces had been washed. The residue is of a brown color, and has a saline, bitter taste. On addition of an acid to its solution in water, it coagulates, and a fatty matter rises to the surface. It is, in fact, a potash soap, to a great extent containing carbonate and acetate of potash, along with chloride of potassium and lime, probably in combination also with fatty acids. It is usually mixed with sand and carbonate of lime.

In 1828, M. Chevreul, who is still alive in Paris, although nearly a century old, published an analysis of merino wool. It consisted of:

	Per cent.
Pure wool	31.23
Soluble _suint_	32.74
Insoluble	8.57
Earthy matter	27.46

	100.00

It is easily seen that *suint* forms a very important constituent of raw wool. Its proportion varies, of course, according to the nature of the pasture on which the sheep are fed, the climate, etc. Wool from Buenos Ayres, for example, contains much less than that analyzed by M. Chevreul; its amount is only 12 per cent. of the weight of the raw wool.

This *suint* contains always about 52 per cent. of residue when ignited. The composition of this residue is:

	Per cent.
Carbonate of potash	86.78
Chloride of potassium	6.18
Sulphate of potash	2.83
Silica, alumina, etc.	4.21

	100.00

In 1859, MM. Maumene and Rogelet patented the use of the water in which wool has been washed as a source of potash, and at present the extraction of potash from *suint* is practiced in France on a large scale. The wool is washed in a systematic manner, in casks, with cold water, which runs out of the last cask with specific gravity 1.1. These washings are evaporated to dryness, and the residue is calcined in iron retorts, the gas evolved being used for illuminating purposes. The remaining cinder, consisting of a mixture of charcoal and carbonate of potash, is treated with water, whereby the latter is dissolved out. The residue left on evaporation of this water consists largely--almost entirely--of white carbonate of potash. At present there are works at Rheims, Elboeuf, Fourmier, and Vervier, which yield about 1,000 tons of carbonate of potash annually. Now, only 15,000 tons are made per annum by Leblanc's process. In 1868, 62,000 tons of wool were imported into Britain from Australia alone, and from this 7,000 to 8,000 tons of carbonate of potash might have been recovered, the value of which is £260,000. Yet it was all wasted! And this estimate does not include the fats of the *suint*, which are worth an even greater sum.

Now, it is evident that there is here a profitable source of economy. So far as I am aware, no work in this country saves its washings. The water all goes to pollute the nearest river.

The use of carbon disulphide has again been introduced, and it is to be hoped with better success, for methods have been devised whereby the wool is not injured by it, but is even rendered better than when scoured by the old process of washing with carbonate of soda and water, or by soap. The process is due to Mr. Thomas J. Mullings. Briefly described, it consists in exposing the wool, placed in a hydro-extractor, to the action of bisulphide of carbon; the machine is then made to revolve, and the excess of solvent is expelled, carrying with it the fatty matters; the solvent finds its way into a tank, from which it flows into a still, heated with steam; the carbon disulphide, which boils at a very low temperature, distills over, and is again ready for use, while the residue in the still consists of *suint* washed from the wool. To remove the last trace of carbon disulphide from the wool in the hydro-extractor, cold water is admitted, and when the wool is soaked, the machine again revolves. On expulsion of the water, the wool is ready for washing in the ordinary machines, but with cold water only instead of hot soapsuds.

The distinguishing features of Mr. Mullings' process are, method by which loss of carbon disulphide is avoided, and the extraction of that solvent by means of cold water. The apparatus consists of a hydro-extractor or centrifugal machine of special construction, fitted with a bell-shaped cover, which can be lifted into and out of position by means of a weighted lever. The rim of this cover fits into an annular cup filled with water, which surrounds the top of the machine, forming an effective seal or joint. Upon the spindle of this machine is suspended, as in ordinary forms of the hydro-extractor, a perforated basket, and in this basket is placed the wool to be treated. The cover being closed, the carbon disulphide is admitted, and passing through the wool, the greasy matter is dissolved, and along with the solvent enters a reservoir. The machine is now set in motion, and the bulk of the solvent is drawn off. Cold water is then admitted, and the machine being again caused to rotate, the whole of the bisulphide is expelled. It is a curious fact that, although wool soaks remarkably easily with carbon disulphide, and at once becomes wet, cold water expels and replaces almost all that liquid. This operation takes about twenty minutes, and at one operation about 1½ cwt. of raw wool may be treated. The wool is then washed in suitable washing machines of the ordinary type, but with cold water, no soap or alkali being employed. The bisulphide of carbon, mixed with water, flows into a reservoir, provided with diaphragms to prevent splashing, and consequent loss by evaporation. From its gravity it sinks, forming a layer below the water; it is then separated and recovered by distillation, and may be used in subsequent operations.

The point in which this process differs from the old and unsuccessful ones formerly tried, is in the expulsion of the carbon disulphide. It was imagined that it was necessary to expel it by means of heat or steam. Now, when wool moist with bisulphide is heated, it invariably turns yellow. No heat must, therefore, be employed. As already remarked, the solvent is expelled with cold water.

The residue, after distillation of the carbon disulphide, is a grayish colored, very viscous oily matter, still retaining a little bisulphide, as may be perceived from the smell. It has not the composition of ordinary *suint*, inasmuch as it contains no carbonate of potash, and indeed little mineral matter of any kind. A sample which I analyzed lost in drying 36.2 per cent., the loss consisting of water and carbon disulphide. It gave a residue on ignition amounting only to 1.6 per cent. of the original fatty matter, or 2.5 per cent. of the dried fat. The oil appears, from some experiments which I made, to be a mixture of a glycerine salt and a cholesterine salt of fatty acids. It distills without much decomposition, giving a brown-yellow oil, which fluoresces strongly, and has a somewhat pungent smell. The molecular weight was determined by saponification with alcoholic potash, and subsequent titration of the excess of potash employed. This was found to equal 546.3. This would correspond to a mixture of 18.7 parts of stearate, palmitate, and oleate of glycerine, with 81.3 parts of the same acids combined with cholesteryl. But this is largely conjecture. The boiling point of the oil is high, much above the range of a mercurial thermometer, so that it is difficult to gain an insight into its composition.

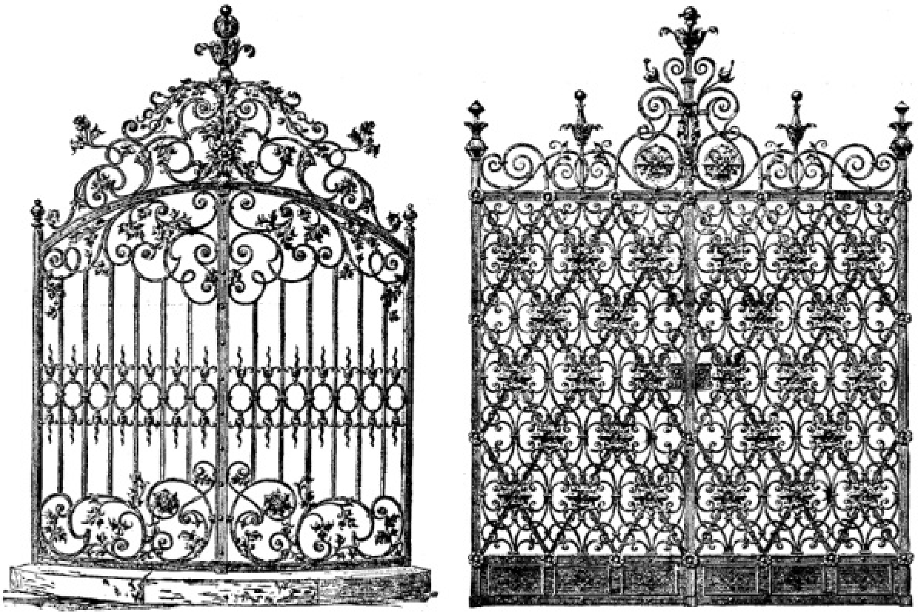
An objection which has been raised to this process is that the use of such an easily inflammable substance as bisulphide of carbon is attended by great risk of fire. Were the bisulphide to be exposed to free air, there might be force in this objection; but there is no reason why it should ever be removed from under a layer of water. The apparatus, to make all safe, should not be under the same roof as the mill; and no open fire need be used in the building set apart for it. It is easy to rotate the centrifugal machine by a belt from the mill, but better by a small engine attached, the power for which can be conducted by a small steam-pipe, and the distillation of the bisulphide can also be conducted without danger by the use of steam, as its boiling point is a very low one. The question may be naturally asked, "How do the wool and fabric made from the wool scoured by this process, compare with that scoured in the usual way?" To answer this question I may refer to a test made by Messrs. Isaac Holden & Co., at their works at Roubaix. A sample of wool was divided into two portions, one of which was scoured by the usual method, and the other by the turbine or Mullings' process. Skilled workers then span each sample to as fine a thread as possible. Now the thinness to which a wool can be spun is evidence of its power of cohesion--in other words, its strength. The weight of 1,000 meters of the wool cleaned by the new process bore to that scoured by the old process the proportion of 1,015 to 1,085, showing that a considerably finer thread had been produced. And in total quantity, 67.53 kilos. of the former corresponded to 71.77 kilos. of the latter, showing a proportionately less waste. Such fine yarn had never before been obtained from similar wool. The yarn of the soap-washed wool could not be spun, for it could not withstand the strain; whereas, that scoured by the new process gave an admirable thread.

Another test to which it was subjected may be cited. It is the custom in France, before the wool is scoured, to put it through a sorting process, by which all the short lengths are weeded out. On a quantity exceeding 11,000 kilogrammes, half of which was scoured by the turbine process, and half by the ordinary process, the former in scouring lost in weight 2 per cent. less than the latter, although the short length extracted from the moiety thus treated weighed only 10 kilogrammes, while that taken from the other weighed over 150 kilogrammes. This saving, even with the unequal treatment, amounted in value to from 30 to 40 centimes per kilogramme.

In order that the importance of this application may be realized, I shall conclude with some figures:

The raw wool imported into England, in the year 1882, amounted to 1,487,169 bales, its total value being about £22,000,000. The cost of washing this wool by the old process, with carbonate of soda, amounts to about ½d. per lb. of the raw material. The cost for the total quantity of wool imported is at least £1,214,000. But it is customary to wash wool with soap, especially for the combing trade, and the cost is then about 1d. per lb. The cost of scouring by the new process is about £1 5s. per ton, or 0.13d. per lb. Taking the least favorable comparison, were all the imported wool (home-grown wool is here left out of the calculation, for want of sufficient returns) cleansed by the turbine process, the actual saving would be £1,214,500 *minus* £315,700, or nearly £900,000 per annum.

It is thus seen that there is room for a very important economy in the treatment of wool. I have endeavored to show how economy may be practiced in scouring by the old process with soap, and how one dye stuff may be profitably recovered. It is to be hoped that means of extracting other dyes from the residue may soon follow. Unless the process were too costly to repay the trouble of extraction, it would be well worth practicing; for it would not merely be a solution of the problem of how to avoid waste, but would at the same time prevent the pollution of our streams, now, unfortunately, only too rarely pellucid; and were the last process to have as successful a future as I hope it may have, a very important saving of expense would result, and a large quantity of valuable fatty matter would no longer be thrown away.



SUGGESTIONS IN DECORATIVE ART.--DESIGNS FOR IRON GATES.

COAL AND ITS USES.

[Footnote: From a paper lately read before the Association of Foremen Engineers.]

By JAMES PYKE.

The records from which geologists draw their information can scarcely be compared to written or printed histories. There are, however, nations of whom no written account exists, who perhaps never had any written history, but about whom we are still able to gather from other sources a vast amount of information. Their houses, their monuments, their weapons, and their tools have survived, and these tell us the kind of life, the state of civilization, and the skill of the men to whom they belonged; from the contents of their tombs we learn what manner of men they were physically; sometimes a sudden change in the appointments and belongings of the folk indicates that tribes which had for a long time inhabited a district were driven out and replaced by a new race. Thus, then, from waifs and strays we can piece together a fairly connected account of the events of a period long antecedent to any written history.

The investigations of Dr. Schliemann on the supposed site of the city of Troy furnish a good example of this method of research. He found lying, one on the top of another, traces of the existence of five successive communities of men, differing in customs and social development, and was able to establish the fact that some of the cities had been destroyed by fire, and that later on other towns had grown up over the buried remains of the earlier settlements. The lowest layers were, of course, the oldest, and the position of each layer in the pile gives its date, not in years, but with regard to the layers above and below it.

Now, from time immemorial nature has been at work building up monuments and providing tombs which tell us what were the events going on, and what kind of inhabitants the earth had long before man made his appearance on its surface. The monuments are the rocks which compose the ground under our feet, and these, like many ancient monuments of human construction, are the tombs of the creatures that lived while they were being built.

Many facts testify that the earth's crust did not come into existence exactly as we find it now, but that its rocks have been built up by the slow action of natural agencies. These rocks constantly inclose the remains of plants and animals, and as it is evident that neither plant nor animal could have lived in the heart of a solid rock, this fact shows that the rock must in some way have gathered round the remains that are now found in it. Again, many of these remains, or fossils, belonged to animals that lived in water, the larger part, indeed, to marine creatures. This indicates that the rock was formed beneath the sea, and when we examine the way in which the constituents of the rock are arranged, we frequently find it to correspond exactly with the manner in which the sand and mud that rivers sweep down into the sea or lakes are spread out over the bottom of the water. In a pile of rocks formed in this way it is clear that the lowest is the oldest of all, and that any one stratum lying above is younger than the one beneath it. Further, the occurrence of rocks inland containing marine fossils far above the sea level shows that the sea and land have changed places. When, again, we find that the fossils of one group of rocks differ entirely from those of a group lying above them, we learn that one race of creatures died out and was supplanted by a new assemblage of animal forms.

These general remarks will, I trust, give some notion of the evidence which is available for reconstructing the history of those remote periods with which geology deals, and of the kind of reasoning which the geologist employs for interpreting the records that are submitted to him.

We will now briefly examine, by aid of these methods, the group of rocks in which coal occurs in Great Britain, and see how far we can read the story they have to tell.

The group with which we have to deal is called the carboniferous or coal bearing system, and it includes four classes of rocks, viz.: 1, sandstone; 2, shale or bind; 3, limestone; 4, coal and underclay.

We will take the sandstones and shales first. They are grains of sand known to mineralogists as quartz, and consisting of a substance called silica by chemists. The grains of sand are bound together by a cement which in some few cases is identical in composition with themselves, and consists of pure silica, but usually is a mixture of sandy, clayey, and other substances. The shales are made up very largely of clay, mixed, however, usually with sand and other substances, forming a conglomerate. Both sandstones and shales are divided into layers or beds, and are said to be stratified. It is this stratified or bedded structure that gives us the first clew to the way in which these rocks were formed. Rivers are constantly carrying down sand and mud into the sea or lakes, and when their flow is slackened on entering the still water the materials they bring down with them sink and are spread out in layers over the bottom. The structure of the sandstones and shales shows that they were formed in this way; they often inclose the remains of plants that have been carried down from land, and occasionally of animals that lived in the water where they were deposited.

The next we have to consider is limestone, which is mainly made up of a substance known to chemists as calcium carbonate, or carbonate of lime.

In some districts, especially in volcanic countries, springs occur very highly charged with carbonate of lime. The warm springs of Matlock are a case in point; they are probably the last vestige of volcanic action which was in operation in that neighborhood during carboniferous times. Limestone is chiefly formed by the agency of small marine creatures of low organization. By the aid of these animals the carbonate of lime is brought back to a solid form; at their death their hard parts fall to the bottom and accumulate in a mass of pure limestone, which afterward becomes solidified into limestone rock.

The information that limestone gives us is this:

When we find, as is often the case, a mass of limestone hundreds of feet thick, and composed of little else but carbonate of lime, we know that the spot where it occurs was, at the time it was formed, far out at sea, covered by the clear water of mid ocean; and when we find that this limestone grows in certain directions earthy and impure, and that layers of shale and sandstone, thin at first, but gradually thickening out in a wedge-shape form, come in between its beds, we know that in those directions we are traveling toward the shore lines of that sea whence the water was receiving from time to time supplies of muddy and sandy sediment.

The next class of rocks are the clays that are found beneath every bed of coal, and which are known as *underclays*, or *warrant*, or *spavins*. They vary very much in mineral composition. Sometimes they are soft clay; sometimes clay mixed with a certain portion of sand; and sometimes they contain such a large proportion of silicious matters that they become hard, flinty rock, which many of you know under the name of *gannister*. But all underclays agree in two points: they are all unstratified. They differ totally from the shales and sandstones in this respect, and instead of splitting up readily into thin flakes, they break up into irregular lumpy masses. And they all contain a very peculiar vegetable fossil called *Stigmaria*.

This strange fossil was for a long time a sore puzzle to fossil botanists, and after much discussion the question was fairly solved by Mr. Binney by the discovery of a tree embedded in the coal measures, and standing erect just as it grew, with its roots spread out into the stratum on which it stood. These roots were Stigmaria, and the stuff into which they penetrated was an underclay. Sir Charles Lyell mentions an individual sigillaria 72 feet in length found at Newcastle, and a specimen taken from the Jarrow coal mine was more than 40 feet in length and 13 feet in diameter near the base. It is not often these trees are found erect, because the action of water, combined with natural decay, has generally thrown them down. They are, however, found in very large numbers in the roof of the coal, evidently having been tossed over, and lying there flat and squeezed thin by the pressure of the measures that lie above them.

Lastly, we come to coal itself--a rock which constitutes a small portion of the whole bulk of the carboniferous deposits, but which may be fairly looked upon as the most important member of that group, both on account of its intrinsic value and also from the interest that attaches to its history. That coal is little else but mineralized vegetable matter is a point on which there has for a long time been but small doubt. The more minute investigations of recent years have not only placed this completely beyond question, but have also enabled us to say what the plants were which contributed to the formation of coal, and in some cases even to decide what portions of those plants enter into its composition. It is a thing so universally admitted on all hands, that I shall take it for granted you are all perfectly convinced that coal has been nothing in the world but a great mass of vegetable matter. The only question is: How were these great masses of vegetable matter brought together? And you must realize that they were very large masses indeed. Just to take one instance. The Yorkshire and Derbyshire coal field is somewhere about 700 to 800 square miles in area, and Lancashire about 200. Well, in both these coal fields you have a great number of beds of coal that spread over the whole of them with tolerable regularity and thickness, and very often with scarcely any break whatever. And this is only a very small portion of what must have been the original sheet of coal, so that you see we have to account for a mass of vegetable matter perfectly free from any admixture of sand, mud, or dirt, and laid down with tolerably uniform thickness over many hundreds of square miles.

At one time it was supposed that coal was formed out of dead trees and plants which were swept down by rivers into the sea, just in the same way as shales and sandstones were formed out of mud and sand so swept down. The fatal objection to this theory, however, is that rivers would not bring down dead wood alone, but they would bring down sand and mud, and other matters, and that in the bottom of the sea the dead wood would be mixed with these matters, and instead of getting a perfectly unmixed mass of vegetable matter, we should get a mixture of dead plants, sand, mud, and other things, which would give rise to something like coal, but something very different, as any one who tries to burn such coal will soon find out, from really good, pure house coal. So that this theory, which is generally known as the "drift" theory, was totally inadequate to account for the facts as we know them.

The other theory was that coal was formed out of plants and trees that grew on the spot where we now find coal itself. On this supposition it is easy to account for the absence of foreign admixtures of sand, mud, and clay in the coal; and we can also understand very much better than by the aid of the drift theory how the coal had accumulated with such wonderful uniformity of thickness over such very large areas. This theory was for some time but poorly received; but after the discovery of Sir William Logan, that every bed of coal had a bed of underclay beneath, and the discovery of Mr. Binney, that these underclays were true soils on which plants had undoubtedly grown, there was no doubt whatever that this was the real and true explanation of the matter.

I dare say many of you have had occasion to walk across peat bogs. The peat bog is a great mass of vegetable matter, which is every year growing thicker and thicker; and underneath it there is almost always a bed of thin clay, in look very much like the underclays, and this thin clay is penetrated by the rootlets of the moss forming the peat, exactly the same way as the underclays of the coal measures are penetrated by the stigmaria and its rootlets. But you must not suppose that the plants out of which coal was formed were exactly the same low type of moss which forms our present peat bogs. However, it is pretty certain that they were for the most part of a loose, succulent texture, and that they grew very rapidly indeed.

You will have noticed that there is one step more wanted to make good this theory of the growth of coal on the spot where we now find it. The coal is found, as already described, interbedded with shales and sandstones. These shales and sandstones, as shown, were formed beneath the water of the sea, and as long as they remained there of course no plants could grow upon them. The question is, How was the land surface formed for the growth of plants? It must have been formed in some way or other by the sea bottom having been raised above the level of the water. Now, we have distinct proof in many cases that elevation of the sea bottom and depression of the land is now going on in many parts of the earth's surface. And, therefore, we shall be assuming nothing beyond the range of experience if we say that such elevations and depressions went on during coal measure times. The coal measure times must have been times during which the same spot was now below the sea, and now dry land, over and over again. There was a land surface on which plants grew fast and multiplied rapidly, and as they died fell and accumulated in a great heap of dead vegetable matter. After a time this layer of vegetable matter was slowly and gently let down beneath the waters of the sea--so slowly that the water flowing over it did not, as a rule, disturb the loose, pasty mass; and then, by the method I have described to you, shales and sandstones were deposited on the top of this mass of dead vegetable matter. By their weight they compressed it, and by certain chemical changes (which we have not time to go into this evening) this dense mass of vegetable matter became converted into coal. After a time the shales and sandstones which had been piled above this stuff, which was to form coal for the future, were again elevated to form a land surface; upon this another forest sprang up, and by its decay produced another mass of vegetable matter fit to form coal. This again was let down below the water, more shales and sandstones were deposited on the top, and this process went on over and over again till the whole mass of our present coal measures was formed. You will now see how it is that trees are so seldom found in an upright position in the coal beds. As the land went down, they would in very many cases be toppled over by the water as it flowed against them, or their base would be rotted, and they would then either fall or be blown over; that is the reason why in most cases they are found lying flat on the roof of the coal bed. But in a few cases, when the depression was very gentle and gradual, the trees were not overthrown, and the shales and sandstones accumulated round them and preserved them in the position in which they grew.

I do not know that I can point out to you anything nowadays that exactly resembles the state of things that must have gone on during the times these coal measures were being formed; but there are a great many cases strikingly analogous to them. I shall not attempt to describe them to you, but may just mention the mangrove swamps that very often fringe the coasts in the tropics, and the cypress swamps of the Mississippi, which are so well described by Sir Charles Lyell in his recent works; also the great Dismal Swamp of Virginia, which appears to me to furnish the nearest analogue to the state of things that existed during coal measure times.

Having explained the way in which coal measures have been formed, we will now take a brief sketch of its uses and products. The year 1259 is memorable in the annals of coal mining. Hitherto the mineral had not been raised by authority, but in that year Henry III. granted a charter to the freemen of Newcastle-on-Tyne for liberty to dig coal, and a considerable export trade was established with London, and it speedily became an article among the various manufacturers of the metropolis. But its popularity was but short lived. An impression became general that the smoke arising therefrom contaminated the atmosphere and was injurious to public health. Years of experience have proved the fallacy of the imputation; but in 1306 the outcry became so general that a proclamation was issued by Edward I forbidding the use of the offending fuel, and authorizing the destruction of all furnaces, etc., of those persons who should persist in using it. Prejudice gradually gave way as the value of the fossil fuel became better known, and from that time downward its use has become more and more extended down to the enormous extent of our present trade. The annual increase in the production of coal in the British Isles since the year 1854 is over 2½ million tons. In that year the coal produce was about 65 million tons, and it has grown up to the year 1880 to the grand total of 135 million tons.

We will now deal with some of the uses that this valuable black diamond is now being put to. It is, in the first place, the center of all our enterprise and prosperity, and upon it depends our chief success as a manufacturing nation for the future. When it is exhausted we shall have to look forward to the condition of things which now obtains in those regions where there is no coal--that is to say, instead of our being a nation full of manufacturing and mercantile enterprise, a great nation to which all the people of the earth resort, we shall be merely a people who live for ourselves by the cultivation of the ground. The duration of our coal fields has been ascertained within certain limits. Mr. Hall, an accomplished geologist, tells us that in England at the present time we have a stock of coal sufficient for our consumption for no less than 1,000 years. On the other hand, Professor Jevons, whose opinion is worthy of the very greatest weight on such questions, calculates that 100 years is about the tenure of our coal fields, according to the present rate of increase in the consumption. Whichever view we take, sooner or later the end must ultimately come when the coal will be exhausted; when the great mainspring of our commercial enterprise will be gone, and we shall revert to that condition in which we were before the coal fields were worked. In this point of view, therefore, coal has an especial interest to us as engineers. If coal is important in this direction, it is no less important in a purely scientific point of view, apart from any mercantile end.

The chemist or physicist will tell you the wondrous story that the black substance which you burn is simply so much light and heat and motion borrowed from the sun and invested in the tissues of plants. He will tell you that when you sit round your firesides the flame which enlivens you, and the gas which enables you to read, and which civilizes you, is nothing in the world but so much sunlight and so much sunheat bottled up in the tissues of vegetables, and simply reproduced in your grates and gas burners. Very few persons, I am afraid, realize this, which is one of the many stories which science in its higher teachings shows us--one of those fairy tales which are the result of the most careful scientific investigation. Of the hundred and odd million tons of coal which we in this country burn in the course of a year, about 20,000,000 tons are thrown on our house fires; 30,000,000 tons find their way into our blast furnaces, or are otherwise used in the smelting and manufacture of metals; about 48,000,000 are burnt under steam boilers; 6,000,000 are used in gas-making; while the remainder is consumed in potteries, glass works, brick and lime kilns, chemical works, and other sundries which I need not speak of.

To go into the chemistry of coal is quite sufficient to take up more time than I have at my disposal this evening, therefore I will briefly touch on a few of the main points. Coal gas is made, as you are all aware, by heating coal or cannel, which is the special form of coal most valued for the purpose, on account of the high quality of gas it produces in cylindrical fireclay retorts.

The by-products obtained in the manufacture of coal gas, the tar and the ammonia water, are nowadays scarcely less important than the coal gas itself. The ammonia water furnishes large quantities of salts to be used, among other applications, as food for plants. We thus restore to-day to our vegetation the nitrogen which existed in plants of primeval times. The tar, black and noisome though it be, is a marvelous product, by the reason of scores of beautiful substances which are concealed within it.

Coal tar when distilled yields three main products: naphtha, dead oil, and pitch or asphalt. The naphtha on redistillation yields benzine, from which are prepared some of our most beautiful dyes; the dead oil, as the less volatile portion is termed, furnishes carbolic acid, used as a disinfectant and antiseptic, together with anthracene and naphthaline; all three substances the starting points of new series of coloring matters.

This discovery of these coloring matters marks an era in the history of chemical science; it exercised an extraordinary influence on the development of organic chemistry. Theoretical and applied chemistry were knit together in closer union than ever, and dye followed dye in quick succession; after mauve came magenta, and in close attendance followed a brilliant train of reds, yellows, oranges, greens, blues, and violets; in fact, all the simple and beautiful colors of the rainbow.

But there is still another story of coal tar to be told. Among the many curious substances that wonderful fluid contains is the beautiful wax-like body called paraffine, the development of which chiefly owes its origin to the genius and energy of Mr. James Young. As early as 1848, Mr. Young had worked a small petroleum spring in a coal mine in Derbyshire, and had produced oils suitable for burning and lubricating purposes, but the spring gave out, and then Mr. Young sought to obtain these oils by distilling coal. After many trials, in conjunction with other gentlemen connected therewith, he proved successful, and the present magnitude of this industry is without parallel in the history of British manufactures.

In Scotland alone there are about sixty paraffine oil works, one alone occupying a site of nearly forty acres. Here about 120,000 gallons of crude oil are produced weekly, and among the various works in Scotland about 800,000 tons of shale are distilled per annum, producing nearly 30,000,000 gallons of crude oil, from which about 12,000,000 gallons of refined burning oil are obtained in addition to the large quantities of naphtha, solid paraffine, ammonia, and other chemical products. Twenty-five years ago scarcely a dozen persons had seen this paraffine, and now it is turned out by the ton, fashioned into candles delicately tinted with colors obtained from coal tar.

I might dwell on this subject until it becomes wearisome to you, therefore I will not trespass too much on your time. But from every point we look we reach this fact, that our coal trade is one which develops itself according to laws that we are perfectly powerless to control; if it seems to promise a less rapid increase here, it is only that it may spread abroad with accelerated vigor elsewhere; if it is our slave in some aspects, it seems as if it were our master in others.

Finally, we have to ask, What of our export coals? Rapid as has been the growth of our total production during the last twenty-three years, the growth of our export of coals has been greater still. Beginning at 4,300,000 tons in '54, we find it reaching 16,250,000 tons in '76, and an increase at a corresponding ratio up to the present date as far as statistics will carry us. At such a rate of increase it would seem as if our whole annual production would be ultimately swallowed up in our exports, and it is not, perhaps, impossible that after we have ceased to be to any great extent a manufacturing people, a certain export trade in coal may still continue. Just the same as the export trade in coal preceded by centuries our own uses for it other than domestic, so may it also survive these by a period as prolonged. If our descent from our present favored position be a gradual one, much may be done in the interval to adapt ourselves to the future outcome, but it is certain that nothing will be done except under the stern persuasion of necessity.

When our coal fields become exhausted, be it soon or late, he would be a wise or, perhaps, a rash speculator who fixed himself to a year or a generation. Being inevitable, the best philosophy is to make our decline more gradual and less bitter. Sentimental regrets that these hills and valleys will no longer resound with the din of labor, or be blackened by the smoke of the factory, would surely be out of place. What we might regret is that Britain, which we know and are proud of, the Britain of great achievements in politics and literature, of free thought and self-respecting obedience, of a thousand years of high endeavor and constant progress, was indeed to perish when these factories and furnaces whirled and blazed their last. But, it is not so. This country's fortunes are gradually being merged into those of a Greater Britain, which largely, through the aid of coal, whose prospective loss we are lamenting, has grown beyond the limits of these islands to overspread the vastest and richest regions of the earth; and we have no reason to fear that the great inheritance that America and Australia and New Zealand have accepted from us will in their hands be dealt unworthily with in the future.

GASTON PLANTE.

This eminent scientist was born in Orthez (Department of Basses-Pyrénées) on the 22d of April, 1834; at present in his fiftieth year. He began his scientific career as assistant to Edmund Becquerel at the Conservatoire des Arts et Métiers at Paris. In the year 1859, after resigning his position at the above named institution, he entered upon his researches in electricity, and has continued them ever since. His work entitled "Recherches sur l'Electricité" is a model of clear language and elegant demonstration, and contains all the papers presented by Planté to the Paris Academy of Sciences since 1859.

GASTON PLANTE.

At the Paris Electrical Exhibition in 1881, Planté received a Diploma of Honor, the highest distinction conferred, while in the same year the Academy of Sciences voted him the "Lacaze" prize, and the Society for the Encouragement of National Industry presented him with the "Ampère" medal, its highest award.

Planté deserves not only the honors conferred upon him by his own country, but those of the world on account of his cosmopolitan character--a rarity among his countrymen. He sends his apparatus to all exhibitions of any consequence; they appeared at Munich and Vienna, where their interpretation by the attendant added considerably to the renown of their author.--*Zeitch f. Elektrotechnik*.

WARREN COLBURN.

Warren Colburn, the eminent American mathematician, was born in Dedham, Mass., March 1, 1793.

He was the eldest son of a large family of children. His parents were poor, and "Warren" was, during his childhood, frequently employed in different manufacturing establishments to aid the family by his small earnings.

In early boyhood he manifested an unusual taste for mathematics, and in the common district school was regarded as remarkable in this department. He learned the trade of a machinist, studying winters, until he was over twenty-two years of age, when he began to fit for Harvard College, which he entered in 1817 and graduated with high honors in 1820. He taught school in the winter months, while in college, in Boston, Leominster, and in Canton, Mass. From 1820 to 1823 he taught a select school in Boston.

While in college he was regarded as by far the best mathematician in his class, and during this period thought there was the necessity for such a book as his "First Lessons in Intellectual Arithmetic." This conviction had been forced upon his mind by his experience in teaching. In the autumn of 1821 he published his "first edition." His plan was well digested, although he was accustomed to say that "the pupils who were under his tuition made his arithmetic for him;" that the questions they asked and the necessary answers and explanations which he gave in reply were embodied in the book, which has had a sale unprecedented for any book on elementary arithmetic in the world, having reached over 2,000,000 copies in this country, and the sale still continues, both in this country and in Great Britain. It has been translated into most of the European languages and by missionaries into many Asiatic languages.

After teaching in Boston about two and one-half years, he was chosen superintendent of the Boston Manufacturing Company's works at Waltham, Mass., and accepted the position; and in August, 1824, owing to the mechanical genius he displayed in applying power to machinery, combined with his great administrative ability, he was appointed superintendent of the Lowell Merrimac Manufacturing Co., at Lowell, Mass. Here he projected a system of lectures of an instructive character, presenting commerce and useful subjects in such a way as to gain attention and enlighten the people.

For several years he delivered gratuitous lectures on the Natural History of Animals, Light, Electricity, the Seasons, Hydraulics, Eclipses, etc. His knowledge of machinery enabled him admirably to illustrate these lectures by models of his own construction; and his successful experiments and simple teaching added much to the practical knowledge of his operatives.

He proposed to occupy the space between the common schools and the college halls by carrying, so far as might be practicable, the design of the Rumford Lectures of Harvard into the community of the actual workers of common life.

In the mean time he discharged his official duties efficiently, and the superintendence of the schools of Lowell was also added to his labors. He never relinquished, during these busy years, the design formed in his college days of furnishing to the children of the country a series of text-books on the *inductive plan* in mathematics.

His "Algebra upon the Inductive Method of Instruction," appeared in 1825, and his "Sequel to Intellectual Arithmetic" in 1836. He regarded the "Sequel" as a book of more merit and importance than the "First Lessons."

He also published a series of selections from Miss Edgeworth's stories, in a suitable form for reading exercises for the younger classes of the Lowell schools, in the use of which the teachers were carefully instructed.

In May, 1827, he was elected a Fellow of the American Academy of Sciences. For several years he was a member of the Examining Committee for Mathematics at Harvard College.

He was a member of the Superintending School Committee of Lowell; and so busy were he and his coworkers that they were repeatedly obliged to hold their meetings at six o'clock in the morning.

Warren Colburn was ardently admired--almost revered--by the teachers who were trained to use his "Inductive Methods of Instruction" in teaching elementary mathematics.

In personal appearance Mr. Colburn was decidedly pleasing. His height was five feet ten, and his figure was well proportioned. His face was one not to be forgotten; it indicated sweetness of disposition, benevolence, intelligence, and refinement. His mental operations were not rapid, and it was only by great patience and long continued thought that he achieved his objects. He was not fluent in conversation; his hesitancy of speech, however, was not so great when with friends as with strangers. The tendency of his mind was toward the practical in knowledge; his study was to simplify science, and to make it accessible to common minds.

Mr. Colburn will live in educational history as the author of "Warren Colburn's First Lessons," one of the very best books ever written, and which, for a quarter of a century, was in almost universal use as a text-book in the best common schools, not only in the primary and intermediate grades, but also in the grammar school classes.

In accordance with the method of this famous book, the pupils were taught in a natural way, a knowledge of the fundamental principles of arithmetic. By its use they developed the ability to solve mentally and with great facility all of the simple questions likely to occur in the every day business of common life.

Undoubtedly Pestalozzi first conceived the idea of the true "inductive method" of teaching numbers; but it was Mr. Colburn who adapted it to the needs of the children of the common elementary schools. It has wrought a great change in teaching, and placed Warren Colburn on the roll as one of the educational benefactors of his age.

He died at Lowell, Mass., Sept. 13, 1883, at the age of 90 years.--*Journal of Education*.

THURY'S DYNAMO-ELECTRIC MACHINE.

Thury's dynamo-electric machine, which presents some peculiarities, has never to our knowledge been employed outside of Sweden and a few neighboring regions; but this is doubtless due to some personal motive or other of its constructors, since it has, it would seem, given excellent results in every application that has been made of it. It is represented in perspective in Fig. 1, and in longitudinal section and elevation in Figs. 2 and 3.

As may be seen, it is a multipolar (6-pole) machine in which an attempt has been made to utilize magnetically, as far as possible, all the iron used in the frame. For this reason the system has been given the form of a hexagonal prism, whose faces are formed of flat electro-magnets, A, A, xxx, constituting the inductors.

The internal angles of this prism are filled by polar expansions, P, P, xxx, alternately north and south, that thus form in the interior of the apparatus an inscribed cylinder designed to receive the armature. This latter belongs to the kinds that are wound upon a cylinder in which the wire is external thereto.

The conductors are placed upon the iron drum longitudinally and parallel with its axis. But instead of being connected with each other at the posterier end of the armature, as in the Siemens system, they are connected according to chords that correspond to a fourth, a sixth, or any equal fraction whatever of the circumference. Fig. 4 gives a perspective view of the cylinder, upon which the conductors 1, 2, 3, 4, and so on, are placed according to generatrices. The armature is supposed to be divided into six parts, each conductor passing over the bases of the drum through a chord equal to the radius, that is to say, corresponding to a sixth of the circumference.

Three conductors are all connected together in such a way as to form but a single circuit closed upon itself. Conductor 1, for example, is connected with No. 6 in such a way that the end issuing from 1 becomes the end that enters No. 6. Conductor No. 3 is connected in the same way with No. 8, and so on, up to the last conductor, which is connected in its turn with the end that enters the first.

As the figure shows, the conductor before passing from 3 to 8, for example, returns several times upon itself in following 6 and 3, and the same is the case with all the rest of the winding.

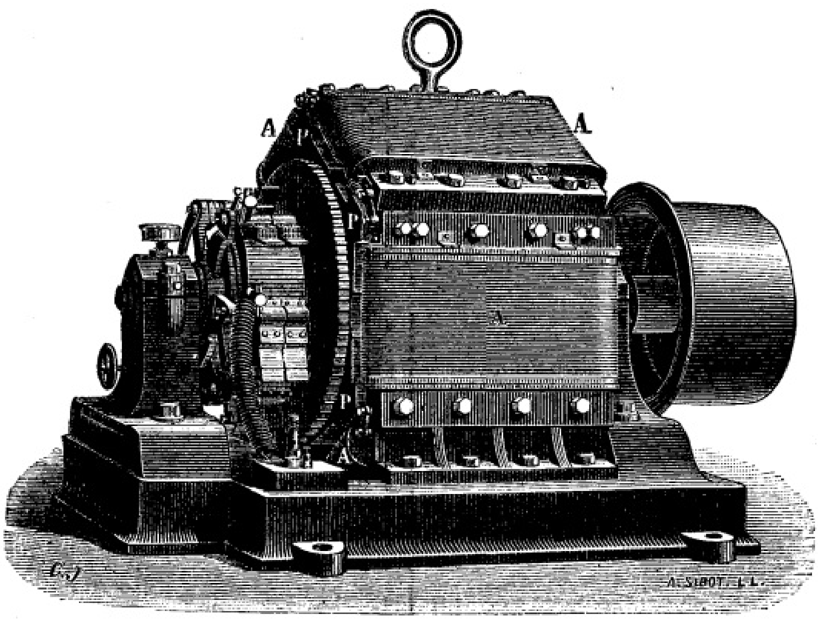
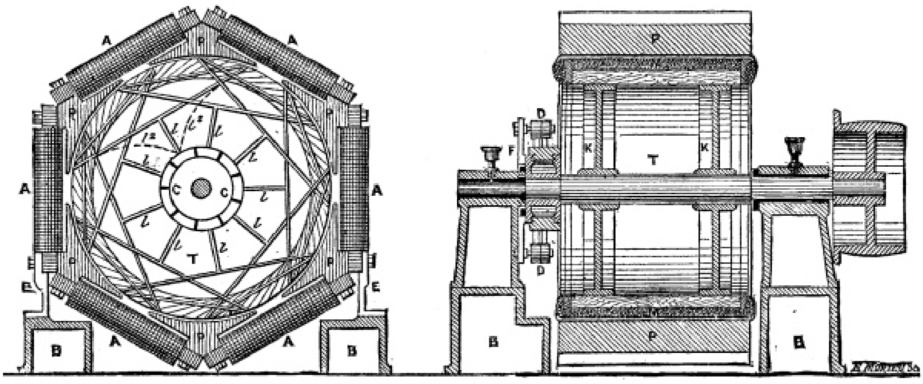


FIG. 1. PERSPECTIVE VIEW OF THE THURY MACHINE.

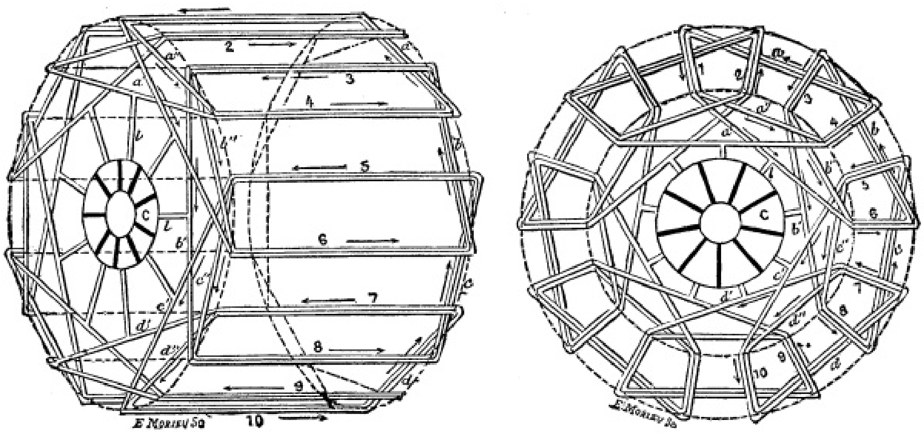
In this way the cylinder becomes inclosed within nine rectangular wire frames, each of which is connected with the following one by a conductor that is at the same time connected with one of the nine plates of the collector. The number of the rubbers corresponds to that of the inducting poles. They may be coupled in different ways, but they are in most cases united for quantity.

It will be seen that the Thury armature resembles, in the system of winding, those of the Siemens machines and their derivatives. But it differs from these, however, in the details connected with the coupling of the wires, from the very fact that the features of a two-pole machine are not found exactly in a multipolar one.



FIGS. 2 AND 3.

This latter kind of machine is considered advantageous by its inventors, in that there is no need of revolving it with much velocity. It must not be forgotten, however, that although we reduce the velocity by this mode of construction, we are, on another hand, obliged to increase the size of the machine, so that, according to the circumstances under which we chanced to be placed, the advantage may now be on the one side and now on the other.



FIGS. 4 AND 5.

It goes without saying that Fig. 4 is essentially diagrammatic, and is designed to give a clearer idea of the mode of winding the armature. In practice the number of the frames, and consequently that of the plates of the conductor, is much greater, and the arrangement that we have described is repeated a certain number of times, the conducter always forming a circuit that is closed upon itself.

The Thury machines are constructed in different styles. No. 1 is a 100-lamp (16 candles and 100 volts) machine, and Nos. 2 and 3 are nominally 250-lamp ones, but may be more. Their weight is 1,100 kilogrammes, and their velocity, for 100 volts, is from 400 to 500 revolutions, according to the mode of coupling.

A later type, now in course of construction, is to furnish from 750 to 2,000 lamps, with 250 revolutions, for 100 volts, and is not to weigh more than 2,000 kilogrammes. Let us add that Messrs. Meuron and Cuenod, the manufacturers, have likewise applied their mode of winding to conductors arranged radially upon the surface of a circle. Fig. 5 shows this arrangement.

In this case the inductors will, it is unnecessary to say, be arranged laterally as in all flat ring machines. The arrangement will recall, for example, that of the Victoria machines (Brush-Mordey).

We do not think that the inventors have applied this radial arrangement practically, for it does not appear to be advantageous. The parts of conductors which are perpendicular to the radius, and which can be only inert (even if they do not become the seat of disadvantageous currents), have, in fact, too great an importance with respect to the radial parts.--*A. Guerout, in La Lumiere Electrique*.

BREGUET'S TELEPHONE.

Prof. G. Forbes gives the following description: The instrument which I call Breguét's telephone is founded upon the instrument which was described by Lipmann, called the capillary electrometer. The phenomenon may be shown in a variety of ways. One of the easiest methods to show it is by taking a long glass tube and bending it into two glasses of dilute acid, and, the tube being filled with acid itself, a piece of mercury is placed in the center of the tube. Then if one pole of a battery is connected with one vessel of acid, and the other pole of the battery is connected with the other vessel of acid, at the moment of connection the bit of mercury will be seen to travel to the right or left, according to the direction of the current. M. Lipmann explained the action by showing that the electro-motive force which is generated tends to alter the convexity of the surface of the mercury. The surface of the mercury, looked at from one side, has a convex form, which is altered by the electro-motive force set up when connection is made with the battery. The equilibrium of the mercury is dependent upon the convexity, and consequently when the convexity is disturbed the mercury moves to one side or the other. Lipmann also showed that if a tube containing a bit of mercury, and tapering to a point, is taken and dipped into acid, and then the tube filled with acid, on one pole of a battery being dipped into the tube and another into the acid the mercury will move up or down, showing similar action to that which I have just described.

Lipmann further showed the reverse effect, that if a piece of mercury be forcibly pressed, so as to alter the convexity of its surface, such as by bringing it into a narrower part of the tube, then there is an electro-motive force produced.

It occurred to me, and no doubt it did to Breguet also, that if we speak either against the surface of the glass tube, and caused the tube to vibrate, or if the mercury were caused to vibrate in the manner I have shown, we ought to be able to introduce a varying current in the wires which might have sufficient electro-motive force to produce audible speech in a Bell telephone. Further, the same instrument, since varying electro-motive force affected the drop of mercury and produced varying displacement, ought also to act as a receiving instrument, and should vibrate in accordance with the currents that arrive. My experiments have only been in the way of using the instrument as a transmitter; but Breguét, I find, used it as a receiver as well as a transmitter, though I am not aware that M. Breguet made any actual experiments so as to produce articulate speech. I presume that this was done, although I have not come across any description of the experiments, and it was for that reason that I thought possibly some account of my own experiments might be interesting to the members of the Society. The first tubes that I used were bits of glass tube about a centimeter diameter, and simply drawn out to a tapering point. I have the tubes here. The first experiment I tried was by tapping the glass tube so as to mechanically shift the position of the mercury, and by listening on the telephone for the effect. For a long time, at least an hour, I could get no effect at all. At last I got a sound, but could not understand how it was that at one time of tapping I could not hear, while at another time it was quite loud.

At the top I always got sound, but at the side I got no sound, although the mercury was shaking. I then tried to see how feeble a current was audible in the telephone. An assistant tapped the tube while I stood out of the way, and where I could not see. I got him to tap it gentler and gentler, and could hear the most feeble tap. A pellet of paper was next dropped from various heights down to an inch, and each tap was perfectly audible in the telephone. I tried many methods, and one, purely accidentally chosen, was a piece of glass tube which I had drawn out into a tube about 2 mm. diameter, and then nearly closed the end of it. I have that tube here, and you will see what an ill-shapen and ugly-looking tube it is, but it is one of the best tubes I ever got; and finally, I found that small bits of thermometer tube, which were simply closed at their ends with a blow-pipe, gave very good results, and I was able to make them useful for various purposes. I then tried mounting a tube on the end of a speaking-trumpet and speaking to the mercury, but got no effect. In every place where I attached the glass tube itself to a sounding-board I got a very accurate reproduction. I put one on a piece of ferrotype plate, and that gave really the best result I ever got. The tube was fastened with sealing-wax, and with it I got excellent speech heard in a Bell receiver. I tried putting in a large number of these tubes, all in quantity, on the bottom of a ferrotype plate, but with no advantage. I have not yet tried putting them in series, one behind the other, so as to increase the electro-motive force, but I think that probably would be an improvement; of course it would require many vessels of acidulated water to dip into. The most distinct articulate speech was obtained from an ordinary ferrotype telephone plate, secured at the edges, and one of the glass tubes you see here attached to it.

MUNRO'S TELEPHONIC EXPERIMENTS.

Mr. J. Munro, whose name is well known not only as a very clear writer upon electrical subjects, but as an original investigator, has recently, with the assistance of Mr. Benjamin Warwick, been conducting a most interesting experimental investigation of the action of the microphone as a telephonic transmitter, with the result of proving that metals may advantageously be employed in the place of carbon in a transmitting instrument, a practical development of one of the very earliest of Professor Hughes' microphones. The fact that metallic electrodes can practically be employed in microphonic transmitters has been denied of late with so much assurance and in such high quarters, that Mr. Munro's successful applications of that portion of Professor Hughes' discovery possess an especial interest, and must to a considerable extent affect the aspect of litigation in future contests in which the discovery of the microphone and the invention of the carbon transmitter are vital points at issue.

In investigating the properties of metallic conductors employed in the construction of microphones, Mr. Munro's first experiments were made with wires. These, in some cases, were caused by the action of a diaphragm, to rub the one on the other in such a manner as to make the point of contact vary (under the influence of the vibrations of the diaphragms) on one side or other of a position of normal potential, so that by the movement of a wire attached to a vibrating tympan along a fixed wire conveying a current from a battery, and thereby shunting the current at various positions along the length of the fixed wire, the strength of the current in the derived circuit, in which was included a suitable receiver, was varied accordingly. In other experiments mercury was employed, either as a sliding-drop, inclosing the fixed wire, or as an oscillating column; but these experiments, though instructive and interesting, did not for various reasons give encouraging results with a view to the practical application of the principle.

They, however, led Mr. Munro to proceed with compound wire structures, such as gratings resting upon or rubbing against one another, and one of the first experiments in this direction proved very successful, and led Mr. Munro to the construction of his gauze telephone, which is the most characteristic and efficient of his practical apparatus.

This instrument consists essentially of two pieces of iron-wire gauze, the one fixed in a vertical plane, and the other resting more or less lightly against it, the pressure between them being regulated by an adjustable spring or weight. These gauze plates are so connected in a telephonic circuit as to constitute the electrodes of a microphone; for touching one another lightly in several points, they allow the current to be transmitted between them in inverse proportion to the resistance offered to it in its passage from one to the other. Under the influence of sonorous vibrations the one plate dances more or less on the other, thus varying the resistance; and very perfect articulation is produced in a telephonic receiver included in the circuit. The gauze transmitter so constructed may be fixed within a wall-box with or without a mouthpiece; but as the sound waves acting directly upon the gauze plates set them into agitation through their sympathetic vibration or by direct impact, no sort of diaphragm or equivalent device is necessary, and none is employed.

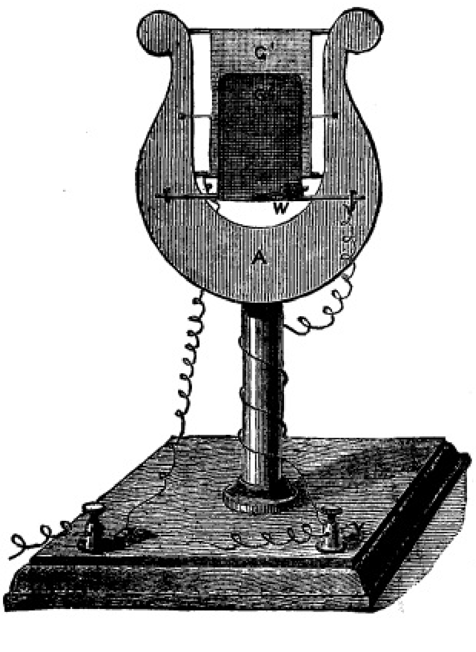


FIG. 1.

A convenient form of this apparatus is shown in Fig. 1, and to which the name of

"The Lyre Telephone" has been given from its resemblance to that impossible musical instrument. In this apparatus, G^1 is a plate of iron wire gauze stretched vertically between two horizontal wires attached to a lyre-shaped framework of mahogany; against the plate rests the smaller plate, G^2, the normal pressure between them being regulated by an adjustable spring acting in opposition to a weighted lever, W. The two plates are connected respectively with the attachment screws, X and Y, by which the instrument is placed in a circuit with a battery and telephonic circuit.

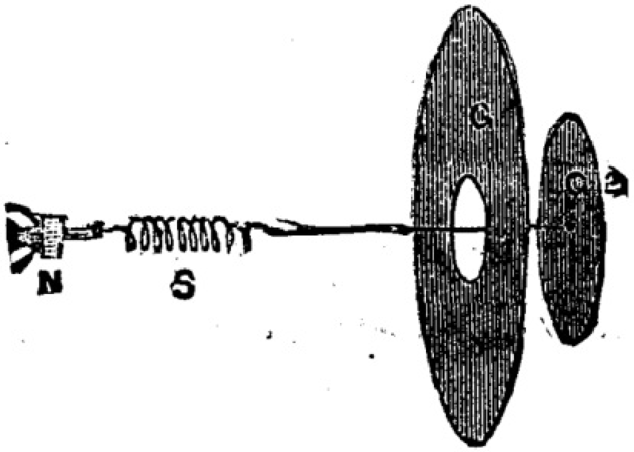


FIG. 2.

A modification of this apparatus is shown in the diagram sketch, Fig. 2, which will probably be a more practical form. In this instrument the electrodes consist of two circular disks of iron wire gauze of different diameters, the larger disk, G^1, which is fixed, being pierced with holes of smaller diameter than the smaller disk, G^2. In the diagram the two disks are shown separated for the purpose of explanation, but in reality they rest the one against the other; the smaller and movable disk, G^2, is held up against G^1 with greater or less pressure by the spiral spring, S, the tension of which can be adjusted by a screw or other suitable device at N. This form of the apparatus is more suitable for inclosure in a wall box with or without a mouthpiece, but it does not require the employment of any kind of diaphragm or tympan. Mr. Munro can employ with all his instruments an induction coil for installations where the resistance of the line wire makes it desirable to do so; the microphone and battery being included in the primary circuit and the telephones in the secondary.

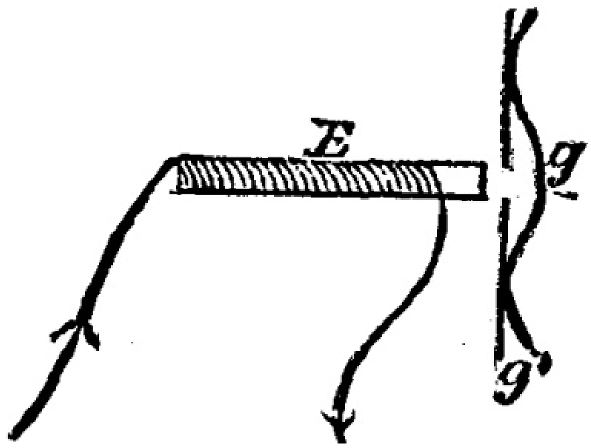


FIG. 3.

Fig. 3 is an ingenious arrangement devised by Mr. Munro, in which the adjusting spring or weight is substituted by a magnet which may be either a permanent or an electro-magnet. The figure shows an arrangement in which the fixed gauze, g^1, is perforated as in the apparatus illustrated in Fig. 2, and the movable electrode, g, is bent or dished so as to press upon g^1 around its edge. E is a magnet which by its attractive influence upon g holds t up against g^1 with a pressure dependent upon its magnetic intensity and upon its distance from the gauze. By making E an electro-magnet, and including its coil in the telephonic circuit, an instrument may be constructed in which the normal pressure between the electrodes can be automatically adjusted to the strength of the current, and in cases where an induction coil is employed the magnet, E, may be the core of such a coil.

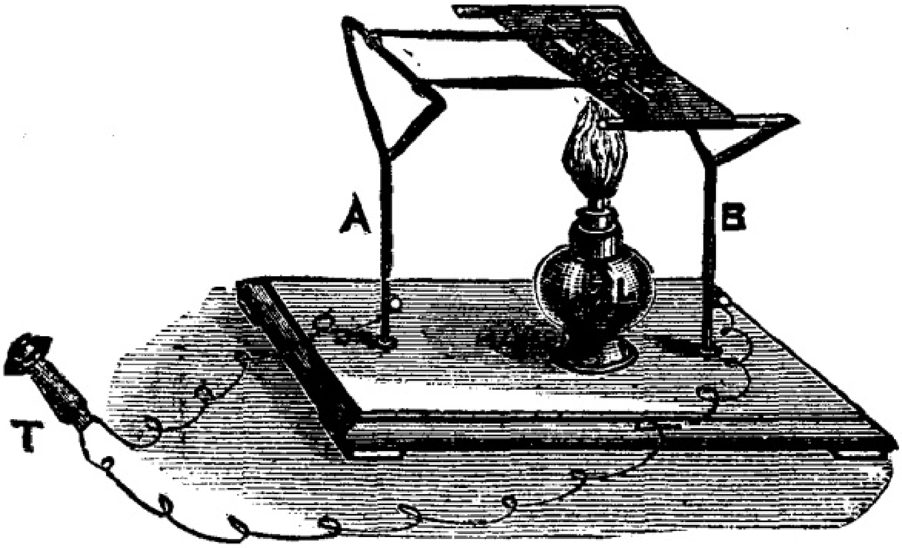


FIG. 4.

Fig. 4 illustrates an apparatus devised by Mr. Munro, and to which the name thermo-microphone might be given, as it is a microphone in which thermo-electric currents are employed in the place of voltaic currents, its special feature of interest lying in the fact that the heated junction of the thermo-electric couple is identical with the microphone contacts of the two electrodes. In this very elegant experiment a piece of iron wire gauze, G, is supported in a horizontal position by a light metallic support, B. To another support. A, is loosely hinged a frame, which at its further extremity carries a little coil of German silver wire, C, which by its weight rests upon the center of the gauze plate, G; and in contact therewith, and to increase the pressure of contact, a little bar weight is laid within the convolutions of the core. The two electrodes, the gauze, and the coil are connected, as shown, to a receiving telephone, T. Upon the application of heat, as from the flame of a spirit lamp placed below, a thermo-electric current is set up throughout the circuit; in this condition the apparatus becomes a very perfect microphone, and when the pressure between the electrodes is properly adjusted it is a very efficient telephonic transmitter, transmitting articulate speech and musical sounds with remarkable clearness and fidelity.

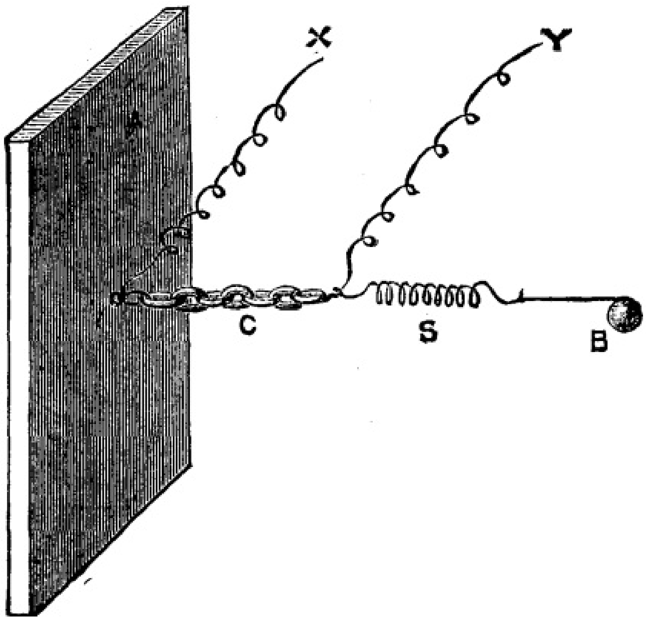


FIG. 5

Mr. Munro is, with the aid of Mr. Warwick's manipulative skill, extending this portion of his investigation further by experimenting with gauzes and coils of various metals forming other couples in the thermo-electric series, as well as with iron and other gauzes electrotyped with bismuth and other metals, and we hope in due time to lay the results of those experiments before our readers.

Mr. Munro has, moreover, observed that if two pieces of gauze of identical material and in microphonic contact be heated, a peculiar sighing sound is heard in a telephone connected with them and with a battery, and he attributes this phenomenon to the electrical discharge between the gauze plates being facilitated and increased by the action of heat, but we are rather inclined to trace the effect to the mechanical action of the one gauze moving over the other under the influence of expansion and contraction of the metals by the variable temperature of the flame and convection currents of heated air, such movement producing the sounds just as would be produced if one of the electrodes of an ordinary microphone were as delicately moved by the hand or other agent.

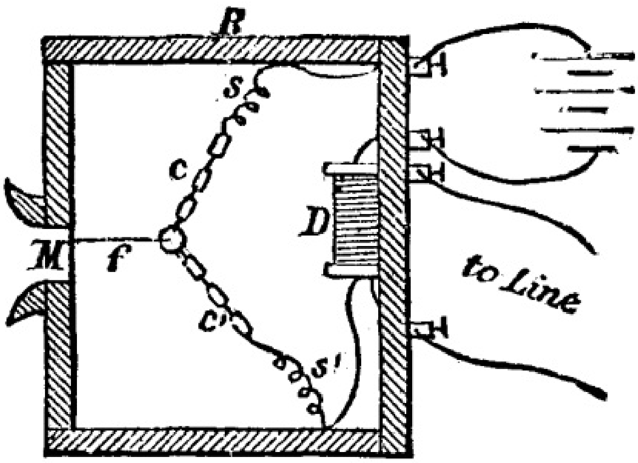


FIG. 6

Figs. 5 and 6 illustrate another and distinct form of metallic microphone transmitter designed by Mr. Munro and Mr. Warwick, in which a small chain, preferably of iron, forms the microphonic portion of the apparatus. In Fig. 5, A is a plate of sonorous wood forming a diaphragm or collector of the sonorous waves; to the back of this is attached a short length of chain, C, the opposite ends of which are by the wires, X and Y, included in the telephonic circuit. The points of junction of the links with one another constitute the variable microphonic contacts, and the normal pressure between them is adjusted by the spiral spring, S, the tension of which may be varied by the cord and winding pin, B. Fig. 6 is the section of a transmitter constructed upon this principle, and in which two chains, c and c', are employed attached at one end by a wire, f, to a diaphragm mouthpiece, N, and at their opposite extremities to the adjusting springs, s and s'; an induction coil, D, may be employed if the resistance of the line render it advantageous.

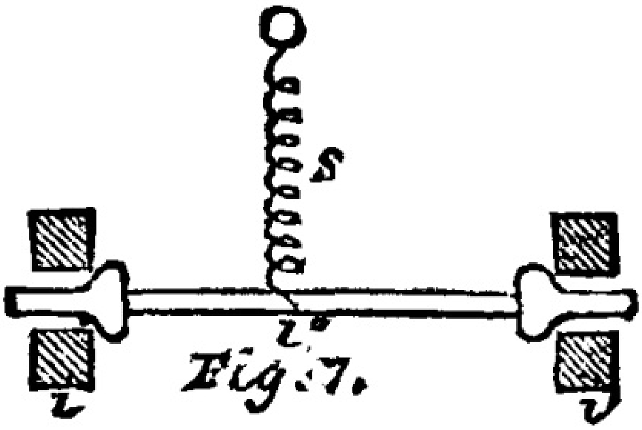


FIG. 7

Fig. 7 is a form of pencil microphone experimented with by Mr. Munro, which differs from some of the Hughes' transmitters adopted by Crossley, Gower, Ader, and many others only in the material of which it is composed, Mr. Munro's being of cast iron, while the others to which we have referred are of carbon rods such as are used in electric lighting. In Fig. 7 a light cast-iron bar, i^2, of the form shown, is supported in holes drilled in two blocks of cast iron, i i', and the pressure between the bar and the blocks can be adjusted by a regulating spring, s. In connection with this apparatus Mr. Munro has observed that rust has no appreciable effect upon the efficiency of the instrument unless it be to such an extent as to cause the two to adhere, or to be "rusted up" together.

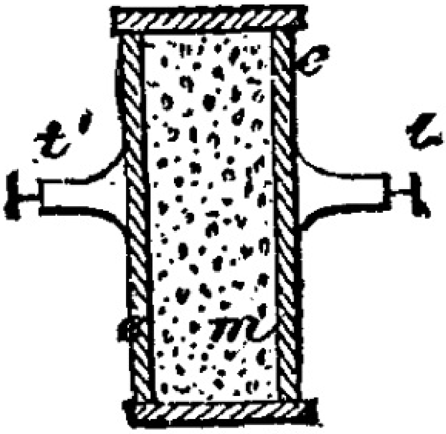


FIG. 8

We now come to another class of metallic transmitters with which Mr. Munro and his associate have been making experiments, and to which he has given the name "Grain transmitter," since it consists of a box having metallic sides, e e', to which terminal screws, t t', are attached and filled in between with iron or brass filings, granules of spongy iron, or indeed small metallic particles in any form; one of the most efficient transmitters being a box such as is shown in Fig. 8, filled with a quantity of ¼ in. screws.

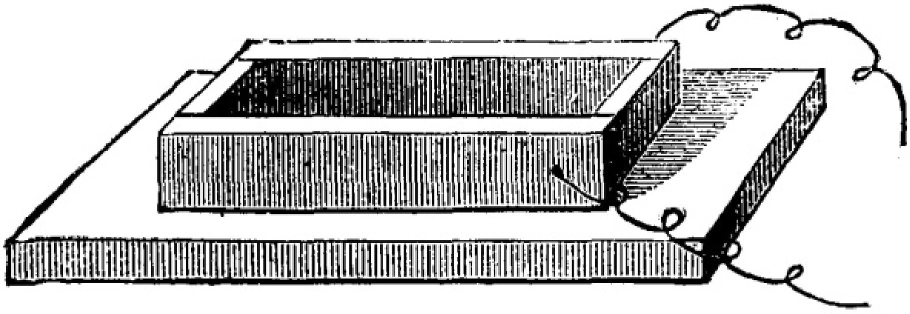


FIG. 9

The results of Mr. Munro's experiments have led him to the opinion that the action of the microphone must be attributed to the action of sonorous vibrations upon the air or gaseous medium separating the so-called contact-points of the electrodes, and that across these spaces, or films of gaseous matter, silent electrical discharges take place, the strengths of which, being determined by the thickness of the gaseous strata through which they pass, vary with the motion of the electrodes; and as, according to this hypothesis, the distances of the electrodes from one another is determined by the sound-waves, the sound in that way controls the current.--*Engineering*.

APPARATUS FOR MANEUVRING BICHROMATE OF POTASSA PILES FROM A DISTANCE.

Bichromate of potassa piles, especially those single liquid ones that are applied to domestic lighting, all present the grave defect of consuming almost as much zinc in open as in closed circuit, and of becoming rapidly exhausted if care be not taken to remove the zinc from the liquid when the battery is not in use. This operation, which is a purely mechanical one, has hitherto required the pile to be located near the place where it was to be used, or to have at one's disposal a system of mechanical transmission that was complicated and not very ornamental.

In order to do away with this inconvenience, which is inherent to all bichromate piles, Mr. G. Mareschal has invented and had constructed an ingenious system that we shall now describe.

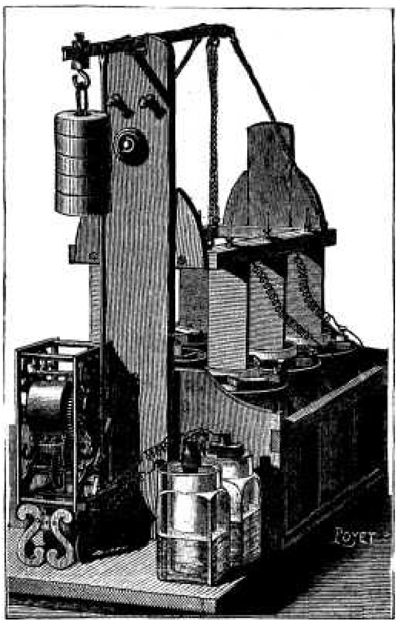


FIG. 1.--BICHROMATE OF POTASSIUM PILE, WITH MANEUVERING APPARATUS.

Mr. Mareschal's plan consists in suspending the frame that carries all the battery zincs (Fig. 1) from the extremity of a horizontal beam, and balancing them by means of weights at the other extremity.

The system, being balanced, the lifting or immersion of the zincs then only requires a slight mechanical power, such as may be obtained from an ordinary kitchen jack through a combination that will be readily understood upon reference to Fig. 2. The axis, M, of the jack, on revolving, carries along a crank, MD, to which is fixed a connecting-rod, A, whose other extremity is attached to the horizontal beam that supports the zincs and counterpoises. If the axle, M, be given a continuous revolution, it will communicate to the rod, A, an upward and downward motion that will be transmitted to the beam and produce an alternate immersion and emersion of the zincs.

Upon stopping the jack at certain properly selected positions of the rod, MD, the zincs may, at will, be kept immersed in the liquids, or *vice versa*. This is brought about by Mr. Mareschal in the following way: The jack carries along in its motion a horizontal fly-wheel, V, against whose rim there bears an iron shoe, F, placed opposite an electro-magnet, E. In the ordinary position, this shoe, which is fixed to a spring, bears against the felly of the wheel and stops the jack through friction. When a current is sent into the electro-magnet, E, the brake shoe, F, is attracted, leaves the fly wheel, and sets free the jack, which continues to revolve until the current ceases to pass into the electro.

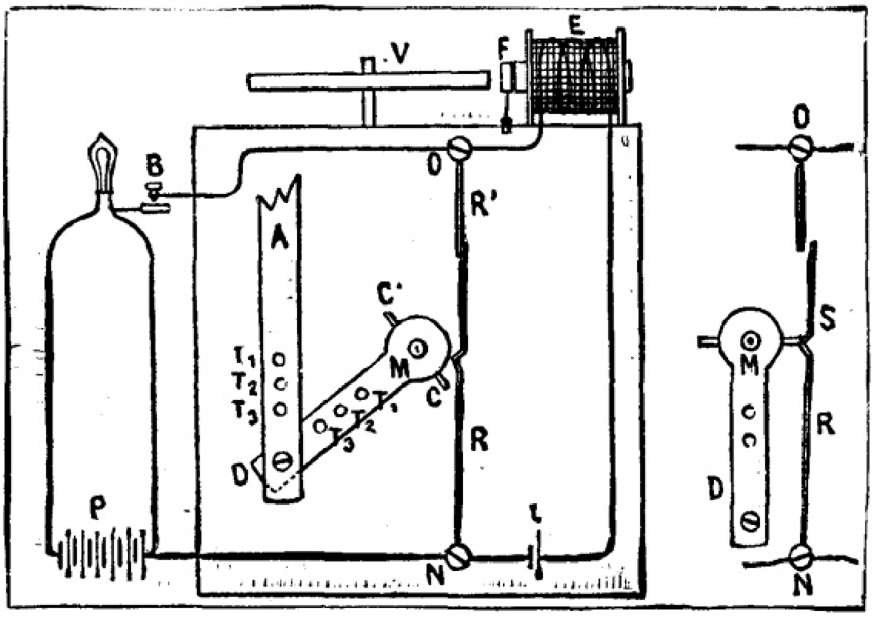


FIG. 2.--PRINCIPLE OF THE APPARATUS.

The problem, then, is reduced to sending a current into the electro and in shutting it off at the proper moment. This result is obtained very simply by means of an auxiliary

Leclauche pile. (The piles got up for house bells will answer.) The current from this pile is cut off from the electro, F, by means of a button, B, when it is desired to light or extinguish the lamps. In a position of rest, for example, the crank, MD, is vertical, as shown in the diagram to the right in Fig. 2. The circuit is open between M and N through the effect of the small rod, C, which separates the spring, R, from the spring, R'. As soon as the circuit has been closed, be it only for an instant, the crank leaves its vertical position, the rod, C, quits the bend, S, and the spring, R, by virtue of its elasticity, touches the spring, R', and continues its contact until the crank, MD, having made a half revolution, the rod, C', repulses the spring, R, and breaks the circuit anew. The brake then acts, and the crank stops after making a revolution of 180°, and immersing the zincs to a maximum depth. In order to extinguish the lamp, it is only necessary to press the button, B, again. The axle, M, will then make another half revolution, and, when it stops, the zinks will be entirely out of the liquid. The depth of immersion is regulated by fixing the crank-pin. D, in the apertures, T_1, or T_2, of the connecting rod. This permits the travel, and consequently the degree of immersion, to be varied.

The device requires three wires, two for connecting the lamp with the battery, and one for maneuvering the apparatus through a closing of the contact, B.

With Mr. Mareschal's system, bichromate of potassa piles may be utilized in a large number of cases where a light of but short duration is required until the battery is exhausted, without the tedious maneuvering of a winch and without inconvenience. The jack permits of a large number of lightings and extinctions being effected before it becomes necessary to wind up its clockwork movement. This operation, however, is very simple, and may be performed every time the battery is visited in order to see what state it is in.

We regard Mr. Mareschal's apparatus as an indispensable addition to every case of domestic electric lighting in which bichromate of potassa piles are used, and, in general, to all cases where the pile becomes uselessly exhausted in open circuit. It will likewise find an application in laboratories, where the bichromate pile is in much demand because of its powerful qualities, and where it is often necessary to order it from quite a distant point.--*La Nature*.

MAGNETIC ROTATIONS.

By E. L. VOICE.

The remarkable researches and experiments of Professor Hughes clearly show that magnetism is totally independent of iron, and that its molecules, particles, or polarities are capable of rotation in that metal. It would also appear that by reason of the friction between magnetism and iron, the molecules of the latter are only partially moved, such movement being the result of the tendency of iron to retard magnetic change.

I have found that the magnetic molecules also possess inertia, that they are capable of acquiring momentum, and that their rotation continues for a considerable time after the exciting cause of their rotation has ceased.

These facts may be proved in a very evident manner, inasmuch as induced electric currents are generated by this *after* rotation, which may be made to light incandescent lamps.

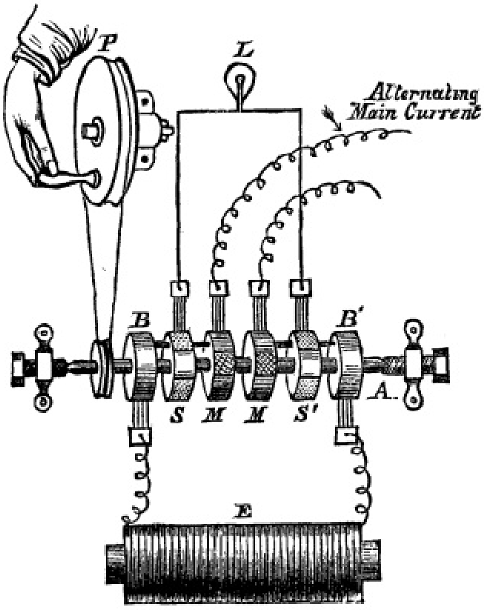
In this case the magnetic rotations are produced in an electro magnet by means of alternate currents supplied by alternating Gramme machine.

In order to better explain the action, it will be necessary to refer to a new electro-motor, which was the subject of an article in the *Electrical Review* of February 19 last. It is of that type of motor in which the field magnet and armature poles are alternately arranged, and which requires a periodical reversibility of magnetism in the armature to cause the latter to revolve, as in the Griscom motor. The insulating strips in the commutator are sufficiently wide to demagnetize the whole of the machine before reversibility in the armature takes place, and this demagnetization sets up a *direct* induced current, which is caught in a shunt circuit by the aid of a second commutator, which only comes into action when the first commutator goes out.

When this motor is supplied by a continuous current, it is easy to understand that the induced current which passes through the shunt circuit, and which is caused by the demagnetization, is proportional to the mass of iron and wire of which the machine is composed, or proportional to its inductive capacity. This current is purely a secondary effect, of short duration, and only occurs once at each break of the commutator.

The motor is of such a size that when supplied with a continuous current of proper strength the induced electrical effect in the shunt circuit will light one incandescent lamp. If, however, it is supplied with an alternating current of the same power, it will light eight lamps, and the mechanical power given off is even more than with a continuous current, provided that the alternations from the dynamo do not exceed 6,000 a minute.

At first I was considerably puzzled by this great difference, because in both cases it is impossible for the lamp circuit to be acted upon by the main current. It occurred to me, however, that the rapid alternations of the exciting current from the dynamo, and the consequent speed of magnetic molecular rotation, gave the latter a certain momentum, and that by widening the insulating strips of the first or main current commutator, and proportionately increasing the width of conducting surface in the shunt commutator up to certain limits, this effect would be increased. I found such to be the case, from which I inferred that the increase of induced current in the shunt circuit was on account of its longer duration, by reason of the acquired momentum of the magnetic molecular rotations *after* the alternating exciting current had ceased.



Those who have facilities for carrying out experiments may prove it in the following manner:

E, in the inclosed drawing, is an electro-magnet whose brushes press on two metallic bands, B and B¹, fixed to but insulated from the spindle, A. The band, B, is in electrical circuit with the shunt commutator, S, and the main commutator, M; while the band, B¹, is in contact with shunt commutator, S¹, and main commutator, M¹. This contact is made by conducting rods, as indicated. The commutators, as regards their brushes, are so arranged that when M and M¹ are in action, S and S¹ are out of action, and *vice versa*. The spindle and commutators are rotated by the pulley, P. L is an incandescent lamp in the shunt circuit.

Let us now suppose the apparatus at rest, and the brushes in electrical contact with the main commutators, M and M¹. The current from an alternating dynamo passes into the magnet, E, and rapidly reverses its polarity. By actuating the pulley, P, the commutators are rotated, when M and M¹ go out of, and the shunt commutators, S and S¹, come into action, enabling the *after* current set up in the magnet to light the lamp, L, in the shunt circuit.

In order to make comparative tests, the same apparatus may be supplied with continuous instead of alternating currents. The after current in the former case, however, is much smaller, consisting of one electrical impulse only at each break of the commutator, whereas in the alternating system these impulses are practically continued; the result being that, all things being equal, a far greater number of lamps may be used in the shunt than when supplied by continuous current only, and it would appear that this difference can only be attributed to the fact that the rotatory motion of magnetic molecules, or polarity of the magnet, E, acquires momentum when acted upon by a suitable physical cause, such as alternating currents of electricity; this momentum lasting a sensible time after the cessation of the acting cause.

If we had the gift of magnetic sight, and could see what is going on in the electro-magnet when it is excited by alternating currents, we should probably see the molecules or polarities tumbling over each other at an enormous rate. I do not think, however, that we should see anything but a vibratory motion as regards the iron molecules.--*Elec. Review.*

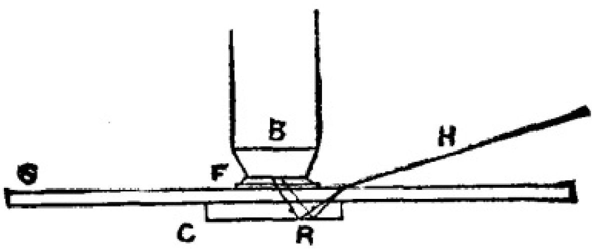
[AMER. MICROSCOP. JOUR.]

LIGHTON'S IMMERSION ILLUMINATOR

The following extremely simple plan for an immersion illuminator was first brought to the notice of microscopists a few years ago, and, in the absence of the inventor, was kindly described by Prof. Albert McCalla, at the meeting of the American Society of Microscopists, at Columbus, O. It consists of a small disk of silvered plate glass, c, about one-eighth of an inch thick, which is cemented by glycerine or some homogeneous immersion medium to the under surface of the glass-slide, s. Let r represent the silvered surface of the glass disk, b, the immersion objective, f, the thin glass cover. It will be easily seen that the ray of light, h, from the mirror or condenser above the stage will enter the slide and thence be refracted to the silvered surface of the illuminator, r, whence it is reflected at a corresponding angle to the object in the focus of the objective. A shield to prevent unnecessary light from entering the objective can be made of any material at hand, by taking a strip one inch long and three-fourths of an inch wide and turning up one end. A hole not more than three-sixteenths of an inch in diameter should be made at the angle. The shield should be placed on the upper surface of the slide, so that the hole will cover the point where the light from the mirror enters the glass. With this illuminator Möller's balsam test-plate is resolved with ease, with suitable objectives. Diatoms mounted dry are shown in a manner far surpassing that by the usual arrangement of mirror, particularly with large angle dry objectives.

Ottumwa, Ia.

WM. LIGHTON.



LIGHTON'S ILLUMINATOR.

FOUCAULT'S PENDULUM EXPERIMENTS.

By RICHARD A. PROCTOR.

Science owes to M. Foucault the suggestion that the motions of a pendulum so suspended as to be free to swing in any vertical plane might be made to give ocular demonstration of the earth's rotation. The principle of proof may be easily exhibited, though, like nearly all of the evidences of the earth's rotation, the complete theory of the matter can only be mastered by the aid of mathematical researches of considerable complexity. Suppose A B (Fig. 1) to be a straight rod in a horizontal position bearing the free pendulum C D suspended in some such manner as is indicated at C; and suppose the pendulum to be set swinging in the direction of the length of the rod A B, so that the bob D remains throughout the oscillations vertically under the rod A B. Now, if A B be shifted in the manner indicated by the arrows, its horizontality being preserved, it will be found that the pendulum does not partake in this motion. Thus, if the direction of A B was north and south at first, so that the pendulum was set swinging in a north and south direction, it will be found that, the pendulum will still swing in that direction, even though the rod be made to take up an east and west position.

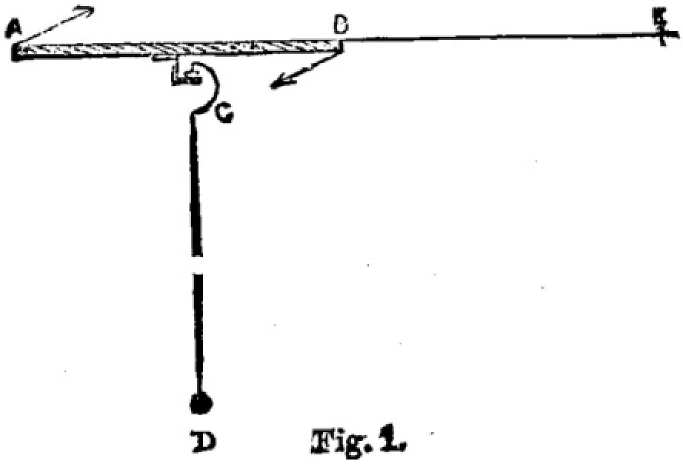


Fig. 1.

Nor will it matter if we suppose B (say) fixed and the rod shifted by moving the end A horizontally round B. Further, as this is true whatever the length of the rod, it is clear that the same fixity of the plane of swing will be observed if the rod be shifted horizontally as though forming part of a radial line from a point E in its length. In these cases the plane of the pendulum's swing will indeed be shifted *bodily*, but the direction of swing will still continue to be from north to south.

Now, let P O P' represent the polar axis of the earth; a b a horizontal rod at the pole bearing a pendulum, as in Fig. 1. It is clear that if the earth is rotating about P O P' in the direction shown by the arrow, the rod a b is being shifted round, precisely as in the case first considered. The swinging pendulum below it will not partake in its motion; and thus, through whatever arc the earth rotates from west to east, through the same arc will the plane of swing of the pendulum appear to travel from east to west under a b.

But we cannot set up a pendulum to swing at the pole of the earth. Let us inquire, then, whether the experiment ought to have similar results if carried out elsewhere.

Suppose A B to be our pendulum-bearing rod, placed (for convenience of description merely) in a north and south position. Then it is clear that A B produced meets the polar axis produced (in E, suppose), and when, owing to the earth's rotation, the rod has been carried to the position A' B', it still passes through the point E. Hence it has shifted through the angle A E A', a motion which corresponds to the case of the motion of A B (in Fig. 1) about the point E,[1] and the plane of the pendulum's swing will therefore show a displacement equal to the angle A E A'. It will be at once seen that for a given arc of rotation the displacement is smaller in this case than in the former, since the angle A E A' is obviously less than the angle A K A'.[2] In our latitude a free pendulum should seem to shift through one degree in about five minutes.

[Footnote 1: In reality A E moves to the position A' E over the surface of a cone having E P' as axis, and E as vertex; but for any small part of its motion, the effect is the same as though it traveled in a plane through E, touching this cone; and the sum of the effects should clearly be proportioned to the sum of the angular displacements.]

[Footnote 2: In fact, the former angle is less than the latter, in the same proportion that A K is less than A E, or in the proportion of the sine of the angle A E P, which is obviously the same as the sine of the latitude.]

It is obvious that a great deal depends on the mode of suspension. What is needed is that the pendulum should be as little affected as possible by its connection with the rotating earth. It will surprise many, perhaps, to learn that in Foucault's original mode of suspension the upper end of the wire bearing the pendulum bob was fastened to a metal plate by means of a screw. It might be supposed that the torsion of the wire would appreciably affect the result. In reality, however, the torsion was very small.

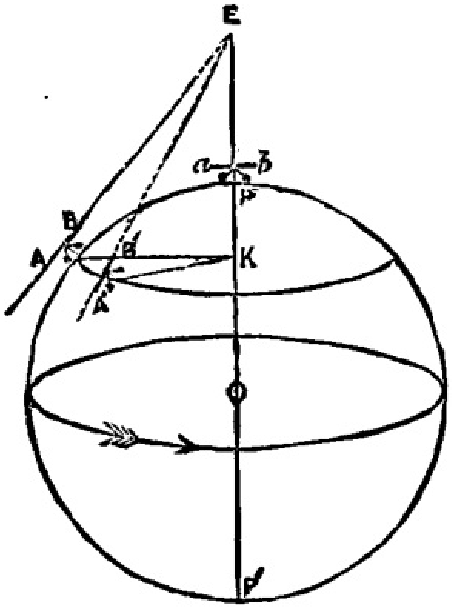


Fig. 2.

Still, other modes of suspension are obviously suggested by the requirements of the problem. Hansen made use of the mode of suspension exhibited in Fig. 3. Mr. Worms, in a series of experiments carried out at King's College, London, adopted a somewhat similar arrangement, but in place of the hemispherical segment he employed a conoid, as shown in Fig. 4, and a socket was provided in which the conoid could work freely. From some experiments I made myself a score of years ago, I am inclined to prefer a plane surface for the conoid to work upon. Care must be taken that the first swing of the pendulum may take place truly in one plane. The mode of liberation is also a matter of importance.

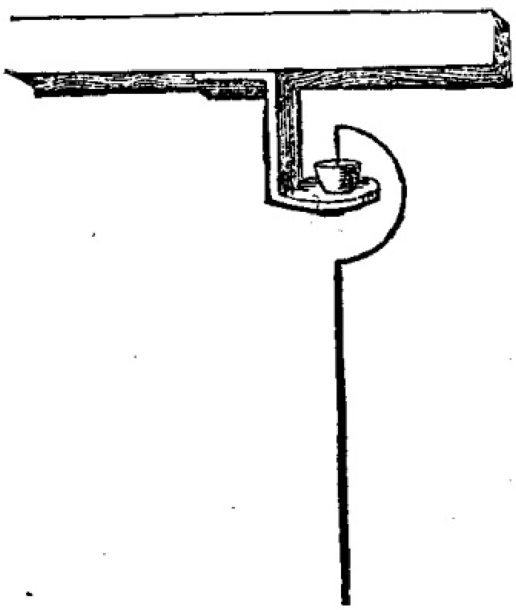


Fig.3.

Many interesting experiments have been made upon the motions of a free pendulum, regarded as a proof of the earth's rotation, and when carefully conducted, the experiments have never failed to afford the most satisfactory results. Space, however, will only permit me to dwell on a single series of experiments. I select those made by Mr. Worms in the Hall of King's College, London, in the year 1859:

"The bob was a truly turned ball of brass weighing 40 lb.; the suspending medium was a thick steel wire; the length of the pendulum was 17 feet 9 inches. The amplitude of the first oscillation was 6° 42', and during the time of the experiment--about half an hour--the arcs were not much diminished. As I had to demonstrate to a large number of spectators, I encountered considerable difficulty," says Mr. Worms, "in rendering the small deviations of the plane of oscillation visible to all. I accomplished it in three different ways." These he proceeds to describe. He had first a set of small cones set up, which were successively knocked down as the change in the plane of the pendulum slowly brought the pointer under the bob to bear on cone after cone. Secondly, a small cannon was so placed that the first touch of the pendulum pointer against a platinum wire across the touch-hole completed a galvanic circuit, and so fired the cannon. Lastly, a candle was placed so as to throw the shadow of the pendulum bob upon a ground-glass screen, and so to exhibit the gradual change of the plane of swing.

The results accorded most satisfactorily with the deductions from the theory of the earth's rotation.

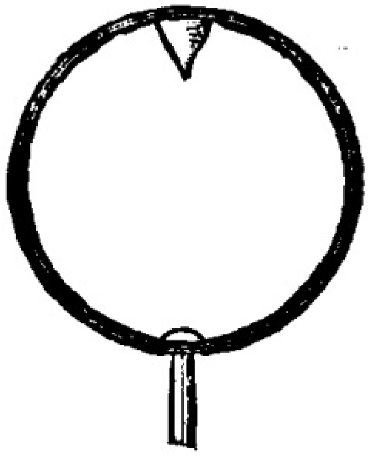


Fig.4.

A NEW LUNARIAN.

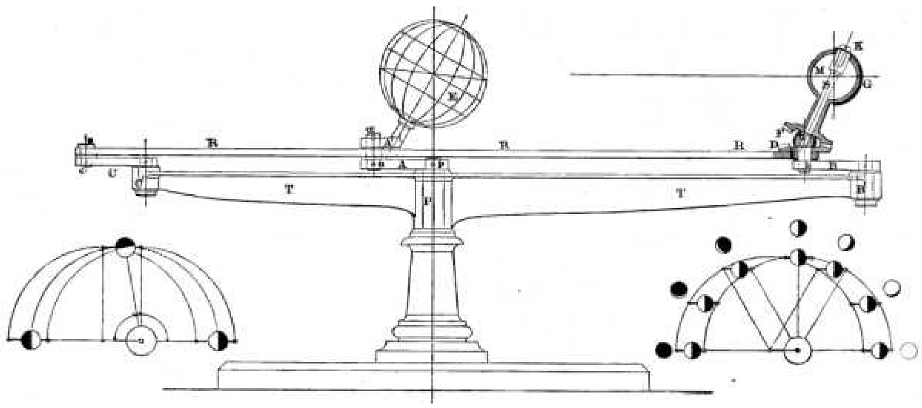
By Prof. C. W. MACCORD, Sc.D.

The construction of apparatus for illustrating the motions of the heavenly bodies has often occupied the attention of both mathematicians and mechanicians, who have produced many very ingenious, and in some cases very complicated, combinations. These may be divided into two classes; the object of the first being to represent *exactly* what occurs--to reproduce the precise movements of the various bodies represented in their true proportions and relations to each other, in respect to distances, magnitudes, times, and phases. When the absolute complexity of the movements of the bodies composing the solar system is considered, it is not so much a matter of wonder that a planetarium which shall thus imitate them is a very delicate and complicated machine as that it should lie within the limits of human ingenuity.

In the second class, the object is to show the nature and the causes of specific phenomena, without regard to others perhaps, and without necessarily paying attention to exact proportions of distances and dimensions. Indeed, it is often the case that the illustration is made clearer by exaggerating some of these and reducing others; thus, for example, the causes of the variation in the lengths of the days and nights, and of the changes in the seasons, can be exhibited to much better advantage by an apparatus in which the diameter of the sun and its distance from the earth are enormously reduced than they possibly could be were they of their proper proportionate magnitudes; nor is the presence of any other planet, or the attendance of a satellite, at all necessary or even desirable for the purpose named.

It is apparent that machines of this class can be made much more simple than those of the first, while at the same time it may safely be asserted that for educational purposes they are far more useful.

In both classes, the action involves the use of some sort of epicyclic train, since the motions to be explained are both orbital and axial. The planetary body is carried round by a train-arm, and its rotation about its axis is usually given it by a train of gearing, the inner or central wheel of which is stationary, being fastened to the fixed frame supporting the whole.



AN IMPROVED LUNARIAN.

The lunarian which we herewith present belongs to the second of the classes above named; in its construction an attempt has been made to show by as simple means and in as clear a manner as possible the nature of the following phenomena, viz.:

1. Apogee and perigee.

2. The moon's phases.

3. The rotation on her axis, by reason of which she always presents nearly the same face to the earth.

4. The inclination of her axis to the plane of her orbit, and her consequent libration in latitude.

5. Her varying angular velocity, and consequent libration in longitude.

The mechanism consists of a train-arm, T, which turns upon the vertical pivot, P, fixed in the stand. In this arm, T, are the bearings of two cranks, B and C. equal in length to each other and to a third crank, A, which is stationary, being fixed to the pivot, P, by a pin, p. To the crank-pin of A is secured a reverted arm, A', which supports the earth, E, and keeps it also stationary. The three cranks are connected by the rod, R, like the parallel rod of a locomotive: to which is fastened by a steady-pin, o, the bevel wheel, D, concentric with the crank-pin, b. The head of this crank-pin is first made spherical, then faced off at an angle with the axis of b, and in the sloping face is firmly fixed the long screw, S, forming the support for the moon, M, which is caused to rotate about the axis of S, by means of the wheel, F, equal to and engaging with D. The upper end of S projects slightly through a perforation in the moon, and to it the hemispherical black shell or cap, G, is fixed by the screw, K; this cap represents the unilluminated part of the moon, and since G, s, b, and B, are in effect but one piece, the cap moves precisely as the crank does.

Now as the train-arm, T, is carried round, the cranks, B and C, will turn in their bearings; but by their connection with A, they are compelled to remain always parallel to themselves, and thus the axis of the moon receives a motion of translation. But since during this action the wheel D turns relatively to the pin b, the moon evidently rotates about its axis with an angular velocity precisely equal to that of its orbital motion.

The black shell however has the motion of translation only, and thus exhibits the phases of the moon, on the supposition that the source of light is infinitely remote and the rays come always in the same direction, which is not strictly true, of course; but the reasons of the varying appearance are as clearly shown as if it were absolutely exact. The same may be said in regard to the phenomena of libration; the inclination of the moon's axis to the plane of her orbit is really small, but is purposely exaggerated in this apparatus in order to make the results apparent; in the position represented, it is quite obvious that an observer upon the earth can see a little past one pole, and cannot quite see the other, as well as that this condition will be reversed after half a revolution.

The action in reference to the phases is clearly shown in the small diagram on the right. The one on the left illustrates the manner in which the libration in longitude is made apparent. It will be noted that the center of M is not directly over the axis of the bearing of the crank, B, so that after half a revolution the moon will be farther from the earth than she is here shown. Her orbit here is circular, whereas, in fact, it is an ellipse; but the earth not being in the center, her angular velocity in relation to the earth is variable, the result of which is that, when she is near her quadrature, the actual force presented to the earth is slightly different from that presented when in conjunction or opposition.

Thus these various peculiarities of the motion of our satellite are exhibited by comparatively simple means--the number of moving parts being, it is believed, as small as it can be made; and the substitution of a crank motion for the usual train of wheels, we think, is a new device.

THE UPRIGHT ATTITUDE OF MANKIND.

Every one must have heard or have read of the supposed perfect adaptation of the human frame to bipedal locomotion and to an upright attitude, as well as the advantages which we gain by this erect position. We are told, and with perfect truth, that in man the occipital foramen--the aperture through which the brain is connected with the spinal cord--is so placed that the head is nearly in equilibrium when he stands upright. In other mammalia this aperture lies further back, and takes a more oblique direction, so that the head is thrown forward, and requires to be upheld partly by muscular effort and partly by the ligamentum nuchæ, popularly known in cattle as the "pax-wax."

Again, the relative lengths of the bones of the hinder extremities in man form an obstacle to his walking on all-fours. If we keep the legs straight we may touch the ground in front of our feet with the tips of the fingers, but we cannot place the palms of the hands upon the ground and use them to support any part of our weight in walking. Not a few other points of a similar tendency have been so often enlarged upon, in works of a teleological character, that there can be no need even to specify them at present.

But till lately it has never been asked, "Is man's adaptation to an upright posture perfect?" and "Is this posture attended with no drawbacks?" These questions have been raised by Dr. S. V. Clevenger in a lecture delivered before the Chicago University Club, on April 18, 1882, and recently published in the *American Naturalist*. This lecture, we may add, cost the speaker the chair of Comparative Anatomy and Physiology at the Chicago University!

Dr. Clevenger first discusses the position of the valves in the veins. The teleologists have long told us that the valves in the veins of the arms and legs assist in the return of blood to the heart against gravitation. But what earthly use has a man for valves in the intercostal veins which carry blood almost horizontally backward to the azygos veins? When recumbent, these valves are an actual obstacle to the free flow of the blood. The inferior thyroid veins which drop their blood into the innominate are obstructed by valves at their junction. Two pairs of valves are situate in the external jugular, and another pair in the internal jugular, but they do not prevent regurgitation of blood upward.

An anomaly exists in the absence of valves from parts where they are most needed, such as the venæ cavæ, the spinal, iliac, hæmorrhoidal, and portal veins.

But if we place man upon all-fours these anomalies disappear, and a law is found regulating the presence or absence of valves, and, according to Dr. Clevenger, it is applicable to all quadrupeds and to the so-called Quadrumana. Veins flowing toward the back, i.e., against gravitation in the all-fours posture--are fitted with valves; those flowing in other directions are without. For the few exceptions a very feasible explanation is given.

Valves in the hæmorrhoidal veins would be useless to quadrupeds; but to man, in his upright position, they would be very valuable. "To their absence in man many a life has been and will be sacrificed, to say nothing of the discomfort and distress occasioned by the engorgement known as piles, which the presence of valves in their veins would obviate."

A noticeable departure from the rule obtaining in the vascular system of mammalia also occurs to the exposed situation of the femoral artery in man. The arteries lie deeper than the veins, or are otherwise protected, for the purpose--as a teleologist would say--of preventing serious loss of blood from superficial cuts. Translating this view into evolutionary language, it appears that only animals with deeply placed arteries can survive and transmit their structural peculiarities to their offspring. The ordinary abrasions to which all animals are exposed, not to mention their onslaughts upon each other, would quickly kill off species with superficially placed arteries. But when man assumed the upright posture the femoral artery, which in the quadrupedal position is placed out of reach on the inner part of the thigh, became exposed. Were not this defect greatly compensated by man's ability to protect this part in ways not open to brutes, he, too, might have become extinct. As it is, this exposure of so large an artery is a fruitful cause of trouble and death.

We may here mention some other disadvantages of the upright position which Dr. Clevenger has omitted. Foremost comes the liability to fall due to an erect posture supported upon two feet only. Four-footed animals in their natural haunts are little liable to fall; if one foot slips or fails to find hold, the other three are available. If a fall does occur on level ground, there is very little danger to any mammal nearly approaching man in bulk and weight. Their vital parts, especially the heart and the head, are ordinarily so near the ground that to them the shock is comparatively slight. To human beings the effects of a fall on smooth, level ground are often serious, or even deadly. We need merely call to mind the case of the illustrious physicist whom we have so recently and suddenly lost.

The upright attitude involves a further sourge of danger. In few parts (if any) of the body is a blow more fatal than over what is popularly called the "pit of the stomach." In the quadruped this part is little exposed either to accidental or intentional injuries. In man it is quite open to both. A blow, a kick, a fall among stones, etc., may thus easily prove fatal.

Another point is the exposure and prominence of the generative organs, which in most other animals are well protected. Leaving danger out of the question, it may be asked whether we have not here the origin of clothing? The assumption of the upright posture may have made primitive man aware of his nakedness.

Returning to the illustrations furnished by Dr. Clevenger, we are reminded that another disadvantage which occurs from the upright position of man is his greater liability to inguinal hernia. In quadrupeds the main weight of the abdominal viscera is supported by the ribs and by strong pectoral and abdominal muscles. The weakest part of the latter group of muscles is in the region of Poupart's ligament, above the groin. Inguinal hernia is rare in other vertebrates because this weak part is relieved by the pressure of the viscera. In man the pelvis receives almost the entire load of the intestines, and hence Art is called in to compensate the deficiencies of nature, and an immense number of trusses have to be manufactured and used. It is calculated that 20 per cent. of the human family suffer in this way. Strangulated hernia frequently causes death. The liability to femoral hernia is in like manner increased by the upright position.

Now, if man has always been erect from his creation--or, if that term be disliked, from his origin--we have evidently nothing to hope from the future in the way of an amendment of this and other defects. But if we have sprung from a quadrupedal animal, and have by degrees adopted an upright position, to which we are as yet imperfectly adapted, the muscular tissues of the abdomen will doubtless in the lapse of ages become strengthened to meet the demand made upon them, so that the liability to rupture will decrease. In like manner the other defects above enumerated may gradually be rendered less serious.

A most important point remains; the peritoneal ligaments of the uterus fully subserve suspensory functions. The anterior, posterior, and lateral ligaments are mainly concerned in preventing the gravid uterus, in quadrupeds, from pitching too far forward toward the diaphragm. The round ligaments are utterly unmeaning in the human female, but in the lower animals they serve the same purpose as the other ligaments. Prolapsus uteri, from the erect position and the absence of supports adapted to the position, is thus rendered common, destroying the health and happiness of multitudes.

As a simple deduction from mechanical laws, it would readily follow that any animal or race of men which had for the longest time maintained an erect position would have straighter abdomens, wider pelvic brims with contracted pelvic outlets, and that the weight of the spinal column would force the sacrum lower down. This, generally speaking, we find to be the case. In quadrupeds the box-shaped pelvis, which admits of easy parturition, is prevalent. Where the position of the animal is such as to throw the weight of the viscera into the pelvis, the brim necessarily widens, these weighty organs sink lower, and the beads of the thigh-bones acting as fulcra permit the crest of the ilium to be carried outward, while the lower part of the pelvis is at the same time contracted.

In the innominate bones of a young child the box-shape exists, while its prominent abdomen resembles that of the gorilla. The gibbon exhibits this iliac expansion through the sitting posture which developed his ischial callosities. Similarly iliac expansion occurs in the chimpanzee. The megatherium had wide iliacal expansions due to its semi-erect habits; but as its weight was in great part supported by the huge tail, and as the fermora rested in acetabula placed far forward, the leverage necessary to contract the lower portion of the pelvis was absent.

Prof. Weber, of Bonn, quoted in Karl Vogt's "Vorlesungen ueber den Mensohen," distinguishes four chief forms of the pelvis in mankind--the oval in Aryans, the round among the Red Indians, the square in the Mongols, and the wedge-shaped in the Negro. Examining this question mechanically it would seem that the longer a race had remained in an upright position the lower is the sacrum, and the greater is the tendency to approximate to the larger lateral diameter of the European female. The front to back diameter of the ape's pelvis is usually greater than the measurement from side to side. A similar condition affords the cuneiform, from which it may be inferred that the erect position in the Negro has not been maintained so long as in the Mongol, whose pelvis has assumed the quadrilateral shape owing to persistence of spinal axis weight for a greater time. This pressure has finally culminated in forcing the sacrum of the European nearer the pubes, with consequent lateral expansion and contraction of the diameter from front to back. From the marsupials to the lemurs the box-shaped pelvis remains. With the wedge-shape occasioned in the lowest human types there occurs a further remarkable phenomenon in the increased size of the foetal head accompanying the contraction of the pelvic outlet. While the marsupial head is about one-sixth the size of the narrowest part of the bony parturient canal, the moment we pass to erect animals the greater relative increase is there seen in cranial size, with a coexisting decrease in the area of the outlet. This altered condition of things has caused the death of millions of otherwise perfectly healthy and well-formed human mothers and children. The palæontologist might tell us if some such case of ischial approximation by natural mechanical causes has not caused the probable extinction of whole genera of vertebrates. "If we are to believe that for our original sin the pangs and labor of childbirth were increased, and if we also believe in the disproportionate contraction of the pelvic space being an efficient cause of the same difficulties of parturition, the logical inference is that man's original sin consisted in his getting upon his hind legs."

This subject is not without direct applications. Accoucheurs cause their patients to assume what is called the knee-chest position, a prone one, for the purpose of restoring the uterus to something near a natural position. Brown-Sequard recommends, in myelitis, or spinal congestion, drawing away the blood from the spine by placing the patient on his abdomen or side, with hands and feet somewhat hanging down. The liability to *spina bifida* is greatest in the human infant, through the stress thrown on the spine. The easy parturition in the lower human races is due to the discrepancy between cranial and pelvic sizes not having been as yet reached by those races. The Sandwich Island mother has a difficult delivery only when her child is half white, and has consequently a longer head than the unmixed native strain.

At present the world goes on in its blindness, apparently satisfied that everything is all right because its exists, ignorant of the evil consequences of apparently beneficial pecularities, vaunting man's erectness and its advantages, while ignoring the disadvantages.

The observation that the lower the animal the more prolific (not universally true!) would warrant the belief that the higher the animal the more difficulties encompass its propagation and development. The cranio-pelvic difficulty may perhaps settle the Malthusian question as far as the higher races of men are concerned by their extinction.

[If the facts brought forward by Dr. Clevenger cannot be controverted, they seem to prove that man must have originated by gradual development from a four-footed being. Had he been created an erect, bipedal animal, as we find him, his structure would have been not in partial, but in perfect, adaptation to the conditions of that attitude. That some of the peculiarities of his structure are better in harmony with a horizontal than a vertical position of the spinal column, is perhaps the strongest argument against the theory of direct creation and the radical *toto coelo* distinction between man and beast that has yet been advanced. We cannot at the moment lay our hands upon any thorough and trustworthy account of the valves in the veins of the sloth: as that animal spends its life hanging, back downward, the structure of the veins would be interesting in this connection.--ED. J. S.]--*Journal of Science*.

OUR ENEMIES, THE MICROBES.

We have seen the microbes, as our servants[1], often performing, unbeknown to us, the work of purifying and regenerating the soil and atmosphere. Let us now examine our enemies, for they are numerous. Everywhere frequent--in the air, in the earth, in the water--they only await an occasion to introduce themselves into our body in order to engage in a contest for existence with the cells that make up our tissues; and, often victorious, they cause death with fearful rapidity. When we have named charbon, septicæmia, diphtheria, typhoid fever, pork measles, etc., we shall have indicated the serious affections that microbes are capable of engendering in the animal organism.

[Footnote 1: SUPPLEMENT, No. 446, page 7125.]

We call those diseases "parasitic" that are occasioned by the introduction of a living organism into the bodies of animals. Although a knowledge of such diseases is easy where it concerns parasites such as acari and worms, it becomes very difficult when it is a question of diseases that are caused by the Bacteriaceæ. In fact, the germs of these plants exist in the air in large quantities, as is shown by the analysis of pure air by a sunbeam, and we are obliged to take minute precautions to prevent then from invading organic substances. If, then, during an autopsy of an individual or animal, a microscopic examination reveals the presence of microbes, we cannot affirm that the latter were the cause of the affection that it is desired to study, since they might have introduced themselves during the manipulation, and by reason of their rapid vegetation have invaded the tissues of the dead animal in a very short time. The presumption exists, nevertheless, that when the same form of bacteria is present in the same tissue with the same affection, it is connected with the disease. This was what Davaine was the first to show with regard to *Bacillus anthracis*, which causes charbon. He, in 1850, having examined the blood of an animal that had died of this disease, found therein amid the globules (Fig. 1), small, immovable, very narrow rods of a length double that of the blood corpuscles. It was not till 1863 that he suspected the active role of these organisms in the charbon malady, and endeavored to demonstrate it by experiments in inoculation. Is the presence of these little rods in the blood of an animal that has died of charbon sufficient of itself to demonstrate the parasitic nature of the affection? No; in order that the demonstration shall be complete, the bacteria must be isolated, cultivated in a state of purity in proper liquids, and then be used to inoculate animals with. If the latter die with all the symptoms of charbon, the demonstration will be complete. Davaine did, indeed, perform some experiments in inoculation that were successful, but his results were contradicted by the experiments of Messrs. Jaillard and Leplat, and those of Mr. Bert concerning the toxic influence of oxygen at high tension upon microbes. As Davaine was unable to explain the contradiction between his results and those of Messrs. Jaillard, Leplat, and Bert, minds were not as yet convinced, notwithstanding the support that his ideas received from Mr. Koch's researches.

In 1877 Mr. Pasteur took up Davaine's experiments, and confirmed his affirmations step by step by employing the method of culture that he had used with such success in his studies upon fermentation. He isolated Davaine's bacterium by cultivating it in a decoction of beer yeast that had been previously sterilized (Fig. 2); and after from ten to twenty cultures, he found that a portion of the liquid containing a few bacteria, when used for inoculating a rabbit, quickly caused the latter to die of charbon, while the same liquid, when filtered through plaster or porcelain, became harmless.

Davaine's bacterium develops exclusively in the blood, and is never found at any depth in the tissues. This is due to the fact that the alga, having need of oxygen in order to live, borrows its flow from the blood, and thus extracts from the globules that which they should have carried to the tissue. The animal therefore dies asphyxiated. It is on account of the absence of oxygen in the blood that the latter assumes the blackish-brown color that characterizes the malady, and that has given its name of *charbon* (coal).

The parasitic nature of charbon was therefore absolutely demonstrated, first, by the constant presence of *Bacillus anthracis* in the blood of anthracoid animals, and second, by the pure culture of the parasite and the inoculation of animals with charbon by means of it.

Davaine began the demonstration in 1863, and Pasteur finished it in 1877. These facts are now incontestable; yet, to show how slowly truth is propagated, even in these days of telegraphs and telephones, there might have been read a few months ago, in an interesting article on microbes, by Dr. Fol, a distinguished savant, the statement that charbon and tuberculosis were discovered by Dr. Koch!

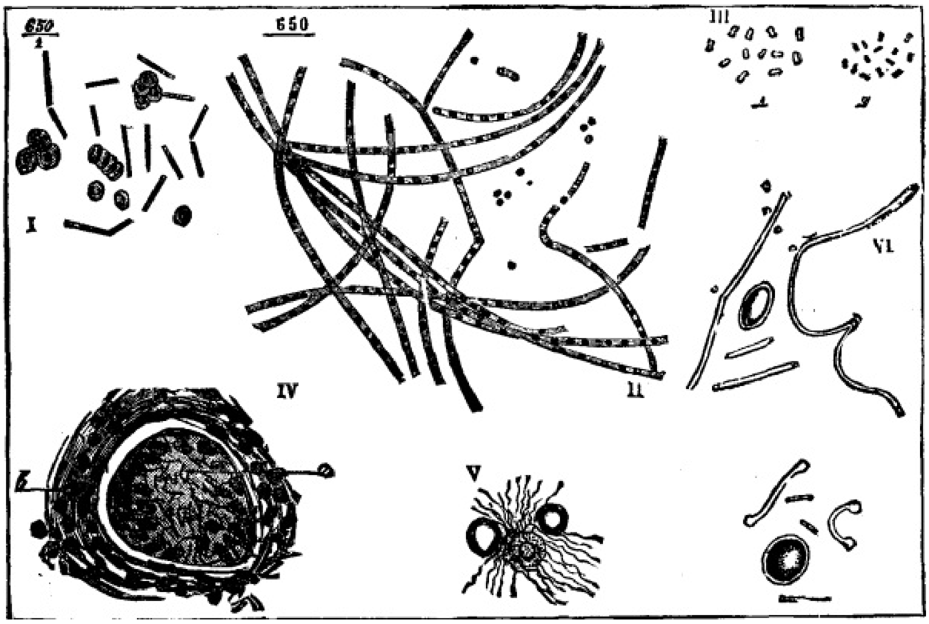
New parasitic affections, whose existence was suspected, were soon discovered and scientifically demonstrated, such, for example, as senticæmia, or the putrefaction which occurs in living animals, which in ambulances causes so fearful havoc among the wounded, and which proceeds from *Bacillus septicus*. This parasite exhibits itself under the form of little articulated rods that live isolated from oxygen in the mass of the tissues, and disorganize the latter in disengaging a large quantity of putrid gas. Other parasites of this class are the *micrococcus* of chicken cholera (Fig. 3), the *micrococcus* of hog measles, and the *Spirochoete Obermeieri* of recurrent fever, discovered by Obermeier (Fig. 5).

Besides these, there are a certain number of maladies that seem as if they must be due to the Bacteriaceæ, although a demonstration of the fact by the method of cultures and inoculation has not as yet been attempted. Among such, we may cite typhoid fever, diphtheria, murrain, tuberculosis (Fig. 4), malarial fever (Fig. 6), etc.

As may be seen, the list is already a long one, and it tends every day to still further increase. All the progress that has been made in so few years in our knowledge of contagious or epidemic diseases is due exclusively to M. Pasteur and the scientific method that he introduced through his remarkable labors on fermentation. Now that we know our most formidable enemies, how shall we defend ourselves against them?

As we have seen, bacteria exist everywhere, mixed with the dust that interferes with the transparency of the air and covers all objects; and they are likewise found in water.

Under normal conditions, our body is closed to these organisms through the epidermis and epithelium, and, as has been shown by Mr. Pasteur, no bacteria are found in the blood and tissues of living animals. But let a rupture or wound occur, and bacteria will enter the body, and, when once the enemy is in place, it will be too late. One sole chance of safety remains to us, and that is that in the warfare that it is raging against our tissues the enemy may succumb. M. Pasteur has shown that the blood corpsucles sometimes engage in the contest against bacterides and come off victorious. In fact, chickens are proof against poisoning by charbon, because, owing to the high temperature of their blood, the bacterides are unable to extract oxygen from the corpuscles thereof. But, if the chickens be chilled, the conditions are changed, and they will die of charbon just as do cattle and sheep; but, as the result of the contest cannot always be foreseen, it is necessary at any cost to prevent bacterides from entering the body.



I. Bacteria of charbon (*Bacillus antracis.*) II. The same cultivated in yeast. III. The *Micrococcus* of chicken cholera. IV. The *Bacillus* of tuberculosis. V. The *Spirillun* of recurrent fever. VI. The *Bacillus* of malaria.

Under ordinary circumstances a severe hygiene will suffice to preserve us; if a wound is received it should be washed with water mixed with antiseptics, such as phenic acid, borax, or salicylic acid. If water is impure, it must be boiled and then aerated before it is drunk. If the air is the vehicle of the germs of the disease, it will have to be filtered by means of a muslin curtain kept wet with a hygroscopic solution, glycerine for example. Finally, when, after an epidemic, contaminated apartments are to be occupied, the walls and floor and the clothing must be washed with antiseptic solutions whose nature will vary according to circumstances--steam charged with phenic acid, water mixed with a millionth part of sulphuric acid, boric acid, ozone, chlorine, etc.

These preventives only prove efficient on condition that they be used persistently. Let our vigilance be lacking for an instant, and the enemy will enter to work destruction, for it only requires a spore less than a hundredth of a millimeter in diameter to produce the most serious affections.

Fortunately, and it is again to Mr. Pasteur that we owe these wonderful discoveries, the parasitic microbes themselves, which sow sickness and death, may, through proper culture, become true vaccine viri that are capable of preserving the organism against any future attack of the disease that they were capable of producing; such vaccine matters have been discovered for charbon, chicken cholera, the measles of swine, etc.

When the *micrococcus* of chicken cholera (Fig. 3.) is cultivated, it is seen that the activity of the microbe in cultures exposed to the air gradually diminishes. While a drop of the liquid would, in twenty-four hours, have killed all the chickens that were inoculated with it, its effect after two, three, or four days considerably diminishes, and an inoculation with it produces nothing more than a slight indisposition in the animal, and one that is never followed by a serious accident. It is then said that the virulence of the microbe is attenuated.

The air is the agent of this transformation that gradually renders the bacteria benign, for in cultures made under the same circumstances as the preceding, but with the absence of air, the activity of these algæ is preserved for days or weeks, and they will then cause death just as surely as they would have done at the end of one day.

What is remarkable is that animals inoculated with the attenuated *micrococcus* become for a varying length of time refractory to the action of the most formidable parasites of this kind. Mr. Pasteur has discovered two such vaccine viri--one for chicken cholera and the other for charbon. His results have not been accepted without a struggle, and it required nothing less than public experiment in vaccination, both in France and abroad, to convince the incredulous. There are still people at the present time who assert that Mr. Pasteur's process of vaccination has not a great practical range! And yet, here we have the results; more than 400,000 animals have been vaccinated since 1881, and it has been found that the mortality is ten times less in these than in those that have not been vaccinated!

An impetus has now been given, and we can look to the future with confidence, for, if our enemies are numerous, the use of a severe hygiene and preventive vaccination will permit us to gradually free humanity from the terrible scourges that sap the sources of fortune and life.--*Science et Nature*.

THE WINE FLY.

At the last meeting of the New York Microscopical Society, a paper was read by Dr. Samuel Lockwood, secretary of the New Jersey State Microscopical Society. His subject was the Wine Fly, *Drosophila ampelophila*. The paper was a contribution to the life-history of this minute insect. He had given in part three years to its study, beginning in September, 1881, when nothing whatever of its life-history seemed to have been known. In October the flies attacked his Concords. He found upon a grape which he was inspecting with a pocket-lens an extremely small white egg; but lost it. The grapes when brought on the table were infested by the flies, which proved to be the above mentioned species. When driven from the grapes they would fly to the window, where he captured two of them These were placed in a jar with a grape for food. In two days he found one egg on the outer skin of the grape. The laying was kept up for four or five days, until there were about thirty, some on the outside of the grape and some at an opening where the two flies had fed. The egg had a pair of curious suspenders near the end where the mouth of the larva would develop. These suspenders were attached at their ends to the grape, but where the egg was laid in the soft part of the fruit the suspenders were spread out at the surface; thus the larva would emerge clean from the shell. The egg was 0.5 mm. in length, and about a fourth of that in width. The larva when grown was at least four times as long as the egg. As the larva burrowed in the juices of the fruit, two quite prominent breathing tubes at the posterior end were kept in the air. Between these cardinal tubes were several teat-like points, much smaller, but having a similar function.

The larvae appeared in five days after the eggs were laid. In about as many more days the puparium state would be entered, and in about six days more the fly or imago would appear. In ovipositing the suspensors would leave the oviparous duct last. The paper claimed that the curious shape of the egg compelled the female to oviposit slowly, as it took time for the egg to assume its form; hence, the eggs were not laid in strings or masses, but singly and at considerable intervals.

The flies are very hairy, especially the females. The neck and even the eyes are very hirsute. The eyes are red, quite large and pretty, though somewhat *outre* under the microscope, for from between the little lenses are projecting, straight, stiff hairs. As the insect is quite active, it must be that this fringing of the tiny eyelets with hair does not materially obscure its vision. When the minuteness of this singular arrangement is considered, it is surely remarkable. This general hairiness of the female especially, and that about the head, neck, and forward part of the thorax, stands correlated to a beautiful structure found only in the male, which has on the tarsus of each leg in the forward pair what the lecturer called a sexual comb. It is a beautiful comb of a very dark brown color, each comb having ten pointed and strong teeth. In the nuptial embrace these combs are fixed in the hairy front of the thorax of the female, thus becoming little grapnels.

The flies love any vegetable substance in fermentation, whether acetic or vinous. Hence it will abound about cider mills, swarm on preserves in the pantry, and in cellars or places where wine is being made or stored. The paper showed the tendency of the glucose in the over-ripe grape to the vinous ferment, and that the fly delighted in it. A singular accident showed how they loved even the very high spirits. In making some of the mounts shown to the society, Dr. Lockwood had left a bottle of 90 per cent. alcohol uncorked over night. Next morning he was astonished to find his alcohol of a beautiful amethystine color, and the cork out. Inspection showed a number of these tiny creatures, which, when filled with the purple juice of the grape, had smelt the alcohol in the open bottle, and had gone in to drink. They had ignominiously perished, and had given color to the liquid.--*Micro. Journal*.

[NATURE.]

THE "POTETOMETER," AN INSTRUMENT FOR MEASURING THE TRANSPIRATION OF WATER BY PLANTS.

In view of the interest now attaching to recent advances in vegetable physiology, it seems not unlikely that a description of the instrument bearing the above name, lately published by Moll (*Archives Neerlandaises*, t. xviii.), will serve as useful purpose. The apparatus was designed to do away with certain sources of error in Sachs' older form of the instrument, described in his "Experimental Physiologie"--errors chiefly due to the continual alteration of pressure during the progress of the experiment.

As shown in the diagram, the "potetometer" consists essentially of a glass tube, a d, open at both ends, and blown out into a bulb near the lower end; an aperture also exists on either side of the bulb at or about its equator. The two ends of the main tube are governed by the stopcocks, a and d, and the greater length of the tube is graduated. A perforated caoutchouc stopper is fitted into one aparture of the bulb, e, and the tube, g k, fits hermetically to the other. This latter tube is dilated into a cup at h to receive the caoutchouc stopper, into which the end of the shoot to be experimented upon is properly fixed.

The fixing of the shoot is effected by caoutchouc and wire or silk, as shown at i, and must be performed so that the clean-cut end of the shoot is exactly at the level of a tube passing through the perforated stopper, e, of the bulb; this is easily managed, and is provided for by the bending of the tube, g h. The tube, f, passing horizontally through the caoutchouc stopper, e, is intended to admit bubbles of air, and so equalize the pressure and at the same time afford a means of measuring the rapidity of the absorption of water by the transpiring shoot. This tube (see Fig. 2, f) is a short piece of capillary glass tubing, to which is fixed a thin sheath of copper, b', which slides on it, and supports a small plate of polished copper, a', in such a manner that the latter can be held vertically at a small distance from the inner opening of the tube, and so regulate the size of the bubble of air to be directed upward into the graduated tube, a b.

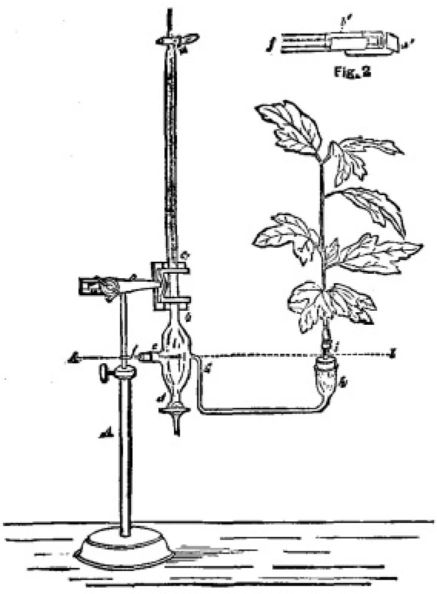


Fig. 2

Fig. 1

The apparatus is filled by placing the lower end of the main tube under water, closing the tubes, f and i (with caoutchouc tubing and clips), and opening the stopcocks, a and d. Water is then sucked in from a, and the whole apparatus carefully filled. The cocks are then turned, and the cut end of the shoot fixed into i, as stated; care must be taken that no air remains under the cut end at i, and the end of the shoot must be at the level, k l. This done, the tube, f, may then be opened.

The leaves of the shoot transpire water, which is replaced through the stem at the cut end in i from the water in the apparatus. A bubble of air passes through the tube, f, and at once ascends into the graduated tube, a c. The descent of the water-level in this tube--which may conveniently be graduated to measure cubic millimeters--enables the experimenter at once to read off the amount of water employed in a given time.

It is not necessary to dwell on obvious modifications of these essentials, nor to speak of the slight difficulties of manipulation (especially with the tube, f). Of course the apparatus might be mounted in several ways; and excellent results for demonstration in class could be obtained by arranging the whole on one of the pans of a sensitive balance. H. MARSHALL WARD.

Botanical Laboratory, Owens College.

BOLIVIAN CINCHONA FORESTS.

The great progress made in the acclimation of cinchona trees in India, Ceylon, and elsewhere has awakened the governments of countries where the plants are indigenous to the necessity of conserving from reckless destruction, and replanting denuded forests, so as to be able to keep up the supply of this valuable product.

In Bolivia, since 1878, according to the report of the Netherlands Consul, private individuals and land owners have taken up the question with great earnestness, and at the present time on the banks of the Mapiri, in the department of La Paz, there are over a million of young trees growing.

New plantations have also sprung up in various other localities, either on private ground or that owned by Government. The competition of India and Ceylon in supplying the markets has had also the effect of inducing more care in collecting and also of revisiting old spots, often with the result of a rich harvest of bark which had been left on partly denuded trunks, and the opening up of new localities. The new shoots springing up from the old stumps have yielded much quill bark, and the root bark of the old stumps has also been utilized.

The replanting entails very little expense. The Indian tenant on an estate has a house and land from the owner (hacienda) of the estate. For this he binds himself to work for two to four days a week, at from 28 to 36 cents per day, women and children obtaining 16 to 21 cents per day. Thus the planting, weeding, etc., during the first two years is but nominal in expense; after this period the trees may be left to themselves.

On Government land the expense is greater, as, after an application being made, the land is put up to public auction, and may fetch a very low or higher price according to the bidding. The land secured, contracts are made with natives of the lower class to clear the forest and plant cinchona. The contracts are often sublet to Indians. The young plants are planted from five to six feet apart, with banana trees between, on account of their rapid growth and the shade the latter afford. From March to June, after the wet season is over, is the best time for planting, and the contractor keeps the plantation free from weeds and in good order for twelve months, when it is handed over to the owner. The following is given as the cost of the Mapiri River plantation of an area from 60 or more miles in extent:

Ground.	$1,200
300,000 plants at $0.14.	42,000
Superintendent, buildings, etc.	4,400
Interest.	4,800

Total.	$52,400

Till the plants are above two years of age, they are liable to die from drought or the attacks of ants, and during 1878 many thousands died from these causes. At the end of the fourth year some proprietors begin to collect the quill bark by the method of coppicing.

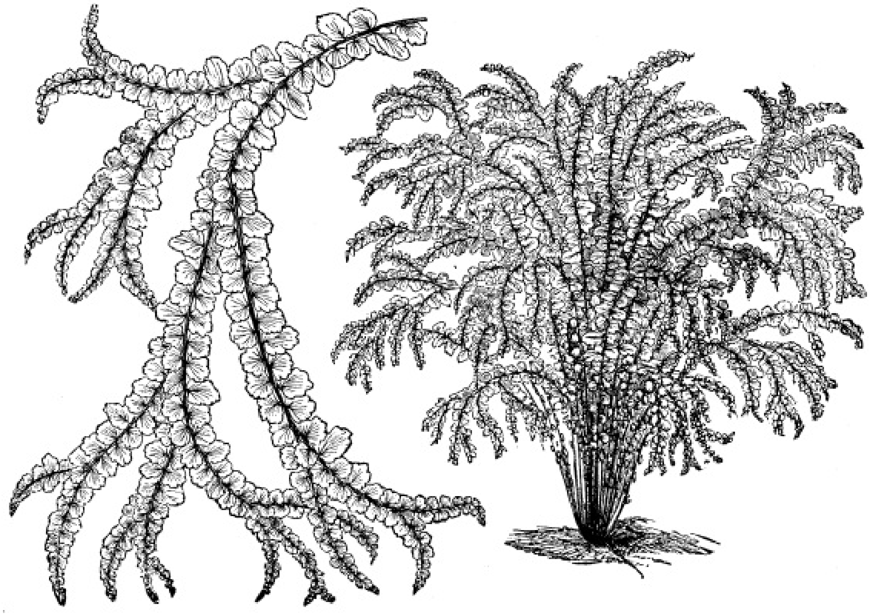
It is feared by some that, should this new venture be successful, it will prove a dangerous rival to the plantations of India, Ceylon, and Java, and lower the price of bark considerably.--*Jour. Society of Arts*.

FERNS.

N. Davallioides Furcans.--Among the many crested ferns in cultivation, this, of which the annexed is an illustration, is one of the most distinct; so different indeed it is from the type, that it is questionable if it really is a form of it; the most essential characteristic, that of the fructification at the extreme edge of the lobes of the pinnæ, is altogether absent, and the whole habit of the plant is also thoroughly distinct. It is of equally robust growth, but its handsomely arching fronds, which are from 3 feet to 4 feet in length, are produced in great abundance from a central tuft or agglomeration of crowns. Its most distinct characteristic is the furcation of the pinnæ, which are all of the same dimensions, whether sterile or fertile; they are all opposite and closely set along the mid-rib, whereas those of N. davallioides are set much further apart. In the barren pinnæ which are only situated on the lower portion of the frond, and which generally are only few in number, the furcation is rudimentary; in the fertile pinnæ it is twice and even three times repeated in the extremities of the first division, becoming more complex toward the point of the frond, where it often forms quite a large tassel, whose weight gives the fronds quite an elegant, arching habit. On that account this plant is valuable for growing in baskets of large dimensions, in which it shows itself off to good advantage, and never fails to prove attractive. Although it produces spores freely, it is best to propagate it by means of the young plants produced from rhizomes in the ordinary way, on account of the extreme variations which take place among the seedlings, a small percentage only of which are possessed of the true character of the parent plant. Stove.--*The Garden.*

NEPHROLEPIS DAVALLIOIDES FURCANS.

N. Duffi.--This pretty, neat-habited species, of which an illustration, kindly lent us by Mr. Bull, appears in another place, is a native of the Duke of York's Island, in the South Pacific Ocean, and is undoubtedly one of the most interesting of the whole genus. Its compact habit, its comparatively small dimensions, and the bright, glossy color of its beautifully tasseled fronds render it a most welcome addition to a group of ferns naturally rich in decorative plants. Its curiously and irregularly pinnate fronds are borne on slender stalks, terete toward the base, and covered with reddish brown, downy scales, instead of being produced loosely, as in most other Nephrolepises; these are densily crowded, and the outcome of closely clustered crowns. They measure from 15 inches to 18 inches long, and are terminated by very handsome massive crests, which vary in size according to the temperature in which the plant is grown. We have at different times heard complaints of these fronds being simply furcate, when the same plant, after being subjected to a greater amount of heat and moisture, produced fronds very heavily tasseled, and partaking of an elegant vase-shaped appearance. In fact, nothing short of the moist heat of a stove will induce it to show its characters in their best condition. The pinnæ, which are small, of different sizes, rounded and serrated at the edges, are produced in pairs, one overlying the other, and, curiously enough, those on the top are the largest. The pairs are sometimes opposite, but mostly alternate, distant toward the base, approximate higher up, and crowded and quite overlapping in the crested portion of the frond. This, being a thoroughly barren kind, can only be propagated by division of the crowns, an operation easily done at any time of the year, but most safely in early spring and by young plants produced from the rhizomes, which, however, are produced much more sparingly than in any other species. It is also one of the best adapted for pot or pan culture, its somewhat upright habit making it less suitable for baskets, brackets, and wall covering than other species. Stove.--*The Garden*.



NEPHROLEPIS DUFFI.

FORMATION OF SUGAR.

A paper on "The Formation of Sugar in the Sugar-cane" was recently read by M. Aimé Girard before the Paris Academy of Sciences. By comparative investigations of the amount of cane sugar and grape sugar in different parts of the sugar-cane in the afternoon and before sunrise, the author has found that only in the substance of the leaves does this quantity vary, and that the quantity of cane sugar sinks during the night to one-half, while the quantity of reducing sugar remains almost unaltered. He finds further that the quantity of sugar-cane in the leaves increases with the illumination, on very bright days reaching nearly one per cent., considerably less on dull ones, and in either case diminishing during the night by one-half. From this the author concludes that the formation of saccharose from glucose takes place entirely in the leaves under the influence of sunlight, and that the saccharose thereupon ascends the cane through the petioles, etc., and collects there.

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