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The Editor does not hold himself responsible for opinions expressed by his correspondents.
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THE BRITISH ASSOCIATION.

It is quite possible that fifty years hence the celebrated article, that appeared two years ago in the *Times* upon the British Association and Canada, will excite as much amusement, as the old quarterly articles upon Keats and Wordsworth afford us at the present day. The increased friendliness between the United States and the mother country joined with the rapidly expanding facilities for locomotion, owing to which a trip from London to New York or even to Montreal is a considerably less formidable undertaking than a journey between London and Edinburgh was to our grandfathers, make it more than probable that the pending meeting of the British Association in Montreal will not be the last visit of that body to our continent. If this should prove to be the case, it would be difficult to overestimate the favourable results of the further approximation of Great Britain to her Transatlantic colonies. It is curious to notice that, in this matter, the high priests of science have followed the lead of their religious brethren, Pan-Anglican and Pan-Presbyterian synods having anticipated the International British scientific gatherings of the future.

All this may be, but then again it may not. It is quite possible that the present move will prove an exception, and that the conservatism of the British philosopher will regard a visit to the colonies of the old country as a work of supererogatory condescension, too costly to be repeated. However this may be, the advent of the British Association will, long be remembered in the city of Montreal, and in Canada generally. We certainly cannot recall a social and scientific event of similar importance in the history of our Dominion, and we hope that all will take advantage of the coming of the wise men from the east to our shores.

To look at things from the lowest point of view, the visit of the Association will be a capital advertisement for Canada as a home for emigrants. The farmer or the labourer will not feel that he is going to a strange land, when he remembers that it has been the spot chosen for the gathering of his scientific teachers. But if from a commercial point of view we entertain just hopes of benefits accruing to our country from the coming visit, much more should we profit from it intellectually. The presence of Rayleigh, Reynolds, Adams, Dawkins, Gladstone, Roscoe, Thompson and Tylor, will doubtless prove a furthur spur to the genius of our Hunts and our Dawsons.

Nay, not only shall we profit from the *ex cathedra* utterances of our scientific visitors, but we must doubtless expect something similar to the criticism that our southern neighbour has received at the hands of Herbert Spencer and Matthew Arnold. Those who have grown up in an older and different stage of civilization will see much here to admire, but much too to blame and censure. They will remark upon the splendid capabilities of the site of Montreal, situated on the gentle slope of a hill, and they will notice also our imperfect sanitary arrangements, our defective drainage and bad lighting. If they visit the purlieus of our city, they will see much of the squalor of London, without the excuses that must be made for that old and over-crowded city. Criticism such as this we must expect, and we should hail it gladly, remembering that we are not yet perfect, and that the Englishman is naturally disposed to grumble and, as our young emigrants have taught us, to express a wholesome contempt for all that differs from the state of things with which he is familiar at home.

Discoveries in Madagascar.—Several persons living in the interior of Madagascar have written freely respecting the discovery of gold and precious stones in the interior. One gentleman, writing recently, says: "Gold has been found to exist in considerable quantities, and diamonds also; the diggers are beginning to move in units, but there is danger of a rush." Another says that "the prospects of the country are good, as gold has been found, and precious stones also."

A NEW BOOK.

A Treatise on Toothed Gearing. By J. Howard PH.B. (New York, John Wiley & Sons.)

In this work the author endeavors to set before the student in a concise and simple manner the principles governing the design of toothed gearing. Commencing in the first three sections with a discussion of the proper form of tooth-profiles, the conditions necessary for minimum friction and for uniform velocity, and the comparative advantages and disadvantages of cycloidal and involute teeth, he goes on in the next six sections to explain the various gears (internal, bevel, screw and hyperbolic) and the methods employed for laying out the teeth. Sections IX to XV are devoted to a consideration of the relations between diameter, circumference, pitch, number of teeth, velocity-ratios, arcs of approach and recess and contact, the strength of teeth and arms, &c. After setting forth complete detailed designs of different wheels, and giving certain special practical applications, the work concludes with an appendix shewing the relative values of circumferential and diametral pitches, and an explanation of the process of cutting gear-teeth.

In compiling this treatise the author has made use of the works of many standard authors, and in order to meet the demands of those mechanics, "who continue to look with extreme distrust upon anything in the shape of book, because books are generally too deep and too theoretical," he has a number of simple rules and formulæ, for performing each and every operation necessary in the design of the different gears.

NOTES ON ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

(*Continued from page* 219.)

Applying this test to copper and zinc at ordinary temperatures it appears that the difference of potential is less than the millionth part of the electro-motive force developed by a pair of copper and zinc plates immersed in dilute sulphuric acid, and moreover the copper is at a h gher potential than the zinc. Hence it appears that the difference of potential due to the contact of zinc and copper may safely be neglected in discussing the theory of the Voltaic cell.

If we apply the same test in order to determine the difference of potential between either of the metals and the acid in contact with it, we at once meet with a new difficulty, for we can no longer say that when work is done by the electric forces, the only source of energy is the heat absorbed, or that when work is done against the electric forces the whole of the energy expended must appear as heat, inasmuch as a chemical action is going on in contact with the metallic surfaces. If we knew how much heat was being developed or absorbed by this chemical action we might apply the necessary corrections, but though we know what is the whole amount of heat developed (or absorbed) in the battery cell (or the decomposing cell) we do not knew what is the exact nature of the action which takes place in the neighbourhood of each metal plate. For example, in the case of a copper and a zinc plate immersed in dilute sulphuric acid we know how much heat is developed when a pound of zinc is dissolved, and the corresponding amount (about half an ounce) of hydrogen liberated ; but when the battery is in action the hydrogen is not liberated at the zinc plate, but in contact with the copper plate, and we do not know what is the condition of hydrogen while it is travelling from the the zinc through the acid to the copper plate.

Thus, it may happen that the hydrogen before it can be liberated as free gas at the surface of the copper plate must absorb a considerable amount of heat, and this effect would mask the heat developed or absorbed by the electricity in entering the copper plate from the acid ; while in the neighbourhood of the zinc plate the heat developed by the chemical action would be in excess of that due to the solution of the zinc and the liberation of *free* hydrogen, by the unknown amount of heat absorbed by the hydrogen when liberated from the copper plate.

In 1843 Prince Louis Napoleon, then a prisoner, writing to Arago, described two forms of battery in which only one metal was employed, so that there was nowhere a contact of dissimilar metals. The first consisted of a copper plate immersed in dilute nitric acid, (which acts strongly on the copper), contained in a porous cell. The porous cell was placed in a jar containing dilute sulphuric acid in which was immersed a second copper plate. On connecting the plate with a galvanometer, a current flowed through the galvanometer from the plate immersed in the sulphuric acid to that immersed in the nitric acid. With a battery consisting of two of these cells he decomposed potassic iodide and cupric sulphate. The second battery consisted of two zinc plates, one immersed in dilute sulphuric acid contained in a porous pot, and the other in tepid water in a vessel surrounding the porous pot. This battery produced effects similar to that just described.

Napoleon then attempted to reverse "the usual order of the metals." He placed a copper plate in dilute nitric acid contained in a porous jar, while a plate of zinc was placed in pure (?) water surrounding the porous jar. On connecting the metals a current flowed from the zinc to the copper through the wire. These experiments alone seem sufficient to condemn the contact theory, as held by those who maintain that the E. M. F. of a battery is due simply to the contact of dissimilar metals. More recently several other forms of battery have been devised, in which there is no contact of dissimilar metals. Napoleon complained that he was unable to measure the E. M. F. of his batteries, as the iron bars of his prison interfered with his galvanometers.

If we suppose that when the zinc and sulphuric acid are in contact and in equilibruim the potential of the acid is very much greater than that of the zinc, and similarly in the case of copper and sulphuric acid, the potential of the acid is much greater than that of the copper, but the difference in the case of the copper is less than in the case of the zinc, while we further suppose, as vindicated by the Peltier effect, that there is no sensible difference of potential between copper and zinc when in contact, we can explain the action of the Voltaic cell.

Suppose a plate of copper and a plate of zinc to be immersed in sulphuric acid, but no contact to be made between the plates. Then the acid must be at the same potential throughout, or it could not be in electrical equilibrium. Hence, since the difference of potential between the acid and the zinc is greater than that between the acid and the copper, the potential of the zinc plate will be lower than that of the copper and a quadrant electrometer will be capable of measuring this difference of potential which will be the electromotive force of the cell. If the copper and zinc are connected by a wire a current will flow from the copper to the zinc along the wire, lowering the potential of the copper and raising that of the zinc, so that the equilibrium between the metals and the acid becomes disturbed, electricity flows from the zinc to the acid and from the acid to the copper, so that the potential of the acid near the zinc is raised abovs that of the acid near the copper, and a current therefore flows through the acid from the zinc to the copper thus completing the circuit.

If a plate of copper and a plate of zinc be connected together, and the free end of the copper plate dipped into one vessel of dilute sulphuric acid and the free end of the zinc plate into another vessel of the same liquid, the acid into which the zinc is dipped will be at a higher potential than that into which the copper is dipped. If now a connection is made between the two vessels of acid, by inverting a syphon filled with acid so that one leg is in one vessel and the other in the other, electricity must flow from the acid in the vessel in which the zinc dips to that in the other vessel, the equilibruim will be disturbed and a continuous current will flow through the circuit as before.

In the frictional electric machines, in the Voss and Holtz machines, in the replenisher and electrophorus, the electrical energy developed is derived from the work done by the agent in overcoming the electrical attractions and keeping the machine in motion, or, in the case of electrophorus, in raising the carrier plate in opposition to the attraction of the electrified ebonite. In the case of a thermo-electric couple the energy of the current is derived from the heat absorbed at the hot junction on account of the Peltier effect, or absorbed as the current flows from hot to cold or cold to hot along the metals on account of the Thomson effect. In the Voltaic circuit the energy of the current is derived from the chemical action which takes place between the metals, or one of the metals, and the acid (or electrolyte). That the energy of the current in ordinary batteries is due to the solution of the zinc in the acid was shewn by Dr. Joule, who determined the amount of heat developed by a pound of zinc in sulphuric acid. He then immersed a battery in a calorimeter, and determined the whole amount of heat developed for each pound of zinc dissolved when the wire throgh which the current flowed was wholly contained within the calorimeter. The amount of heat so obtained was the same as when the zinc was dissolved in the acid without the production of any current. On causing the current from the battery to pass out of the calorimeter and to flow through a wire immersed in a second calorimeter, the heat developed in the battery for each pound of zinc dissolved was less than before, but the deficiency was exactly compensated by the heat developed by the current in the external wire, and communicated to the water of the second calorimeter. From these experiments it appears that when a battery is employed in sending a current the heat corresponding to the chemical action taking place in the battery is not wholly developed within the battery, but a portion of it is employed in making the current flow through the circuit, and is reconverted into heat wherever the current does work against resistance.

Faraday shewed that when a pound of zinc is dissolved in a battery a definite quantity of electricity passes round the circuit. This will be referred to again in speaking of Faraday's law of electro-chemical equivalents. The electromotive force of the battery is the number of units of work done on the unit of electricity in going round the circuit. Hence when a pound of zinc is dissolved in a single cell, the electrical work done is proportional to the E.M.F. of the cell, being equal to the product of this E.M.F. and the number of units of electricity which flow round the circuit for each pound of zinc dissolved, and which is the same for all batteries. Now it is clear that this work cannot exceed the energy developed by the whole amount of chemical action which takes place in the cell in consequence of the solution of the pound of zinc. Thus the nature of the chemical action taking place in the cell fixes a superior limit to the E.M.F. obtainable therefrom. For example, if zinc is dissolved and free hydrogen liberated, the work done in the cell is that due to the combination of zinc with sulphion, (SO_4) diminished by the energy absorbed in liberating the equivalent of hydrogen from the sulphion. If instead of liberating the hydrogen as free gas it is allowed to combine with oxygen (*i.e.* burnt) within the battery, the work done by the combination of the zinc with the sulphion will not have to be diminished by so large a quantity and the E.M.F. of the cell may be considerably increased. Thus, in Groves' cell in which the liberated hydroged is burnt at the expense of the oxygen of nitric acid, and in the "bichromate battery," in which the hydrogen combines with the oxygen of potassic bichromate, the E.M.F. is greater than that which would be developed if the same plates (zinc and platinum or zinc and carbon) were simply plunged in dilute sulphuric acid.

Def. The resistance of a conductor is that property in virtue of which a finite electro-motive force is incapable of doing more than a finite amount of work in sending electricity through the conductor.

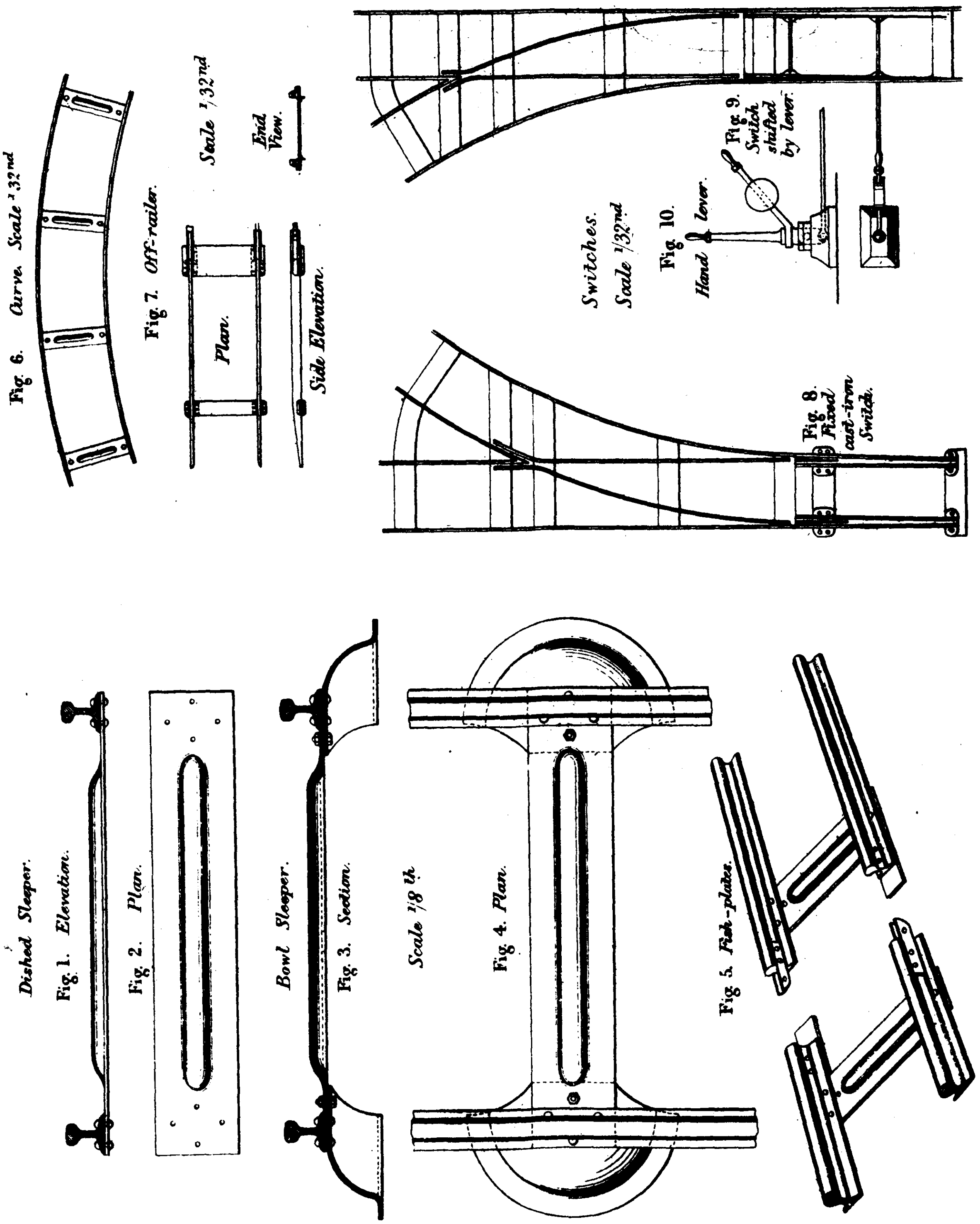
Def. The conductivity of a conductor is the inverse of its resistance, *i.e.*, if the resistance be denoted by R the conductivity will be represented by $\frac{1}{R}$

All bodies possess a certain amount of resistance, and only a certain amount, though the interval between the best conductors (such as copper) and the best insulators, or worse conductors, such as sulphur or paraffin wax, is very great indeed. The resistance of a bar of glass is not less than 600,000,000,000,000,000,000, 000,000 times that of a bar of copper of the same dimensions.

The first measurement of the resistance of conductors were made by Henry Cavendish, who not only compared the resistance of metallic wires but also of liquids (electrolytes), especially of solutions of common salt. These measurements were undertaken mainly in connection with his experiments on the torpedo, which led to the measurement of the resistance of sea water. From Cavendish's results it appears that the conductivities of saline solutions of different strengths are nearly proportional to the per centage of salt present, a fact recently rediscovered by Kohlrausch. Though

PORTABLE RAILWAYS.

(*See page* 231.)



PORTABLE RAILWAYS.

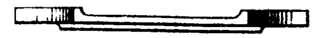
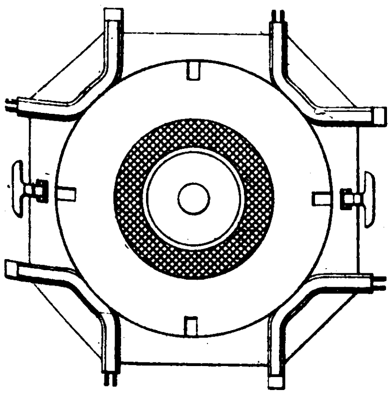
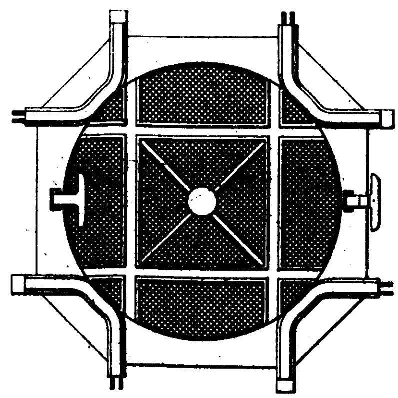
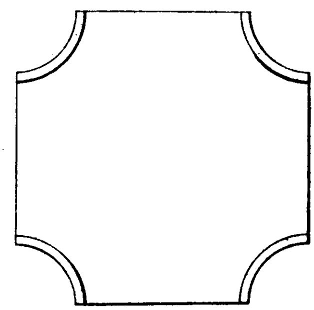


Fig. 11. *Smooth Turntable.* Fig. 12. *Grooved Turntable.* Fig. 13. *Dead Plate.*







Scale 1/16th.

Truck for Cannon, Timber, &c.

Fig. 15. *End Elevation.*

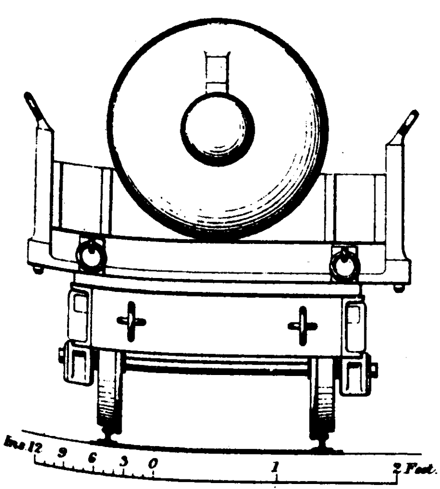


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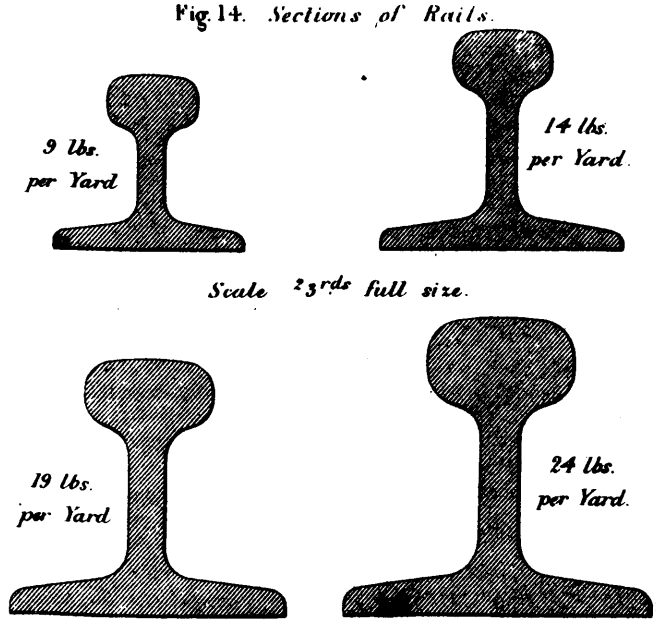
Fig. 14. *Sections of Rails.*



Cavendish employed a Leyden jar for his source of electricity, and measured the resistance of the conductor simply by sending the charge of the jar through the conductor and his own body, and estimating the intensity of the shock; his results, so far as they apply to solutions of salts, were not improved upon until Kohlrausch took up the matter in 1857. Cavendish appears to have understood the theory of divided circuits and practically to have arrived at Ohm's law, though he did not formerly enunciate the law.

The relation between the electro-motive force in a circuit and the current produced by it is expressed by Ohm's law. As ordinarily enunciated this law is as follows:—

The current in any conductor is equal to the electro-motive force between its extremities divided by its resistance.

From this it follows that the current in any simple circuit is equal to the whole E.M.F. around the circuit divided by the whole resistance of the circuit.

Ohm's law may be converted into the following statements:

The resistance of a conductor is equal to the electro-motive force between its extremities divided by the current produced in it.

As no method by which resistance is to be measured has yet been explained, it may appear at first sight, that Ohm's law simply gives a definition of the measure of resistance, and this is all that is formally stated, but, like Newton's laws of motion, there is more implied in the law than appears on the surface. The fact that resistance is an attribute which may be assigned to a conductor without qualification as regards the current flowing in it, implies that the resistance of a conductor is constant so long as its temperature, mechanical condition, etc., remain unchanged. Hence, in the same conductor the current will be proportional to the electro-motive force between its extremities. Hence, if the E.M.F, be doubled, the current also will be doubled, and so on, and this is the law implied in the statement.

The clearest conception of the meaning of Ohm's law, may perhaps be gained by considering what is implied in its denial. Thus, if we deny that the current is proportional to the electro-motive force, we may hold that if the E.M.F. is increased, the current will be increased in a higher or in a lower ratio. Both these views have been maintained. According to the first hypothesis, the resistance of a conductor will diminish as the current in it is increased, as though the increased E.M.F. partially broke down the resisting power of the conductor. According to the second hypotheeis, the resistance will increase with the increase of the current. Now the measurement of the resistance of a conductor is an operation which can be carried to a higher degree of accuracy than any other physical measurement, except, perhaps, the measurement of mass by weighing. Thus, the equality of the resistances of two wires can be ascertained to within one part in a million. It is, therefore, possible to apply very severe tests to Ohm's law, but the law holds good under the most severe tests which have yet been applied.

When a current flows along a wire and can only enter or leave the wire by the ends, there will be the same current across every section of the wire. If the wire be of the same material throughout and of uniform thickness, there is no reason why the potential should fall more rapidly in one part of the wire than in another. Thus, there will be a steady fall of potential at a uniform rate, from the ends at which the current enters to that at which it leaves the wire. Hence, the difference of potential between any two points in the wire is proportional to the distance between the points. But the current in every portion of the wire is the same; hence, for any length of the wire, the difference of potential between its extremities is proportional to its resistance, and therefore the resistance of any portion of the wire is proportional to its length.

If the resistances of a round wire and a ribbon of the same material and having the same sectional area, be compared, they will be found to be the same, length for length. But if the sectional area be the same, the surface of the flat ribbon will be very much greater than that of the round wire. Hence, it follows, that the resistance of a wire depends on its sectional area and not on its surface, and the conduction of electricity is a phenomenon which takes place uniformly throughout the substance of a conductor and not on its surface. It follows, therefore, that two wires of the same length, material and section, placed side by side and having both their extremities joined, will be electrically equivalent to a single wire of double the sectional area of either, and so on. But if a given electro-motive force act between their extremities, the two wires will carry twice the current that either wire would carry, and so on if there are more than two wires. Hence, the resistance of the compound conductor will be inversely proportional to the number of wires. It follows, therefore, that the resistance of a single wire of given length and material will be inversely proportional to its sectional area. Hence:—

The resistance of a conductor of uniform section is directly proportional to its length, and inversely proportional to its sectional area.

Thus, if two wires are taken, one, say, 100 times as long as the other, and of 100 times the sectional area, the resistances of these wires will be the same whatever be the strength of the currents flowing through them, if Ohm's law is true, *but not otherwise.* The experiment has been tried by Prof. Chrystal in the Cavendish laboratory (with slight necessary modifications due to the heating of the fine wire), the wires being balanced against one another, and very strong, and comparatively feeble currents being sent through the wires in rapid succession, when it was found that precisely the same adjustment produced a balance both for the strong and feeble currents, though the currents in the fine wire were such as to raise the wire to a red heat. This experiment, therefore, proved the truth of Ohm's law to a very high order of approximation. The method of comparing resistances will form the subject of a future lecture.

When a number of conductors are connected so that the same current flows through each in succession, they are said to be arranged *in series*, and the *resistance* of the compound conductor is the sum of the resistances of its constituents.

When a number of conductors are so connected that the current divides itself between the conductors, part flowing through one and part through another, they are said to be arranged *in multiple arc*, and the *con-*

ductivity of the compound conductor is the *sum of the conductivities* of its constituents.

Thus, if conductors whose resistances are R_1, R_2, R_3 . . . are arranged in series, the resistances of the system will be $R_1 + R_2 + R_3 + \ldots$ If they are arranged in multiple arc, the conductivity of the system will be

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

and its resistance will be

$$\frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

A number of battery cells are said to be arranged in series when the same current flows through each in succession, the zinc of one cell being connected to the copper (platinum, carbon, &c.) of the next and so on. In this case the electro motive force of the battery is the sum of the electro-motive forces of the several cells, while its resistance is the sum of their resistances.

A battery is connected in multiple arc when all the zinc plates are connected together as well as all the copper (platinum, carbon, &c.) plates, so that the current is divided between the cells. If all the cells have the same E.M.F. and the same resistance, the E.M.F. of the battery will be equal to that of one cell, while the resistance will be inversely proportional to the number of cells.

Sometimes a battery is soconnected, that several sets of cells are connected in series, the several series then treated as single cells and connected in multiple arc. Suppose there are nm cells, each of electro-motive force E and resistance r, and that they are arranged in m series, each series containing n cells, and let the m series then be connected in multiple arc and the terminals of the battery connected by an external conductor of resistance R. The E.M.F. of each series of n cells will be n E, which will therefore be the E.M.F. of the whole battery. The resistance of each series will be nr, therefore the resistance of the whole battery will be $\frac{nr}{m}$ Hence the assistance of the whole circuit will be $\frac{nr}{m} + R$, and by Ohm's law the current, C will be given by the equation :

$$C = \frac{nE}{\frac{nr}{m} + R}.$$

The quantity $\frac{nr}{m}$ is sometimes called the *niternal* resistance of the battery while R is called the *external* resistance of the circuit. For a given number of cells, that is, for a given value of nm, the currents will be greatest when the external and internal resistances are as nearly as possible equal.

Thus, if there is a battery of 80 Grove cells, each having a resistance of ·2 ohm (the ohm is a unit of resistance to be defined later on), and it is desired to send a current through an electro-magnet having a resistance of one ohm, the best arrangement will be to set up the battery in four series each of 20 cells. The resistance of each series will then be 4 ohms, and that of the whole battery 1 ohm, that of the whole circuit being 2 ohms, while the E.M.F. will be 20 E, (the E.M.F. of a single cell being denoted by E), and the current will be 10 E.

(To be Continued.)

ON PORTABLE RAILWAYS.

BY M. PAUL DECAUVILLE, OF PETIT-BOURG (SEINE AND OISE), FRANCE.

Narrow-gauge railways have been known for a very long time in Great Britain. The most familiar lines of this description are in Wales, and it is enough to instance the Festiniog Railway (2 feet gauge), which has been used for the carriage of passengers and goods for nearly half a century. The prosperous condition of this railway, which has been so successfully improved by Mr. James Spooner and his son Mr. Charles Spooner, affords sufficient proof that narrow-gauge railways are not only of great utility but may be also very remunerative.

In Wales the first narrow-gauge railway dates from 1832. It was constructed merely for the carriage of slates from Festiniog to Port-Madoc; and some years later another was made from the slate quarries at Penrhyn to the Port of Bangor. As the tract of country traversed by the railways became richer by degrees, the idea was conceived of substituting locomotives for horses, and of adapting the line to the carriage of goods of all sorts, and finally of passengers also.

But these railways, although very economical, are at the same time very complicated in construction. Their arrangements are based upon the same principles as railways of the ordinary gauge, and are not by any means capable of being adapted to agriculture, to public works, or to any other purpose where the tracks are constantly liable to removal. These permanent narrow-gauge lines, the laying of which demands the service of engineers, and the maintenance of which entails considerable expense, suggested to the author, then a gentleman-farmer and distiller at Petit-Bourg, near Paris, the idea of forming a system of Portable Railways composed entirely of metal, and capable of being readily laid. Cultivating one of the largest farms in the neighbourhood of Paris, he contemplated at first nothing further than a farm railroad; and he contrived an extremely portable plant, adapted for clearing the land of beetroot, for spreading manure, and for the other needs of his farm.

From the beginning, in his first railroads, the use of timber materials was rigidly rejected; and all parts, whether the straight or curved rails, crossing turntables, &c., were formed of a single piece, and did not require any special workman to lay them down. By degrees he developed his system, and erected special workshops for the construction of his portable plant; making use of his farm, and of some quarries of which he is possessed in the neighbourhood, as experimental places. At the present time the the system of portable railways is in use for all the purposes of agriculture, of commerce, of manufactures, and even of war.

Within so limited a space it would be impossible to give a detailed description of the rails and fastenings used in all these different applications. The object of this is rather to direct the attention of mechanical engineers to the various uses to which narrow-gauge portable railways may be put, to the important saving of labour which is effected by their adoption, and to the ease with which they are worked.

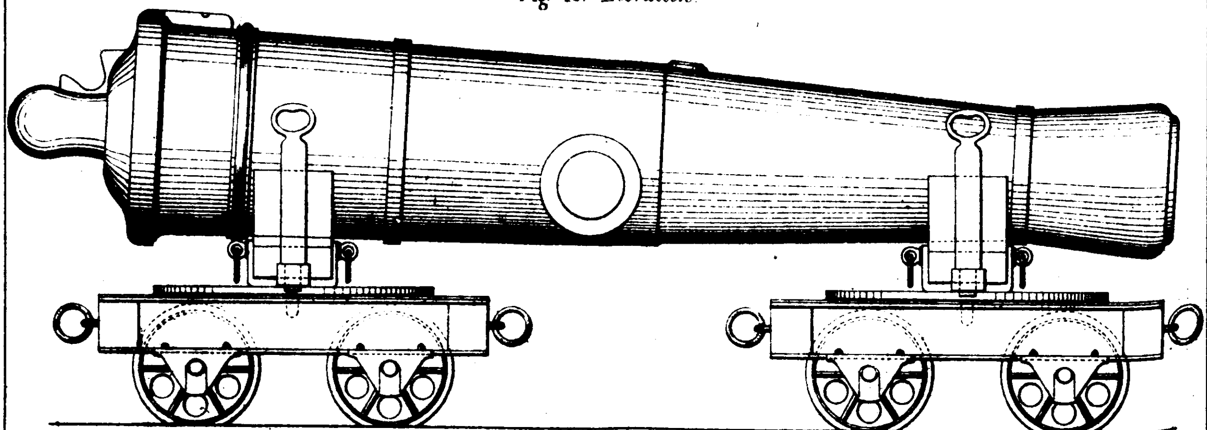
The success of the Decauville railway has been so rapid and so great that many inventors have entered the same field; but they have almost all constructed the portable track with sleepers that can be detached. There are thus, at present, two systems of portable tracks; those in which the sleepers are capable of being detached, and those in which they are not.

The portable track of the Decauville system is not capable of so coming apart. The steel rails and sleepers are riveted together and form only one piece. The chief advantage of these railways is their great firmness; besides this, since the line has only to be laid on the surface just as it stands, there

PORTABLE RAILWAYS.

Trucks for carrying Cannon, Timber, &c.

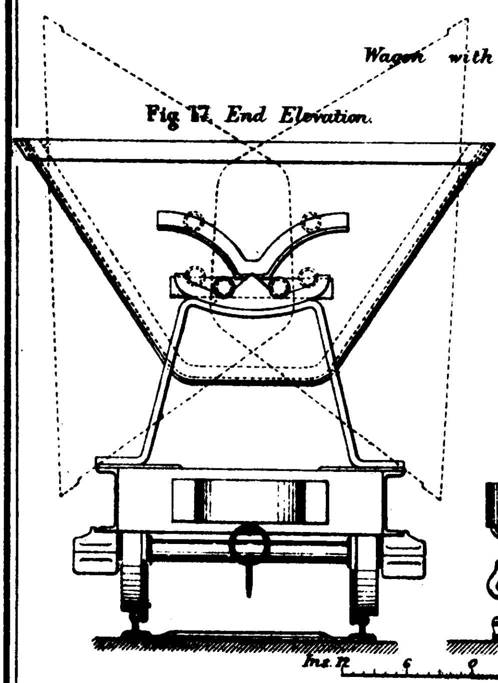
Fig. 16. *Elevation.*

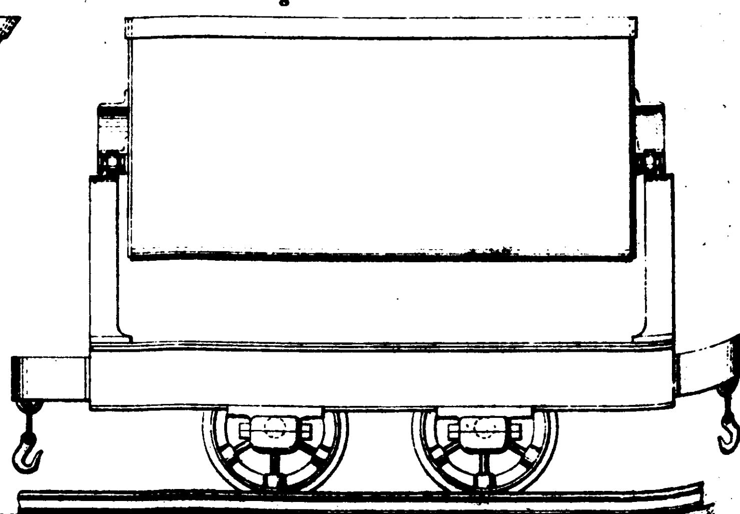


Scale $1/16^{th}$ Ins. 12 6 0 1 2 3 4 Feet.

Wagon with Tipping-box, for heavy earthwork.

Fig 17. *End Elevation.* *Scale* $1/15^{th}$ Fig. 18. *Side Elevation.*

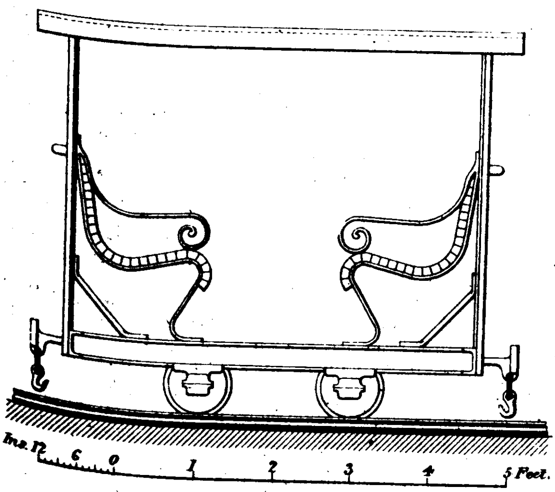




Ins. 12 6 0 1 2 3 4 5 Feet.

PORTABLE RAILWAYS.

Fig. 20. *Inspector's Carriage for Channel Tunnel.*



Scale 1/24 th

Fig. 19. *Section of Channel Tunnel.*

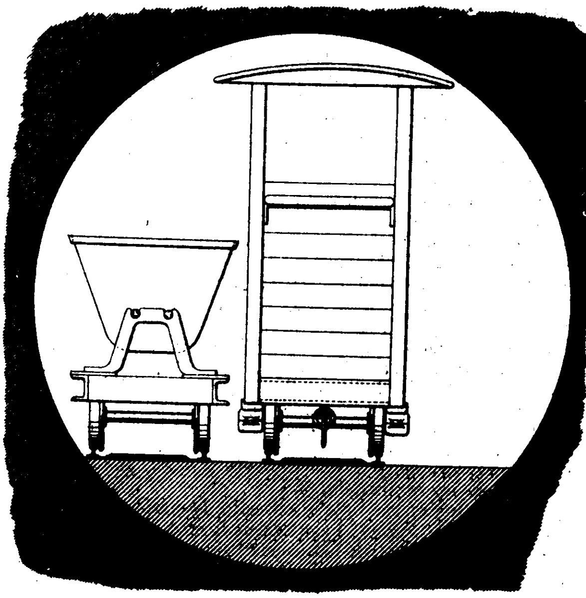
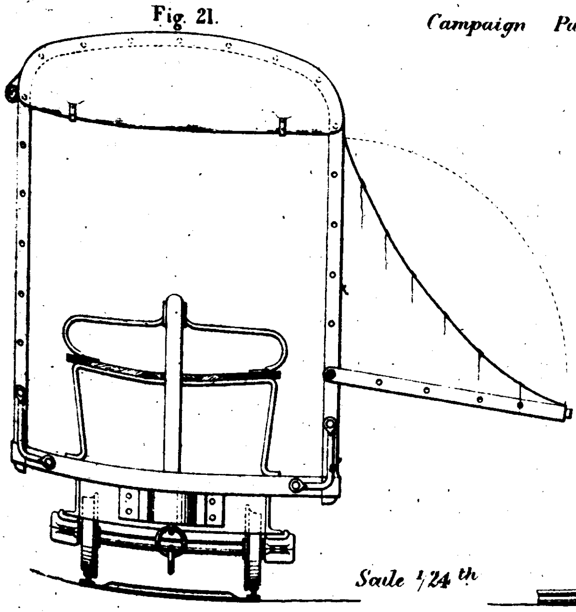


Fig. 21. *Campaign Passenger Carriage.* Fig. 22.



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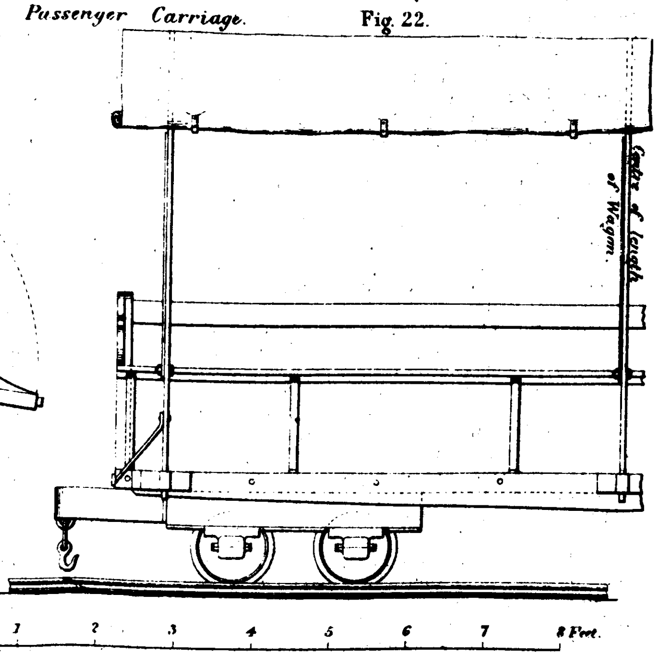

there are not those costs of maintenance which become unavoidable where the sleepers are fixed by means of bolts, clamps, or other adjuncts, only too liable to be lost. Moreover, tracks which are not capable of separation are lighter and therefore more portable than those in which the sleepers can be detached.

With regard to sleepers, a distinction must be drawn between those which project beyond the rails, and those which do not so project. The author has adopted the latter system, because it offers sufficient strength, while the lines are lighter and less cumbersome.

Where at first he used flat iron sleepers, he now fits his line with dished steel sleepers, in accordance with Figs. 1 and 2, Page 228. This sleeper presents very great stiffness, at the same time preserving its lightness ; and the feature which specially distinguishes this railway from others of the same class is not only its extreme strength but above all its solidity, which results from its bearing equally upon the ground by means of the rail-base and the sleepers.

In special case, the author provides also railroads with projecting sleepers, either of flat steel beaten out and rounded, or of channel of iron; but the sleeper and the rail are always inseparable, so as to avoid lessening the strength, and also to facilitate the laying of the line. If the ground is too soft, the railway is supported by bowl sleepers of dished steel, Figs. 3 and 4, Page 228, especially at the curves ; but the necessity for using these is but seldom experienced. The sleepers are riveted cold. The rivets are of soft steel, and the pressure with which this riveting is effected is so heavy that the sleepers cannot be separated from the rails, even after cutting off both heads of the rivets, except by heavy blows of the hammer, the rivets being driven so thoroughly into the holes in the rails and sleepers as to fill them up completely.

The jointing of the rails is exceedin ·ly simple. The rail to the right hand, Fig. 5, Page 228, is furnished with two fishplates : that to the left has a small steel plate riveted underneath the rail and projecting 1¼ inch beyond it. It is only necessary to lay the lengths end to end, making the rail which is furnished with the small plate come in between the two fishplates, and the junction can at once be effected by fish-bolts. A single fish bolt, passing through the holes in the fish-plates, and through an oval in the rail-end, is sufficient for the purpose.

With this description of railway it does not matter whether the curves are to the right or to the left. The pair of rails are curved to a suitable radius, Fig. 6, Page 228, and only need turning end for end to form a curve in either direction. The rails, Fig. 14, Page 229, weigh 9 lbs. per yard, 14 lbs., 19 lbs., and 24 lbs. per yard ; and are very similar to the rails used on the main railways of France, except that their base has a greater width in proportion. As to the strength of the rails it is much greater in proportion to the load then would at first sight be thought : all narrow-gauge railways being formed on the principal of distributing the load over a large number of axles, and so reducing the amount on each wheel. For instance, the 9 lbs.rail used for the portable railway bears easily a weight of half a ton for each pair of wheels.

The distance apart between the rails differs according to the purpose for which they are intended. The most usual gaugs are 16, 20, and 24 inches. The line of 16 ins. gauge, with 9 lbs. rails, although extremely light, is used very successfully in farming, and in the interior of workshops.

A length of 16 ft. 5 ins. of 16 ins. gauge, with 9 lbs. steel rails and sleepers &c., weighs scarcely more than 1 cwt., and may therefore be readily carried by a man placing himself in the middle and taking a rail in each hand.

The members of the Institution who recently visited the new Port of Antwerp well recollect seeing there the portable railway which Messrs. Couvreux and Hersent had in use ; and as the works at the Port of Antwerp gave rise to the idea of this paper, it will be well to begin with a description of this style of contractors' plant.

The earth in such works may be shifted by hand, horse.power or locomotive. For small works the railway of 16 ins. gauge, with the 9 lbs. rails, is commonly used, and the trucks carry double-equilibrium tipping-boxes, containing 9 to 11 cub. ft. These wagons, of smaller size than those shown in Figs. 17 and 18, Page 232, but of similar construction, having tipping-boxes without any mechanical appliances, are very serviceable ; the box, having neither door nor hinge, is not liable to need repairs, and it keeps perfectly in equilibrium upon the worst roads. To tip it up to the right or left, as shown dotted in Fig. 17, it must simply be pushed from the opposite side, and the contents are at once emptied clean out. In order that the bodies of the wagons may not touch at the top, when several are coupled together, each end of the wagon is furnished with a buffer, composed of a flat iron bar cranked, and provided with a hanging hook.

Plant of this description is now being used in an important English undertaking at the port of Newhaven, where it is employed not only on the earthworks, but also for transporting the concrete manufactured with Mr. Carey's special concrete machine.

These little wagons, of from 9 to 11 cub. ft. capacity run along with the greatest ease ; and a lad cou'd propel one of them with its load for 300 yards at a cost of 3*d*. per cubic yard. In earthworks the saving over the wheelbarrow is 80 per cent. ; for the costs of wagons propelled by hand comes to 1*d*. per cubic yard carried 100 yards, while to go this distance with a barrow costs 5*d*. A horse draws without difficulty, walking by the side of the line, a train of from 8 to 10 trucks on the level, or 5 on an incline of 7 per cent. (1 in 14).

One mile of this railway, of 16 ins. gauge and 9 lbs. steel rails, with 16 wagons, each having double-equilibrium tipping-box sontaining 11 cubic feet, and all accessories, represents a weight of 20 tons,—a very light weight, if it is considered that all the materials are entirely of metal. Its net costs price per mile is £450, the wagons included.

Large contracts for earthwork with horse haulage are carried on to the greatest advantage with the railway of 20 ins. gauge and 14 lbs. rails. The length of 16 ft. 5 ins. of this railway weighs 170 lbs. ; and so on can be carried easily by two men, one at each end. The wagons most in use for these works are those with double-equilibrium tipping-boxes, holding 18 cub. ft., Figs. 17 and 18, Page 232. These are now being employed in one of the greatest undertakings of the present time—namely, the cutting of the Pannama Canal, where there are in use upwards of 2700 such wagons and more than 35 miles of track.

A mile of this railway of 20 ins. gauge with 14 lbs. rails, together with 16 wagons of 18 cubic feet capacity, with appurtenances, costs about £660, and represents a total weight of 33 tons.

This description of plant is used for all contracts exceeding 20,000 cubic yards.

A very curious and interesting use of the narrow-gauge line, and the wagons with double-equilibrium tipping-box, was made by the Société des Chemins de fer Sous-Marins on the proposed tunnel between France and England. Fig. 19, Page 233, represents a section of the tunnel, with two lines of rails, on one of which is a train of wagons, and on the other an inspection carriage with two seats. The line used is that of 16 ins. gauge, with 9 lbs. rails.

The first heading of the tunnel, which was driven by means of a special machine by Colonel Beaumont, had a diameter of only 2. 13 m. (7 ft.) ; the tipping-boxes have therefore a breadth of only 2 feet, and contain 7¼ cubic feet. The boxes are perfectly balanced, and are most easily emptied. The wagons run on two lines, the one being for the loaded trains, and the other for the empty trains.

The engineers and inspectors, in the discharge of their duties, make use of the Lilliputian carriages shown in Figs. 19 and 20, Page 233. The feet of the travellers go between the wheels, and are nearly on a level with the rails : nevertheless they are tolerable comfortable. They are certainly the smallest carriages for passengers that have ever been built ; and the builder prophesies that these will be the first to enter England through the Channel Tunnel.

One of the most important use to which a narrow-gauge line can be put is that of a military railway. The Dutch, Russian, and French governments have tried it for the transport of provisions, of war material, and of the wounded, in their recent campaigns. In Sumatra, in Turkestan, and in Tunis, these military railroads have excited much interest, and have so fully established their value that a short description will here suffice.

The campaign of the Russians against the Turcomans presented two great difficulties, in the crossing of the districts where water was extremely scarce or failed entirely, and in the victualling of the expeditionary forces. The latter object was compeletely effected by means of 67 miles of railway, or 20 ins. gauge and 14 lbs. steel rails, with 500 carriages for food, water, and passengers. The rails being laid simply on the sand, small locomotives could not be used, and had to be replaced by Kirghiz horses, which drew with ease from 16 cwts. to one ton for 25 miles per day.

In the Tunisian war this railroad of 20 ins. gauge with 14 lbs. rails was replaced by that of 2 feet gauge, with 14 lbs. and 19 lbs. rails. There were quite as great difficulties as in the Turcoman campaign, and the country to be crossed was entirely unknown. The observations made before the war spoke of a flat and sandy country. In reality a more uneven country could not be imagined: alternating slopes of about 1 in 10 continually succeeded each other, and before reaching Kairouan 7½ miles of a swamp had to be crossed. Nevertheless the horses harnessed to the railway carriages did on an average twelve to seventeen times the work of those working ordinary carriages. In this campaign also, on account of the steep ascents, the use of locomotives had to be given up. The track served for the conveyance not only of victuals, war material, and cannon, but also of the wounded; and a large number of the survivors owe their lives to this railway, which supplied the means of their speedy removal, and without great sufferings, from the temporary hospitals, and of carrying them to places where more care could be bestowed upon them.

The carriages which did duty in this campaign are shown on Pages 233 and 236. They are wagons with a platform entirely of metal, resting upon eight wheels. The platform is 13 ft. 1 in. long and 2 ft. 11 ins. wide. The total length over buffers is 14 ft. 9 ins., as shown. This carriage may be turned at will into a goods wagon; or into a passenger carriage for sixteen persons, with seats back to back, as in Figs. 21 and 22, Page 233; or into an ambulance wagon for eight wounded persons, as in Figs. 23 and 24.

For the transport of cannon the French military engineers have adopted small trucks similar to Figs. 15 and 16, Pages 229 and 232. A complete equipage, capable of carryingguns weighing from 3 to 9 tons, is composed of trucks with two or three axles, each being fitted with a pivot support, by means of which it is rendered possible to turn the trucks, carrying the heaviest pieces of ordance, on turntables, and to push them forward without their going off the rails at the curves.

The trucks which have been adopted for the service of the new forts in Paris are drawn by six men, three at each end of the gun; and those are capable of moving with the greatest ease guns weighing 3 tons.

The narrow-gauge railway was tested during the war in Tunis more thoroughly than in any preceding campaign; and the military authorities decided, after peace had been restored in that country, to mantain the narrow-gauge railways permanently; this is a satisfactory proof of their having rendered good service. The line from Sousse to Kairouan is still open for regular traffic. In January, 1883, an express was established, which leaves Sousse every morning and arrives at Kairouan—a distance of forty miles—in five hours, by means of regularly organized relays. The number of carriages and trucks, for the transport of passengers and goods, is 118.

The success thus attained by the narrow-gauge line goes far to prove how unfounded is the opinion that light railways will never suffice for continuous traffic. The opinion is based on certain cases in the Colonies, where it was thought fit to adopt a light rail weighing about 18 to 27 lbs. per yard, but keeping to the old normal gauge. It is nevertheless evident that it is impossible to construct cheap railways on the normal gauge system, as the maintenance as such would-be light railways is far more costly in proportion than that of standard railways.

The narrow-gauge is altogether in its right place in countries where, as notable in the case of the Colonies, the traffic is not sufficient to warrant capitalising the expense of constructing a normal-gauge railway.

Very recently the Eastern Railway Company of the Province of Buenos Ayres have adopted narrow-gauge for connecting two of their stations, the gauge being 24 ins. and the weight of the rails 19 lbs. per yard. They have constructed altogether six miles of narrow-gauge road, with a rolling stock of thirty passenger carriages and goods trucks and two engines, at a net cost price of £7,500, engines included. This line works as regularly as the main line with which it is connected. The composite carriages in use are shown in Figs. 25 and 26, Page 237, and leaves nothing to be desired with regard to their appearance and the comfort they offer. Third-class carriages, covered and open, and covered goods wagons, are also employed.

All these carriages are constructed according to the model of these on the Festiniog Railway. The engines weigh 4 tons, and run at 12½ miles per hour for express trains with a live load of 16 tons; while for goods trains carrying 35 tons the rate is 7½ mile an hour.

Another purpose for which the narrow gauge road is of the highest importance in colonial commerce is the transport of sugar cane. There are two systems in use for the service of sugar plantations:

1. Traction by horses, mules or oxen.
2. Traction by steam-engine.

In the former case, the narrow-gauge of 20 ins. with 14 lbs. rails is used, with platform trucks and iron tipping cradles about 5 ft. long and 4 ft. wide, as shown in Figs. 27 and 28, Page 237. The use of these wagons is particularly advantageous for clearing away the sugar cane from the fields, because, as the crop to be carried off is followed by another harvest, it is important to prevent the injury done by the wheels of heavily laden wagons. The cradles may be made to contain as much as 1300 lbs. of cane for animal traction, and 2000 lbs. for steam traction; the cane is cut up into pieces of 4 to 5 ft. length, which are laid transversely across the cradle. In those colonies where the cane is not cut up into pieces, long platform wagons are used, made entirely of metal, and on eight wheels, in which the cane is laid longitudinally. When the traction is effected by horses or mules, a chain 14½ft. long is used, and the animals are driven alongside the road. Oxen are harnessed to a yoke, longer by 20 to 24 ins. than the ordinary yoke, and are driven along on each side of the road. On plantations where it is desirable to have passenger carriages, or where the narrow-gauge line may come to be required for the regular transport of passengers and goods, the 20-inch line is replaced by one of 24 ins. gauge.

The transport of refuse of sugar cane is effected by means of tilting basket-wagons, the lower part of which consists of plate iron, as in earthwork wagons, while the upper consists of an open grating or network, offering thus a very great holding capacity without being being excessively heavy. The content of these wagons is 90 cubic feet (2500 litres.) To use them for the transport of earth, sand, or rubbish, the grating has merely to be taken off. The cost of one mile of the 20-inch road, with 14 lbs. rails, thirty basket wagons, and accessories for the transport of sugar cane, is £700; and the total weight of this plant amounts to 35 tons.

In case where the transport of sugar cane has to be effected by steam power, the most suitable width of road is 24 ins., with 19 lbs. rails; and this line should be laid down and ballasted most carefully.

Owing to the great lightness of the portable railways, and the facility with which they can be worked, the attention of explorers has repeatedly been attracted by them. The expedition of the Ogowé in October 1880, that of the Upper Congo in November 1881, and the Congo mission under Savorgnan de Brazza, have all made use of the Decauville narrow-gauge railways system.

During these expeditions to Central Africa, one of the greatest obstacles to be surmounted was the transport of boats, where the rivers ceased to be navigable; for it was then necessary to employ a great number of negroes for carrying both the boats and the luggage. The explorers, were, more or less, left to the mercy of the natives, and but very slow progress could be made.

On returning from one of these expeditions in Africa, Dr. Balap and M. Mizon consulted the author as to whether the narrow-gauge line might not be profitably adapted for the next expedition. He accordingly proposed to transport their boats, without either taking them to pieces or unloading them, by placing them on to pivot trollies, in the same manner as guns are transported in fortifications and in the field. The first experiments were made at Petit-Bourg with a pleasure yacht. The hull, weighing 4 tons, was placed on two gun-trollies, and was moved about easily across country by means of a portable line of 20 ins. gauge, with 14 lbs. rails. The length of the hull was about 45 ft., depth 6 ft. 7 ins., and breadth of beam 8 ft, 2 ins., that is to say, five times the width of the narow-gauge: notwithstanding which the wheels never left the rails. The sections of line were taken up and replaced as the boat advanced, and a speed of ⅝ mile per hour was attained. Dr. Balay and M. Mizon declared that this result far exceeded their hopes, because during their last voyage the passage of the rapids had sometimes required a whole week for one kilometre (⅝ mile), and they had considered themselves very lucky indeed if they could attain a speed of one kilometre per day. The same narrow-gauge system has since been three times adopted by African explorers, on which occasions it was found that the 20-inch line, with 9 lbs. or 14 lbs. rails, was the most suitable for scientific expeditions of this nature.

The trucks used are of the kind usually employed for military

PORTABLE RAILWAYS.

Ambulance Wagon.

Fig. 23.

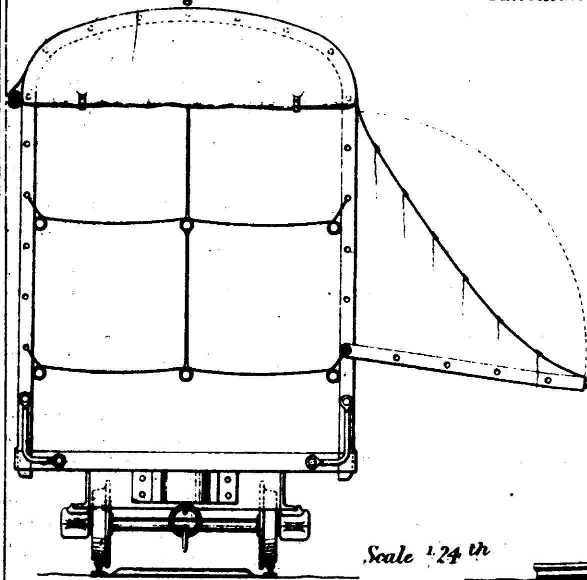

Fig. 24.

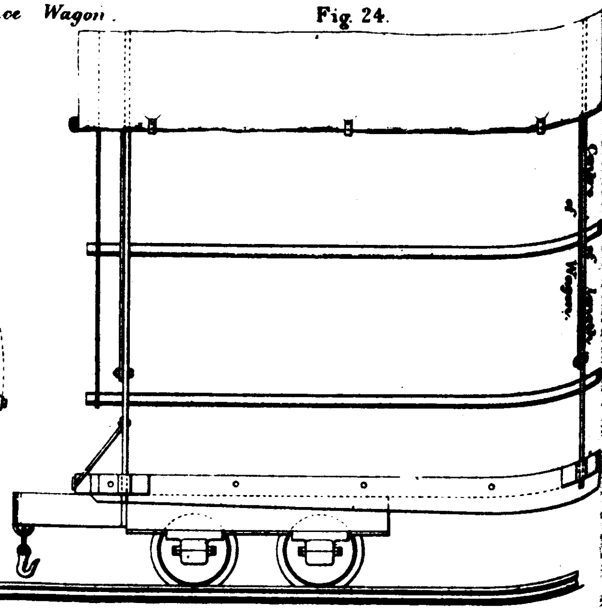

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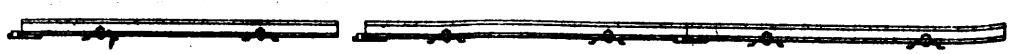
Fig. 29.



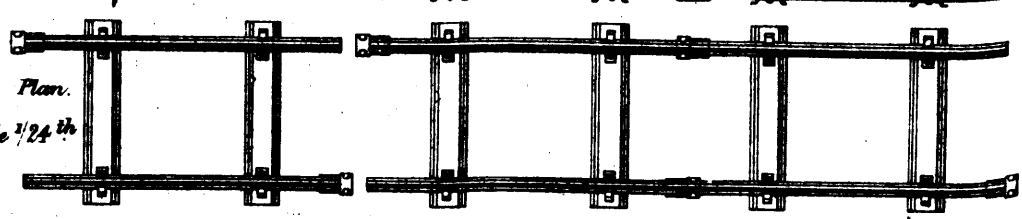
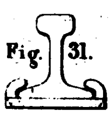


Fig. 30. *Plan.*

Scale 1/24th

Fig. 31.



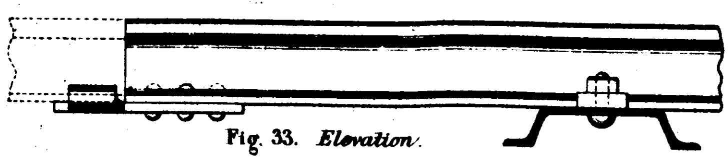


Fig. 32.

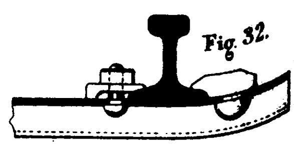
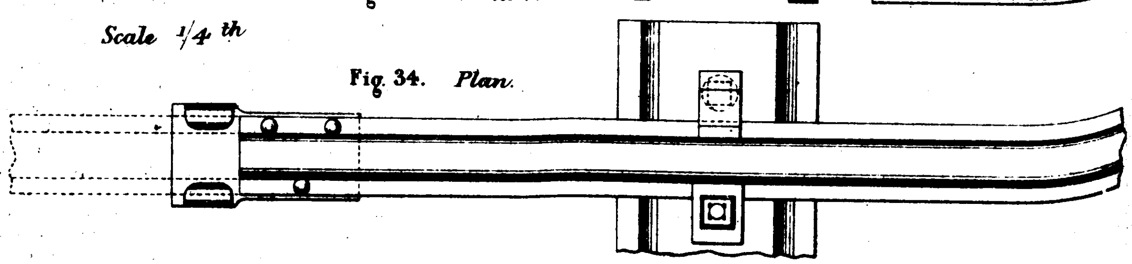


Fig. 33. *Elevation.*

Scale 1/4th

Fig. 34. *Plan.*



PORTABLE RAILWAYS.

Fig. 25. *Composite Passenger Carriage.*

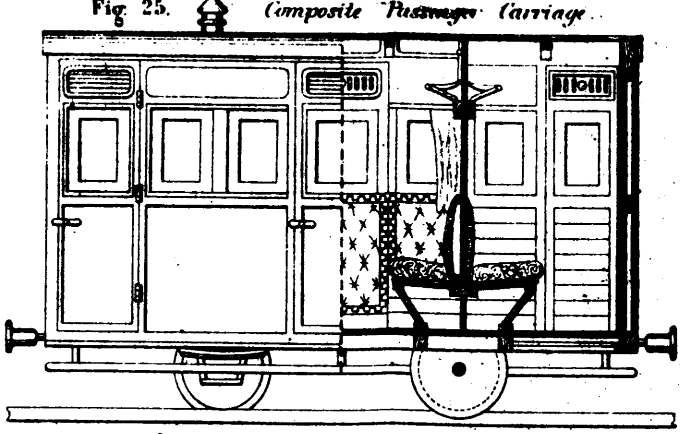


Fig. 26. *Transverse Section.*

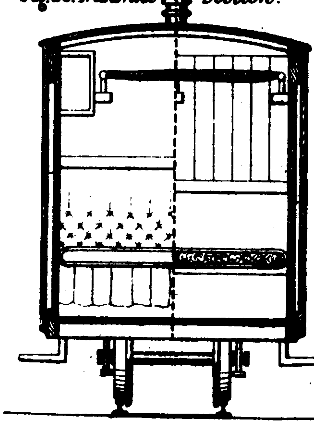


Fig. 27. *Sugar-Cane Wagon with tipping cradle. End Elevation.*

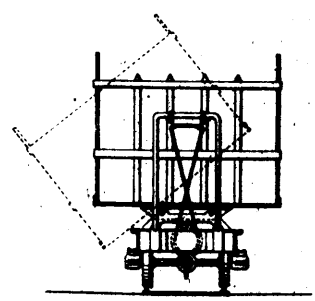
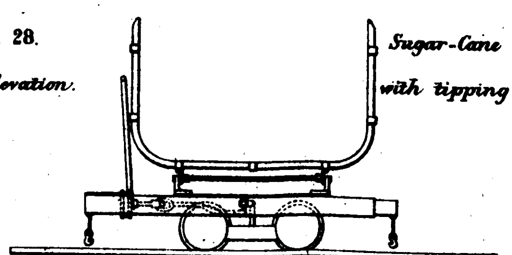


Fig. 28. *Side Elevation.* *Sugar-Cane Wagon with tipping cradle.*



purposes, with wheels, axles, and pivot bearings of steel; on being dismounted, the bodies of the two trucks form a chest, which is bolted together and contains the wheels, axles, and other accessories. The total weight of the 135 yards of road used by Dr. Balay and M. Mizon during their first voyage was 2900 lbs., and the wagons weighed 5000 lbs. Hence the expedition had to carry a supplementary weight of 3½ tons; but at any moment the material forming this burden became the means of transporting, in its turn, seven boats, representing a total weight of 20 tons.

It is impossible to enumerate in this paper all the various kinds of wagons and trucks suitable for the service of iron works, ship yards, mines, quarries, forests, and many other kinds of works; and the author has therefore limited himself to mentioning only a few instances which suffice to show that the narrow gauge can be applied to works of the most varied nature and under the most adverse circumstances, possible.

It remains only to mention the various accessories which have been invented for the pupose of completing the system. They are illustrated in Figs. 7 to 13, and consists of offrailers, crossings, turntables, &c.

The off-railer, Fig. 7, is used for establishing a portable line, at any point, diverging to the right or left of a permanent line, and for transferring traffic to it without interruption. It consists of a miniature inclined plane, of the same height at one end as the rail, tapering off regularly by degrees towards the other end. It is only necessary to place the off-railer (which, like all the lengths of rail of this system, forms but one piece with its sleepers and fish-plates) on the top of the fixed line, adding a curve in the direction in which it is intended to go, and to push the wagons up the off-railer, when they will leave the fixed line and pass on to the new track.

The switches consist of a rail-end 4 ft. long, which serves as a movable tongue, placed in front of a complete crossing, the rails of which have a radius of 4, 6, or 8 metres; a push with the foot suffices to alter the switch. There are four different models of crossings constructed for each radius, namely:

1. For two curves with symmetrical divergence.
2. For a curve to the right and a straight track, Fig. 8.
3. For a curve to the left and a straight track, Fig. 9.
4. For a meeting of three tracks.

When a fixed line is used, it is better to replace the movable switch by a fixed cast-iron switch, Fig. 8, and to let the men who push the wagons turn them in the direction required. Planed switch-tongues are also used, Fig. 9, having the shape of those employed on the normal tracks, especially for the passage of small engines; in this case the switches are completed by the application of a hand-lever, Fig. 10.

The portable turntable, Figs. 11 and 12, consists of two faced plates, laid one over the other, the lower of thick sheet-iron, and the upper of cast-iron. The sheet-iron plate is fitted with a pivot, round which the cast-iron plate turns. The top plates may either be smooth, Fig. 11, or groved for the wheels, Fig. 12; the former are used chiefly when it is required to turn wagons or trucks of light burden, or, in the case of earthworks, for trucks of moderate weight. These turntables are quite portable; their weight for the 16 ins. gauge does not exceed 200 lbs. For engineering works a turntable plate with variable width of track has been designed, admitting of different tracks being used over the same turntable.

For permanent lines, and to carry heavy loads, turntables with a cast-iron box are required, constructed on the principal of ordinary railway turntables. The heaviest wagons may be placed on these box turntables, without any portion suffering damage or disturbing the level of the ground. In the case of coal mines, paper-mills, cow-houses, &c., with permanent lines, fixed or dead plates are employed, Fig. 13. Such plates need only be applied where the line is always wet, or in workshops where the use of turntables is not of frequent accurrence. The fixed plate is most useful in farmers' stables, as it does not present any projection which might hurt the feet of the cattle, and it is easy to clean.

The only accident that can happen to the track is the breaking of a fish-plate. It often happens that the fish-plates get twisted, owing to rough handling on the part of the men, and break in the act of being straightened. In order in such cases to facilitate the repairs as much as possible, the fish-plates are not riveted by machine, but by hand; and it is only necessary to cut the rivets with which the fish-plate is fastened, and remove it if broken. A drill passed through the two holes of the rail removes all burr that may be in the way of the new rivet. No vices are required for this operation; the track to be repaired is held by two men at a height of about 28 ins. from the ground, care being taken to let the end under repair rest on a portable anvil, which is furnished with the necessary appliances. The two fish-plates are put in their place at the same time, and the second rivet is held in place with one finger, while the first is being riveted with the hammer; if not so held in its place it may be impossible to put the second rivet in afterwards, as the blows of the hammer often cause the fish-plate to shift, and the holes in the rails are pierced with great accuracy to prevent there being too much clearance. No other accident need be feared with this line; and the breakage above described can easily be repaired in a few minutes without requiring any skilled workman.

The narrow-gauge system, which has recently undergone so great a development on the Continent, where its usefulness and the facility of its application to the most varied purposes have been demonstrated, has not yet met in England with the same universal acceptance; and those Members of the Institution who last year visited Belgium were perhaps surprised to see so large a number of portable railways employed for agricultural and building purposes and for contracters' works But in the hands of so practical a people it may be expected that the portable narrow-gauge railway will soon be applied here to even a large number of purposes than elsewhere.

M. C. L. Flateau, as the manager of M. Decauville's branch works at Corbeil, Paris, expressed the regret of the author at being unable to be present. He exhibited an extensive series of photographs, showing the application of the portable railway and plant to many of the purposes described in the paper.

In regard to the alleged disadvantage of the dished sleepers, which it was supposed were so weak that there would be a risk of the line losing its gauge, it must be remembered that, according to the purpose for which the line was designed, the thickness of metal in the sleepers was changed. If for instance the line was wanted for farming purposes, the sleepers were made much thinner than if it was for heavy earthworks or for a tunnel. With the proper thickness of metal in the sleepers there was no reason for fearing that these dished sleepers would get bent at the places where the rails rested on them. He had had occasion himself some days ago to see a severe practical trial made of the projecting sleepers and the non-projecting sleepers. A commission having been deputed to make some experiments on M. Decauville's grounds had asked him to plough up a short length of the ground over which the portable railway lay. It had accordingly been ploughed up, and the line was then laid down again over the ploughed ground, without the fish-plates being even bolted together, and a 4-ton locomotive was run over it, together with several trucks loaded to 7 tons each; and after this experiment had been continued all day the gauge was specially examined by the commissioners, who could not find any place where the non-projecting dished sleepers had given way.

With regard to the shoe-plate which had been described in the discussion, for joining the rail-ends by means of a clip or jaw, as far as his own experience went he did not think it was so very practicable a plan as had been represented; because if that shoe-plate were lying for any length of time on the ground it would of course get rusty, and no doubt some difficulty would be experienced in undoing the joint, and it would certainly be necessary to use tools to undo it; but when it came to putting the joint together again, it would be found quite an impossibility to get the rail-end into the jaw on account of the rust. The ordinary fish-plates shown in Fig. 5, which had been spoken of as not being strong enough for a locomotive line, were not used for such cases; on lines to be worked by locomotives stronger fish-plates were used, which were very similar to those used on permanent narrow-gauge railways.

The crossing shown in Fig. 8, which had been alluded to as being made of cast-iron, was not made of cast-iron at all, but was formed of the ends of the rails themselves; it was nothing else than four rails meeting together, and those rails which represented the curve were bent. The fixed cast-iron switch shown in Fig. 8, was used only for permanent lines. When it came to lines which were very often shifted from one place to another, as for instance in earthworks, there the switch was nothing else than a simple piece of rail about 4 feet long, which could be moved right or left by foot or by a stick or a bar of iron.

As regard the coupling of the trucks, the paper was only of a general character, and it could hardly be expected therefore that all the details should be mentioned. For ordinary work, such as farming purposes, several kinds of buffers were adopted. For earthworks the central dead buffer shown in Figs. 17 and 18, Plate 9, was used, and it did very well so long as there was but little shock, as was the case with the tipping boxes, Plate 9; but when it came to heavy earthworks, when the trucks were drawn by horses, then a dead buffer like that shown in Plate 9 was used on one side of the wagon, and on the other side a buffer with a spring, the object being to prevent the wagons from coming off the rails. Of course in wagons intended for conveying soldiers and for other similar purposes, all the buffers were made with a spiral spring inside.

As to the turntables, he had himself made many experiments with them, and he had been present many times at experiments which had been made with them for the transport of guns. He had taken great interest in the transport of war materials, because he always considered that this portable railway was of the greatest use not only for common purposes, such as earthworks, farming, and so on, but also for the transport of very heavy cannon where great quickness and great facility in using the plant were necessary. In his own experiments, employing unskilled workmen taken from the fields, a gun weighing $4\frac{1}{2}$ tons had been turned end for end on the turntable, that is to say first the breech and then the muzzle; and this had been done with the greatest facility. In some other experiments at which he had been present, very heavy pieces had to be carried over ditches 5 to 8 feet wide, where it seemed that a bridge would be necessary; and he had himself made trial of putting a simple straight section of the railway over such a ditch, with a plank alongside for the men who drew the gun to go over; and he had found that not only did the rails not bend very much, but no rivet had given way, and the length of railway across the ditch had remained perfectly safe under the load.

COMPARISON OF THE TRANSMISSION OF FORCE BY ELECTRICITY AS COMPARED WITH THE OTHER MOST COMMON MECHANICAL TRANSMISSION.

BY A. BERINGER.

If we admit that the local conditions are equally favourable to the four systems (viz., electricity, water under pressure, compressed air and telo-dynamic cables), that is to say, if we set on one side particular conditions which may render one or the other system more suitable in a given case, the comparison of prices shows that electricity and telo-dynamic cables are the most favourable agents for the transmission of power. Between these two we must choose the cable as effecting the cheaper transmission up to a distance of 1 kilometre, but for greater distances electricity is preferable.

We note, in passing, the interesting result that a hydraulic motive power transmitted by electricity to a distance of 20 kilometres costs less than the same power produced on the spot by a large improved steam-engine, even if we calculate the water-power at 0·03 franc per horse-power hourly. It follows that a powerful water-fall will supply, within a radius of four leagues, power cheaper than that produced by steam-engines of 100—200 horse-power, and within a far wider radius it will compete advantageously with small steam-engines, or with gas.

Although cables are very suitable for distributing power in the country to a few separate places they are quite out of the question when it is required to effect unlimited sub-divisions, *e.g.*, in a distribution of power from house to house in a town. In this case the three other systems remain alone in the field.

For distances of less than 1 kilometre electricity has only the advantage of a few centimes over air and water, but its advantage increases for longer distances. Thus the hourly cost per horse-power for ½ kilometre is 0·24 franc, for 1 kilometre 0·25 franc, and for 12 kilometres 0·37 franc, whilst water and air reach this price for 1½ to 2 kilometres.

Transmissions by water and air are therefore far surpassed by electric transmission, and if we wish to produce power by steam in a central establishment and distribute it from house to house within a radius of 10 kilometres electricity alone could furnish an economical solution of the problem.

We must here remark that such a distribution of power can only be, for the present, useful in the small trades, for if more than 10 horse-power is required a special motor is more advantageous.

If we divide the region to be supplied with power into squares of 8 to 10 kilometres a side, having each a large steam-motor, we may supply a horse power at 0·25 franc hourly as against 0·32 franc, which would be the cost of a gas motor, which is a considerable economy in favour of electricity.

There are numerous cases where local conditions render it impossible to set up a motor at the place where the power is required, and only certain systems of transmission can here be employed. Thus in mining and tunnelling, air and electricity only are applicable, and if we suppose that there is need for 10 horse-power we see, on comparing the price of the power transmitted by compressed air and by electricity, that the advantage is greatly in favour of the latter. For more considerable transmissions of power the prices agree fairly well up to 5 kilometres, but beyond this the advantage of electricity becomes very decided. In addition, an electric transmission is more easily established than the conduction of compressed air, and it is much easier to extend a system of the first kind than of the second.

Certainly boring machines with compressed air often suffice for ventilation, whilst an electric transmission of power requires to be accompanied by special appliances for this purpose. Still the advantages of electricity as regards convenience and economy are so great that we cannot hesitate to employ it whenever there is no fear that sparks from the dynamo-machines may occasion explosions, especially as electricity can at the same time serve for lighting.

In conclusion, in cases were telo-dynamic cables are not applicable electric transmission is much preferable to transmission by water or compressed air. It is more economical than gas-motors for transmissions up to 5 kilometres. When transmission by cable is applicable it is the more economical up to 1 kilometre. From 1 to 5 kilometres electricity has the advantage.—*Revue des Mines.*

CONDUCTIVITY OF METALS AND ALLOYS.

M. Lazare Weiller has conducted a new and independent investigation into the electrical conductivity of certain metals and alloys, the results of which he lately presented to the Société Internationale des Electricians. For the purposes of his experiments he caused small bars of metal to be cast of a diameter of about 13 mm. (0.51 in.) These were divided in such a way as to show the grain of the fracture, and one part was drawn into wire to be used in the trials. Those alloys which can neither be drawn or rolled easily, such as silicides and phosphides, were tested directly on the cast bars after the method of Sir William Thomson. In the trials the bars, fitted with binding screws at each end, rested upon knife edges at an invariable distance apart. These knife edges were respectively in communication with two resistances composed of two parts, of which the one was the thousandth part of the other. The extremity of one was connected to the fixed terminal of a Wheatstone bridge with a sliding contact, and the other to the slider itself. The two points which separated the resistances communicated with the galvanometer. Finally the extremities of the bridge were connected to the binding screws by means of a circuit, which included a battery of four elements and a contact key. The resistance sought was then equal to the resistance measured upon the wire of the bridge, divided by 1000. The measurements, which were very carefully and accurately conducted and were effected on a great number of specimens, were made in part by M. Weiller himself, and in part by M. Duflon, in the laboratory of Messrs. Breguet. The results are given in the following Table:

1.	Pure silver	100
2.	" copper	100
3.	Refined and crystallised copper	99.9
4.	Telegraphic silicious bronze	98
5.	Alloy of copper and silver (50 per cent.)	86.65
6.	Pure gold	78
7.	Silicide of copper, with 4 per cent. of silicium	75
8.	Silicide of copper with 12 per cent. of silicium	54.7
9.	Pure aluminium	54.2
10.	Tin with 12 per cent. of sodium	46.9
11.	Telephonic silicious bronze	35
12.	Copper with 10 per cent. of lead	30
13.	Pure zinc	29.9
14.	Telephonic phosphor-bronze	29
15.	Silicious brass with 25 per cent. of zinc	26.49
16.	Brass with 35 per cent. of zinc	21.5
17.	Phosphor tin	17.7
18.	Alloy of gold and silver (50 per cent.)	16.12
19.	Swedish iron	16
20.	Pure Banca tin	15.45
21.	Antimonial copper	12.7
22.	Aluminium bronze (10 per cent.)	12.6
23.	Siemens' steel	12
24.	Pure platinum	10.6
25.	Copper with 10 per cent. of nickel	10.6
26.	Cadmium amalgam (15 per cent.)	10.2
27.	Drnier mercurial bronze	10.14
28.	Arsenical copper (10 per cent.)	9.1
29.	Pure lead	8.88
30.	Bronze with 20 per cent. of tin	8.4
31.	Pure nickel	7.89
32.	Phosphor-bronze with 10 per cent. of tin	6.5
33.	Phosphor copper with 9 per cent. of phosphorus	4.9
34.	Antimony	3.88

The resistances are not given in ohms, but as proportions to a given body. They may be reduced to the conventional standard on the assumption that a wire of pure silver, one millimetre in diameter, has, at a temperature of zero Cent. a resistance of 19.37 ohms per kilometre.

STATISTICS OF PAPER-MAKING.—Some very curious statistics as to paper-making have recently been compiled on the Continent. It seems that there are 3,985 paper-mills on the face of the earth, in which annually 1,904 million pounds of paper are manufactured. Half of this paper is used for printing; 600 million pounds only for newspapers, the consumption of which has risen by 200 million pounds during the last ten years. As to the use of paper by individuals, an average of 11½ lbs. is used by an Englishman. 10¼ lb. by an American, 8 lb. by a German, 7½ lb. by a Frenchman, 3½ lb. by an Italian or Austrian, 1½ lb. by a Spaniard, 1 lb. by a Russian, and ½ lb. by a Mexican. If the consumption of paper is a gauge of civilisation, this table of averages is very flattering to our national conceit.

A MEXICAN CUPELLATION-HEARTH.

BY W. LAWRENCE AUSTIN, PH.D., SANTA BARBARA, CHIHUAHUA, MEXICO.

At the Troy meeting of the Institute, in October, 1883, I presented a paper entitled "Smelting Notes from Chihuahua, Mexico," in which was briefly described a cupellation-hearth, commonly met with in the northern part of Mexico, called in the vernacular *un vaso*.

Since writing the paper I have had occasion to construct a hearth of this description for myself, using it, in conjunction with a water-jacket, for the reduction of a very refractory ore in the form of concentrates; and I now avail myself of this opportunity to qualify some of the statements made in the paper referred to. At the same time I wish to present some sketches which will enable anyone to run up a similar furnace within three days, should occasion demand it. As it is built entirely of common clay (the more refractory the better) and the ashes of scrub-oak taken from the ash-pit of the furnace itself, the materials necessary for its construction are available anywhere. Even the grate-bars of the fireplace are made of adobes cut in two. There are, scattered over the West, small deposits of refractory lead-silver ores, which, because of their rebellious nature or the isolation of the locality, do not admit of the ordinary smelting process, and are not amenable to amalgamation or any other system of reduction commonly practised; yet with the help of litharge, or, in other words, by performing a crucible assay on a large scale, these ores can be readily and cheaply beneficiated, even where iron and coke are unattainable. I am at the present time engaged in an operation of this discription, and am producing fine silver from a mixture of galena, pyrites, and blende, using as fuel oak-charcoal, doing without the valuable fluxing-ores attainable in most smelting-camps, and depending wholly upon the litharge produced by the little *adobe* hearth I am about to describe. In doing this I am only imitating the common Mexican practice, which has been in use for century or more.

In building the furnace which is the subject of the accompanying sketch, I made use of labor and materials as follows:

Cost of Constructing One Furnace.

300 adobes, @ $0.01	$3 00
40 gallons clay, 80 gallons ashes, } for test,	nothing
One builder, 4 days, @ $1.20	4 80
Two helpers, 4 days, @ $0.60	4 80
Two boys, 4 days, @ $0.30	2 40
Total	$15 00

By comparison with my former figures these will be found somewhat in excess, a fact that arises from two causes: first the inaccuracy of the statements upon which my calculations were based, and secondly, the fact that the natives of Mexico, from one of whom I obtained the figures referred to, are, in their own country, always able to get work done more cheaply than a stranger can. This fact, by the way, it is well to bear in mind when forming estimates in that country, since the cheap operations of small proprietors often allure the inexperienced to commit grave errors of judgment. It will only be in rare instances that the profits of native proprietors can be augmented by handling large amounts of their ore with American machinery.

The Mexican is a good miner and a better metallurgist. It is well to examine closely the property he offers for sale, especially when it has a fine record and still cannot yield him sufficient for his simple wants.

But, to return to our *vaso*, the difference between the figures given above and those of my former paper is so slight as not to merit comment were it not for the lesson it conveys.

Lead-ore, even when poor in silver, is very desirable in silver-lead smelting operations, and is sometimes paid for beyond its value. Again, the shipment of silver bars may, under certain conditions, be preferable to handling lead bullion. When a cupellation-hearth can be put up, a cheap lead-flux provided, and the advantages of the former method of shipment tested without incurring serious expense, it might, in some cases, be worth a trial. The Mexican *vaso* requires no expense for castings, no exorbitant freight-charges on the material for its construction; in fact, it is simplicity itself, and answers very well for an experiment or where limited amounts of material are handled. In firing-up, care is necessary not to crack the test, but heat can be applied immediately after tamping-in. Eighteen hours later, the furnace is hot and ready for charging. Should the test be defective or worn out, chisel off the surface for six or eight inches, tamp it in again, and the furnace is ready for firing. In putting in the test, the whole amount of material (clay, 4 parts, and ashes 8 parts, by measure), after being thoroughly mixed and dampened so as to retain the form of the hand when pressed, is thrown in together and tamped solid with wooden poles 5 feet long and 3 inches in diameter, sharpened at one end to a point $1\frac{1}{2}$ inches square. The reason for putting the whole amount of material in at once is that by this means the whole is beaten into a compact mass; whereas, by tamping in a little at a time, thin layers are formed, which easily peel off. After the whole is thoroughly pounded in, the test is cut out with a piece of hoop-iron. The accompanying diagrams, exhibiting cross-sections and plan of the furnace, are self-explanatory. The *adobes*, or sun-dried bricks used, are 18 inches × 9 inches × 4 inches, excepting those forming the roof of the canal leading from the fireplace and covering the test, which are 26 inches × 11 inches × $3\frac{1}{2}$ inches. Extra care is necessary in their preparation and they are dried in the

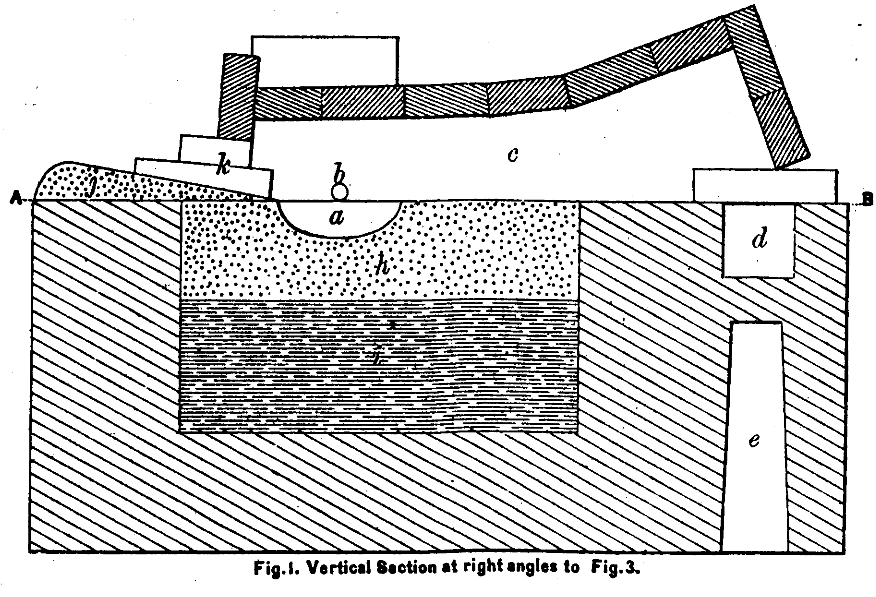


Fig. 1. Vertical Section at right angles to Fig. 3.

A MEXICAN CUPELLATION-HEARTH.

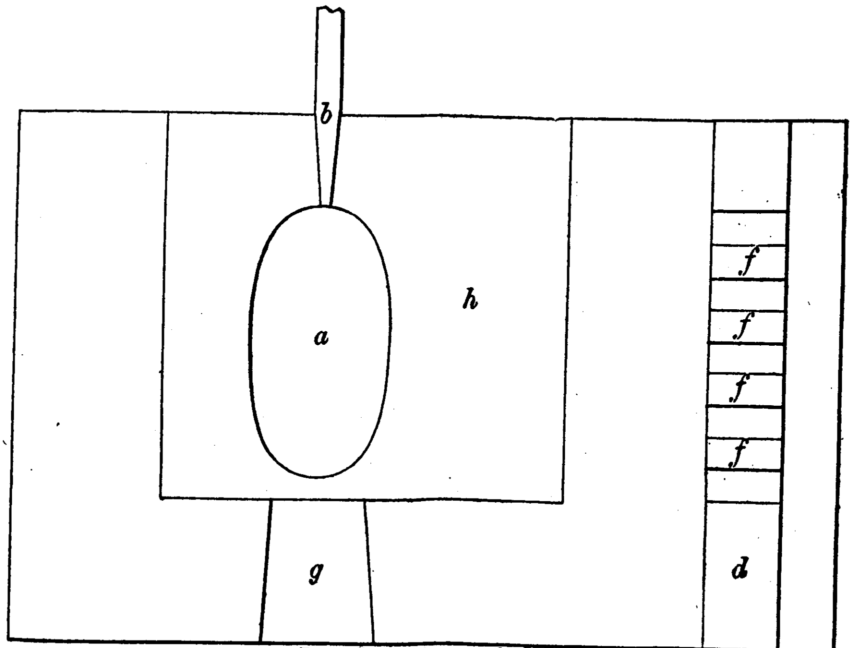


Fig. 2. Plan on line A—B (Fig. I.)

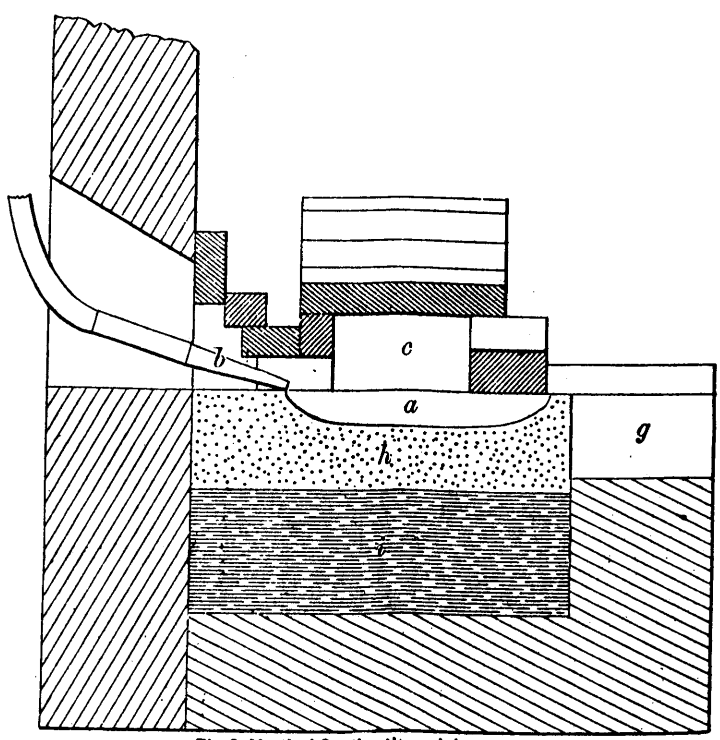


Fig. 3. Vertical Section through b, a, g, (Fig. 2.)

shade to avoid sun-cracks. The capacity of a furnace of this description is something over one ton of lead-bullion in twenty-four hours, consuming less than half a cord of wood, and requiring the the attendance of four men, two on the shift, whose collective wages amount to about $2.80 per ton.

We have, therefore, in this apparatus, a fifteen-dollar furnace, built in three days, capable of reducing one ton of bullion to almost pure silver in twenty four hours, at a cost of $6.80 per ton. The operation of the furnace is very simple. The bullion is placed on the inclined hearth at *k*, where flame passing over the molten metal strikes and gradually melts it down. Blast is not put on until the test, which holds 300 pounds of lead, is filled, when its strength is so gauged as to cause slight ripples to play over the surface of the bath. The litharge is drawn off as it accumulates into a basin outside the furnace, where it soldifies and is lifted off in cakes. It is noticeable that no stack exists, yet the flame shoots firecely out over the metal whenever a stick of wood is laid in the fireplace. Repairs on the test made necessary by the corroding properties of the litharge, are attended to when the silver is taken out. An old test pounded up finely and mixed with wood-ashes furnishes the material for making such repairs. The silver is allowed to cool gradually in the furnace, and, when solid, is removed, and the cake is thrown into water.—*Trans. Am. Inst. Mec. Eng.*

PETROLEUM FUEL FOR LOCOMOTIVES.—*Engineering.*

On the meeting being resumed on Wednesday morning the first paper read was one by Mr. Thoms Urquhart, of Borisoglebsk, Russia, "On the Use of Petroleum Refuse as Fuel in Locomotive Engines." This was an excellent paper on an interesting subject and gave rise to a well-maintained discussion. In his paper Mr. Urquhart stated that the first experiments on the use of petroleum for fuel on locomotives, were made in 1874 by the author on the Grazi and Tsaritsin Railway, South Russia, but at that time the great costof the fuel prevented its extended use. Naphtha refuse has a theoretical evaporative power of 16.2 lb. of water, and anthracite of 12.2 lb. at 120 lb. pressure per square inch. hence petroleum has, weight for weight, 33 per cent, higher evaporative value than anthracite. In locomotive practice a mean evaporation of 7 lb. to 7½ lb. of water per pound of anthracite is generally obtained, thus showing 60 per cent. of efficiency. But with petroleum, the author said, an evaporation of 12.25 lb. is practically obtained, giving 75 per cent. efficiency, and hence the practical evaporative value of petroleum must be taken at 63 to 75 per cent. higher than that of anthracite.

The form of spray injectors, which had been found by the writer to give the best results, was illustrated by diagrams. The combustion chamber is constructed with firebrick inside it, which, when heated, acts as a regenerator, retaining the ignited gases long enough to secure their thorough admixture with air. In certain instances the incoming air at the forward ash-pan damper, was heated by passing through a narrow channel in the brickwork. All the locomotive sprays were worked with steam, but in a tyre-heating furnace the author uses an air blast from a Roots blower. In this the cost of fuel is only one-third of what it was with bituminous coal, and the work done per day has increased 25 per cent. Four spray nozzles are arranged tangentially to the tyre, and there is a circulation of flame all round.

To get up steam in a petroleum-fed locomotive, it is temporarily connected to a shunting locomotive or stationary boiler, to obtain steam for the blower and the spray jet. Steam can be raised to 45 lb. in 20 minutes, and to 120 lb. in 55 minutes. If the water be already hot, the full pressure is obtained in 25 minutes. In lighting up, the spray nozzle is first cleared of water by the steam jet, and at the same time the blower in the chimney is started for a few seconds, to draw the gas, if any, out of the smoke box. A piece of cotton waste or a handful of lighted shavings, is put in the combustion chamber, and the spray turned on; the oil immediately ignites without an explosion, and then its quantity can be augmented at pleasure. When the fuel is turned off, as in descending a long incline, the ash-pan doors are closed, and also the revolving air damper in the chimney. to retain the heat. When the fuel is turned on again, the box is hot enough to light it.

There are 72 locomotives running with petroleum under the author's care; 10 of them are passenger engines, 17 are eight-wheel coupled goods engines, and 45 are six-wheel coupled. The length of line over which they run is 291 miles, from Tsaritzin to Burnack; and there are four main storage reservoirs, each holding 2050 tons. At each shed there is a distributing reservoir provided with a gauge-glass and a scale.

The paper ends with a number of tables. The first gives the specific gravity and weight of petroleum refuse at different temperatures. The second is the record of 17 trips, giving a mean consumption of 39·15 lb. per train mile. The third gives the results of comparative trials of different kinds of fuel in summer and winter. In comparison with anthracite, the saving in favour of petroleum was 55 per cent. in cost, and 41 per cent. in weight. With bituminous coal there was a difference of 49 per cent. as to weight, and 61 per cent as to cost. The fourth table is the record of 19 trials in summer, and shows a consumption of 32.08 lb. per train mile. Other tables give the consumption for each month in the year. In conclusion, the author said that although it was scarcely possible that petroleum firing will ever be of use for locomotive in England on ordinary railways, yet its employment on underground lines would be an enormous boon.

In the discussion which followed Mr. Urquhart's paper the first speaker was Mr. Joseph Tomlinson, Jun., who directed attention to the difference between the relative comparative values of petroleum and anthracite as given in the earlier part of the paper with the saving effected in actual practice with locomotives as recorded in the latter portion of the communication, the advantage possessed by the liquid fuel in the latter case being much smaller than in the former. Considering how largely Mr. Urquhart has used the liquid fuel he (Mr. Tomlinson) wondered that he had not constructed a special locomotive boiler for its use, while with regard to Mr. Urquhart's suggestion that the petroleum fuel was well fitted for use on underground lines, he considered that it would never do to use it on the Metropolitan Railway, on account of the danger attending its storage and other considerations. He added that at present there was practically no smoke made on the Metropolitan line, the engine chimneys being entirely free from any soot deposit and only dust being discharged.

Mr. William Boyd, of Newcastle, who spoke next, remarked that he had no experience in working locomotives with liquid fuel, but he had supplied the machinery of some steamers for service on the Caspian Sea which were fitted up for using such fuel. A diagram showing the arrangement adopted in this case was exhibited. The boiler shown had two furnaces and the petreloum fuel was brought to it from a storage tank by a pipe passing across the front just below the firehole doors. From this pipe branches, fitted with cocks, conveyed it to two brass arms—one to each furnace. These arms had double passages formed in them, the upper passage in each arm receiving the petroleum refuse, while to the lower steam was admitted. At the end of each arm, facing the centre of the furnace, were two jets directed at an angle of about 45 deg., so that the steam discharged from one met the liquid fuel discharged from the other, and injected it into the furnace. The furnace had an ordinary grate, provision being made for closing the ash-pit by a damper. A lump of greasy waste placed on the grate served to ignite the jet. The arrangement described had been fitted to five vessels, and the only special point about the boilers was that the tubes were longer than usual in proportion to their diameters. In the first boilers the tubes were made 3¼ in. in diameter and 7 ft. long, but in the latest they had been made 2¾ in. in diameter and 9 ft. long. He (Mr. Boyd) had been struck by the value (20s. and 21s. per ton) placed on the petroleum fuel by Mr. Urquhart. On the Caspian the value was very much less. He regretted that he had not any accurate data as to the evaporative performance of the boilers to which he had referred, but it appeared that the consumption of the petroleum was about 2½ lb. per indicated horse-power per hour. Judging from the reports he had received, however, he believed that, owing to its excessive cheapness, it was carelessly used. Mr. Boyd also referred to the Tables given in Mr. Urquhart's paper, and directed attention to the enormous difference between the consumption of fuel in the summer and winter months; he wished to know if this was a normal result. Finally he observed that petroleum fuel gave the power of raising steam very rapidly, more rapidly in fact than was desirable in the case of ordinary marine boilers.

Mr. G. B. Rennie remarked that the system of burning petroleum described in the paper closely resembled one which his firm had tried some twelve or fourteen years ago. They had then used it on their workshop boiler, and the results of the experiment—running one month with coal and another with the liquid fuel—showed an advantage in favour of the latter. The price of the petroleum, however, increased, and its use was then abandoned. His firm had also fitted the injecting apparatus to a steamer sent out for service on the Tigris, where it had been used, but the difficulty of getting clean oil and the consequent clogging of the jet led to its abandonment.

Mr. Tartt, the superintendent engineer of the company for whom the steamer referred to by Mr. Rennie had been constructed, next read an interesting statement of the results which had been obtained with liquid fuel in this case. We cannot give Mr. Tartt's figures, but we may say that the economical results were decidedly in favour of the liquid fuel It was however, at one time found very difficult to obtain steady supplies of this fuel suitable quality, hence its use was abandoned. In the earlier experiments the fuel was injected on some bricks laid loosely on the bars, and covered with ashes, and it was found that dense smoke was evolved, and that there was a strong smell of unburnt petroleum. In a subsequent trial the bridges were built up to the crowns of the furnaces, interstices being left between the bricks for the gases to pass through. In this case there were also evidences of incomplete combustion until the bricks got thoroughly hot, when a clear, bright flame was obtained.

Mr. T. R. Crampton, who spoke next, had no doubt that petroleum refuse could be successfully burnt; the only question as to its employment here was one of cost. When such fuel was experimented with some years ago, it was found that owing to the limited supply here, its employment at once led to increase of cost. With reference to the mode of burning such fuel described in the paper, he thought that it would be improved if the air required was taken in with the steam and fuel, and proper means provided for regulating its supply. With proper arrangements perfectly constant results should be obtained. He added that it was desirable to know how the smokebox temperatures were affected by the use of petroleum fuel; he anticipated that with this fuel the temperature would be lower.

Mr. F.C. Marshall, of Newcastle, stated that his firm (Messrs. R. and W. Hawthorn,) had also fitted up a marine boiler for using petroleum fuel, the arrangement being very like that described by Mr. Boyd. He had found it desirable to use very long tubes, and had made them even longer than Mr. Boyd had done, they being 2½ in. in diameter with a length of 10 ft. Even with these proportions the flame came out at the ends. The question of properly adjusting the supply of air was a most important one, and he agreed with Mr. Crompton as to the desirability of the air being taken in with the steam and fuel. In the boiler to which he had referred the want of more air was very evident, much smoke being formed. This evolution of dense smoke was a subject of complaint on the Volga in the case of steamers using liquid fuel. He was not able to give any data as to the performance of the boiler he had mentioned, but the engineer stated that when using petroleum steam was kept up much more easily than when burning wood. Referring to the remarks of Mr. Boyd as to petroleum fuel giving the power of getting up steam in a marine boiler more rapidly than is desirable, Mr. Marshall observed that it was a pity that we had not yet been able to produce a marine boiler in which there was an efficient circulation while steam was being got up. He believed that the time would come when many steamers trading in the Mediterranean, would find it preferable to obtain liquid fuel from some of the Black Sea ports rather than coal from England. The question of smokebox temperatures required more attention than it had generally received; he would like to see a chimney dispensed with and the products of combustion passing off at a temperature little above that of the steam in the boiler.

Referring to the different arrangements which had been described Mr. Jeremiah Head pointed out that in the locomotive fireboxes described by Mr. Urquhart, there were large masses of brickwork which were absent in the marine boiler furnaces mentioned by others speakers. This would account for some difference in the results as far as the attainment of complete combustion is concerned. There was no doubt that an accumulator of heat was much wanted with liquid fuel, while it also appeared important that both the fuel prior to injection, and the air required to support combustion, should be preliminarily heated. He doubted if the steam used for injection was decomposed; he rather thought it probable that it passed into the smokebox as steam.

Mr. P. F. Nursey observed that in 1878 he was present on board a steamer fitted up for burning liquid fuel, when it was tried between London and Gravesend. The results were satisfactory as far as the combution of the petroleum refuse was concerned, but it was subsequently found that no regular supply of the required fuel could be obtained at a moderate price, and the intention of regularly working the steamer with such fuel was abandoned. He added that some years ago he had been interested in the introduction of petroleum into steam boilers for the purpose of preventing priming, according to the system patented by a Danish engineer. The plan had been tried very successfully, amongst other cases, on the steamer Ida, belonging to the London, Brighton, and South Coast Railway Company, and trading between Newhaven and Dieppe. The boilers of the vessel primed so bodly that it was proposed to take them out; but by the employment of the petroleum this fault was cured. The petroleum was injected with the feed, a small quantity being put in at the commencement, and again about the middle, of each trip. It was found that not only did this use of petroleum prevent priming, but also that it did away with hard incrustation in the boiler, and rendered unnecessary any lubrication in the engine cylinders.

(To be continued.)

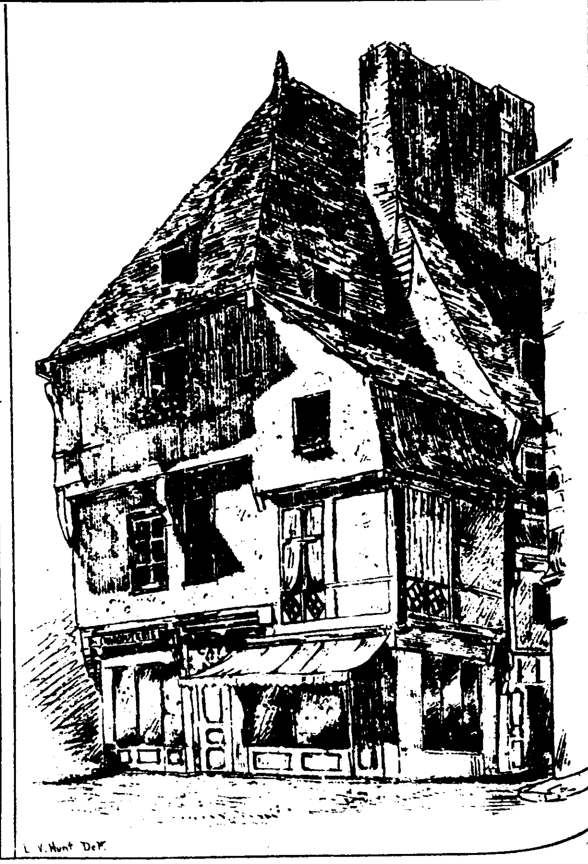
Scientific Notes.

Manganese in Animals and Plants.—Recent researches by Mr. Maumené have shown that the metal manganese exists in wheat, rice, and a great variety of vegetables. Wheat contains from $\frac{1}{5000}$ to $\frac{1}{1500}$ of its weight of the metal, which exists chiefly as a salt of an organic acid. It is also found in potatoes, beetroot, carrots, beans, peas, asparagus, apples, grapes, and so on. The leaves of the young vine are very rich in it; so are the stones of apricots. The proportion in cacao is very great, as it is in coffee, tobacco, and especially tea. In the 50 grammes of ashes left by a kilogamme of tea, there was found 5 grains of metallic manganese. There are vegetables, however, in which no manganese can be found, as, for example, oranges, lemons, onions, &c. Many medicinal plants contain it, as, for example, cinchona, white mustard, and the lichen (*Roccella tinctoria*). Animal blood does not always contain it, but it is found in milk, bones, and even hair. Mr. Maumené regards its presence in the human body as an accident, and not of vital importance. He also suggests that doctors should cease to employ manganese as a succedaneum with iron, for while the latter is useful to the blood, the former is an intruder which is only tolerated in small traces, and rejected in larger quantities. Tea, coffee, and other vegetables require abundance of manganese in the soil for their proper cultivation, and the absence of it may account for the failure of many plantations.

According to the *Times* Paris Correspondent, M. Pasteur's experiments with the virus of hydrophobia are going on with unbroken success. He has thus far experimented on 57 dogs, 19 of them mad and 38 bitten by them under uniform conditions. Out of these 38 half had been previously inoculated, the other half not. The latter without a single exception, died with unmistakable signs of hydrophobia, whereas the 19 others are about and as well as ever. They will be watched for a year by veterinary doctors to see whether the inoculation holds good permanently or only temporarily.

Electric Conductivity of Solutions.—According to the recent researches of Mr. Bouty, the neutral salts in very extended solutions of water form a group apart as regard their electric conductivity. For example, ethyelic alcohol, glycerine, erythrite and phenol, glucose and candied sugar, ordinary ether and dichlorhydrine, ethylic aldehyde and acetone, as well as albumen, all conduct very badly. Mr. Bouty has also come to the conclusion, from his experiments, that an anhydrous alkali or acid is not a conductor, but that a hydrated acid or alkali conducts like a salt.

AN OLD HOUSE AT LISIEUX.



AN OLD HOUSE AT DINAN, BRITTANY.

THE EVOLUTION OF FLOWERS.

BY GRANT ALLEN.

Some Higher Lilies.

(*Continued from page* 218.)

All the true lilies with which we have dealt so far have had bulbs to grow from, and have been, on the whole, very succulent and herbaceous in character. They have also persisted in the primitive lily habit of producing dry capsules, each of of the three cells in which contained numerous seeds.

There are, however, some higher types of lily, not very largely represented in our British flora, which differ considerably from the tulip, the fritillary, and the tiger-lilies in one or other of these central characteristics. I propose briefly glancing at two of these to-day, the common asparagus (*Asparagas officinalis*) and the butcher's broom (*Ruscus aculeatus*). They are our two English representatives of the sub-order of Liliaceæ known as Asparageæ.

Dismiss from your mind entirely the ordinary garden notion of asparagus, as a thick, stumpy, succulent shoot, and try to realise the life of the wild plant itself as it grows by the sandy, tideless levels of the Mediterranean, or far more sparingly on a few isolated rocky headlands of our own Cornish or Irish coast. Essentially a maritime weed, the wild asparagus has, instead of a bulb, a deep creeping root-stock, buried far out of harm's reach in the sand or the crannies; and from this stock it sends up every spring a few soft, scaly, annual shoots, thin and wiry, which branch out afterward into tufted feathery heads of minute foliage. In our gardens, we trench and manure the selected and cultivated varieties, so that each year the annual stems grow very large, high, bushy, and collect abundant material for the next spring's growth, which they conceal during the winter in the buried root-stock. Hence the young shoots in the garden kind have become unnaturally large, thick, and luscious. But in the wild state, asparagus seldom attains more than one quarter the height of the big, luxuriant, cultivated variety, and its spring shoots are far thinner, stringier, and more woody in texture.

On the edible young stems of the garden asparagus everybody must have noticed a few short, stumpy scales, generally of a faint mauve colour; and these are almost the only true leaves the plant ever produces. When it grows older, the place of foliage is fulfilled by the fine clustered hair-like green points, which are, in fact, very small branches, or, if you like to be extremely scientific, abortive pedicels (that is to say, flower-stalks whose buds and blossoms have never developed). Look very closely at the base of each such a cluster—the full-grown garden asparagus will do quite as well for this purpose as its wild ancestor—and you will see that it is enclosed by very tiny dry scales, each of which is really a bract or leaf similar to those on the spring shoots. From the axils or angles made by these bracts with the stem, the cluster of abortive pedicels springs, just as each separate blossom in a wild hyacinth or a common spotted orchis, springs from a small bract of a far more auspicuous character. One may say, in fact, that each cluster of so-called leaves in the asparagus answers to a whole head of flowers in the bluebell or orchis, only that the actual blossoms themselves are in this case never developed.

Why the asparagus has thus taken to producing these innumerable pedicels instead of true leaves would be a long and difficult question to answer fully. It must suffice here to say briefly that in many plants of dry places (for example, in the stonecrops) the stem and branches as well as the leaves are filled with chlorophyll, and help to perform the foliar functions. In others (for example, in the cactuses) the true leaves have dwindled away absolutely to nothing because the succulent stem performs their functions better under its own peculiar circumstances. In asparagus, the true leaves remain only as protective scales, but the work of foliage has been taken on by the stem and pedicels, simply because they could do the work more conveniently.

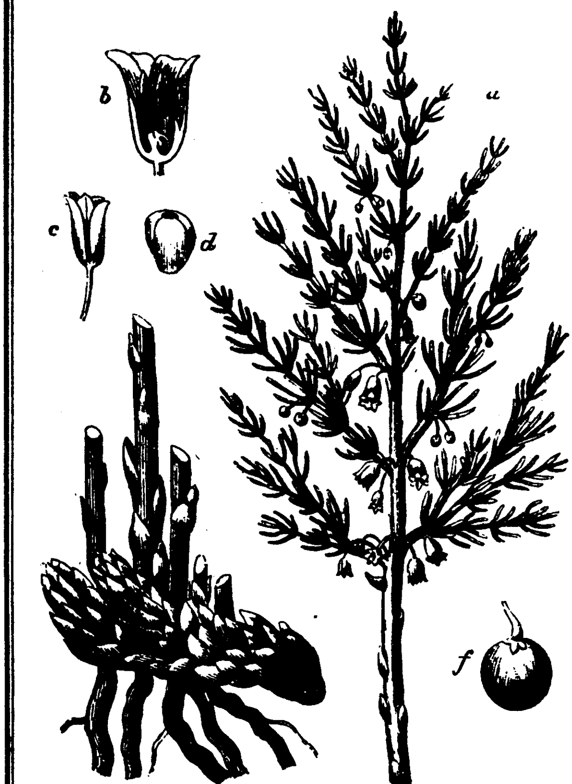


Fig. 1.—Asparagus Officinalis.

The flowers of the asparagus are small and greenish, and at first sight very inconspicuous. On looking closer, however, you will see that they are perfect little lilies, each with six distinct perianth-pieces—that is to say, three sepals and three petals, the distinction being here well marked—and the usual six stamens and three-celled ovary. Many of the flowers, however, have stamens only; others have pistils with abortive stamens: the plant is just beginning to separate the sexes in distinct blossoms. But the separation has not yet gone far; none of the female flowers have as yet quite lost their stamens, though they are reduced to useless filaments bearing abortive anthers. Indeed, a few blossom on each plant usually still retain both stamens and pistils. Unattractive as they are in colour, the asparagus flowers have a delicate perfume, and secrete abundant honey; hence they are visited and fertilised by hive bees and a few other insects.

But the most marked peculiarity about the asparagus, as distinguished from the other lilies we have hitherto examined, is certainly the fact that it produces red berries, instead of dry green or brown capsules. This berry has, of course, been produced, like all others, by the intervention of birds, which thus distribute the seeds in the best possible situations. Accordingly, the plant is able to lessen the number of seeds in each cell to one only. To be sure, the flower has two ovules or young seeds in each cell of the ovary; but as the fruit ripens, one of these usually becomes abortive. This is just the exact reversal of what we saw happen in an earlier stage of evolution; and yet it is only a further step in the same direction, under a slight disguise. We noticed that the earliest monocotyledons, such as the alismas, had many carpels in every flower, each containing one seed. In the simpler lilies, such as the tulip and fritillary, the number of carpels was reduced to three (united in a single capsule), while, by way of compensation, the seeds in each cell were increased to several. But in the asparagus, the improved mode of dispersion by the aid of birds enables the plant still further to simplify its plan by reducing the number of seeds in each cell to one. It thus effects the greatest possible saving both in fertilisation and in dispersion of seeds.

The butcher's broom is a still more singular modification of the lily type, in which the foliar functions are performed by flattened, leaf-like branches, exactly simulating true leaves. It stands alone among British monocotyledons in attaining a shrubby, woody, tree-like habit. The branches are so extremely like leaves in outward appearance that their true nature can only be discovered by reasoning and analogy. Most of them bear on their under surface (or rather on the upper side, which is so twisted as to turn downward) a single small, whitish lily flower, having six distinct perianth pieces, and either three stamens or a three-cell ovary, for the division of the sexes is here almost complete, though a few hermaphrodite blossoms occasionally occur. If you look very closely, however, you will see that each flower is borne on a small pedicel, united along its whole length with the leaf-like branch (well shown at *b* in the accompanying woodcut), and that a very tiny scale or bract lies under every blossom. Similar very small scales, the last relics of the true leaves, now abortive, are found beneath the leaf-like branches. The flowers and fruits seem accordingly to grow out of the middle of a leaf, a peculiarity which gives butcher's broom a very strange and uncanny appearance. In the immature ovary, there are two ovules in each cell, but, as the fruit ripens, one in each cell always becomes abortive, so that at most there are but three seeds in the berry. More often, however, only two perfect seeds are developed, and it is not uncommon to find berries with only one; so that butcher's broom, in fact, carries all the tendencies of the asparagus just one stage further. The berries are bright red, and very attractive to birds, but the seeds are excessively hard and indigestible. Butcher's broom is a glossy evergreen, and the leaf-like branches are stiff and prickly, effectually deterring cattle from browzing off its tempting foliage.—*Knowledge.*

Fig. 2.—Ruscus Aculeatus.

LIFE OF STONES.

Some months ago these pages had an article on the "Decay of Building Stones." The subject is worthy more than a passing paper, as it affects not only the permanency of public buildings, but the lasting qualities of the mementoes to our own dead. A run through the graveyards of the oldest settled portions of the country proves that some of our more recently formed stones possess an enormous amount of durability; the slates, for instance, outlasting even marble, to say nothing of sandstone. But the oldest stones which have been found, those retaining their inscriptions legibly, are those from such quarries as the Bolton Ledge, in Connecticut, specimens of which may be found in other localities. But the chief value of this stone is that it is a resistant to the acids in the atmosphere, especially those generated in manufacturing localities from combined smoke and steam emitters. This stone appears to be a slate impregnated with mica so closely mixed that it gives the entire surface an almost glassy appearance. It is much in favor for pavements for hospitals, chemical laboratories, and other places where the floor would be exposed to the action of acids and other chemicals. In the early story of the country, especially of New England, these stones, being easily quarried, were largely used for memorial headstones, and the inscriptions, although shallow, are still quite legible. Even when set on edge and exposed for a century or more to the changes of our northern climate, the layers refuse to separate, and even the face wears out sooner than the stone disintegrates.

Slates, of the dark blue color, have withstood the wear of a century and still retain all the sharpness of their inscription. There is something peculiar about this stone. It is simply a clay deposit under water, but it is a great resistant of water and is almost fire-proof — much more so than marble or granite.

Sandstones, either of the light shades or the dark red colors, are peculiarly susceptible to elementary or weather influences in this climate. Monuments in cemeteries composed of the Portland red sandstone show marks of weather wear within ten years. Buildings composed of this stone are defaced almost before the elements have given them the seal of age by their mellowing influence. Window stools of churches, steps, balustrades, hoods, and projecting caps peel off in flakes or crack as though under too much weight. This stone is only sharp sea-sand agglutinized and cemented by the oxide of iron. It disintegrates too rapidly on exposure to the atmosphere to be fit for enduring structures. So certain is this to those who cut the cheese-like stone from its natural quarry that their cemeteries, in close vicinage to the quarries, show very few of these stones in their monuments.

Granite, where not exposed to destructive heat, as to great fires like the memorable ones of Chicago and Boston, is very enduring. Its clean surface will not encourage even the attachment of moss, while sun heat and frost cold seem to have little influence on it. It is almost absolutely proof against chemical attacks from the atmosphere, and so for sustaining crushing force there is nothing in the merely mineral materials than can equal it, Quincy granite and Westerly granite approaching in their resistant qualities to crude cast iron.

Marble is a carbonate of lime, and this simple statement is sufficient to show that marble is not an appropriate material to meet our frigid Winters and torrid Summers. The public buildings that have recently been constructed of marble show already signs of decay. If our climate encouraged the cryptogamous growth on mural stones that the air of England, the British Isles, and even of Southern Europe does, our marble edifices might be sure of a life of ten or more generations. But there is no surety of permanency in the marble buildings erected nowadays. The marble is not pure, and the climate is not fitted for even the purest marble. Our granite and blue stone quarries will be forever our best resorts for building and monumental stone.—*Scientific American.*

SOLDERING ALUMINIUM.

The use of aluminium in the arts has been much restricted by our ignorance of any method of soldering it, either to itself or other metals. Now, however a French engineer, M. Bourbouze, has discovered a way of effecting both classes of the operation with ease. The process consists in plating both surfaces to be soldered, not with pure tin, but alloys of tin and zinc, or tin, bismuth, and aluminium, &c. Good results are obtained with all such alloys, but those containing tin and aluminium are best. They should contain different proportions, according to the work the soldered parts have to do. For parts to be fashioned after soldering, the alloy should be composed of 45 parts of tin and 10 of aluminium, as it is sufficiently malleable to resist the hammer. Pieces thus united can also be turned. Parts which have not to worked, after being soldered, may be united with a soft solder of tin containing less aluminium. This last solder can be applied with a hot soldering iron, as one solders white iron, or even with a flame. Neither of these solders requires any prior preparation of the pieces to be soldered. It suffices to apply the solder, and extend it by help of the iron over the parts to be joined. When, however, it is desired to solder certain metals with aluminium, it is best to plate the part of the metals to be soldered with pure tin. It is sufficient then to apply to the part the aluminium plated with alloy, and to finish the operation in the usual manner.

Engineering Notes.

THE UTILISATION OF THE NIAGARA FALLS.—At a recent meeting of the American Association of Civil Engineers, Mr. Benjamin Rhodes described what had been done and what might be done towards the utilisation of Niagara for electrical purposes. He said: "The power of Niagara can be estimated very approximately. The average flow of the river according to many careful measurements is 275,000 cubic feet per second. The fall in the river through the rapids immediately above the fall is 60 feet. The height of the falls is 165 feet, making a total of 230 feet; thus we have for the whole power 7,000,000 horse-power. To utilise this amount of power by water-wheels, generate electrical currents, and transmit to various cities within 500 miles, would necessitate a plant represented at $5,000,000,000. Such figures as these give some idea of the enormous amount of power here in reserve." He states that on the Canadian side the entire use of the falls is represented by a small over shot wheel, which propels a pump, furnishing a meagre supply of water to the adjoining village. On the American side there are five separate raceways, developing in all 800 to 1,000 horse-power. After describing the hydraulic canal, the greatest power now in use at Niagara, he says: "Further developments of power at Niagara may be made at little expense. The hydraulic canal can be deepened and widened, and wheels may be set under greater heads, the total amount thus made available here being equal to the necessities of many years. It may safely be said that the use of Niagara has just begun. Low water is unknown; troubles from ice are slight; hours of use are not limited to 8 or 10, but 24 hours in the day and 365 days in the year, and unlimited power is ready, making the most reliable, as it is the grandest, water-power in the world."

THE SILVER VOLTAMETER.—At the last meeting of the Physical Society for the present session, Lord Rayleigh, president elect of the British Association, exhibited the platinum bowl voltameter which he has designed for measuring the strength of an electric current. This is the best means yet found for estimating the current in absolute measure. The platinum bowl is the cathode in his apparatus; the anode being a sheet of silver wrapped up in clean filter-paper sealed round it. The filter paper is a sheath for the anode to catch any grains of silver which may be loosened from it in the act of decomposition, and prevents them from falling on the bottom of the bowl or cathode. The bowl is filled with a solution of silver salt, the pure nitrate or pure chlorate being preferred. Silver acetate ought not to be used, as it does not give such good results. The anode is dipped in the solution till the sheet is quite immersed; and the current turned on. One ampère deposits 4 grammes of silver in an hour, therefore a quarter to half an hour is sufficient to give one to two grammes, a quantity which can be weighed with sufficient accuracy in a chemical balance. Any current from $\frac{1}{10}$ to 5 ampères can be successfully measured in this way.

NEW METHOD OF PRODUCING STEEL PLATES.—Dr. Henry Muirhead, president of the Physiological Society of Glasgow, has recently brought before that body some particulars of a method of manufacturing steel plates for shipbuilding and boiler-making purposes which is of much interest, although its leading feature is not a novel one. It is the invention of Mr. Joseph Whitley, of Leeds, who has erected works for prosecuting the manufacture. Briefly describing the process, Dr. Muirhead said, a hollow metal cylinder, lined with ganister or other brick, revolves at high speed, the axis being horizontal. A gutter or rhone, perforated with holes, passes into the interior, along its whole length. Into this gutter is poured molten mild steel, which, escaping through the holes, is carried round by the swiftly revolving case, and is formed into an inner cylinder of steel of an inch or more in thickness. This cylinder, while still hot, is drawn, cut across by means of a saw, put into a rolling mill, and rolled to the length and thickness required. In his communication to Dr. Muirhead on the subject, Mr. Whitley wrote as follows: "Suppose I wish a plate for ship-building; then, given a mould five feet in diameter and five feet long, in it I cast a cylinder an inch thick. This, when taken out and cut, is fully fifteen feet long and five feet broad. It is then rolled down to half an inch in thickness. Such a plate is then thirty feet long and five feet broad. The present mould is nine feet long and five feet in diameter. With it I have successfully cast a mild steel shell weighing about 30 cwt."

New Potato-Digger.—A United States manufacturer is bringing out a new form of potato-digger which has been so successful in America, and especially in Illinois, where 500 are said to have been sold in three years, that he is endeavouring to find a sale for it in the English colonial markets. It differs considerably as regards construction from the potato-diggers made in this country. In general appearance it resembles a plough, and it is drawn by a horse and guided like an ordinary plough. Instead of a share under the drag-beam, there is a kind of inverted shovel, set at an angle of about 15 degrees, which scoops up the earth. Attached to the upper end of this blade or shovel are a number of bars or fingers, about an inch in diameter, spread out in fan shape, which lift up the potatoes and separate them from any earth with which they may be mixed. To the right and left of the blade, and set at an angle to the line of motion of the digger, are two concave steel discs or wings, which clear a way through the weeds or hulm, and also throw off, without cutting the potatoes, any superfluous earth. About two feet behind the blades is an iron bar, also supplied with fingers, which raises any potatoes near the surface which may have been left partially or wholly covered. This implement is reported to be of light draught, and to leave a field comparatively even, while it digs potatoes as fast as a team can walk. By verbal description alone it is difficult to convey a correct idea of the invention, but it is one to which English makers of this class of implement might, perhaps, with advantage turn their attention.

The Automatic Continuous Brake.—Two remarkable instances of the value of an automatic continuous brake have been reported recently, which may be commended alike to the attention of the Board of Trade and certain railway companies in this country. While the Chicago limited express was running at the rate of forty miles an hour, the boiler of the locomotive exploded, killing the driver and fireman instantly, and causing the front vehicles to leave the metals. Fortunately the brake pipes were shattered, and, the brake-blocks being immediately applied throughout the train, prevented the rear coaches from over-running and telescoping those in front. With the exception of the driver and fireman no lives were lost, and the only injuries were distributed amongst the passengers in the smoking-car, who were knocked about as their vehicle went over the embankment. The other instance happened on the Eastern of France Railway, near Bar le Duc, when, owing to some miscreant having loosened a rail, the engine and front carriage left the metals. A prompt application of the brake stopped the train in its own length, and saved it from running bodily into the river, the only persons injured being the driver and fireman, who received a few contusions. These are two of many instances which serve to establish the efficiency of the modern brake in preventing accidents, and railway travellers may well ask how much longer the companies will wait for "something to turn up," instead of adopting a uniform system on all the connected lines in the kingdom.

The Testing of Steel Rivets.—The following are the latest instructions issued by the British Admiralty for testing steel rivets: The rivets are to be made from steel bars, having an ultimate tensile strength of not less than 58,000 pounds per square inch of section, not more than 67,000 pounds, with a minimum elongation of not less than 20 per cent. in a length of eight inches. A portion of one bar in every fifty is to be taken for testing before being made into rivets. Pieces cut from every bar, heated uniformly to a low cherry red, and cooled in water at 82 degrees Fahrenheit, must stand bending in a press to a curve of which the inner radius is equal to the radius of the bar tested. Rivets are to be properly heated in making, and the finished rivets allowed to cool gradually. The rivets are to stand the following forge tests: (1.) The shank to be bent double cold, without fracture, to a radius equal to the radius of the shank. (2.) Bent double hot, without breaking, to as small a radius as possible. (3.) Flattening of the rivet head while hot, without cracking at the edges—the head to be flattened until its diameter is 2½ times the diameter of the rivet shank. (4.) The shank of the rivet to be nicked on one side, and bent over to show the quality of the material. One rivet in every hundred to be forge-tested as a sample.

Electric Light Wires as Lightning Conductors.—The new drill hall of the State University at Minneapolis, which stands on an eminence, was recently struck by lightning during the progress of a musical festival. A workman on the roof had his shoe torn off, and his leg badly burned; another person in proximity to one of the masts was temporarily paralysed; and two or three ladies fainted; but that was all the damage sustained. A loud report was heard, as if of heavy ordnance, balls of fires were distinctly seen through the large skylight, and following the electric wires away from the building. Subsequent examination showed that the lightning first struck the flag staff surmounting the door, thence pierced an oaken beam to which the staff was fastened, the splinters, or the concussion, breaking the glass in the skylight. An iron rod conducted the fluid to the network of electric wires below, where the charge was divided, a portion being harmlessly distributed over the general circuit, and the remainder shattering several electric masts near the building. A metallic ball surmounting the flag staff is supposed to have attracted the lightning.

A New Submarine Boat.—The *Pall Mall Gazette* is our authority for the following:—A submarine boat which ought to be able to destroy the navies of the world has been made at Stockholm. It was tried on the Mälar lake, and will shortly be brought over to France. The boat has the shape of a cigar, is 64 feet long, 6 feet wide, and has an engine of 30-horse power. It is said that it can be navigated under water, goes at the speed of ten nautical miles the hour, and that four persons can, without any danger, remain in it for six hours running. The funnel shaped cylinder is the only part of the boat which is visible. A winding stair leads to the boat, which is steered from the top of the cylinder, where a glass roof enables the man at the wheel to see the surface of the water, and direct the course of his strange submarine engine of destruction.

New Method of Rolling Shaped Bloom.—The Pittsburgh Steel Casting Company rolled recently, in six hours, 92,940 lbs. of shaped deck beam blooms. At no time during the operation was there a longer interval than sixty minutes from the melted iron to the shaped blooms. The steel was of low carbon, with a guaranteed elongation of 23 per cent, in 8 inches. The special difficulty in rolling deck-beam shapes lies in the fact that there is 22 per cent. more reduction on one side than the other. This new method of rolling direct from the ingot will tend to a reduction in the cost of producing shapes of all kinds. A patent has been applied for by the Pittsburgh Steel Casting Company which will cover this process.

ON THE EVOLUTION OF FORMS OF ORNAMENT.

(*Nature.*)

The statement that modern culture can be understood only through a study of all its stages of development is equally true of its several branches.

Let us assume that decorative art is one of these. In contains in itself, like language and writing, elements of ancient and even of prehistoric forms, but it must, like these other expressions of culture, which are for ever undergoing changes, adapt itself to the new demands which are made upon it, not excepting the very arbitrary ones of fashion; and it is owing to this cause that, sometimes even in the early stages of its development, little or nothing of its original form is recognizable.

Investigations, the object of which is to clear up this process of development as far as possible are likely to be of some service: a person is more likely to recognize the beauties in the details of ornamental works of art if he has an acquaintance with the leading styles, and the artist who is freed from the bondage of absolute tradition will be put into a better position to discriminate between accidental and arbitrary, and organic and legitimate forms, and will thus have his work in the creation of new ones made more easy for him.

Hence I venture to claim some measure of indulgence in communicating the results of the following somewhat theoretical investigations, as they are not altogether without a practical importance. I must ask the reader to follow me into a modern drawing-room, not into one that will dazzle us with its cold elegance, but into one whose comfort invites us to remain in it.

The simple stucco ceiling presents a central rosette, which passes over by light conventional floral forms into the general pattern of the ceiling. The frieze also, which is made of the same material, presents a similar but somewhat more compact floral pattern as its chief motive. Neither of these, though they belong to an old and never extinct species, has as yet attained the dignity of a special name.

The walls are covered with a paper the ornamentation of

FIG. 1.

which is based upon the designs of the splendid textile fabrics of the Middle Ages, and represents a floral pattern of spirals and climbing plants, and bears evident traces of the influence of Eastern culture. It is called a pomegranate or pine-apple pattern, although in this case neither pomegranates nor pineapples are recognizable.

Similarly with respect to the pattern of the coverings of the chairs and sofas and of the stove-tiles; these, however, show the influence of Eastern culture more distinctly.

The carpet also, which is not a true Oriental one, fails to rivet the attention, but gives a quiet satisfaction to the eye which, as it were, casually glances over it, by its simple pattern, which is derived from Persian-Indian archetypes (Cashmere pattern, Indian palmettas), and which is ever rhythmically repeating itself (see Fig. 1.)

The floral pattern on the dressing-gown of the master of the house, as well as on the light woolen shawl that is thrown round the shoulders of his wife, and even the brightly coloured glass knick-knacks on the mantel-piece, manufactured in Silesia, after the Indian patterns of the Reuleaux collection, again show the same motive; in the one case, in the more geometrical linear arrangement, in the other, in the more freely entwined spirals.

Now you will perhaps permit me to denominate these three groups of patterns that occur in our new home fabrics as modern patterns. Whether we shall in the next season be able, in the widest sense of the word, to call these patterns modern, naturally depends on the ruling fashion of the day, which of course cannot be calculated upon (Fig. 2).

FIG. 9.

I beg to be allowed to postpone the nearer definition of the forms that occur in the three groups, which, however, on a closer examination all present a good deal that they have in common. Taking them in a general way, they all show a leaf-form inclosing an inflorescence in the form of an ear, or thistle; or at other times a fruit or a fruit-form. In the same way with the stucco ornaments and the wall-paper pattern.

The Cashmere pattern also essentially consists of a leaf with its apex laterally expanded; it encloses an ear-shaped flower-stem, set with small florets, which in exceptional cases protrude beyond the outline of the leaf; the whole is treated rigorously as an absolute flat ornament, and hence its recognition is rendered somewhat more difficult. The blank expansion of the leaf is not quite unrelieved by ornament, but is set off with small points, spots, and blossoms. This will be thought less

FIG. 10.

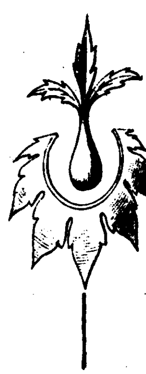


FIG. 11.

strange if we reflect on the Eastern representations of animals, in the portrayal of which the flat expanses produced by the muscle-layers are often treated from a purely decorative point of view, which strikes us as an exaggeration of convention.

One cannot go wrong in taking for granted that plant-forms were the archetypes of all these patterns. Now we know that it holds good, as a general principle in the history of civilisation, that the tiller of the ground supplants the shepherd, as the shepherd supplants the hunter: and the like holds also in the history of the branch of art we are discussing,—representations of animals are the first to make their appearance, and they are at this period remarkable for a wonderful sharpness of characterisation. At a later stage man first begins to exhibit a preference for plant-forms as subjects for representation, and above all for such as can in any way be useful or hurtful to him. We, however, meet such plant-forms used in

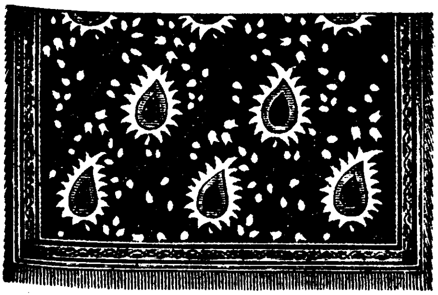


FIG. 2.

ornament in the oldest extant monuments of art in Egypt, side by side with representations of animals; but the previous history of this very developed culture is unknown. In such cases as afford us an opportunity of studying more primitive though not equally ancient stages of culture, as for instance among the Greeks, we find the above dictum confirmed, at any rate in cases where we have to deal with the representation of the indigenous flora as contradistinguished from such representations of plants as were imported from foreign civilisations. In the case that is now to occupy us we have not to go back so very far in the history of the world.

The ornamental representations of plants are of two

FIG. 3.

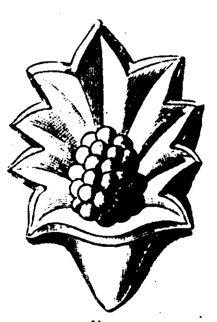


FIG. 4.

kinds. Where we have to deal with a simple pictorial reproduction of plants as symbols (laurel branches, boughs of olive and fir, and branches of ivy), *i.e.* with a mere characteristic decoration of a technical structure, stress is laid upon the most faithful reproduction of the object possible,—the artist is again and again referred to the study of Nature in order to imitate her. Hence, as a general rule, there is less difficulty in the explanation of these forms, because even the minute details of the natural object now and then offer points that one can fasten upon. It is quite another thing when we have to deal with actual decoration which does not aim at anything further than at employing the structural laws of organisms in order to organise the unwieldy substance, to endow the stone with a higher vitality. These latter forms depart, even at the time when they originate, very considerably from the natural objects. The successors of the originators soon still further modify them by adapting them to particular purposes, combining and fusing them with other forms so as to produce particular individual forms which have each their own history (*e.g.* the Acanthus ornament, which, in its developed form, differs very greatly from the Acanthus plant itself); and in a wider sense we may here enumerate all such forms as have been raised by art to the dignity of perfectly viable beings, *e.g.* griffins, sphinxes, dragons, and angels.

The deciphering and derivation of such forms as these is naturally enough more difficult; in the case of most of

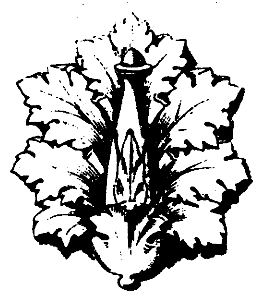


FIG. 5.

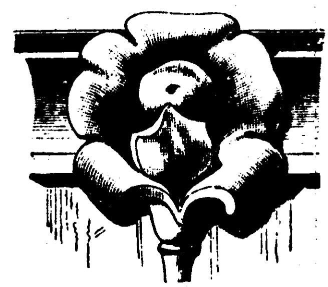


FIG. 6.

them we are not even in possession of the most necessary preliminaries to the investigation, and in the case of others there are very important links missing (*e.g.* for the well-known Greek palmettas). In proportion as the representation of the plant was a secondary object, the travesty has been more and more complete. As in the case of language, where the root is hardly recognisable in the later word, so in decorative art the original form is indistinguishable in the ornament. The migration of races and the early commercial intercourse between distant lands have done much to bring about the fusion of types; but again in contrast to this we find, in the case of extensive tracts of country, notably in the Asiatic continent, a fixity, throughout centuries, of forms that have once been

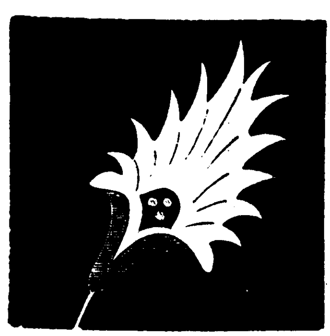


FIG. 7.

FIG. 8.

introduced, which occasions a confusion between ancient and modern works of art, and renders investigations much more difficult. An old French traveller writes:—"J'ai vu dans le trésor d'Ispahan les vêtements de Tamerlan; ils ne diffèrent en rien de ceux d'aujourd'hui." Ethnology, the natural sciences, and last, but not least, the history of technical art are here set face to face with great problems.

In the case in point, the study of the first group of artistic forms that have been elaborated by Western art leads to definite results, because the execution of the forms in stone can be followed on monuments that are relatively not very old, that are dated, and of which the remains are still extant. In order to follow the development, I ask your permission to go back at once to the very oldest of the known forms. They come down to to us from the golden era of Greek decorative art—from the forth or fifth century B.C.,—when the older simple styles of architecture were supplanted to styles characterised by a greater richness of structure and more developed ornament. A number of flowers from capitals in Priene, Miletus, Eleusis, Athens (monument of Lysicrates), and Pergamon; also flowers from the calathos of a Greek caryatid in the Villa Albani near Rome, upon many Greek sepulchral wreaths, upon the magnificent gold helmet of a Grecian warrior (in the Museum of St. Petersburg),—these show us the simplest type of the pattern in question, a folded leaf, that has been bulged out, inclosing a kob or a little blossom (see Fig. 3 and 4). This is an example from the Temple of Apollo at Miletus, one that was constructed about ten years ago, for educational purposes. Here is the specimen of the flower of the monument to Lysicrates at Athens, of which the central part consists of a small flower or fruits (Figs. 5 and 6.)

The form passes over into Roman art. The larger scale of the buildings, and the pretensions to a greater richness in details, lead to a further splitting up of the leaf into Acanthus-like forms. Instead of a fruit-form a fir-cone appears, or a pine-apple or other fruit in an almost naturalistic form.

In a still larger scale we have the club-shaped knob developing into a plant-stem branching off something after the fashion of a candelabra, and the lower part of the leaf, where it is folded together in a somewhat bell-shaped fashion, becomes in the true sense of the word a campanulum, out of which an absolute vessel-shaped form, as *e.g.* is to seen in the friese of the Basilica Ulpia in Rome, become developed.

Such remains of pictorial representation as are still extant present us with an equally perfect series of developments. The splendid Græco-Italian vessels, the richly ornamented Apulian vases, show flowers in the spirals of the ornaments, and even in the foreground of the pictorial representations, which correspond exactly to the above-mention Greek relief representations. [The lecturerer sent round, among other illustrations, a small photograph of a celebrated vase in Naples (representing the funeral rites of Patroclus) in which the flower in question appears in the foreground, and is perhaps also employed as ornament (Figs. 7 and 8).]

The Pompeian paintings and mosaics, and the Roman paintings, of which unfortunately very few specimens have come down to us, show that the further developments of this form were most manifold, and indeed they form in conjunction with the Roman achievements in plastic art the highest point that this form reached in its development, a point that the Renaissance, which followed hard upon it, did not get beyond.

Thus the work of Raphael from the loggias follows in unbroken succession upon the forms from the Thermæ of Titus. It is only afterwards that a freer handling of the traditional pattern arose, characterised by the substitution of, for instance, maple, or whitethorn, for the Acanthus-like forms. Often even the central part falls away completely, or is replaced by overlapping leaves. In the form of this century we have the same process repeated. Schinkel and Bötticher began with the Greek form, and have put it to various uses; Stüler, Strack, Gropius, and others followed in their wake until the more close resemblance to the forms of the period of the Renaissance in regard to Roman art which characterises the present day was attained (Fig. 5.)

Now what plants suggest this almost indispensable form of ornament, which ranks along with the Acanthus and Palmetta, and which has almost become so important by a certain fashion with the structural laws of both?

We meet with the organism of the form in the family of the Araceæ or Aroid plants. An enveloping leaf (bract), called the spathe, which is often brilliantly coloured, surrounds the florets, or fruits, that are disposed upon a spadix. Even the older writers—Theophrastus, Dioscorides, Galen, and Pliny—devote a considerable amount of attention to several species of this interesting family, especially to the value of their swollen stems as a food-stuff, to their uses in medicine, &c. Some species of Arum were eaten, and even nowadays the value of the swollen stems of some species of the family causes them to be cultivated, as, for instance, in Egypt and India, &c., (the so-called Portland sago, Portland Island arrowroot, is prepared from the swollen stem of *Arum maculatum*). In contrast with the smooth or softly undulating outlines of the spathe of Mediterranean Araceæ, one species stands out in relief, in which the sharply-marked fold of the spathe almost corresponds to the forms of the ornaments which we are discussing. It is *Dracunculus vulgaris*, and derives its name from its stem, which is spotted like a snake. This plant, which is pretty widely distributed in olive-woods and in the river-valleys of the countries bordering on the Mediterranean, was employed to a considerable extent in medicine by the ancients (and is so still nowadays, according to von Heldreich, in Greece). It was, besides, the object of particular regard, because it was said not only to heal snake-bites, but the mere fact of having it about one was supposed to keep away snakes, who were said altogether to avoid the places where it grew. But, apart from this, the striking appearance of this plant, which often grows to an enormous size, would be sufficient to suggest its employment in art. According to measurements of Dr. Julius Schmidt, who is not long since dead, and was the director of the Observatory at Athens, a number of these plants grow in the Valley of Cephisis, and attain a height of as much as two metres, the spathe alone measuring nearly one metre. [The lecturer here exhibited a drawing (natural size) of this species, drawn to the measurements above referred to.]

Dr. Sintenis, the botanist, who last year travelled through Asia Minor and Greece, tells me that he saw beautiful specimens of the plant in many places *e g.* in Asses, in the Neighbourhood of the Dardanelles, under the cypresses of the Turkish cemeteries.

The inflorescence corresponds almost exactly to the ornament but the multipartite leaf has almost had a particular influence upon its development and upon that of several collateral forms which I cannot now discuss. The shape of the leaf accounts for several as yet unexplained extraordinary forms in the ancient plane-ornament, and in the Renaissance forms that have been thence developed. It first suggested the idea to me of studying the plant attentively after having had the opportunity five years ago of seeing the leaves in the Botanic Gardens at Pisa. It was only afterwards that I succeeded in growing some flowers which fully confirmed the expectations that I had of them (Fig. 10 and 11.)

(*To be continued.*)

THE VITIATION OF AIR BY DIFFERENT ILLUMINANTS.

The following table, prepared for the *Engineering and Mining Journal*, shows the oxygen consumed, the carbonic acid produced and the air vitiated by the combustion of certain bodies burnt so as to give the light of twelve standard sperm candles, each candle burning at the rate of 120 grains an hour:

Burnt to give light of 12 candles equal to 120 grs. per hour.	Cubic feet of oxygen consumed.	Cubic feet of air consumed.	Cubic feet of carbonic acid produced.	Cubic feet of air vitiated.	Heat produced in lbs. of water raised 10° F.
Cannel gas	3·30	16·50	2·01	217·50	195·0
Common gas	5·45	17·25	3·21	348·25	278·6
Sperm oil	4·75	23·75	3·33	356·75	233·5
Benzole	4·46	22·30	3·54	376·30	232·6
Paraffin	6·81	34·05	4·50	484·05	361·9
Camphine	6·65	33·25	4·77	510·25	325·1
Sperm candles	7·57	37.85	5·77	614·85	351·7
Wax	8·41	42·05	5·90	632·25	383·1
Stearic	8·82	44·10	6.25	669·10	374·7
Tallow	12·00	60·00	8·73	933·00	305·4
Electric light	none.	none.	none.	none.	13·8

Gas Engines and Electric Lighting.—Sufficient experience, says the *Leeds Express* of the 20th inst., has now been gained of the lighting by electricity of a portion of the Leeds new municipal buildings in Calverley Street to place its success beyond doubt. This result is the more gratifying, inasmuch as the employment of gas engines in driving the dynamo-machines which generate the electric current was, for long, the subject of strong opposition, and it was only by prolonged and persistent investigation, and after much trouble that those who pinned their faith to gas engines secured their adoption. The employment of steam engines and boilers would be inconvenient and expensive, while the cost of conveying the power from an out-building to the place intended to be lighted would not only have been considerable, but in transmission a serious proportion of the power would be lost. Thus, it was calculated that, supposing the copper in the mains for conducting the power cast £1 per light when the lamps were distant two hundred yards from the engine, it would cost £4 per light if they were distant four hundred yards; while there would be a constant loss in the conducting wires equal to about ten per cent. of the total power. Some members of the Corporation Committee, however, held that the makers of the "Otto" gas engines had now reached a point in their manufacture which did away with the risks and disadvantages urged against their use for this purpose. Those who visit the new library any evening now can see in the perfectly satisfactory nature of the lighting how well grounded this belief was. So perfect is the lighting, and so well have the "leads" been arranged, that the variation of power in the light from the top to the bottom of the building—from the starting place to the furthest point to which the power is carried—does not exceed two per cent. For the first few days of the lighting those who had predicted evil things of the gas motors found cause of complaint in a concussion produced by their working, arising from the explosion caused by the gas. This, however, was quickly remedied by the completion of the exhaust receiver—a brick enclosure filled with rubble, over-laid by a four-inch deposit of river sand; by which the noise of the explosion is rendered imperceptible. The engines are of 12 horse-power each, and are supplied from two 80-light meters.

THE ENTOMOLOGY OF A POND.—(*Knowledge.*)

BY E. A. BUTLER.

(*Continued from page* 224.)

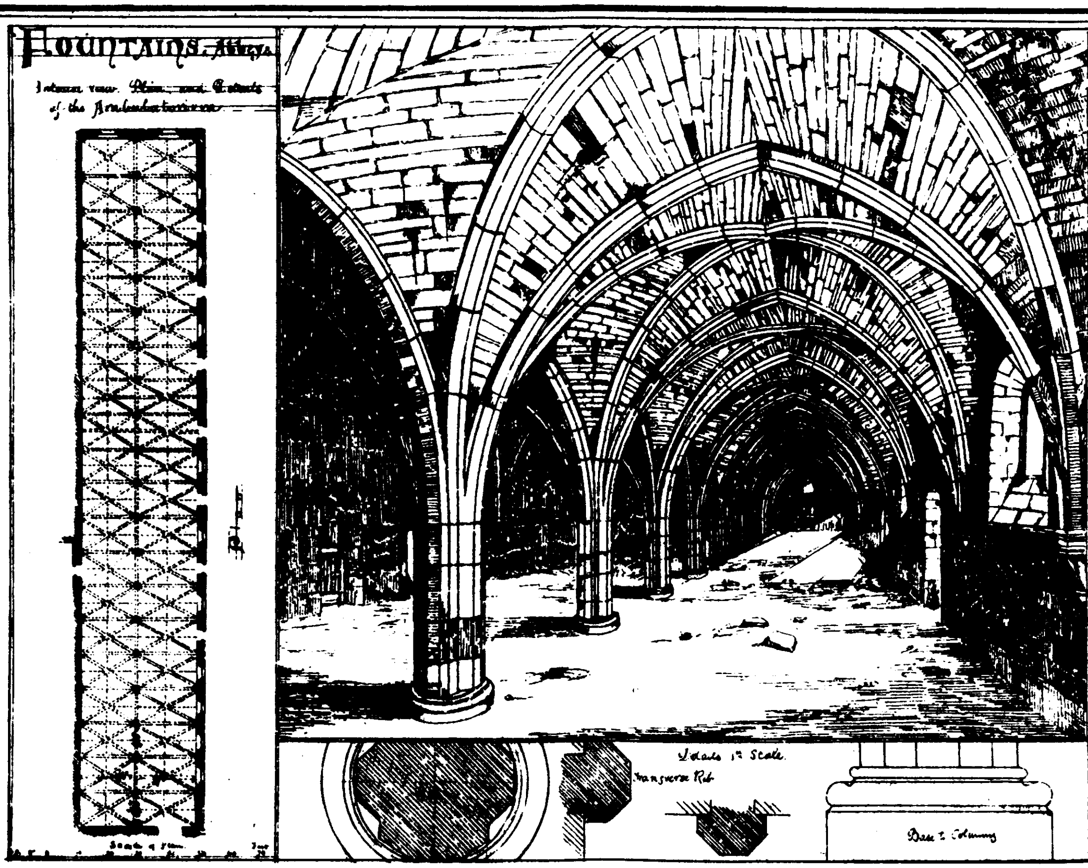
The Middle Depths.

About a month after the hatching of the eggs, it is time for this aquatic life to close, and an existence less gross and far more ethereal now lies before the little creature, which has, however, by this time nearly completed the cycle of its moral life, and so has but scant opportunity left to enjoy the greater freedom and pleasures which the acquisition of superior powers will bring. Within that ugly, limbless pupa-case has been formed a delicate, long-legged, feathery-horned, two-winged, sylph-like being, which, like the Prince in the old story of "Beauty and the Beast," is but waiting the removal of its hideous disguise to appear in all its rightful elegance and grace. The moment of deliverance having at length arrived, the pupa tail is brought up level with the surface, a considerable part of the thorax being thereby caused to rise above the water. The skin then splits between the two horns, and the imprisoned fly begins to emerge at the opening. This is the most critical moment in its whole career, for with head and thorax released, but legs still encumbered by their encasement, the creature is perfectly helpless and, at the same time, rather top-heavy, so that a sudden gust of wind may in a moment capsize the tiny boat and disappoint the hopes of the half-liberated fly, which can then look forward to nothing but a miserable death by drowning. If, however, no such mishap occurs, the struggling insect gradually drags out first one pair of legs and then another, and then, leaning forward, rests them on the water and draws out the third pair; then making use of the empty pupa skin as a sort of canoe, it soon dries its wings and mounts aloft to join its companions, who everywhere around are at the same time putting on their adult costume. In their society we will leave it for the present, hoping to meet it again later on.

The larvæ of the midges are called bloodworms, and are probably familiar to everyone who has kept a rain-water butt, for such receptacles often swarm with the wriggling, blood-red, worm-like things. They are also abundant in ponds, and, indeed in any stagnant water. The remarks made above concerning the life-history of the gnat apply in great measure to the present insects also. These red, worm-like things, however, must not be confounded with a certain red worm that also inhabits fresh water, forming vertical burrows in the mud of rivers; they are gregarious, and crowd their tiny burrows close together, remaining with their bodies partly protruded, and thus forming large red patches upon the mud, and it is amusing to see the sudden disappearance of such a patch as they all sharply retreat into their holes on the approach of an intruder. These, however, are not insects at all, but true worms, or, as they are called in scientific language, annelids, and have reached, in this vermiform condition, the highest stage in their development. The fly, which is the parent of the red wrigglers of the water butt and stagnant pond, is called *Chironomus plumosus*. The larva is rather more worm-like than that of the common gnat, and the pupa carries some elegant plumes of fine hairs on its ungainly thorax.

There is a beautiful little creature, clear and transparent as crystal, that is the larva of an another member of this group, and is noteworthy for the variety of curious appendages it carries on the fore-part of its body. Imagine an animal with a pair of arm-like bodies consisting of a stem with long bristles at the end, and used to lash the water, then a stout bundle of hairs movable *en masse*, then a pair of little saws, then a kind of policeman's truncheon, with bunches of hairs at the end, also capable of swaying backwards and forwards, and then a pair of jaws and a set of bristles, and you will see at once that *Corethra plumicornis*, as it is called, must have enough to do to manage properly all these contrivances. Such is its transparency, that it may easily elude observation till its wriggling, jerky motions betray its presence. This same transparency, however, affords wonderful facilities to the microscopist for the study of its internal anatomy and physiology, for, by aid of the microscope, all that is going on in its interior is made plainly visible. It is, of course, a distinct advantage to be able to study the action of an animal's internal organisation without interfering with the free action of its parts, or placing it under abnormal conditions, as there is thus less chance of mistaking for essential peculiarities accidental ones, such as might be induced by the altered circumstances. It is not to be wondered at, therefore, that this creature has become classic by having been made the subject of elaborate investigation by more than one observer; and, indeed, there are few more entrancing occupations to those who have a desire to search out the secrets of nature than to watch, hour after hour, under a good microscope, the varied actions and vital processes of this and other minutiæ of animal life. It must not be ignored, however, that the very transparency of parts tends also to introduce a certain element of difficulty into the investigation; for where several organs overlie one another it is not always easy to trace their relative position, and it becomes necessary to examine the object from different points of view before such a matter can be settled.

Through the transparent skin of Corethra can be seen, first the whole of the digestive apparatus, forming a long tube of varying diameter, stretching almost from one end of the body to the other; then, on one side of this (the mouth side) can be traced the greater part of the nerve system, looking like a long string, with knots tied in it at tolerably regular intervals. Where it approaches the mouth, however, the string divides, and sending one branch on each side of the throat tube, terminates on the opposite side of the digestive tract in a double mass of nervous matter, which is all the representative of brain the poor creature possesses. Then all down the back (to be traced with a little more difficulty, on account of its extreme transparency) is the "dorsal vessel," as it is called, which is an insect's equivalent of a heart. Those who have kept silkworms or other pale, smooth-skinned caterpillars, will probably have noticed this apparatus as a dark line running along the back just underneath the skin, and alternately contracting and expanding from behind forwards at the rate of from forty to fifty pulsations per minute; in the present insect the pulsations are not so rapid, being only about twelve per minute. Then there can be seen the numerous oblique bands of muscles by which it is enabled to effect its wriggling movements, as well as those strips by which the motions of its various appendages are controlled. Again, at each of two places, one near the head, the other much farther down, will be noticed a pair of black bags, which are air-receptacles connected with the system of breathing-tubes distributed over the body; the tracing of these latter, however, is, on account of their extreme minuteness, a matter of much more difficulty. At the tail there are two tufts of feathery hairs, one at the end, the other at the side; small though they are, the hairs are hollow, and connected at their base with the tracheal system, and, whatever other function they discharge, they evidently take part in that of respiration. All these aquatic fly larvæ are more or less transparent, but we have chosen the present for more detailed reference, because its superior transparency renders it best adapted for microscopical investigation. Like the rest of its brethren, it is carnivorous, and its favourite dish seems to be the quaint little creatures called, from their spasmodic, jerky movements, water fleas, though they are not fleas at all, nor, indeed, even insects, but belong to the group of animals of which crabs, lobsters, and shrimps are the most familiar representatives. These specks of creation, which are



considerably more minute than our household fleas, are caught and crunched by Corethra in considerable numbers, and with great avidity. To facilitate the crushing of their hard horny skin, it is furnished with a pair of strong jaws, carrying stout, tooth-like projections.

The large and important group of water-beetles now calls for notice. They are readily divisible into two sections, which differ considerably both in structure and habits. One of these, called the Hydradephaga, is a carnivorous group, and contains, along with a multitude of minute species, some large and highly-predaceous insects. They are, in fact, the aquatic representatives of the most highly carnivorous of all the Coleoptera, the active and rapacious ground-beetles, which are, to beetles generally, as lions, tigers, wolves, and jackals are to the rest of quadrupeds. The Hydradephaga, therefore, are to the ground-beetles as seals, sea-lions, and warlruses are to the above-named terrestrial carnivora—viz., a section of the group specially modified for an aquatic existence, and having as their appointed duty the repression of the super-abundance of aquatic life, just as their terrestrial brethren do their best to prevent an excess of population on land. This function they fulfil admirably, for they are extremely voracious, especially the larger kinds—*e. g.*, one large insect, found on the Continent, was observed on one occasion to devour two frogs within the space of forty hours. They will also attack young fish, as well as other insects. The other group, called the Philhydrida, contains fewer large and conspicuous insects, though one of its members is the largest of all our British water-beetles; they are to a great extent vegetarian in diet, at least in the perfect state, and so remind one of the dugongs and manatees of the mammalian world. To gain a clear notion of the difference between these groups, it will be well to consider a typical example of each; fortunately there are two large insects which are common and well-known, and will very well serve to illustrate the points of distinction. They are the Water-beetles, *par excellence*, *Dytiscus marginalis* and *Hydrophilus piceus*. The former is the carnivore and the latter the herbivore, for which reason Dytiscus is eschewed and Hydrophilus welcomed as an inhabitant of an aquarium.

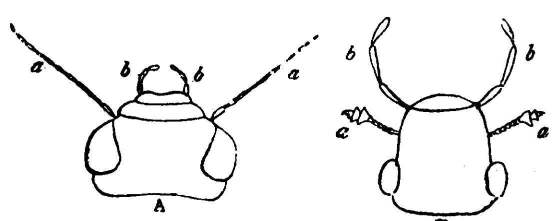


Fig. 1.—Heads of (A) Dytiscus and (B) Hydrophilus.
a. Antennæ. *b.* Maxillary palpi.

Looking first at the general appearance of the two insects we see that while both are of an oval shape, an obvious advantage to creatures that have to cleave their way through the water, the former is a good deal flattened and the latter more convex; in colour, too, they differ, Dytiscus being olive brown with a yellow border, and Hydrophilus uniformly black or olive-black, a difference which is hinted at in the specific names "marginalis" and "piceus." Descending now to structural details, we find the greatest differences in the appendages of the head (Fig. 1). In the carnivore the antennæ are long and thread-like, but in the herbivore short and clubbed; this point, however, may not be made out at a first glance, as Hydrophilus frequently carries its antennæ packed away close to the body out of sight, and flourishes instead a long pair of thread-like organs very similar in appearance to antennæ of Dytiscus, but different in function, differently placed, and composed of fewer joints. These organs are the maxillary palpi, and are attached to the maxillæ or secondary jaws, and correspond to the organs terminating in a hatchet-shaped joint we refe red to when considering "ladybirds." Dytiscus has similar organs, but not so conspicuously developed, and hence they are apt to escape observation, the long, thread-like antennæ being the first things to attract attention.

Examining now the legs in our two typical insects, we see that while the hind pair in each are fringed with hair, and compressed so as to become natatorial, this modification is carried out most completely in Dytiscus; again, whilst the first two pairs are near together in the brown beetle, and the third is placed much farther back, thus giving plenty of room for an extended backward and forward movement in swimming, those of its black cousin are much more regularly disposed. There is a curious point about the hind legs that deserves notice. In beetles, generally, the legs are attached to the body by a rounded joint, which is "let in" to a corresponding perforation in the chitinous armature with which their under surface is protected, and is capable of more or less free movement therein, an arrangement which permits motion of the legs in various directions. If now the hind legs of Dytiscus be compared with those of other beetles, this basal joint seems to be wanting, and the leg therefore seems to have one joint fewer than usual. But it will be observed that each leg is attached to a broad plate (Fig. 2), the pair of which stretch right across the body, and are prolonged in the centre into a bifid spine, which is differently shaped in different species.

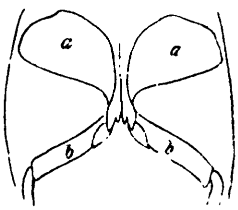


Fig. 2. Part of hind-legs of Dytiscus. *a.* Coxa; *b.* thigh.

Now these plates are really the much-expanded and greatly-modified *coxæ*, or basal joints above-mentioned. Their enormous enlargement provides a large area for the attachment of the muscles that move these limbs, and thus enables vigorous and powerful strokes to be made, though their immobility considerably impairs the freedom of movement of the limbs, and in fact limits it to the horizontal strokes which are most useful in swimming. The coxæ of Hydrophilus also are considerably enlarged, but do not attain the proportions of those of Dytiscus. The former, moreover, may be said to paddle rather than swim, moving its legs alternately, while the latter moves them both together, like a frog. Thus, in every respect Dytiscus is of the two much the better adapted for an aquatic life. Though the smaller insect, too, it has been known to attack and make a meal of its black cousin.

The distinctive peculiarities which characterise these two insects are exemplified more or less clearly in the majority of the members of the two groups. A large number of the Philhydrida, however, have ordinary ambulatory legs, and, indeed, are more given to crawling over subaqueous plants than to independent swimming, and some of the Hydradephaga even are somewhat similarly circumstanced, while the Gyrinidæ, which also belong to this group, are, as we have already seen, an exceedingly aberrant family.

A practical difficulty now suggests itself. Here are air-breathing creatures which spend their existence almost wholly in the water; how is their respiration to be conducted? It is well-known that the air necessary for the oxygenation of an insect's blood is taken in, not at the mouth, or any other part of the head, but through certain openings in the sides, which lead by short tubes to two long ones running the whole length of the body and sending out branches to the different parts. If an insect be cut open, these tubes appear as so many minute silvery threads, branching sometimes like the roots of a tree. Most of the spiracles, or entrances to these tracheal tubes, are, in beetles, situated on the upper surface of the back, under elytra and wings. The back is flat, and the elytra being somewhat arched, but fitting closely to the body at their outer edges, except at the extreme apex, a hollow chamber is thus formed over the spiracles, which can be filled with air, but to which the water has no access. In order to breathe, therefore, the insect repairs to the surface, and, thrusting the tip of its body just out of the water, with head sloping obliquely downwards, balances itself by means of its outstretched oars, whilst it receives the outer air into its air-chamber. The supply thus taken in enters the spiracles as required, and is sufficient to meet the demands of the insect for some time, so that it is perfectly free to enjoy its subaqueous life till the complete vitiation of this store renders another visit to the surface necessary. An advantage following this arrangement is that the wings are always kept dry and ready at any moment to bear their owner *per auras*, if the spirit of migration should come upon it. A similar arrangement holds good for the bugs described in the last paper, as well as for the Gyrinidæ.

The larvæ of these two great water-beetles are elongate, six-footed creatures, with powerful jaws (Fig. 1), presenting no sort of resemblance to the beetles themselves; both are carniverous and extremely voracious, dealing, destruction to great numbers of their companions in pond-life. The ordinary spiracles being aborted, their respiration is conducted through certain projections at the tip of the tail, which are thrust above the surface to imbibe air. Having passed a comparatively short life in the larval condition, the insect quits the water, and, forming a cell in the damp margins of the pond, there effects its change to the pupal state. In due time the beetle is produced from this, at first soft and pale, but acquiring, after a few days' exposure to the air, its normal colour and consistency. The female Hydrophilus forms a marvellous sack for the reception of her egg. It is composed of a gummy substance, the secretion of which is effected not in or near the mouth, but the other end of the alimentary canal. A tough, papery bag is formed, which carries a long spoke, and is attached to subaqueous plants. The eggs, about fifty in number

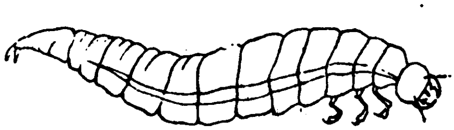


Fig. 1.—Larva of Hydrophilus piceus.

are regularly placed side by side within this, and are thus protected from the attacks of such aquatic creatures as might feel disposed to try the taste of beetles' eggs.

Another of the Philhydrida, a much smaller insect, of yellowish-brown colour, called *Spercheus emarginatus* (Fig. 2), which used to be found at Whittlesea Mere, and was supposed by many to have become extinct as a British species until recently rediscovered by Mr. T. R. Billups at a certain spot in the neighbourhood of South London, forms a bag which the mother carries about on the under surface of her body. This insect, both in the larval and perfect state, is described by the

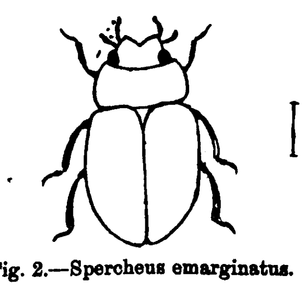


Fig. 2.—Spercheus emarginatus.

Rev. W. W. Fowler, who has kept and watched the species, as having the peculiar habit of walking on the under-side of the surface of the water with its back downwards, after the fashion of a fly on a ceiling, a thin film of air contained between the body and the edges of the elytra seeming to act as a float; the larva, too, is so completely permeated with air by means of its large tracheæ as to be rendered quite buoyant, and to find, apparently, as much difficulty in sinking as a man with a cork jacket on; so it needs no efforts to maintain itself in its inverted position just below the surface.

Water-beetles, as we have already said, are not confined to the water, but at night frequently leave their native ponds and enjoy themselves in the air, or migrate to other quarters. No collection of water is so small as not to prove attractive to them; even cart-ruts that have been converted into so many miniature canals by a heavy rain may soon become tenanted. They cannot boast of any great brilliance of colouring. Yellows of no very conspicuous hue, browns, greys and blacks, singly or intermixed, are the prevailing tints. Some few of the brighter yellow species are spotted with black, and so become rather pretty, and some of the Philhydrida, are slightly adorned with spots and patches of a metallic tint something like that of "peacock copper ore," but with these few exceptions they are a sombre set of insects, and their chief interest certainly lies in the remarkable modifications which fit them for aquatic life.

We now pass to the Dipterous fauna of the middle depths. The Diptera it will be remembered, are the two-winged flies, and none of these in the perfect state inhabit water; some, however, are aquatic during their two earlier stages. Omitting a few very aberrant forms, there may be considered to be two very distinct types of flies, one slender, with abnormally long and fragile legs, and with antennæ of moderate length, and frequently tufted or fringed with hairs; the other stouter and more substantial, with much shorter legs, and antennæ so inconspicuous as often to be unnoticed. It is to the former of these groups that most of the species whose larvæ are aquatic belong. They consist of certain kinds of gnats, midges, and daddy-longlegs, insects whose *names* are as familiar as household words, thought no very exact signification appears to be popularly attached—at any rate to the two former of these, which are often vaguely used for any minute and delicate flying insect, of whatever nature. Very varied are the habits of the long-legged, long-horned flies: some of them are the causes of certain gall-like excrescences that occasionally disfigure plants, and inside which their larvæ live; the larvæ of others, again, live in the earth, especially in damp places, and it is only a few members of the group that are aquatic, and these we have now to deal with.

It may seem difficult to conceive of a method by which so fragile a creature as a gnat, which would be irretrievably damaged by contact with the water, can manage safely to convey its eggs into such a position as will permit the larvæ hatched from them at once to get into their proper element. Most wonderful, indeed, is the plan adopted. Finding some floating shred of straw, stick, grass, or other such support, the expectant mother rests her two fore-legs on this, allows the next pair gently to touch the water, and crosses the third pair behind to form a sort of vice in which to hold the eggs as they are deposited. Then a long oval egg is lodged in the angle formed by the crossed legs, with its longer diameter vertical; another, following it, is glued on to the side of the first in a similar position, and so on till some 200 or 300 are fastened into a sort of raft, or rather life-boat, as the mass is curved upwards at each end. Then the little vessel is abandoned to the mercy of winds and wavelets, and so floats about for a few days, benefiting by sun and air, till the growing embryos, finding their quarters too close, push open a kind of trap-door in the floor of the egg and take a dive at once into their watery home. They are quaint-looking creatures, with a big head and thorax and long, tapering body, and they swim about head downwards. Near the tail, a straight branch, carrying a number of hairs on its tip, projects at an angle with the body. This is a respiratory tube, and communicates both with the outer air at its tip, and with the trachael system at its base. All that is necessary for breathing, therefore, is that the tip of this tube should be above the surface. Accordingly, when at rest, the larva takes up this position, while at other times it goes wriggling about through the water, being of sufficient buoyancy to rise without effort to the surface when occasion demands. After several changes of skins the pupal state is reached, and and the last moult is accompanied by a remarkable alteration in the appearance of the insect. The head and thorax now appear as if thrown into one large mass, from which the body tapers away. But the most astonishing change of all is that which takes place in the respiratory system; the entrance to this is now transferred to the opposite end of the body, and appears as two small twisted horns projecting from the gigantic head. If now the insect were to retain its inverted position, there would obviously be no possibility of bringing these breathing horns nearer the air than a whole body's length; therefore, it turns a somersault in the water, and henceforth goes about head uppermost, an attitude which, when it is at the surface, brings the organs in question just above the water. Though the creature is now a pupa, and can take no nourishment, it is possessed of almost as much freedom of motion as before, and jerks itself about by vigorous wriggling of its awkward form.

(*To be continued.*)

Miscellaneous Notes.

Australian Timber.—A Board appointed to inquire into and experiment on the best kind of timber grown in the Australian colonies, and adapted for the construction of railway vehicles, has sent in its report. Among the woods which the Commissioners mention as suitable are blackwood, mountain ash, bluegum, and Gippsland mahogany. Under test the blackwood presented results which were superior to any other timber. The mountain ash was second to the blackwood for railway purposes. It should be felled, the Commissioners think, during the winter months, when it has attained maturity, and is between 4 ft. and 5 ft. in diameter, and it might remain felled for six months before being broken down into planks for seasoning. Bluegum should be treated in the same manner. Going somewhat beyond its reference, the Board deals with the question of timber licenses, and recommends that getters be compelled to pay for the timber felled, and to confine their operations to a given area, or otherwise that selected lots of trees be sold by tender. It is also strongly recommended that a forest board should be called into existence. [The above, taken from *Engineering*, serves to show that the continually-increasing demand for timber is causing considerable anxiety, not only in Europe and America, but in every quarter of the civilised world.]

Diamonds in Australia.—The diamond field of Bingera, New South Wales, bids far to rival in richness the famous Kimberley District of South Africa. During the last few months hundreds of diamonds have been discovered, the size and number increasing with the depth of the diggings. The work of the miners has been seriously impeded for want of water for washing purposes, but recently a plentiful supply has been struck at a depth of from 50 to 60 feet, the result being not only increased activity on the part of the diamonds miners, but also the formation of new diamond mining companies, and the taking up of nearly all the land in the district for diamond-mining purposes.

Bleaching Tallow.—*The Oil, Paint and Drug Reporter* recommends the following as the best process known to it for bleaching tallow:

About 50 lb. of caustic soda lye are placed into a clean boiler and the steam is turned on. Salt is then added to the lye until it shows 25-28 deg. B. The fat—300 lb.—is now placed in the boiler, and the steam is turned on until the mass is brought to a boil, when the steam is shut off to prevent overflowing. It is allowed to boil up 1-2 inches at the most, and then left to itself for 3 5 hours, so that the fat will clarify. At the end of this time, the upper saponified layer is ladled off; the pure tallow is removed and passed through a hair sieve or linen into a clean vessel, until the lower saponified layer is reached. The residue in the boiler, consisting of sponified fat and lye, is removed and used in the preparation of curd soap, together with the upper layer.

The kettle is thoroughly cleansed, and about 30 35 pounds of water with ¾-1 pound of alum are heated to boiling. To this solution the fat is added, and the mass is allowed to boil for about 15 minutes, until all the filth has disappeared from the fat. The mass is then transferred to another vessel, and left by itself for 3-5 hours.

The pure fat is then again placed into the boiler and heated to boiling, until it shows a temperature of 170 200 deg. C. In this last operation the fat becomes snow-white. The steam must be turned off as soon as the slightest trace of vapor of a disagreeable odor is thrown off. The fat may then be directly used or left to cool.

As has already been stated, the steam must be turned off or the fire removed as soon as a trace of disagreeable vapors becomes visible, whether the temperature be 150 deg. C. or 170 deg. C., for if this is not done the fat will again turn dark.

Freshly rendered, sweet fat (not acid or rancid) is most readily bleached, and may be heated quite high. Still the fat used should not be too fresh, or one will take the risk of saponifying the 300 lb. without leaving any to bleach.

Tallow which has been treated in this way, when used in toilet soaps, gives them a white color and agreeable odor. It is also adapted for candle-making, as it becomes exceedingly hard.

PASTE FOR PAPER HANGING.—Beat up four pounds of good white wheaten flour in cold water—enough to form a stiff batter—sifting the flour first, and beat it well to take out all the lumps. Then add about two ounces of well-powdered alum. Have a quantity of boiling water ready at hand, take it boiling from the fire and pour it gently and quickly over the batter, stirring it rapidly at the same time; and when it is observed to swell and lose the white color of the flour, it is ready for use. The quantities here indicated should make about three-fourths of a pail of solid paste. It is recommended not to use it while hot, as when cool it adheres better and goes further. A little cold water poured over the top of the mass will prevent the formation of a skin from the drying out of the paste. When about to use, a small additional quantity of cold water should be added, so that the paste will spread easily and quickly under the brush. In warm weather this paste must be used quickly, as it cannot be kept for many days without fermenting and souring, when it becomes thin, watery and useless. If it be desired to avoid this, the addition of a few drops of carbolic acid to the mass when it is prepared will enable it to be kept almost indefinitely.

DAIRY INDUSTRY OF CANADA.—The dairy industry of the Dominion of Canada is an indication of the remarkable development of the country in recent years. In 1866 the export of butter was 10,448,789 pounds, valued at 2,000,000 dollars; and of cheese, 8,700 quintals, valued at 123,000 dollars, making a total of 2,217,764 dollars. In 1883 the total value of both exports was 8,157,000 dollars, of which 1,705,817 dollars went to the account of butter, and 6,451,870 dollars to that of cheese. It is also remarked that whereas in 1871 there were in the Dominion 353 cheese factories, there are now more than double that number.

MANUFACTURED MANURES.—During the past ten years the production of manufactured manures has become one of the great industries of the United States, the commercial fertilisers manufactured during the last census year amounting in value to $19,921,400. South Carolina is the chief source of mineral phosphates in the States. In 1880 the total number of establishments for manufacturing commercial manures was 270, and the total product 727,453 tons. South Carolina ranked tenth in the number of establishments, fifth in the product by tons, and fifth in the value of the products, being in advance of all the other Southern States, with the exception of Maryland. In 1880 there were seven fertilizer-manufacturing establishments in the State, which turned out 64,794 tons of fertilisers, of the value of $1,537,236.

PROGRESS OF MANITOBA.—The annual report of the Department of Public Works, presented to the Manitoba Legislature, states that notwithstanding many drawbacks incidental to the opening up of a new country, such as the want of roads, bridges, schools, churches, railways, &c., a steady stream of immigration has poured into the Canadian North-West, the immigrants being for the most part of the best possible description, people of a well-to do class from Great Britain and from Northern Europe, as well as from the other provinces of the Dominion. The people spreading themselves over the fertile prairies of Manitoba have manifested a pluck, energy, and intelligence which give the strongest idea that in the near future Manitoba will be placed in the front rank in the Dominion, holding her own for commercial enterprise and prosperity, as well as for social and educational privileges. It is also stated that a large number of bridges have been built during the past year; that many miles of drainage have been constructed, and a large quantity of grading and road-making completed. It is further stated that the total assessment of the 65 municipalities in the Province reaches a total of $98,300,000.

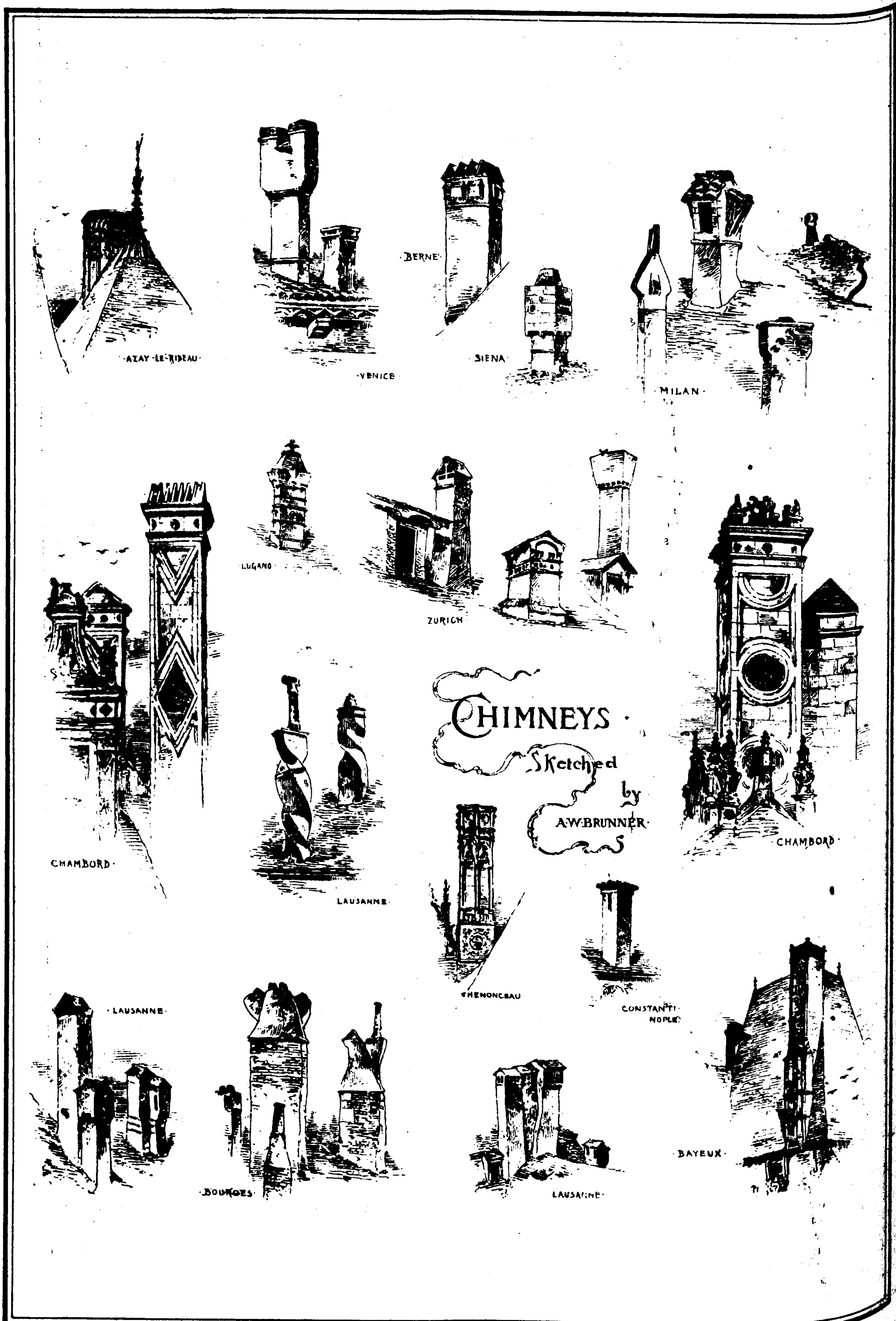
WHALE MEAT FOR HUMAN FOOD.—Some experiments have been made in Norway relative to its use. It is reported that at a recent dinner given to a number of persons interested in the question, it was proved that the article may be prepared for the table in numerous ways, and that various parts exhibited a great want of resemblance, some tasting like turtle, some like beef, and others being as tender and delicate as chickens.

NEW USE FOR PAPER.—AN ingenious individual has discovered a new use for paper, being nothing less than its employment for what he terms a "paper-pad shirt front." According to his plan the bosom of the shirt will consist of several layers, which can be pulled off as desired, each layer on being removed exposing to view a snow-white surface, on the principle of the ordinary blotting-pad. Ingenious as this thrifty-minded inventor undoubtedly is, he has been quite outdone by another, who has devised a method of printing in instalments on the back of each layer a sensational tale of absorbing interest. This, it is calculated, will have the effect of materially increasing the demand for the paper-pad shirt, as so irresistible will be the influence of the story in the direction of continuous perusal, that, instead of removing a layer each day, as contemplated by the first inventor, the wearer will find himself unable to bear the suspense involved by delay in following the course of events in the exciting fiction, and will strip off the layers in quick succession.

A NEW INVENTION.—Dr. George Hand-Smith, well known in the scientific world as a patient student of analytical chemistry, seems to have hit upon a new method of painting upon stone, or rather in stone. His discovery has, doubtless, a future. The free exhibition in Piccadilly Hall, to which amateurs and scientific students are admitted simply on presenting their cards, tells its own tale. After years of patient experiment, Dr. Hand-Smith has got a line of colour to travel down into stone or ivory unaltered, and without spreading beneath the surface. It took him three years to get the colour "keen"—then the rest seemed to follow speedily. The colour at a certain stage "becomes alive;" its molecules seize on the stone molecules and eat their way down without swerving. Any stone can now be painted to almost any depth. On removing the surface the picture remains indelible as the colour reaches, and it is absolutely indestructible. Specimens of Mr. Poynter's work in this new stone-colour art, Miss Butterworth's decorative scrolls, and others are on view, as well as numerous pieces of marble treated to various depths. The colour is a metal oxide, forming part of the stone, and is, therefore, not oxidisable or perishable. The stone thus treated becomes translucent like alabaster, and some very beautiful ruby, emerald, and sapphire-looking slabs are shown against the light, looking like the finest stained glass. From an artistic, decorative, and architectural point of view alike, the invention seems to us to be of very great importance, and it has won the admiration of Mr. Norman Lockyer and other men of science.

THE HUDSON'S BAY ROUTE.—A report on the opening and closing of navigation at York Factory on the west coast of Hudson's Bay, with observations extending from 1828 to 1880, has been communicated by Mr. W. Woods to the Hudson's Bay Company. The latest recorded date of open water in spring is June 1, the earliest closing of navigation November 3. The earliest recorded date of opening was May 4, the latest date of closing December 9. There is, therefore, some six months of open water on the average in the bay itself, but the communication between the bay and the Atlantic can only take place through Hudson's Straits, and this passage is only clear in July, August, and September, with probably a part of October. Further information on this head is much needed, and it is satisfactory to learn that Hudson's Bay is shortly to be properly surveyed, for the question of its navigability is a most important one to the settlers of Manitoba and the Saskatchewan, since they can ship their exports for Europe by this shorter route, instead of by the Red River and the St. Lawrence.

A DISEASED coffee leaf from Natal has been transmitted to Kew by Prof. Macowan, Director of the Botanic Garden, Cape Town. It has been examined by Mr. H. Marshall Ward, lately employed by the Government in the investigation of the coffee disease in Ceylon, and he finds it attacked with a typical form of the fungus *Hemileia vastatrix*, to which the well-known leaf-disease of that colony is due. This is the farthest westward extension of the disease at present. Eastward it has long maintained a position in Fiji.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VENICE
BERNE
SIENA
MILAN
LUGANO
ZURICH
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CHIMNEYS
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LAUSANNE
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CHENONCEAU
CONSTANTI-NOPLE
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