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Canadian Magazine
of
Science and the Industrial Arts.
Patent Office Record.

Vol. 11. MAY, 1883. No 5.

Communications relating to the Editorial Department should be addressed to the Editor, Henry T. Bovey, 31 *McTavish Street, Montreal.*

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

No notice will be taken of anonymous communications.

NEW BOOKS.

The Student's Mechanics. By W. R. Browne, M.I.M.E. (London: Chas. Griffin & Co.)

The object of this well written little book is to exhibit the *Foundations* on which the Science of Mechanics rests in such a manner as to enable the student to comprehend more fully the principles of mechanics as applied to practical construction. The author in his preface makes the following pertinent remarks:—

"The successful prosecution of Mechanics, especially as applied to practical construction, chiefly depends on the obtaining a clear and thorough mastery of a few leading principles (*e.g.*, the Composition of Forces, the Principle of Moments, the Doctrine of Energy) which are alone necessary for the solution of almost all the problems of ordinary practice. It is, of course, easy to learn such propositions sufficiently for the purposes of an examination . it is by no means easy to know and understand them so thoroughly as to be able to use them freely and confidently in attacking questions of practical importance."

That the author has largely succeeded in his aim to facilitate such a study will be granted by all who may read his work, and it may be of interest to give a brief notice of his method of treating the subject.

Part I is devoted to *First Principles,* and commences by pointing out the *deductive* character of mechanics. Motion, force, and their measurement, matter (the meaning of which is usually left to the imagination of the student), and its measurement, are explained clearly and simply. The statement of the laws of motion and their resulting equations is novel and interesting, while the exposition is clear and easily understood by readers of very ordinary mathematical attainments. This is followed by the *Composition of Forces,* and Part I concludes with a concise explanation of the laws of energy, a study of which will render easy of solution many questions involving energy and work, and of great practical importance.

Parts II, III and IV deal respectively, with statics, kinematics, and dynamics. In the last, after describing the effect of impulsive forces, the motion of a particle in a curved line, etc., the author discusses very fully the subject of elasticity and deduces certain definitions and laws, concluding the chapter by a further development of the principles of energy and work.

We feel sure that the Student's Mechanics will realise the expectations of its author and prove a most useful text-book.

Practical Carpentry; By Fred. T. Hodgson. (The Industrial Publication Co., New York.)

This useful little handbook makes no pretentions to originality but gives, in small compass, the gist of larger and more expensive publications, which will probably be beyond the pocket of most of those for whom this is intended.

It aims at comprehensiveness and beginning with practical geometry goes on to describe arch centreing; window tracery, various descriptions of roofs, mitreing of mouldings, dovetailing, mortising and tenoning, door hinging, etc., and concludes with quite a bewildering variety of subjects, more or less connected with practical carpentry, such as estimating cost of work, strength and resistance of timber of various kinds, mensuration of superficies, elements of drawing, weights and measures and a form of building contract.

One would like to have seen the important subject of stair making receive greater attention in a work on practical carpentry but as Mr. Hodgson promises us shortly a separate work to be devoted entirely to this subject we will look with interest for it.

We should have liked also if one or two of the subjects touched upon had been pursued a little further, even though it had been at the cost of leaving out other less germane subjects, but taking it as a whole we think Mr. Hodgson is to be congratulated on having compiled a small book which we feel sure will be helpful to every intelligent workman and for which every carpenter's tool chest should have a niche.

The Storage of Electricity, By Henry Greer. (New York. N. Y. Agent College of Electrical Engineering.)

The storage of electricity forms part of one of the most interesting branches of electrical engineering, and for some time past has been gradually assuming increased importance. Mr. Greer, in his pamphlet on the subject, leads up to the various storage systems by a preliminary discussion of electrical action and reaction, the laws of polarization, the effect of heat, current density, the state of the surface, etc., upon *storage power*.

The Planté, Kabath, Houston and Thomson, and Sutton batteries are briefly sketched, and the salient points of many others are also touched upon, but the chief attention is directed to the Brush storage system, the advantages of which are set forth in such a manner as to impress the reader with the opinion that this system is the best.

The descriptions are popular and readable, and much information is given in a compact form.

Winds and Ocean Currents. By C. A. M. Taber. (Boston: A. Williams & Co.)

In this work, Mr. Taber propounds a theory explaining the principal causes which produce the great prevailing winds and ocean currents.

N. B.—It should have been stated in the last number that the illustration on page 113, viz., "Mountain Homes," was taken from "Building," edited by W. T. Comstock, New York.—*Ed.*

Engineering, Metallurgy, &c.

ENGINEERING EDUCATION.

BY PROF. C. H. McLEOD, MA.E.

(An address to the Graduating Class of 1883, Faculty of Applied Science, McGill University).

Gentlemen, Bachelors of Applied Science :

It is my pleasing duty to address you this day on behalf of the Faculty of Applied Science as Graduates of the University.

It is unnecessary for me to state to you that you have the best wishes of your Professors for your future welfare, and I do not propose to offer you any of the stereotyped advice so common on occasions like this. The best of advice or assistance that we can give is always at your command. Your progress and advancement in life is one with the progress and advance of our practical science school. You have, with us, deeply at heart, I feel assured, the development and perfection of engineering education in Canada. It is to this I would refer, and I trust that the friends of the University assembled here to-day to honor you and your fellow-graduates in Arts will pardon me if I depart somewhat from the usual practice and address you as gentlemen who, in graduating from the University, have taken upon yourselves responsibilities which involve not only the honor and fame of the profession to which you are about to unite yourselves, but also the adequate provision for the education of those who are to come after you in the study of engineering. We, of McGill, are of course chiefly interested in the perfection of our own methods and appliances of education. In order that we may more clearly understand our present position, let us briefly trace the development of modern engineering education.

Our early Engineers, both in America and the mother country, were largely self-taught men; men who rose from the ranks—carpenters, masons, bricklayers, blacksmiths—men having little of what is now called education, but men of courage and patience; men possessing judgments well trained in the observation of nature's laws; these were the men who, by years of persistent toil, founded the profession of engineering. We must always bear in mind that they were men who had to feel their way cautiously through unknown paths, and who only mastered some of the facts and principles which are now familiar to every student of engineering, after much labor and loss of time. There was no such thing as a school of engineering in those days; it was the dawn time of the science of engineering. As public works became more numerous and the demand for Engineers became greater, young men of a practical turn of mind were drawn to the craft—it had not then the rank of a profession—and found occupation as assistants to the older Engineers. In this way the system of apprenticeship arose, under which a young man upon payment of a premium or otherwise entered an Engineer's office to learn what he could. No attempt was made to teach him. He—the engineer of the future—had even yet to rise by self-teaching, but he was given an opportunity to see work being done; to acquire knowledge by observation.

Engineering literature presently began to appear and the apprentice had access to such works as, Pambour on Locomotives, Vicat on Cements, Wood on Railroads; books which were valuable because they had chiefly reference to actual works, being mainly descriptive. This was a time of fact, not of theory, a time when it had not yet begun to be fully understood that theory and practice are one.

While in England the system of apprenticeship continued to be the national school of engineering, the French people set about the education of their engineers in a different way. They established a polytechnic school. In this school, says Professor Vose, "it was recognized that civil engineering was largely a mathematical business, and it seemed to be assumed at the start, that if a little mathematics was good, more mathematics was better, and the most mathematics was the best; many leading minds in that eminently mathematical nation, set to work to reduce engineering to a mathematical science, and volume after volume, upon the location of roads, the stability of retaining walls, the transportation of earth, the application of descriptive geometry to the construction of masonry, and other like matters appeared, in which all the resources of the higher mathematics were exhausted, and which showed the authors to possess every accomplishment except, perhaps, a little common sense." But this statement, though no doubt true, is not the whole truth; the discussion of applied mechanics soon fell into the hands of men having practical as well as scientific skill, and finally the harmony of theory and practice in mechanics was reached and the science of engineering established by such men as Rankine, Weisbach, Willis, Reuleaux.

Professor Vose also informs us that the early American engineering schools were based on the model of the French school which he describes, and intimates that the ideal school was the one which could stuff into its students a maximum of mechanics, practical or unpractical. Here we find the other extreme in engineering education. Too much theory, too little observation and practice.

It is to-day recognized on all hands that mathematical skill must be tempered with a good deal of judgment and practical knowledge before it can be of any great use. But it is equally true that ever so sound a judgment, ever so much common sense, is quite at sea in an attempt to overcome even the simplest engineering problems without a sound scientific training in applied mathematics. Such a statement as this instantly calls to mind works of stability, works which have perhaps won renown for designers who were not scientifically trained men. There may be exceptions, but in general the designs of such men make up in massiveness—which implies unnecessary expenditure of labour and material—what they are unable to provide for by a skillful arrangement of the parts of the structure. There is a perversion of public taste in regard to massive structures, which, as Professor Rankine has observed, "causes works to be admired, not in proportion to their fitness for their purposes, or the the skill evinced in attaining that fitness, but in proportion to their size and cost." At least one of our ablest Canadian engineers and designers does not scruple to confess that he is hampered at every turn by lack of mathematical knowledge. We know that you, in the practice of your profession, will not have cause for such regret, for we have reason to be proud of the training given in McGill, in the subject of applied mathematics. We also know that you have the ability to apply it—to this, any one who has inspected your designs will bear testimony, and I may add, with regard to one of these designs in particular, that it has called forth the warmest admiration of one of our most distinguished engineers, to whom it was exhibited. I mention these facts because I wish those who are here to day to know that we have done and are doing good work, and also because I am going to point out presently certain defects in our instruction, defects which, with our present appliances are unavoidable.

We have seen that the competent Engineer must possess a sound judgment, and we know that to grapple successfully with any problem in engineering science, he must above all things have an intimate knowledge of the nature of the materials he is to employ and his knowledge must not be the knowledge that comes from hearsay, or from books alone, it must be the knowledge that comes of seeing, handling, analyzing and testing. He must know the action of his materials under the various conditions in which they are to be employed. Further than this, he should know how to set about testing his materials, be they iron, steel, sulphur-bronze, delta, stone, timber, cement or brick. He should be able to learn all about them, and to know what to expect of them. To discover the precise value of a material for constructive purposes, its limit of elasticity is of much greater moment than its limit of rupture. To determine the limit of elasticity of a material, involves the power to make very minute measurements. To determine the value of many materials, a chemical analysis is necessary. To understand thoroughly the properties of steam , the values of the different methods of jacketing ; the most economical steam pressure, speed or point of cut off for given conditions ; the relative merits of wet, dry and superheated steam ; and the innumerable other details connected with the management of steam ; the engineer must have the opportunity to study them beside an engine which can be converted at will into any required condition—an experimental engine, in fact—or else he must slowly learn from different forms of engines as he may chance to meet them in his practice. Now, to make these investigations constitutes the work of the mechanical laboratory, and this is just the kind of experience which is best fitted to educate the judgment, to ripen the discerning powers. We have the testimony of no less an authority than Mr. Faraday, that judgment is largely a matter of education.

It is the realization of these facts which has caused what we may perhaps call a reform in engineering education during the last few years. In all the leading schools of England and the United States, we find that extensive mechanical and physical laboratories have been established ; not show establishments, but places where every student has to do the work set before him with he own hands—where he learns to make fingers out of thumbs—and where, to the greatest possible extent, he draws his own conclusions. One of the great results of such an institution as this, is to impart to its students a love for original investigation and a knowledge of the methods of conducting such work, which will, in after years, prove of inestimable value, not only to the student, but also to the country to which he belongs. That such an institution has not been established in McGill is not our fault, nor the fault of the Governors of the university. We have not the means.

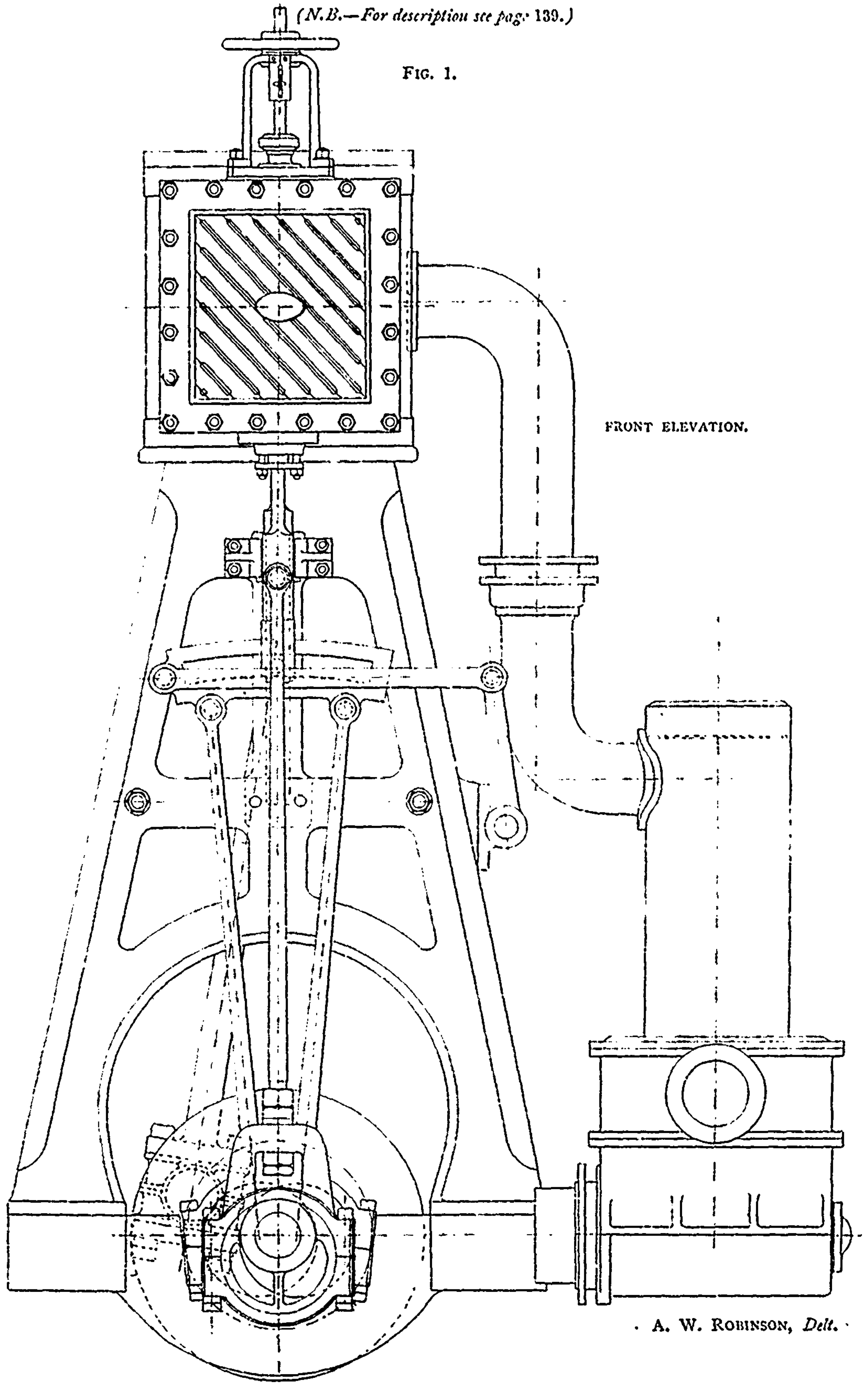
A beginning has at least been made. The students of the first year have for the past two years been doing practical work in the chemical laboratory, and the fact that we require our students to employ themselves on practical engineering work during the summer vacation, and to make a report thereon, and that in addition thereto, we have a six weeks course of field work in the autumn, will serve to show that we are not unmindful of the practical side of education here. But we look forward—and that in the very near future—to much greater things than these. Professor Bovey has already obtained estimates for an experimental engine, a testing machine, a dynamo, and several other important and desirable implements—the two first mentioned instruments would cost $8,000—and now we are anxiously seeking for the man who is to pay the bill, and we shall find him soon we hope. We are here, in the commercial metropolis of Canada, in the very centre of the manufacturing industries of our country, in a town where more wealth has been acquired during the last year than would endow a dozen universities. Should there, amidst such surroundings, be much difficulty in finding the few thousand dollars—say $20,000, which we require to establish a mechanical laboratory ?

I think not. Not at least if our men of wealth would for a moment give the subject the attention it deserves. We all have a common object, the development of the resources of our country, the improvement of the condition of our countrymen. It is our part in this work to educate those who will be the leaders, the moulders, of the Canada of the future ; it is theirs to provide the capital necessary for our proper equipment for this work, just as much as it is to provide plant for their mills and factories. The investment in properly directed educational work will, in the long run, yield the much larger return. Fortunately, we are not looking for support to men who have not already shown that they fully appreciate the necessity of meeting with a liberal hand the requirements of higher education. To the honour of the merchants and the manufacturers of Montreal, be it said, McGill is an

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.)

FIG. 1.

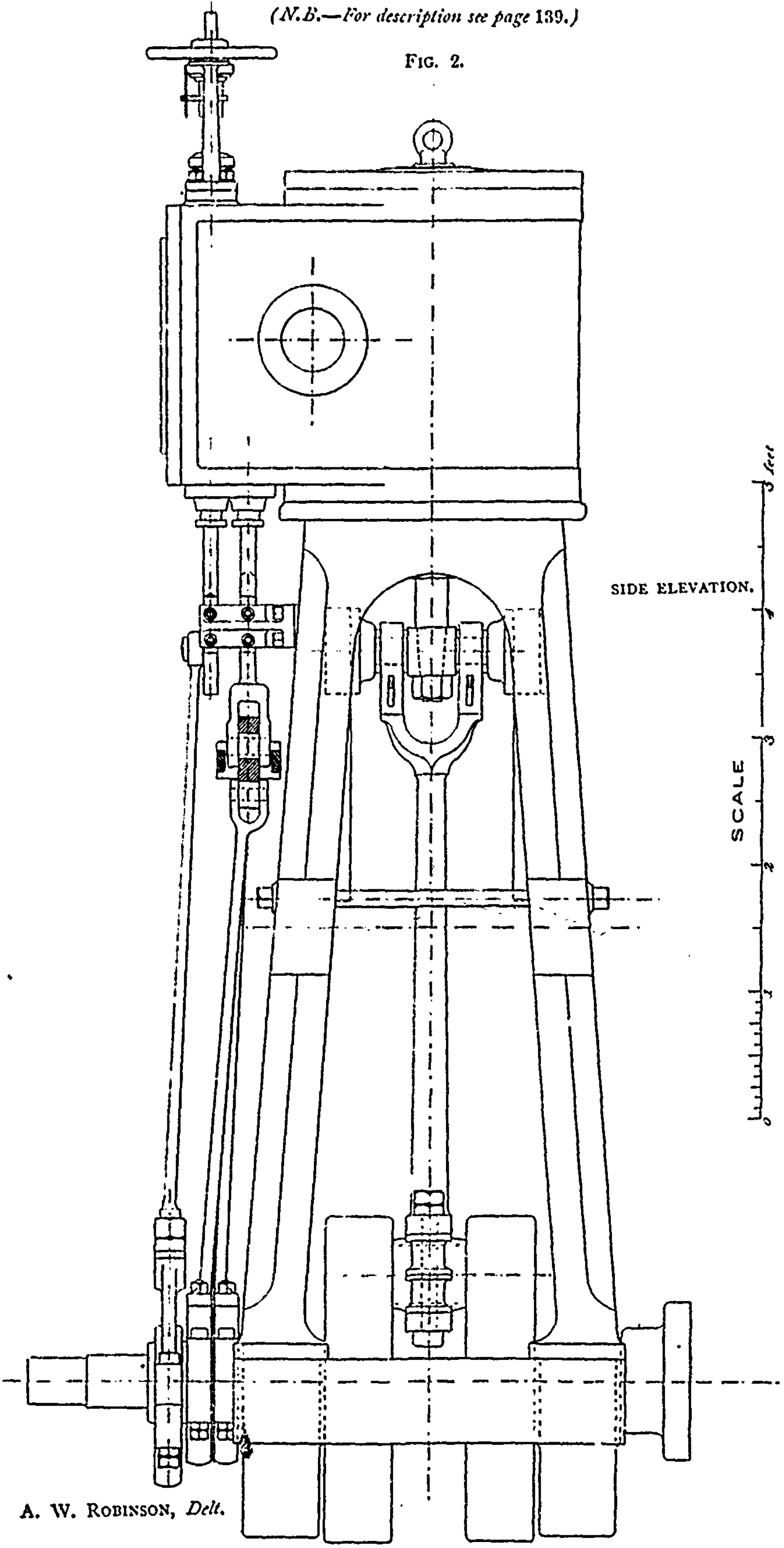


A. W. ROBINSON, *Delt.*

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.*)*

FIG. 2.



A. W. ROBINSON, *Delt.*

institution of their creation, and she need not fear but that by them she will be amply sustained.

My remarks have only been directed towards pointing out one of our most pressing needs—a need, to meet which would vastly increase our usefulness, and one which does not require any very large sum of money to supply. The larger wants of our school have recently been pointed out by Dr. Dawson and I need not refer to them here. There remains, however, one further development of our work which should not be long delayed, and which has not been publicly referred to.

If we are to keep abreast of the requirements of our time, we should very soon establish a course in Electrical Engineering. Such work is being taken up all around us. Cornell and the Massachusetts Institute of Technology have completely equipped schools. The Stevens' Institute is just about establishing one.

Our Faculty of Arts possesses a valuable collection of electrical and other physical apparatus, and is no doubt alive to the necessity of founding a physical laboratory. If this were done, and our mechanical laboratory properly equiped, a course in Electrical Engineering could readily be provided for.

Our school of Engineering was the first of its kind to be established in Canada ; for a time it stood without a rival, but during the last few years it has not been without competition. It is no boast to say that at present we are head and shoulders above our competitors, but if we would retain so honorable a position, it behooves us to study earnestly the educational requirements of our country, and to make fitting provision therefore. We have many advantages, and, we must not conceal it, we have some disadvantages. Amongst our advantages, we count it not the least that we have the wise counsel, the never-failing watchfulness of one to whom we all owe much ; he to whom our school owes its birth, whose fostering care has brought it through the period of infancy, and who now, in the days of its youth, spares neither his time nor his money to forward its objects—our Principal, Dr. Dawson. May we, be it at ever so great a distance, follow his example.

Gentlemen, farewell !

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CHARCOAL AS A FUEL FOR METALLUGICAL PROCESSES.[*]

BY JOHN BIRKINBINE.

(Concluded from Page 102.)

Comparisons of the operation of blast furnaces show that not only is the fuel consumption per ton of pig iron less with charcoal than with mineral fuels, but that the output is greater per cubic foot of capacity, although the bulkiness of charcoal prevents as much ore being in the furnace at a given time as is possible with mineral fuel.

Having considered the quantity of this fuel now used and its quality, the methods of manufacture may receive attention. Formerly all charcoal was made in heaps or meilers. In American practice kilns are rapidly superseding the more wasteful method, and retorts are now taking the place of kilns and meilers in many cases.

Meiler charring should not be employed except under peculiar conditions, and it has been fully described in the *Handbook for Charcoal Burners*, by Svedelien.

Professor Egleston presented to the Institute, at the Pittsburgh meeting, in May, 1879, a very complete paper on "The Manufacture of Charcoal in Kilns." It is, therefore, only necessary at present to consider the system of carbonization in retorts and compare it with the other processes.

At the Lake George meeting of the Institute, in October, 1878, I presented a paper "On the Production of Charcoal for Iron Works," in which the subject of carbonising the wood in closed vessels was considered and reasons were advanced for the more general adoption of this method. During the discussion which followed it was claimed that the collection of acetates was not practicable when charcoal was manufactured for commercial purposes. It is now my privilege to state that the production of charcoal is successfully carried on both in kilns and retorts, and the acetic vapors arising from the carbonization are condensed and made into commercial products.

There are now in operation at the Bangor Furnace, Michigan, fourteen kilns of eighty cords capacity, in which 16,000 cords of wood are annually carbonized, and the Elk Rapids Furnace, Michigan, also has 22 one hundred cord kilns in which 40,000 cords of wood are each year converted into charcoal ; the acetic vapors being exhausted from all of these kilns by Peirce's patent method and converted into acetate of lime and methylic alcohol. The two plants produce daily 17,000 pounds of acetate of lime and 250 gallons of alcohol. In addition, the Elk Rapids furnace has 3 one hundred cord kilns and 10 sixty cord kilns which are not constantly in use.

That the charcoal is not deteriorated by the collection of the acetic vapors is proven by the reports of the managers of these plants and by the remarkable records made by both these furnaces. It is doubtful if any other charcoal blast furnace in the country can show as good work for four consecutive years as that at Bangor. Concerning the discussion above referred to, Major Pickands, the manager, says: "We do not extract acetic vapors, nature throws them off from the wood in process of carbonization, whether that process takes place in a kiln, retort, or dirt pit, and we capture the vapours and utilize them."

The financial success of the chemical department at Bangor encouraged the more pretentious venture at Elk Rapids, and late reports from the latter furnace place it in the front rank for economical fuel consumption and large output.

A number of retorts are scattered throughout the country. The Baltimore Iron Company have sixteen horizontal retorts, the Port Leyden Iron Company have twenty-four Mathieu retorts, and a number of iron works now have or are erecting the latter. The Mathieu retort has met with most favor, and at present is being more rapidly adopted than others, because of its form and setting, and on account of the inventor's making the quality of his charcoal the first claim, and the quantity of acetates collected a secondary consideration. The forms of retorts in use in this country are generally iron cylinders, set either horizontally in nests over fire places, or vertically with flues surrounded them. Departures from this plan are the retorts at Coloma, Michigan, where a semi cylindrical iron bottom is covered by a fire brick arch. these forming a complete cylinder, and the Missau still, in which the carbonization is carried on by the use of superheated steam. This, however, is principally employed with resinous woods.

The Baltimore Iron Company report as the average yield of the horizontal retorts fifty bushels per cord. The Port Leyden Iron Company have been obtaining sixty-six bushels per cord. Part of this difference may be accounted for by the age and character of the wood used, but it is probable that a less uniform carbonization in the horizontal cylinders is obtained than in the Mathieu retorts.

These latter are made nearly crescent shape to give a practically uniform thickness of wood, and are set inclined over fire places. This method of setting is advantageous on account of the convenience of filling and discharging, and of its permitting any condensed acid to drain from the retorts when cold, thus preserving the life of the retorts. It is claimed that while in operation there is little danger of the iron in the retorts being attacked by acetic acid, because the heat maintainev is sufficient for volatilization. Some two hundred of the Mathieu retorts are in place or in process of erection at various works located in different sections of the country. They are constructed of a bottom plate of one-half inch wrought iron, which is protected by an arch of fire brick, the upper portion being formed of one-eighth inch wrought iron connected to the bottom by angle irons. A suitable cast-iron head, with removable door, is placed on either end, to which a nozzle for conveying the vapors from the retort is secured. Each retort is about fourteen feet long. The capacity is one cord of wood ordinarily cut sixteen inches long. With air dried wood, as

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[*] A paper read before the American Institution of Civil Engineers.

commonly used, the retorts require about sixteen hours for carbonization.

There are so many commercial uses to which acetates and acetic acid can be applied, and such possibilities open to any process which cheapens them, that it is strange so little attention has been bestowed upon collecting the immense quantities now wasted in charcoal production, while large works for distilling these products from wood have been erected at, or near to, our cities for supplying print works, etc.

But the importance of carbonizing in closed vessels is not based alone on the value of acetic vapors collected, and the market for them may be a matter of secondary consideration. It is the possibility of obtaining a greater yield from a given amount of wood which makes retorts valuable to those using charcoal as a fuel for metallurgical processes. Liberal averages for the various methods of producing charcoal from ordinary air dried wood of medium age and size are, for meiler charring, 30 bushels per cord ; for kiln charring, 46 bushels per cord ; for retort charring, 66 bushels per cord. A cord of wood will, therefore, produce as much charcoal in retorts as one and one-third cords in kilns, or as two cords in meilers. The reason for this is, that, as the heat is applied extraneously, none of the wood in the retort is consumed, while in the kiln part of its content are burned to carbonize the balance, and the meiler, being more open, less controllable, and of smaller content, wastes more wood than the kiln.

The saving of a large percentage of the wood required (particularly in some of the Western States where charcoal sills are as high as thirty cents per bushel), would soon pay for a plant of retorts, even if all the acetic vapors were wasted.

The first cost of a battery of retorts is considerable, but, based on the outlay per bushel of charcoal made, it compares favorably with the expense of kilns. When placed in nests, fuel for heating the retorts is seldom required, for the uncondensable gases resulting from the carbonization are generally sufficient to maintain the temperature of the retorts at the point desired. The amount of these gases available is insufficient in some parts of the process, and in others abundant, but where a number of retorts are operated together the deficiency of one is made up by the others. The convenience of filling and emptying retorts as compared with kilns compensates for the cost of cutting the wood.

The census statistics of 1880 show that eighteen billion feet of boards were cut in that year. Of this amount there was probably a waste of one-half cord in tops and branches left to rot in the clearings, or in slabs burned at the mills, for each thousand feet of boards saved, or 9,000,000 cords. This would have produced by improved methods probably 50,000,000 bushels of charcoal, or two and one-half times the quantity annually consumed in the country. There is, therefore, an opportunity to produce, from what is now wasted, fuel to do much to advance the industries of our country, and this paper has been prepared to indicate the possibilities of manufacturing charcoal economically in locations where, if it received consideration, most satisfactory results might follow.

If the expensive and wasteful process of producing charcoal in heaps or meilers is persisted in, the practical abandonment of this fuel may easily be prophesied. But if the economies of manufacture are carefully considered, charcoal will be found to be in many locations the cheapest fuel accessible for metallurgical purposes. A number of Pennsylvania charcoal furnaces produce pig iron with no greater money expenditure for fuel per ton of metal, than their near neighbors who use mineral fuels, and in that State the more modern methods of producing charcoal are not generally adopted.

Generally where woods are felled to produce charcoal, it is considered as sacrificing timbered areas. Such is not, or should not be the case ; for it is compatible with successful operations to carry on the production of charcoal in connection with lumbering, or other kindred industries. There is less merchantable timber consumed to-day, in the manufacture of charcoal, than is left in the woods by those who strip bark for tanneries, or cut railway sills and telegraph poles. The waste of the saw mills has been referred to above and needs no further comment.

An industry dependent upon charcoal as fuel must, to be permanent, maintain large forest areas, thus benefiting the surrounding country ; and much of the growing timber, being suitable for other purposes than charcoal making, will be so used whenever the compensation is greater. Anomalous as it may at first appear, the probabilities are that, in the near future, the large consumers of charcoal will be among the most enthusiastic patrons of forest cultivation and preservation.

THE MANUFACTURE AND APPLICATION OF ARTIFICIAL MANURES.—By Mr. Smetham.

(A paper read before the Liverpool Polytechnic Society.)

The manufacture of artificial manures may be looked upon as a modern industry. For many generations it has been known that to produce satisfactory results in the field it was necessary for the farmer to apply to the land manures, *i. e.*, plant food, to supply the loss which had been sustained by the removal of various elements from the soil. But in those former times, the knowledge was such as was obtained by experience only, and absolutely nothing was known of the means whereby crops obtained their nourishment. With the extension of knowledge in vegetable physiology and chemistry, the barriers which had blocked the way to a rational method of manuring were one by one broken down, and with this advance, in which the name of Liebig stands pre-eminent, the way was opened to artificial manuring, and consequently to the manufacture of artificial manure.

Before treating of the methods of manufacture now in vogue, it will be necessary to give a rapid glance at the general principles which govern the growth of plants, and the methods by which they are able to assimilate the food which is placed within their reach : otherwise a just conception of the advantages of the present processes will be impossible.

It must be clear to every one, that plants in order to grow, stand as much in need of food as animals or man. Whence then does the plant obtain this food ? In the first place it obtains whatever water it requires to build up its structure—principally from the soil. The carbon, the element next in importance, is obtained from the carbonic acid of the air, which is decomposed by the green colouring matter of plants (chlorophyll) and is thus assimilated. Since, in this climate at all events, there is an abundant supply of water and carbonic acid it is clear that it is quite unnecessary to artificially supply either of these. But when we come to the other elements which go to build up the structure of plants, the matter is far different. Of these nitrogen is an important element. It is absorbed by the crop chiefly in the form of ammonia or nitric acid, and it is found that although nitrogen in both these conditions exists, the quantity is by no means sufficient to supply the requirements of cultivated crop ; and as plants have not the power of assimilating the free nitrogen of the air, it becomes necessary to supply nitrogen to our soils if we would obtain remunerative results. In the remaining part of plants, the mineral-matters or ash, there are a great variety of elements. The principal of these are :—lime, magnesia, phosphoric acid, sulphuric acid, potash, silica, and chlorine. Soils, almost without exception, contain these these elements in greater or less extent, but few soils, in lands which have been long cultivated, contain the whole of these constituents in sufficient quantities to supply the want of our crops. It is not necessary, however, to use the whole of the foregoing list of elements in an artificial manure, since it is found, both by practice and by the analysis of various soils, that the majority of these are already there in sufficient quantities and in an available form. In the majority of cases it is therefore found that, of the mineral constituents the only two which are required are phosphoric acid and potash, and this latter is moreover only required in certain classes of soils.

For artificial manuring, therefore, the matter resolves itself into the manufacture of manures which shall contain phosphoric acid, nitrogen, and in some instances, potash.

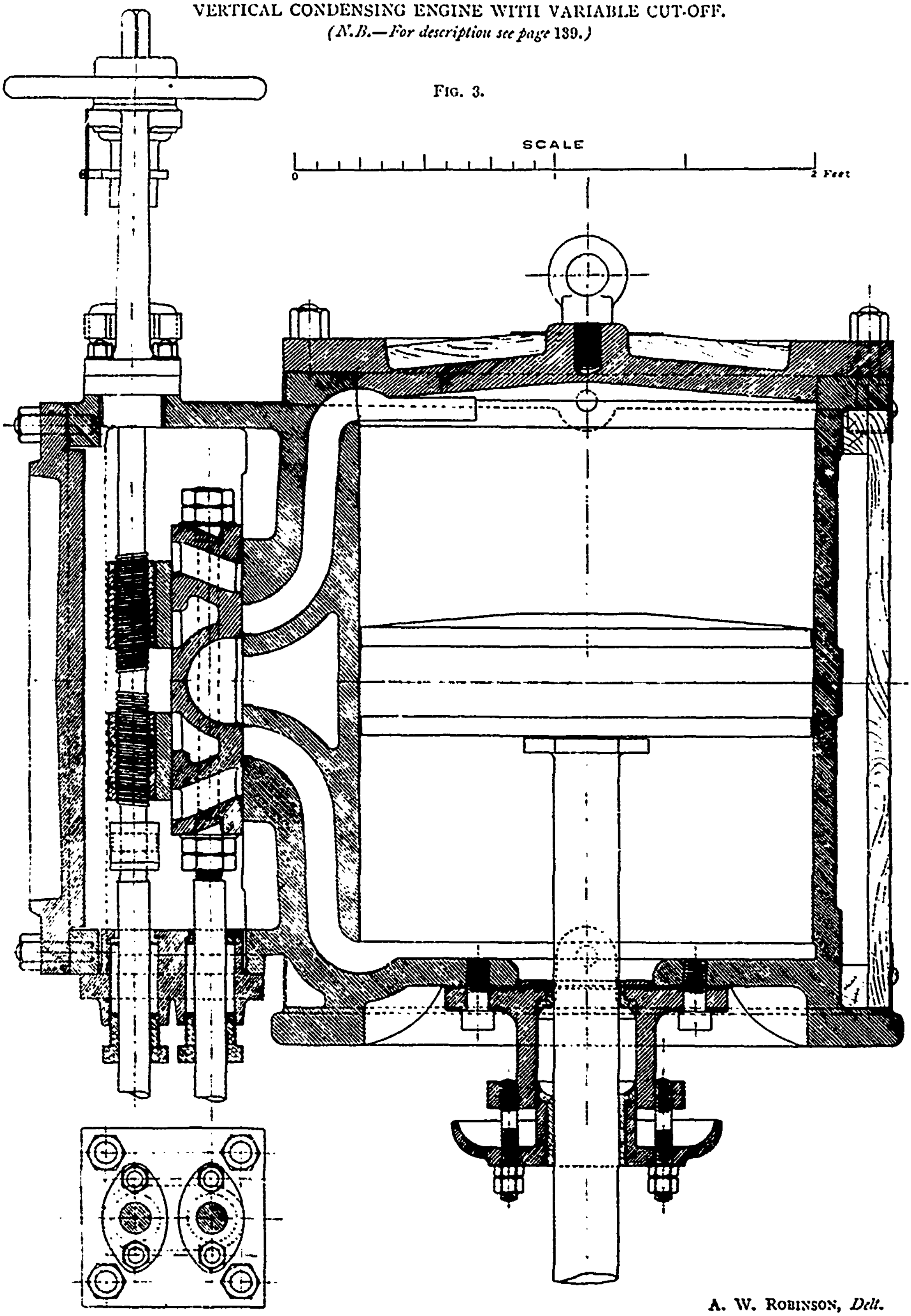
Fortunately there exist in nature large deposits of mineral phosphates, chiefly in the form of tribasic phosphate of lime, combined with a greater or less quantity of extraneous matter. The forms are various and found in almost every country—the most important from a commercial point of view, being Carolina phosphate, Apatite (Norwegian and Canadian), Estramadura phosphate, coprolites, and a considerable variety of so-called phosphatic guanos. Besides these mineral sources we derive a considerable quantity of the phosphate required for agricultural purposes from the bones of various animals, guano and such like animal products.

But, although phosphates are comparatively widely distributed in nature, it has been found that in the condition in which they exist they are, in the case of mineral phosphates, of little value as plant food on account of their practical insolubility in water. Before plants can avail themselves of the mineral constituents of the soil, it is necessary that these substances should be rendered soluble in water, so that they may pass by the rootlets into the plant. Some of the mineral phosphates are almost insoluble in water, and are only very slowly

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.*)*

Fig. 3.

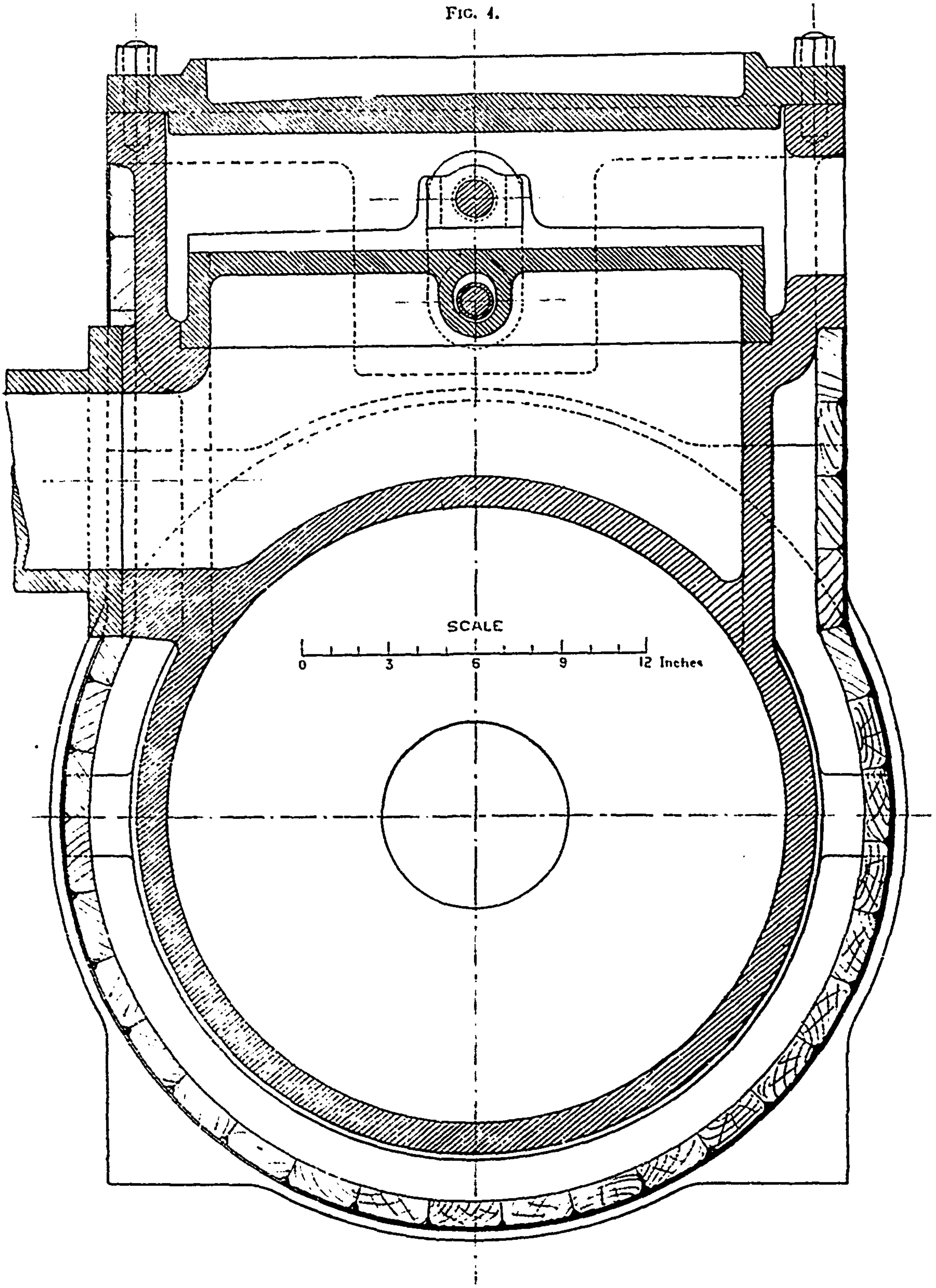


A. W. Robinson, *Delt.*

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.*)*

FIG. 4.



A. W. ROBINSON, *Delt.*

acted upon by the organic matter and carbonic acid, which comes into contact with them in the soil when they are used in the raw state as manure, and it is found that unless ground to an impalpable powder, the solubility is not sufficient to supply the requirements of a growing crop.

To Liebig is due the credit of first devising a means of converting the insoluble phosphate of bone into a soluble and readily available form, and the process was subsequently adopted for mineral phosphate by Lawes. This consists in treating the finely ground mineral phosphate with sulphuric acid, by which means the tribasic phosphate of lime is converted into monobasic phosphate of lime and gypsum, both of which are soluble in water. It is this substance, known in commerce as superphosphate of lime, which forms the basis of the great majority of artificial manures found in the market.

It will, therefore, be my endeavour to place before you the principles on which the manufacture of superphosphate is based and the methods by which it is accomplished, and afterwards to sketch the way in which the various manures are compounded from it. The capital invested in the manufacture of superphosphate and manures is enormous, and the industry is of such great commercial importance, that it is not to be wondered at that many forms of apparatus and modifications of processes have from time to time been devised to effect this object, but I shall restrict myself to the methods generally practised, without attempting to cover the whole ground. With this end in view I shall describe the processes followed in one of the largest and most modern of our manure works, and endeavour, as I proceed, to describe the principles which should regulate the successful working of the processes.

In all large manure works the manufacture of sulphuric acid is carried on, and for this purpose large chamber capacity has often to be provided. The purity of the acid is immaterial, and pyrites is, therefore, almost invariably used as the source of the sulphur. The methods by which the acid is formed are so well known, and have been described in so many books, that any description from me would be out of place, more especially as the manufacture of it is only a means to an end and not an essential part of the manufacture of manure properly so-called.

The mineral phosphate, if in the rock state, is first reduced in a Blake's crusher to a moderately fine condition. This reduction is brought about by a biting action of the machine, which answers its purpose admirably. Any other form of crusher which will reduce the rock to a sufficiently fine condition for the mill stones, through which it has next to be passed, may be used.

The phosphate is then ground between mill-stones until it will pass through sieves of forty meshes to an inch. The process so far, is entirely mechanical, and presents no difficulties to those accustomed to the use of such machinery, but the proper conducting of this part of the operation is of the utmost importance in successful working. A glance at the chemistry of the next operation will make this apparent. To convert the insoluble monocalcic phosphate, it is treated with sulphuric acid of about 1·55 specific gravity. The changes which take place are represented by the following equation:—

$$C_3 P_2 O_8 + 2 (H_2 SO_4 + 2 H_2 O) =$$
$$Ca H_4 P_2 O_8 + 2 (Ca SO_4 2 H_2 O).$$

This, doubtless, is only generally true, as on the manufacturing scale the decomposition is not absolutely complete, and other reactions in a minor degree take place; but the reaction given above is the one which should be aimed at by the manufacturers. But if the raw phosphate has not been ground sufficiently fine it must be evident that, as the acid is only used to conform with the equation given, the sulphuric acid will be diminished in quantity as the reaction proceeds, and the inner portions of the larger pieces of rock will remain unattacked, and consequently the process will be only partially complete, and a part of the phosphate will remain in an insoluble condition to the proportionate detriment of the manure. One of the great secrets of success is, therefore, to grind finely, and the finer the better.

The addition of the acid to the finely ground phosphate is made in what is known as a "horizontal mixer." The acid is contained in a tank with a gauge attached to it for the purpose of measurement, and is allowed to run into the mixer by removing a plug, and is then intimately mixed with the raw phosphates by means of revolving blades. The mixer is slightly inclined to admit of the mixture, which, directly after mixing, is fluid, being run of, when a plug, placed at the lower end for this purpose, is removed. The chemical action which takes place on the addition of the acid causes the temperature to rise very considerably, and it is, therefore, allowed to run into a reservoir placed below, which is technically called a "den," for the purpose of settling and cooling. A good sized "den" will hold forty tons, and may be filled in a day. After the superphosphate has been allowed to remain for a day it will have set and may be dug out and stored for further use. When properly manufactured superphosphate should be in a dry and almost friable condition, as, if at all wet or lumpy, it makes the process of sowing both difficult and unsatisfactory.

The proportions in which the acid and raw phosphate are mixed will depend upon the nature and composition of the phosphate and upon the strength of acid. The most convenient strength of the latter for ordinary purposes is 110° T (1·55 specific gravity).

None of the phosphatic materials are pure, or approximately pure tricalcic phosphate, and consideration has, therefore, to be taken of the action of the sulphuric acid upon these extraneous substances. The principal of these, for matters of calculation, is carbonate of lime. This will be acted upon before the acid attacks the phosphate, but its presence in raw phosphate in moderate proportions is by no means an unmixed evil, as the liberated carbonic acid tends to assist the intimate mixing of the materials, and the gypsum formed by the reaction helps to dry the manure. In large quantities it is prejudicial and renders certain phosphates practically useless except for mixing with other materials which contain but little or no carbonate of lime. The following table shows the quantities of acid of 100 °T which are required by 100 parts of the given substances:—

100 parts require	Sulphuric Acid 110 °F.
Tricalcic Phosphate	100
Calcic Carbonate	156
Ferric Oxide	97
Alumina	151
Calcic Fluoride	200

In practice, however, it is advisable to use a somewhat greater quantity of acid than is indicated in this table. In the majority of cases equal proportions of sulphuric acid and phosphate are found to yield satisfactory results.

Large quantities of superphosphate are sold without any further mixing, the farmer using his own judgement as to what he should apply with it. This is undoubtedly a good plan when there is the requisite knowledge, but it requires an amount of skill which is possessed by only a comparatively few of our agriculturists, and it is, therefore, better for the manufacturer to send out a prepared manure. When, however, the superphosphate is sold as such it should not be bagged until wanted, as it apt to cake and to destroy the bags.

From the description which I have already given of the various kinds of plant food it will be evident that superphosphate is valuable only on account of the soluble phosphate which it contains, the other constituents being of practically little value on the majority of soils. It is customary, therefore, to sell it on the basis of the "soluble phosphate" which it yields. This term has no strictly scientific meaning, but represents the quantity of tribasic phosphate of lime which would have to be rendered soluble in order to yield the quantity stated. So long as the custom is universal it is as convenient as any other basis and fairly represents the true value of the manure. Before leaving the manufacture of superphosphate it is necessary to point out some of the conditions which affect the stability of the compound. It has been long known that certain manures after having been kept for some time yield a less percentage of soluble phosphate than when first manufactured. This is what is technically known as "going back," and the phosphates are said to be "reverted" or "precipitated." The principal cause of this deterioration is undoubtedly the presence of oxide of iron and alumina in the raw material from which the superphosphate is manufactured. The phosphate of iron and alumina which are first formed react after a time upon the monocalcic phosphate and form calcic sulphate and ferric and aluminic phosphate, substances insoluble in water. It is, therefore, advisable in the choice of a raw material to obtain one which is as free as possible from oxide of iron and alumina.

It has been argued, however, by some interested in the matter that these precipitated phosphates are as valuable as the soluble phosphate, and that the manufacturer ought, therefore, to be paid for the phosphates which have been precipitated in the manure on the same basis at which the soluble phosphate is estimated The reason given is this. When superphosphate is sown on the field the first shower of rain dissolves out the soluble phosphate which was contained in it. The solution then immediately comes into contact with the carbonate of lime and oxide of iron of the soil and is at once precipitated either entirely as phosphate of lime and phosphate of iron. By this means the phosphorus acid is very finely divided in the soil, and by the action of water containing carbonic acid is gradually rendered soluble to supply the needs of the growing crop. If it were not for this precipitation which takes place on the soil it is evident that with a heavy fall of rain the phosphoric acid would be washed into the subsoil and lost for all practical purposes.

But it can scarcely be said that phosphate which is precipitated in the manure entirely in the form of ferric and aluminic phosphates which are insoluble in distilled water, are of equal value to the soluble phosphate which in any case must be precipitated partly as phosphate of lime, even in a soil deficient in lime. No doubt the precipitated phosphate is more valuable than the unattacked phosphates; but even this latter is of certain value as a manure. But one of the great aims of manuring should be to apply to the crop the plant food which is required by it at precisely the time at which it requires it most, and this can be done with far greater certainty by the use of a soluble manure like superphosphate than by an insoluble form of phosphate. It is for this reason that superphosphate, or manures containing it, have found such general favour.

On the Continent and in the United States the practice of allowing for the value of precipitated phosphates is in vogue; but I would here insert a word of caution to our large manufacturers. Like every other trade the price of manure is regulated by the laws of supply and demand. Let it be granted that if the practice of estimating the precipitated phosphates were to become a general custom the manufacturers would be the gainers to the extent of the value of these phosphates. This would only last so long as the farmers, the consumers, were ignorant of the value, but when it became evident that the effect in the field was not increased a consequent reduction in the price of soluble phosphates would have to be made, and the objectionable practice of having to sell on two determinations instead of one would have become general. But the evil would not stop here. Small manufacturers would use inferior raw materials such as redonda or navassa phosphate, which, when treated with acid would give comparatively small quantities of soluble phosphate, but would show large quantities of precipitated phosphate. The best makers, who use the better class of materials and who turn out manures in which the great bulk of the phosphoric acid is soluble, would thus have to compete with inferior articles on more nearly equal terms than at present. Any such change as the one proposed appears to me, therefore, to be fraught with danger to both the manufacturer and to the farmer, neither of whom would derive any substantial benefit and each of whom would be saddled with more complicated methods of doing business.

I pointed out in the early part of my paper that an important element of plant food was nitrogen in a combined state. In mixing up manures, therefore, for the market it is necessary to add some compound containing nitrogen to the manure. The quantity of the nitrogen (or its equivalent quantity of ammonia—this being the basis on which it is usually calculated) which will be required in a manure, will depend largely upon the crop for which it is intended; and the same consideration will also influence the choice of the particular form in which it is applied. For instance, for swedes only a small percentage of nitrogen is required and this can be applied partly in a compartively insoluble condition as shoddy, dried blood, etc., but for wheat it is found necessary to apply a manure containing considerable quantities of nitrogen in order to stimulate the plant in the earlier stages of growth. As the manure must be in a solid condition, the *form in which the* nitrogen is added must be solid also. The forms in which it is used are various—crystallized sulphate of ammonia, produced principally from the ammonia liquor of gas works, is a common and exceedingly valuable manuring agent. It contains, when absolutely pure, 21.21% nitrogen, and, as usually found in the market, about 20 to 21½% of nitrogen.

Next in importance is nitrate of soda. This is often used for mixing with manures, but is not so well adapted to the purpose as sulphate of ammonia. If there is an excess of acid in the manure it is apt to decompose the nitrate, and the valuable element will be lost, besides often doing considerable damage by the evolution of nitrous fumes. It is oftener used by itself as a top dressing in spring.

Besides these two sources of nitrogen, there are a variety of forms in which the nitrogen exists, principally in the form of organic compounds. Dried blood, shoddy, ground leather and similar compounds may be taken as examples. It is often *better to mix these with the phosphate previous to the treatment* with acid; but nitrate of soda must on no account be so used.

For reducing to a fine condition and mixing, Carr's disintegrator *is used—and in conjunction* with this an ingenious arrangement is adopted.

The material to be disintegrated is shovelled into pits, in which a Jacob's ladder picks it up and carries it to the floor above, where it is thrown upon a sieve which is kept in constant agitation by a lateral motion. What goes through the sieve passes down a shoot, constructed for the purpose, and is collected in bags at the bottom. The lumps, however, pass off the sieve and are conducted by another shoot to the disintegrater, *where they are broken up, and conveyed again* by the Jacob's ladder to the sieve on the floor above. The process is, therefore, continuous.

The Carr's disintegrator, which is manufactured by the Bristol Wagon Works Co., Limited, and the arrangement just described, are exceedingly useful and answer for a variety of purposes, especially for mixtures of dry materials.

Another form of disintegrator which is little known in this country is Vapart's. It will, I am informed, grind the hardest materials to a fine dust. The principal on which it works is centrifugal force. The material to be ground is dropped upon a revolving plate of iron, and is, of course, instantly projected against the side of a drum in which the plate revolves. *The material then falls in a plate below revolving on the same* rod, and here receives a repetition of the smashing action, and so on, as many times as there are revolving plates.

The other valuable manuring element, which is used in the manufacture of artificial manures, is potash. This is introduced either as Kainite, so-called potash Salts, or muriate of potash. Whatever the form used it is mixed in with the manure together with the sulphate of ammonia and, if the manure is at all damp, dryers in the form of Gypsum are used.

There are other substances, such as bones, guano, etc., which must be included under the head of artificial manures which require no chemical treatment before use.

Bones are gradually rendered soluble by the decomposition *of the gelatine which they contain,* and are exceedingly useful where rapidity of action is not a desideratum. They are sometimes treated with sulphuric acid and sold as pure dissolved bones. It oftener happens, however, that the bones are mixed with varying quantities of ground phosphate previous to treatment, but whether treated separately, or in combination with mineral phosphate, it is not desirable to grind the bone fine. There is sure to be a sufficient quantity of phosphate rendered soluble to supply the immediate requirements of the growing *crop, and the larger, partially attached portions, are gradually* rendered soluble in the soil to give a subsequent supply.

(To be continued.)

On the Application of Variable Expansion Valves to High-Pressure Condensing Engines in Tug-Boats.

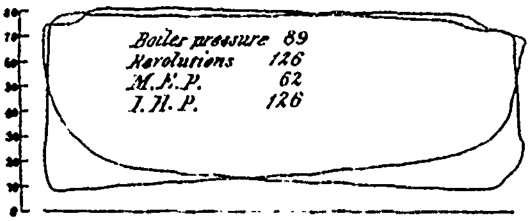
By A. W. Robinson, M. Am. Soc. M. E.

The prevailing type of engine, generally to be found in the smaller class of screw tug-boats on our rivers, lakes and harbours, is the single cylinder, high-pressure, non condensing *engine. The building of* tug-engines, however, has not kept pace with the great advances made in marine engineering of late years, many examples of the kind referred to exhibiting crudity of design, and the power developed being very disproportionate to the fuel consumed.

The engine, of which illustrations are presented, was originally a *high-pressure, non condensing* with a cylinder 16 inches diameter and 20 inches stroke, and a valve of the long D slide description effected the distribution of steam in a particularly defective manner

Diagram No. 1.

Cylinder 16" dia. x 20" stroke.



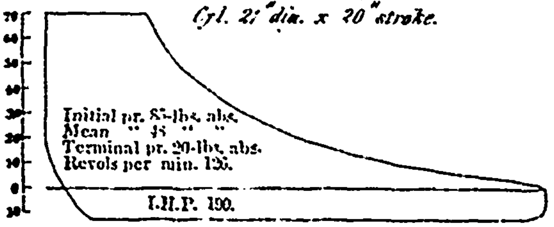
as will be seen by reference to the indicator diagram above No. 1 taken from this engine, where the admission of steam takes place throughout the whole stroke and the exhaust is choked to a back-pressure of 25 lbs. This diagram shows a development of 126 horse-power, which may be taken as a fair average of the engine, although it varies greatly on account of the blast of the exhaust in the smoke-stack being used intermittently causing the steam pressure to vary with the activity of combustion. The diagram also shows a consumption of steam of 2·32 cubic feet per stroke, which reduced to its equivalent weight is equal to ·492 lbs. per stroke or 7440 lbs. per hour. Adding 15 per cent to these calculated weights for condensation and other losses and dividing by the number of horse-power gives us 67·9 lbs. of feed-water per horse-power per hour. Assuming that the boiler will evaporate 7 lbs. of water per lb. of coal, which is an ordinarily good boiler, we get a consumption of 9·7 lbs. of coal per horse-power per hour. In view of the fact that the best modern engines, both land and marine, will develop an indicated horse-power on 2 lbs. of coal per hour, the contrast is at once manifest.

In order to improve this state of affairs the engine was rebuilt and converted into a condensing engine with variable expansion valves as shown on the drawings presented and a condenser and vacuum pump added.

The valves are designed for a range of cut-off from one-eighth to seven-eighths of the stroke, the ordinary point when on a steady run being from one-fourth to one-third, the distribution of steam being then similar to that represented in the diagram No. 2. The steam volumes calculated from this diagram in a similar manner to the former and reduced to an equivalent weight of feed water gives 19.89 lbs. per horse-power per hour, or equal to a saving of 70 per cent. in the consumption of steam by the improved form of engine.

Diagram No. 2.

Cyl. 21" dia. x 20" stroke.



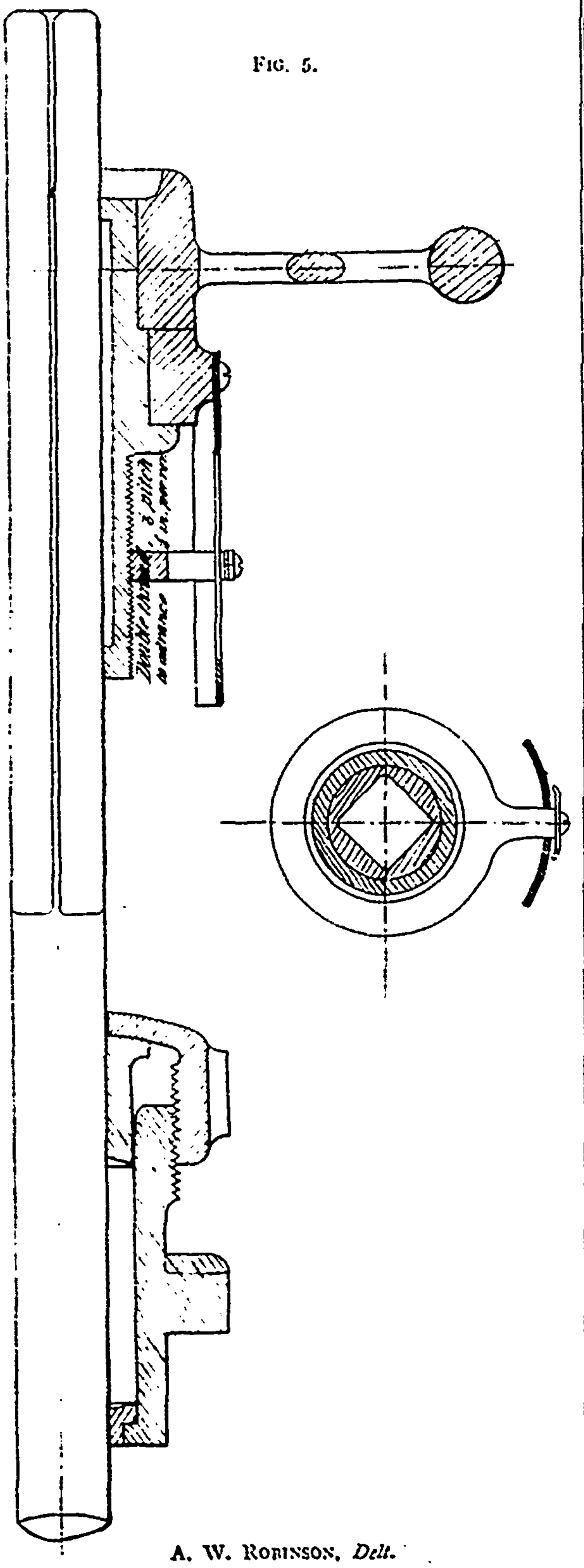
It will be seen on reference to Fig. 3 that the valve gear is of the kind sometimes known as the

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.)

DETAILS OF CUT-OFF REGULATOR.

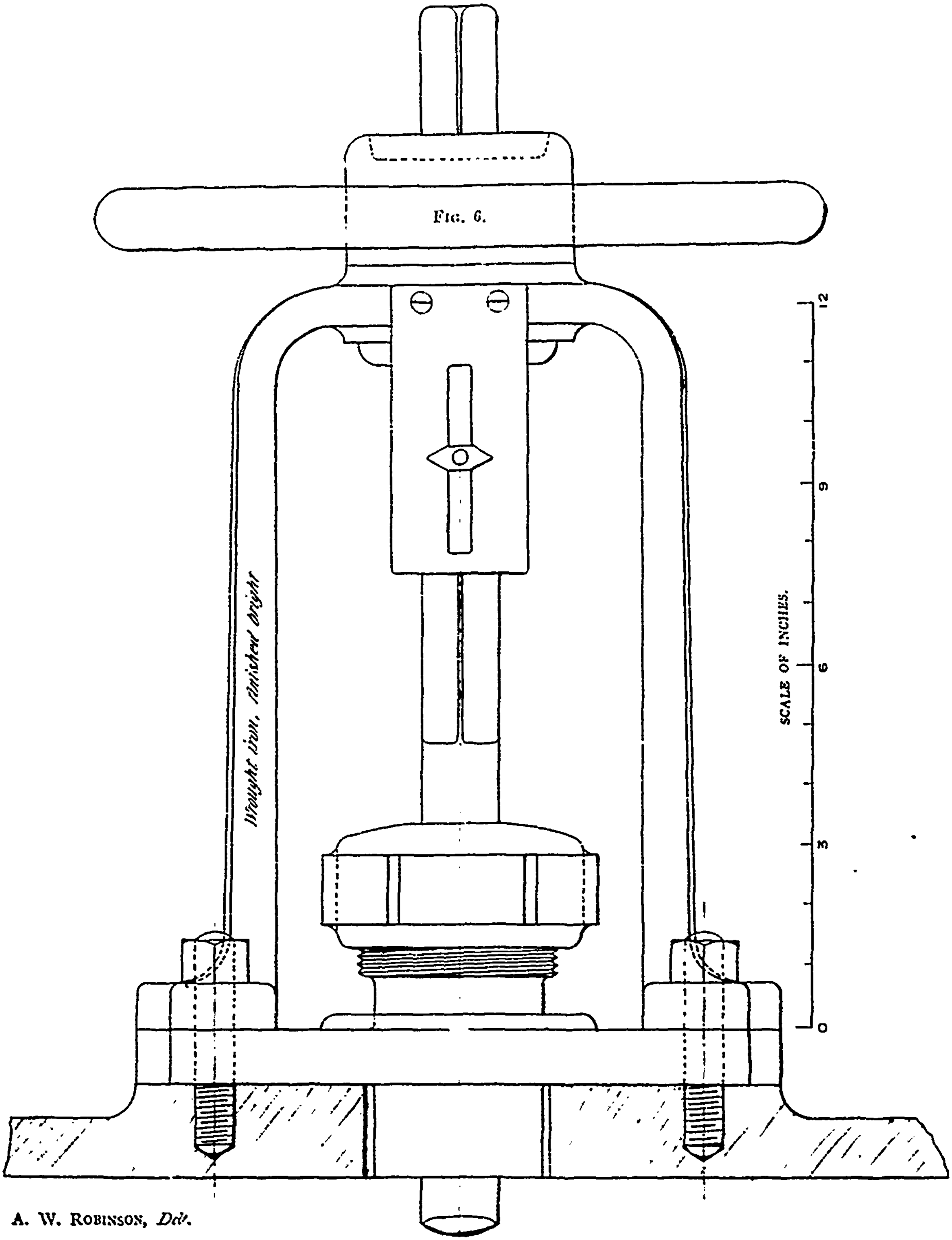
FIG. 5.



A. W. ROBINSON, *Delt.*

DETAILS OF CUT-OFF REGULATOR.

FIG. 6.



A. W. ROBINSON, *Del.*

Meyer and consists of a main slide-valve on the back of which are double cut-off plates, operated by a separate eccentric, and controlling the admission of the steam through the main valve. The relative position of the cut-off valves is variable on the spindle by means of a right and left screw working in brass nuts which are fitted to the valves, and they can be adjusted while in motion to any desired point of cut-off, by the regulator shown in Figs. 9 and 10. This regulator is arranged with an index showing the point at which the valves are cutting off.

The details of vacuum pump are shown in Figs. 7 to 10: it is of the horizontal plunger kind, being driven from an eccentric on the shaft; it is single-acting and the plunger is 10 inches diameter and 8 inches stroke. There are 34 small rubber valves, 17 delivery and 17 suction, both arranged with their spindles upward and inserted from above, so as to be readily accessible on removal of the cover. The top part of the pump chamber forming the seat of the suction valves is inclined to facilitate the exit of air through the delivery valves. The condenser is made of one-quarter inch boiler-plate and receives the cold water injection over a perforated plate in the top.

It may be mentioned that the vessel for which this engine was designed is 76 feet long over all, 17 feet beam and 9 feet depth of hold.

Engineering Notes.

Lifting Apparatus for Stones, Brick, etc.—The principal object of this invention is to reduce the amount of manual labour required in taking building material up to the scaffolding for the purpose of erecting buildings. For this purpose a ladder is placed in a perpendicular position, and at any suitable height up this ladder to suit the scaffolding is placed suitable framework carrying three or other number of pulleys. A rope or chain is passed over these pulleys, and at each end of the rope or chain is a cage or basket, into which the building material is placed. When this apparatus is in use the bottom cage is filled with building material, leaving the upper cage on a level with the scaffold, the labourer then carries his usual weight of material up an ordinary ladder, and after removing his own load of material on to the scaffolding, he gets into the empty cage, the weight of his body counterbalancing the loaded cage, by which means he descends to the ground and lifts the loaded cage up to the scaffold. This operation is then repeated. the empty cage being refilled, and the labourer again ascends the ordinary ladder and descends by the cage, so that he utilizes the weight of his body in lifting up the material. By this method considereble more building material can be taken to the scaflold by one man than can now be accomplished. As the scaffolding is from time to time removed higher to suit the height of the building, the framework carrying the pulleys is raised higher up the perpendicular ladder, and the rope or chain according lengthened accordingly.

Westinghouse Co. Brakes.—According to a circular issued by the Westinghouse Air Brake Company, the number of their brakes now in use thoughout the world is as follows:—In England 15 railroads are supplied with them on 1,312 engines and 9,665 cars; France, 10 roads, 1,443 engines and 8,369 cars; Belgium, 1 road, 359 engines and 2,006 cars; Germany, 4 roads, 65 engines and 143 cars; Austrian, Russian, Holland, Italian, Swedish, Indian, New South Wales (Australian) and Victorian roads have adopted the brake. In the United States 241 roads use it on 3,534 engines and 15,347 cars. The increase in the last two years is 4672 engine and 22,716 car brakes. Total number in use, 10,697 engine and 47,465 car brakes.

To Polish Steel.—Mix half a pound of fine emery powder with the same quantity of soft soap, and add a small piece of soda. Simmer this over a slow fire for two hours, to extract all the moisture. Rub on with flannel, and finish with plenty of dry whiting.

FACULTY OF APPLIED SCIENCE, McGILL UNIVERSITY. PRIZES AND EXHIBITIONS OFFERED FOR SESSION 1883-84.

A Medal or Faculty Prize is open for competition to *Fourth* Year Students of the three courses of Civil, Mechanical and Mining Engineering. Candidates must take a first-class general standing in their Ordinary course, and the Medal or Prize will be awaeded to the Student who stands *first* in the Hydraulics and Steam of the Advanced Course.

The following will be offered for competition at the opening of Session 1883-84:—

(1.)—The Scott Exhibition of $66 (founded by the Caledonian Society of Montreal in commemoration of the Centenary of Sir Walter Scott), to students entering the *Third* Year, the subjects af examination being:—

(*a*.)—The Summer Report. (*b*.)—Macaulay's History of England, Vol. I., Cap. I.; Sir Walter Scott's Lady of the Lake. (*c*.)—Mechanism.

(2.)—An Exhibition of $50, presented by A. T. Drummond, Esq., to Students entering the *Fourth* Year, the subjects of examination being:—

(*a*.).—The Summer Report. (*b*.)—Applied Mechanics.

(3.)—A Prize in books, to the value of $25, presented by L. Skelton Esq., to Students entering the *Third* and *Fourth* Years, for the best Summer Report.

(4.)—Two Prizes of $25 each, one to Students entering the *Fourth* Year, the other to Students entering the *Third* Year, the subjects of Examination being the *Trigonometry, Analytical Geometry*, and *Calculus* of the previous years.

(5.)—A Prize of $25, presented by S. Greenshields, B.A., for the Mathematical subjects of the *Second* Year Matriculation, and open to all Students entering the *Second* Year.

(6.)—An Exhibition of $100, presented by J. H. Burland, B.A.Sc., to Students entering the *Second* Year, the subjects of examination being:—

(*a*.)—Inorganic Chemistry. (*b*.)—Elements of Organic Chemistry. (*c*.)—Practical Chemistry.

◆

Comparative Durability of Iron and Steel Rails.—The *Bulletin* of the Comité des Forges de France gives the following table showing the comparative durability of steel and iron rails on Belgian railways:—

Year of Laying.	Duration.	Percentage of Rails replaced. Iron.	Steel.
1869	12 years	65·74	0.89
1870	11 "	84·54	—
1871	10 "	95·74	—
1872	9 "	72·41	0·44
1873	8 "	41·41	—
1874	7 "	17.44	—
1875	6 "	26.66	—
1876	5 "	14·98	—
1877	4 "	4·19	—
1878	3 "	—	—
1879	2 "	0·23	—
1880	1 "	—	—

Steel Water Pipes.—The Chameroy Company make pipes of steel plate for conveying water under high pressure. The steel plates are coated with lead on both sides by immersion or otherwise, and rolled to form, rivetted and soldered the whole length, and covered with pitch. The first cost of the steel in not much greater than that of iron; and the steel pipes possess considerable advantages over those of iron. The lead coating is superior on account of the fineness of grain in the steel; the resistance to tensile strain and internal pressure is 50 to 60 times and the resistance to deformation longitudinally from 30 to 40 times greater, while the superior elasticity of the steel plate permits of the pipes receiving tolerably hard knocks without being permanently deformed. For equal thickness, the steel tubes stand twice the internal pressure of the iron, and being both light and strong, they are admirably adapted for laying down temporarily and taking up again.

Charcoal.—The best quality of charcoal is made from oak, maple, beech and chestnut. Wood will furnish, when properly charred, about 20 per cent. of coal. A bushel of coal from pine weighs 29 pounds; a bushel of coal from hardwood weighs 30 pounds; 100 parts of oak make nearly 23 of charcoal; red pine, 22.10; white pine, 23.

Production of Steel.—It appears from statistics recently published in *La Houille*, that Great Britain has, at present, twenty-three metallurgical works producing steel, with 115 converters, and a productive capacity of 1,460,000 tons per annum; Belgium has four steel-works with eighteen converters, and a productive capacity of 380,000 tons; Austria, fourteen works, thirty-six converters, 632,000 tons; Germany, twenty-three works, eighty converters, 1,300,000 tons; Russia, five works, ten converters, 100,000 tons; Sweden, thirty-five converters, 80,000 tons; the United States, thirty-four converters, 1,500,000 tons. This applies to Bessemer steel. As regards the Thomas-Gilchrist method, there was produced by it in October last, in Germany, 25,170 tons of steel from eight firms; in England, the works of Bolckow, Vaughan & Co., the only one using this process produced 2,500 tons; Belgium produced 1,687 tons; Russia, 1,270 tons; France, 1,210 tons (the last three have each, like England, only one steelworks using the process) This gives a total, for October, of 46,537 tons of basic steel produced in fifteen works.

Railroad Accidents, and the Earth's Rotation. — R. Randolph shows that the deflective force arising from the earth's rotation is entirely too small to determine derailments, and also, that, as an excess of right-handed derailments has been credited solely to north and south tracks, this proves it to be wholly imaginary; for the deflective force at any latitude is the same for all directions [*Van Nostrand's engin. mag.*, 1883, 117]. The numerical results given are but half their true value, as two elements of the deflective force are omitted [Science, p. 98]; but this does not affect the author's conclusions, as the deflective force is still insignificant, and, for a fast train in this latitude, amounts to but about 1-5000 of the weight.—W. M. D. *in Sc.*

Electricity, Astronomy, Botany, Physiology, &c.

Electric Railway.— A Company has been formed for the construction and working of an electric railway from Charing Cross to Waterloo, a Bill for which was recently obtained. The line will pass under the Thames through iron caissons. The work of construction will commence near the northern end of Northumberland Avenue, opposite the Grand Hotel, and be continued through an arch under that avenue and the Victoria Embankment. Of that arch sixty feet under the Embankment have already been constructed. The railway will pass under the Thames, and again through an arch under College Street and Vine Street, and terminate at Waterloo Station, where it will be directly connected with the platforms of the London and South-Western Railway, with a separate approach from the York Road. The line will be double, and worked by means of a stationary engine at Waterloo, transmitting the power to the carriages, which will run separately, start as filled, and occupy about three and a half minutes in the journey. A tender has been accepted for the construction of the railway, to be ready for opening within eighteen months from the commencement of the work. A contract has also been made with Messrs. Siemens Bros. and Company to provide and erect all requisite electrical machinery, rolling stock, and apparatus not included in the before-mentioned tender.

SOME POINTS IN ELECTRIC LIGHTING.

The fourth of the series of Six Lectures on the Applications of Electricity was delivered at the Institution of Civil Engineerse (Eng.), on Thursday Evening, the 5th of April, by Dr. John Hopkinson, F.R.S., M. Inst. C. E. The subject was "Some Points in Electric Lighting." The following is an abstract of the lecture:—

The science of lighting by electricity was divided by the Lecturer into two principal parts—the methods of production of electric currents, and of conversion of the energy of those currents into heat at such a temperature as to be given off in radiations to which the eye was sensible. The laws known to connect together those phenomena called electrical, were essentially mechanical in form, closely correlated with mechanical laws, and might be most aptly illustrated by mechanical analogues. For example, the terms "potential," "current," and "resistance," had close analogues respectively in "head," "rate of flow," and "co-efficient of friction" in the hydraulic transmission of power. Exactly as in hydraulics head multiplied by velocity of flow was power measured in foot-pounds per second or in H.P., so potential multiplied by current was power and was measurable in the same units. Again, just as water flowing in a pipe had inertia and required an expenditure of work *to set it in motion*, and was capable of producing disruptive effects if that motion were too suddenly arrested, so a current of electricity in a wire had inertia, to set it moving electromotive force must work for a finite time, and if arrested suddenly by breaking the circuit the electricity forced its way across the interval as a spark. Corresponding to mass and moments of inertia in mechanics there existed in electricity co-efficients of self-induction. There was, however, this difference between the inertia of water in a pipe and the inertia of an electric current—the inertia of the water was confined to the water, whereas the inertia of the electric current resided in the surrounding medium. Hence arose the phenomena of induction of currents upon currents, and of magnets *upon moving conductors—phenomena which had no immediate* analogues in hydraulics.

The Laws of induction were then illustrated by means of a mechanical model devised by the late Professor Clerk Maxwell.

In the widest sense, the dynamo-electric machine might be defined as an apparatus for converting mechanical energy into the energy of an electro-static charge, or mechanical power into its equivalent electric current through a conductor. Under this definition would be included the electrophorus and all *frictional machines*; but the term was used in a more restricted sense, for those machines, which produced electric currents by the motion of conductors in a magnetic field, or by the motion of a magnetic field in the neighbourhood of a conductor. The laws on which the action of such machine was based had been the subject of a series of discoveries. Oersted discovered that an electric current in a conductor exerted force upon a magnet; Ampère that two conductors conveying currents *generally* exerted a mechanical force upon each other: Faraday discovered—what Helmholtz and Thomson subsequently proved to be the *necessary consequence of the mechanical reactions between* conductors conveying currents and magnets—namely, that if a closed conductor moved in a magnetic field, there would be a current induced in that conductor *in one direction*, if the number of lines of magnetic force passed through the conductor was increased by the movement, in the other direction if diminished. Now all dynamo-electric machines were based upon Faraday's discovery. Not only so; but however elaborate it might be desired to make the analysis of the action of a dynamo-machine, Faraday's way of presenting the phenomena of electro-magnetism to the mind was in general the best point of departure. The dynamo-machine, then, essentially consisted of a conductor made to move in a magnetic field. This conductor, with the external circuit, formed a closed circuit in which electric currents were induced as the number of lines of magnetic force passing through the closed circuit varied. Since, then, if the current in a closed circuit was in one direction when the number of lines of force was increasing, it was clear that the current in each part of such circuit which passed *through the magnetic field must be alternating in direction*, unless indeed the circuit was such that it was continually cutting more and more lines of force, always in the same direction. Since the current in the wire of *the machine* was alternating, so also must be the current outside the machine, unless something in the nature of a commutator was employed to reverse the connections of *the internal* wires in which the current was induced, and of the external circuit. There were then broadly two classes of dynamo-electric machines; the simplest, the alternating current machine, where no commutator was used; and the continuous-current machine, in which a commutator was used to change the connection with the external circuit just at the moment when the direction of the current would change. The theory of the alternate-current machine was then explained, and it was proved that two independently driven alternate-current machines could not be worked in series, but that they might be worked in parallel circuit, and hence were quite suitable for distribution of electricity for lighting without the necessity of providing a separate circuit *for each machine*.

It was easy to see that, by introducing a commutator revolving with the armature, in an alternate-current machine, and so arranged as to reverse the connection *between the armature* and the external circuit just at the time when the current would reverse, it was possible to obtain a current constant always in direction; but such a current would be far from constant in intensity, and would certainly not accomplish all the results obtained in modern continuous-current machines. This irregularity might, however, be reduced to any extent by multiplying the wires of the armature, giving each its own connection to the outer circuit, and so placing them that the electro-

VERTICAL CONDENSING ENGINE WITH VARIABLE CUT-OFF.

(N.B.—For description see page 139.)

DETAILS OF VACUUM PUMP.

FIG. 7.

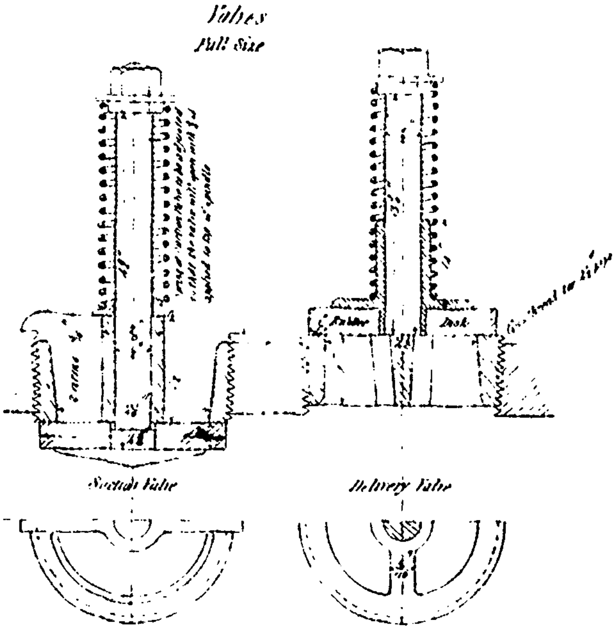


FIG. 8.

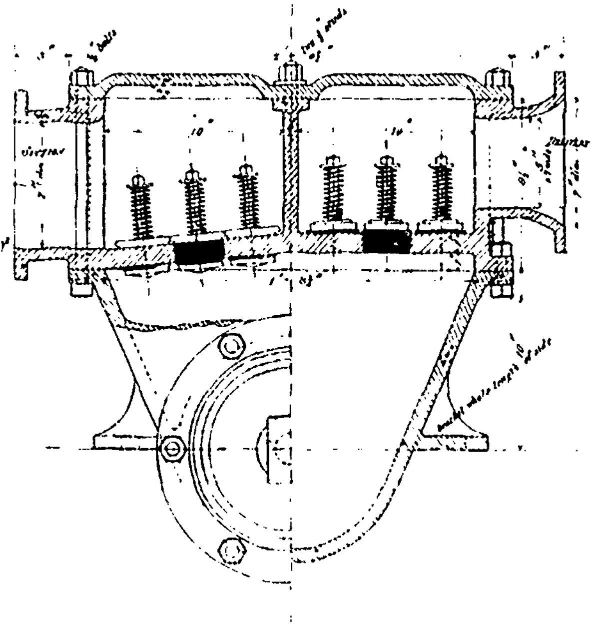


FIG. 9.

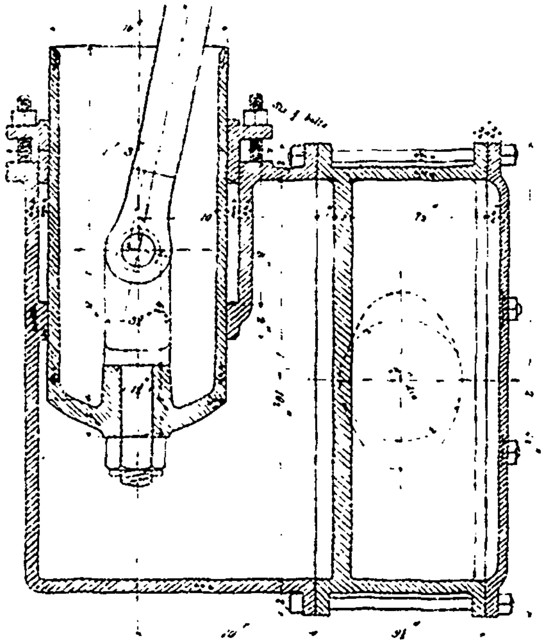
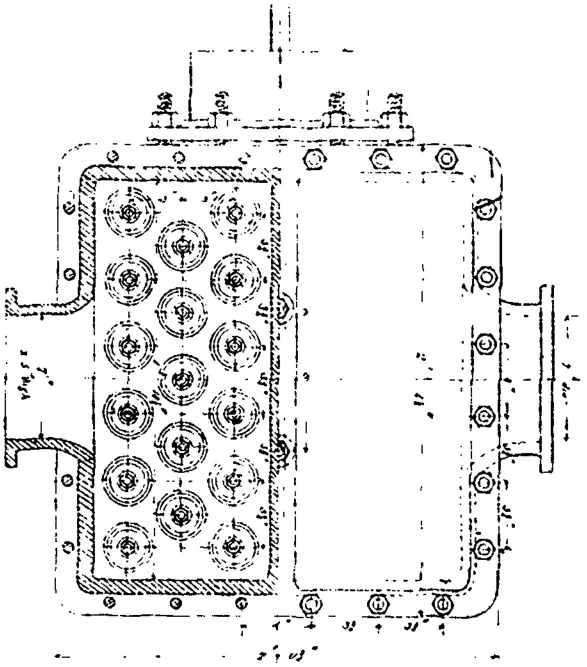


FIG. 10.



A. W. ROBINSON, *Delt.*

motive force attained a maximum successively in the several coils. A practically uniform electric current was first commercially produced with the ring armature of Pacinotti, as perfected by Gramme. A dynamo-machine was not a perfect instrument for converting mechanical into the energy of electric currents. Certain losses inevitably occurred. There was the loss due to friction of bearings, and of the collecting-brushes upon the commutator; there was also the loss due to the production of electric currents in the iron of the machine. When these were accounted for, there remained the actual electrical effect of the machine in the conducting wire; but all of this was not available for external work. The current had to circulate through the armature, which inevitably had electrical resistance; electrical energy must, therefore, be converted into heat in the armature of the machine. Energy must also be expended in the wire of the electro-magnet which produced the field, as the resistance of this also could not be reduced beyond a certain limit. The loss by the resistance of the wires of the armature and of the magnets greatly depended on the dimensions of the machine. To know the properties of any machine thoroughly, it was not enough to know its efficiency and the amount of work it was capable of doing; it was necessary to know what it would do under all circumstances of varying resistance or varying electromotive force; and, under any given conditions, what would be the electromotive force of the armature? Now this electromotive force depended *on the intensity of the magnetic field, and the intensity of the magnetic field* depended on the current passing round the electro-magnet and the current in the armature. The current then in the machine was the proper independent variable in terms of which to express the electromotive force. The simplest case was that of the series-dynamo, in which the current in the electro-magnet and in the armature was the same, for then there was only one independent variable. The *relation between electromotive* force and current might be *most* conveniently expressed by a curve.

When four years ago the lecturer first used such a curve (since named by Deprez the "characteristic curve") for the purpose of expressing the results of his experiments on the Siemens' dynamo-machine, he pointed out that it was capable of solving almost any problem relating to a particular machine, and *that* it was also capable *of giving good* indications of the results of changes in the *winding* of the *magnets*, or of the armatures of such machines. The use of the characteristic curve was illustrated with reference to charging accumulators and Jacobi's law of electric transmission of power.

When the dynamo-machine was not a series-dynamo, but the current in the armature and in the electro-magnet, though possibly dependent upon each other were not necessarily equal, the problem was *not* so simple. In that case there were two variables, the current in the *electro-magnet* and *the current* in the armature; and the proper representation of the properties of the machine would be by a characteristic surface, of which a model was exhibited. By the aid of such a surface any problem relating to a dynamo-machine could be dealt with, no matter how its electro-magnets and its armature were conected together. Of course in actual practice the model of the surface would *not* be used, but the projections of its sections.

The properties of a machine depended much upon its dimensions. Suppose two machines alike in every particular, excepting that the one had all its *linear* dimensions double *that* of *the other*. The *electrical* resistances in the larger machine would be one-half those of the smaller. The current required to produce a given intensity of magnets field would be twice as great in the larger machine as in the smaller. The comparative characteristic curves *of* the two machines, when driven at the same speed, were shown in a diagram. The *two* curves were one the projection of the other, having corresponding points with abscissæ in the ratio of one to two, and the *ordinates* in the *ratio of one to four*. At first sight it would seem that the work done by the larger machine should be thirty-two times as much as that which would be done by the smaller. Practically, however, no such result could possibly be attained for many reasons. First, the iron of the magnets became saturated, and consequently instead of eight times the electromotive force, there would only be four times the electromotive force. Secondly, the current which the armature could carry was limited by the rate at which the heat generated in the armature could escape. Again, the larger machine could not run at so great an angular velocity as the smaller one. And lastly, since in the larger machine the current in the armature was greater in proportion to the saturated magnetic field than in the smaller one, the displacement of the point of contact of the brushes with the commutator would be greater. Shortly, the capacity of *similar* dynamo-machines was pretty nearly proportionate to their weight, that was to the cube of their linear dimensions; the work wasted in producing the magnetic field was directly as the linear dimensions; and the work wasted in heating the wires of the armature was as the square of the linear dimensions.

A consideration of the properties of similar machines had another important practical use. Mr. Froude was able to control the disign of ironclad ships by experiments upon models made in paraffin-wax. *It* was a much easier thing to predict what the performance of a large dynamo-machine would be, from laboratory experiments made upon a model of a very small fraction of its dimensions. As a proof of the practical utility of such methods, the Lecturer stated that by laboratory experiments he had *succeeded* in *greatly increasing the capacity of* the Edison machines, without increasing their cost, and with a small increase of their percentage of efficiency, remarkably high as that efficiency already was.

The electric properties of the electric arc were experimentally illustrated; in particular *it* was shown that the difference of potential between the carbons was nearly independent of the current.

When a current of electricity passed *through* a *continuous* conductor, it encountered resistance, and heat was generated, as shown by Joule, at a rate represented by the resistance multiplied by the square of the current. If the current was sufficiently great, heat would be generated at such a rate that the conductor would become incandescent and radiate light. Attempts had been made to use platinum and platinum iridium as the incandescent conductor. But these bodies were too expensive for general use, and besides that, *refractory* though they were, they were not refractory enough to stand the high temperature required for incandescent lighting, which should be *economical* of power. Commercial success was not *realised until* very thin and very uniform threads or filaments of carbon were produced and enclosed in reservoirs of glass, from which the air was exhausted to the utmost possible limit. Such were the lamps made by Mr. Edison with which the Institution was temporarily lighted. The *electrical properties* of such a lamp were examined, and in particular it was shown that its efficiency increased and its resistance diminished with increase of *current*.

The building was lighted by about 230 lamps, each giving sixteen candles light, produced each by 75 Watts of power developed in the lamp. To produce the same sixteen candles' light in ordinary good flat-flame gas-burners, would reuuire between 7 and 8 cubic *feet* of gas per hour, contributing heat to the atmosphere at the rate of 3,400,000 ft.-lbs. per hour, equivalent to 1,250 Watts, or nearly seventeen times as much heat as the incandescence-lamp of equal power.

At the present time, lighting by electricity in London must cost something more than lighting by gas. What were the prospects of reduction of this cost? Beginning with the engine and boiler, the electrician had no right to look forward to any marked and exceptional advance in their economy. Next came the dynamo, the best of these were so good, that there was little room for economy in the conversion of mechanical into electrical energy; but the prime cost of the *dynamo-machine* was sure to be greatly reduced. Hope of considerably increased economy must be mainly based upon probable improvements in the incandescence-lamp, and *to this the greatest attention* ought to be directed. It had been shown that marked economy of power could be obtained by working the lamps at high-pressure, but, then they soon broke down. In ordinary practice, from 140 to 200 candles were obtained from 1 H.P., developed in the lamps, but for a short time he had seen over 1,000 candles per H.P. from incandescence-lamps. The problem, then, was so to improve the lamp in details, that it would last a reasonable time when pressed to *that degree of eufficiency*. There was no theoretical bar to such improvements, and it must be remembered that incandescence-lamps had only been articles of commerce for about three years, and already much had been done. If such an improvement were realized, it would mean that it would be possible *to get five times* as much light for a sovereign as could be done now. At present electric lighting would succeed commercially where other considerations than cost had weight. *Improvements in the lamps were certain*, and there was a probability that these impeovements might go so far as to reduce the cost to one-fifth of what it now was. He left the meeting to judge whether or not it was probable, nay. almost certain, that lighting by electricity was to be lighting of the future.

THE HEAT OF THE SUN.

BY ERNEST H. COOK, B.SC. (LOND.), F.C.S.

(Continued from page 115.)

The Meteoric Theory.

Born in the little town of Heilbronn, Wurtemburg, the illustrious originator of this theory, would have lived and died a respected German physician had he not possessed a strong mental bias in favour of physical speculations.

In such a case the strong influence which his writings have made upon the thought of the present day would have been wanting and the world would have been ignorant of the name of Robert Julius Mayer. But here we must guard ourselves against falling into the opposite extreme, and giving all the credit to one. I have called Mayer the originator of the theory, and so in truth he was, having published his "Essay on Celestial Dynamics" in 1848. But, as is generally the case, other minds were at the same time actively engaged upon a similar subject. It was not however until the Hull Meeting of the British Association in 1853 that Waterston sketched the same theory, being at the time quite ignorant of Mayer's previous writings. Waterston's paper attracted the attention of the celebrated mathematician and physicist Sir William Thompson, and in a beautiful memoir published in the Transactions of the Royal Society of Edinburgh for 1854, the whole theory is exhaustively worked out and developed.

With the help of these writings we will now endeavour to give as briefly as possible an outline of this interesting theory.

It is necessary however, to a proper appreciation of the subject, to acquire a little preliminary knowledge. Suppose a body to be moving, and we stop that body's motion, we know that we have to exert force to do so. Moreover the heavier the body the greater force is required, or with the same weight, the faster it goes the more force is required. Given the weight and the velocity of motion, we can calculate the works required to be done to bring the body to rest. Again, it has been proved that work of energy and heat are mutually convertible, *i.e.*, that a certain amount of heat can be produced by the expenditure of a certain amount of work, and also that a certain amount of work will heat a given body to a certain degree. This has been called the mechanical equivalent of heat, and we may state it thus:—

If the work required to raise 1390 lbs. one foot high be done upon one pound of water the temperature of that water will be raised 1 ° C. Now as was said above, we can calculate the amount of work which must be done in order to stop the motion of a moving body and therefore if this work be transformed into heat we can find how much the temperature of the body will be increased. Thus we find that the heat given out by stopping the motion of a leaden bullet moving at the rate of 1300 feet a second would raise its temperature about 600 ° C. if all the heat were retained by the bullet.

To the imagination it is an easy matter to rise from the consideration of the impact of a rifle bullet to consider the impact of worlds. In effect this is what the Meteoric Theory does, only instead of worlds it considers the collision to occur between the sun meteors, and comets. In our solar system there exists a numerous class of small bodies called asteroids. These small bodies like the larger ones are subjected to the law of gravitation and are attracted by the sun. Any medium which exists in space, however rare it may be, would exert a comparatively greater action on small bodies, than upon large ones such as the planets*. Thus although these latter may not have their motions affected, the former may be rapidly caused to approach the sun. It is thus supposed that the sun is constantly subject to a cannonade of small bodies upon its surface. But if such a rain of these small bodies is constantly falling from the outermost limits of our system upon the sun, it is evident that as they approach near him they become condensed. We ought therefore to be enabled to see such a crowd of meteors before they fall into the sun. This is supposed to be proved by the existence of the mass of hazy matter which surrounds the sun known as the Zodiacal light. Whether or not this consists of an assemblage of meteors, it is, of course, impossible to say. But the matter composing it has been shown to obey the ordinary laws of planetary rotation and thus to behave exactly as meteors would.

There are two ways in which a body may fall into the sun: it may fall directly upon it, or it may revolve around it in gradually diminishing orbits until it is at last absorbed. The final velocity which it could have, is very different in the two cases; in the first, supposing it to fall from an infinite distance it would have the greatest velocity possible, viz., 390 miles a second. In the second case where the velocity may be supposed a minimum it would be equal to 276 miles a second. Striking the sun with its maximum velocity, the body would generate "more than 9000 times the heat generated by the combustion of an equal amount of coal," striking with its minimum velocity it would produce 4000 times as much heat. "Here then we have an agency competent to restore his lost energy to the sun, and to maintain a temperature which far transcends all terrestrial combustion. . . . It may be contended that this showering down of matter necessitates the growth of the sun; it does so, but the quantity necessary to maintain the observed calorific emission for 4000 years would defeat the scrutiny of our best instruments." (Tyndall). The amount of heat generated by the fall of these meteors is thus undoubtedly sufficient to produce the temperature we find, and there can also be no doubt as to the number of these bodies existing in the solar system. When we remember the large number of meteors which are seen by observers, also that the vast majority can only be seen at night, and the small bulk which the earth occupies in space, we cannot but admit the sufficiency of the cause in regard to quantity. Thus during one observation at Boston there were observed in nine hours, no less than 24,000 meteors, and thus in a year we may conclude that hundreds, perhaps thousands, of millions fall into the earth's atmosphere.

Sir William Thompson in developing this theory in the paper before mentioned has modified it somewhat. His first idea was similar to that of Mayer that the meteoric matter raining down on the sun circulated close to him. But if there be this matter existing round the sun, it is difficult to account for the fact

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*It is interesting to note here that the idea of the universal existence of the atmosphere to introduced in the meteoric theory.

that comets are observed to pass quite close to him, and therefore through this matter without suffering any loss of energy. Thompson has therefore come to the conclusion that the heat of the sun was *produced* in this way but is not thus *maintained*. He considers "the low rate of cooling and consequent constancy of the emission is due to the high specific heat of the materials of which the sun is composed"—Tyndall. Thus in effect the sun is cooling down but at the enormous rate at which he gives out heat; according to our knowledge of terrestrial things we should imagine he would soon be burnt out. But this notion, if it exists must be dispelled, as Thompson proves that the heat thus originally produced is able to supply the sun with sufficient to last him for no less than 20,000,000 years.

But although dealing with small masses of matter, this theory is not confined to them. The heat may be produced by larger masses striking the sun. In the history of astronomical observations we have it set down that occasionally stars are observed to suddenly increase in brilliancy until they reach a maximum and then to decline until they reach their former brightness. Thus, in 1572, an entirely new star suddenly "appeared in the constellation of Cassiopeia, and gradually increased in brilliancy until it surpassed all the other stars. It could be plainly seen in the day-time. On a sudden, Nov. 11th, it was as bright as Venus at her brightest. In the following March it was of the first magnitude. It exhibited various hues of colour in a few months and disappeared in March 1574."—Draper. Since then many similar occurrences have been noted.

These can only be satisfactorily explained by supposing a collision between two bodies to have occurred. Acting upon this idea Sir W. Thompson has calculated the heat which would be given out by the various bodies composing the planetary system falling into the sun. The table is as follows, the heat being expressed as able to sustain the solar emission for the stated times:—

Mercury . . .	6 years	214 days
Venus . . .	83 "	227 "
Earth . . .	94 "	303 "
Mars . . .	12 "	252 "
Jupiter . . .	32,240 "	
Saturn . . .	9659 "	
Uranus . . .	1610 "	
Neptune . . .	1890 "	

Thus if the earth were to fall into the sun the heat which would be given out by the sudden stoppage of the motion would be sufficient to keep up the present rate of solar emission for a period of 94 years 303 days. In addition to the amounts given in the table there must be added the heat which would be produced by the rotation of the planet on its axis, which in the case of the earth would supply the sun for 81 days. "The heat of rotation of the sun and planets, taken together, would cover the solar emission for 134 years, while the total heat of gravitation—that produced by the planets falling into the sun—would cover the emission for 45,589 years."—Tyndall.

In the foregoing sketch of a theory which has influenced so mightily the progress of solar physics, I have endeavoured to confine myself as much as possible to the words of its authors and supporters. In taking a survey of it in its entirety, we cannot but be struck by the really beautiful way in which everything is derived from an original and all pervading law; that of gravitation. Given the existence of matter and the law of gravitation, the theory shows how the universe may have been produced. The same force which causes the apple to fall to the ground acting through distant ages gave us the light and heat of the sun which caused the apple to ascend *on the tree*. Unity and design pervades the whole, and this, if I may be allowed to say so, is what we find everywhere in nature. Again, throughout the whole of the theory, there is no assumption of either hypothetical substances or hypothetical forces. *No luminiferous ether* with its Protean properties, the single blot on the Undulatory theory of light; no attractive and repulsive zones as in the Corpuscular theory. Starting with matter as we find it on the earth, it works out its results according to the *operation of known and thoroughly established laws*.

This is an important point, for the theory was propounded and worked out long before Kirchoff had given to the world his immortal discovery, of terrestrial matter in the sun. *Subsequent discovery* proves that the universe contains no matter not existing on the earth amd the Meteoric Theory calls for no other. . . What I may call the essential elements of a theory are therefore here present, its ultimate fate must therefore depend *upon some more* probable explanation being proposed. We rightly consider the prediction of an hitherto unknown phenomenon, which is afterwards proved to be true as a triumph of theory. Thus, the discovery of Neptune, and that of Conical Refraction, are considered as having fixed, the Gravitation and Undulatory Theories, respectively, on a firm basis. It happens that the Meteoric Theory has also its prediction. Owing, however to its nature, we are and shall be, unfortunately, unable to verify it. The prediction is nothing more nor less than that of the end of our planetary system, and in fact of the universe. Moons will fall into planets, planets into suns and suns, into other suns, and at the last only one mighty sun will remain. This is the end to which all must come. In taking leave of this theory I cannot omit to mention one important point which I do not think has been raised before and which so far as I am aware has not attracted the notice of its supporters. It will be seen that one of its assumptions is that the central body is gradually although very slowly attracting the revolving bodies nearer to itself. Extending this idea very slightly we have that the planets acting as central bodies ought to be gradually attracting their satellites. This point has been ably and fully worked out by Mr. G. H. Darwin and he has come to the conclusion that the moon has been and still is gradually receding from the earth. Upon this point therefore theory and observation seem to be opposed to each other and we shall be glad to see the explanation of the supporters upon it.

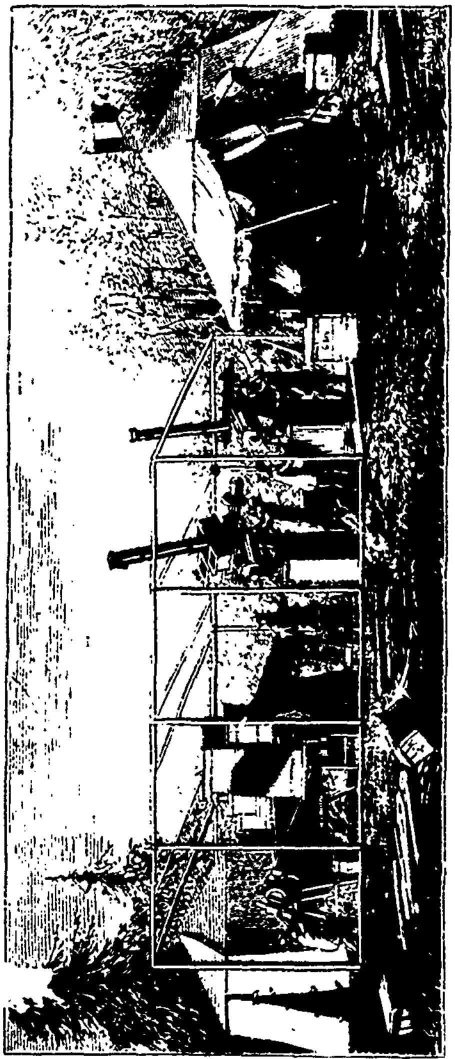
THE CONTRACTION THEORY.

In the above statement of the meteoric theory it is pointed out how comparatively small an addition to the bulk of the sun is able to support the loss of energy which he suffers. But although undoubtedly the amount which has fallen during historic times is small compared to the immense bulk of the sun, yet when we consider geologic times the case is different.

(*To be continued.*)

THE APPROACHING ECLIPSE

THE accompanying illustration from *La Nature* shows the instruments to be used at the total eclipse of May 6, by M. Janssen, who has command of the French expedition. The illustration is after a photograph taken at M. Janssen's Observatory at Meudon. The French expedition, which has probably reached its destination, will be located on Sable Island, near Caroline Island, in the Marquesas Archipelago. Before quitting Paris, M. Janssen had all his instruments and tents erected in order to see that all worked well. The frame surrounding the apparatus is arranged to receive a large awning to protect them. The tent on the right is intended for the astronomers, the furniture consisting of a work-table, several camp-stools, and three beds. The little tent on the left is for photography. The instruments of the French expedition comprise—1. A telescope of short focus for spectroscopic work. 2. An equatorial on which will be arranged a photographic apparatus, containing five cameras which act together. The plates are $0^{m}{\cdot}40$ by $0^{m}{\cdot}50$; they will require an exposure of five minutes. This apparatus is intended for intra-Mercurial planets. 3. A telescope of 6 inches, with a lens of 3 inches, with photographic apparatus acting by means of three cameras at once. This apparatus is intended for the solar corona. 4. A fourth telescope, specially reserved for M. Trouvelot for drawings of the corona and search for intra-Mercurial planets.



Apparatus for French Eclipse Expedition.

THE GREAT INTERNATIONAL FISHERIES EXHIBITION.—(*Nature.*)

The idea of an *international* Fisheries Exhibition arose out of the success of the show of British fishery held at Norwich a short time ago: and the president and executive of the latter formed the nucleus of the far more powerful body by whom the present enterprise has been brought about.

The buildings are well advanced towards completion, and will be finished long before the opening day; the exhibitors will, it is hoped, support the executive by sending in their goods in time, and thus all will be ready for the 12th proximo.

The plan of the buildings embraces the whole of the twenty-two acres of the Horticultural Gardens: the upper half, left in its usual state of cultivation, will form a pleasant lounge and resting-place for visitors in the intervals of their study of the collections. This element of garden accommodation was one of the most attractive features at the Paris Exhibition of 1878.

As the plan of the buildings is straggling and extended, and widely separates the classes, the most convenient mode of seeing the show will probably be found in going through the surrounding buildings first, and then taking the annexes as they occur.

On entering the main doors in the Exhibition Road, we pass through the Vestibule to the Council Room of the Royal Horticultural Society, which has been decorated for the reception of marine paintings, river subjects, and fish pictures of all sorts, by modern artists.

Leaving the Fine Arts behind, the principal building of the Exhibition is before us—that devoted to the deep sea fisheries of Great Britain. It is a handsome wooden structure 750 ft. in length, 50 ft. wide, and 30 ft. at its greatest height. The model of this, as well as of the other temporary wooden buildings, is the same as that of the annexes of the great Exhibition of 1862.

On our left are the Dining Rooms with the Kitchens in the rear. The third room, set apart for cheap fish dinners (one of the features of the Exhibition), is to be decorated at the expense of the Baroness Bardett Coutts, and its walls are to be hung with pictures lent by the Fishmonger's Company, who have also furnished the requisite chairs and tables, and have made arrangements for a daily supply of cheap fish, while almost everything necessary to its maintenance (forks, spoons, table-linen, &c.), will be lent by various firms.

The apsidal building attached is to be devoted to lectures on the cooking of fish.

Having crossed the British Section, and turning to the right and passing by another entrance, we come upon what will be to all one of the most interesting features of the Exhibition, and to the scientific student of ichthyology a collection of paramount importance. We allude to the Western Arcade, in which are placed the Aquaria, which have in their construction given rise to more thoughtful care and deliberation than any other part of the works. On the right, in the bays, are the twenty large asphalt tanks, about 12 ft. long, 3 ft. wide, and 3 ft. deep. These are the largest dimensions that the space at command will allow, but it is feared by some that they will be found somewhat confined for fast going fish. Along the wall on the left are ranged twenty smaller, or table-tanks of slate, which vary somewhat in size: the ten largest are about 5 ft. 8 in. long, 2 ft. 9 in. wide, and 1 ft. 9 in. deep.

In this Western Arcade will be found all the new inventions in fish culture—models of hatching, breeding and rearing establishments, apparatus for the transporting of fish, ova, models, and drawings of fish-passes and ladders, and representations of the development and growth of fish. The chief exhibitors are specialists, and are already well known to our readers. Sir James Gibson Maitland has taken an active part in the arrangement of this branch, and is himself one of the principal contributors.

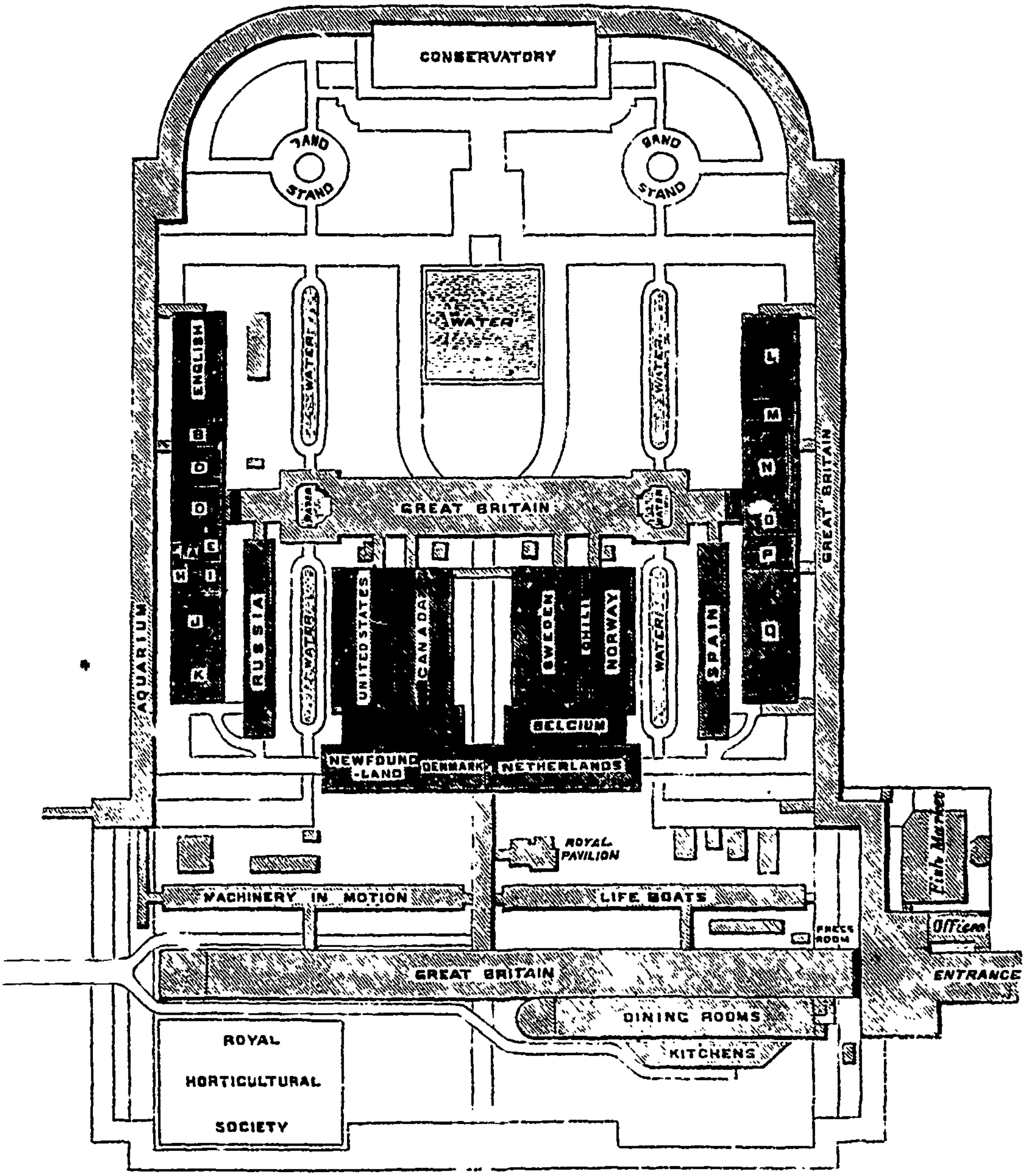
In the north of the Arcade where it curves towards the Conservatory, will be shown an enormous collection of examples of stuffed fish, contributed by many of the prominent angling societies. In front of these on the counter will be ranged microscopic preparations of parasites, &c., and a stand from the Norwich Exhibition of a fauna of fish and fish-eating birds.

Passing behind the Conservatory and down the Eastern Arcade—in which will be arranged Algæ, Sponges, Mollusca, Star-fish, worms used for bait, insects which destroy spawn or which serve as food for fish, &c.—on turning to the left, we find ourselves in the Fish Market, which will probably vie with the Aquaria on the other side in attracting popular attention. This model Billingsgate is to be divided into two parts, the one for the sale of fresh, the other of dried and cured fish.

Next in order come the two long iron sheds appropriated respectively to Life-boats and Machinery in motion. Then past the Royal Pavilion (the idea of which was doubtless taken from its prototype at the Paris Exhibition) to the southern end of the central block, which is shared by the Netherlands and Newfoundland; just to the north of the former Belgium has a place.

While the Committee of the Netherlands was one of the earliest formed, Belgium only came in at the eleventh hour; she will, however, owing to the zealous activity of Mr. Lenders, the Consul in London, send an important contribution worthy of her interest in the North Sea fisheries. We ought also to mention that Newfoundland is among those colonies which have shown great energy, and she may be expected to send a large collection.

Passing northward we come to Sweden and Norway, with Chili between them. These two countries were, like the Netherlands, early in preparing to participate in the Exhibition. Each has had its own Committee, which has been working hard since early in 1882.



Block Plan.—A. Switzerland; B. Isle of Man; C. Bahama and W. I. Islands; D. Hawaii, E. Poland, F. Portugal; G. Austria; H. Germany; I. France; J. Italy; K. Greece; L. China; M. India and Ceylon; N. Straits Settlements; O. Japan; P. Tasmania, Q. New South Wales.—Scale, 200 feet to the inch.

Parallel to the Scandinavian section is that devoted to Canada and the United States. While the American Government has freighted a ship with specimens expected daily, the former has entered heart and soul into the friendly rivalry, and will occupy an equal space—ten thousand square feet.

In the Northern Transept will be placed the inland fisheries of the United Kingdom. At each end of the building is aptly inclosed a basin formerly standing in the gardens · and over the eastern one will be erected the dais from which the Queen will formally declare the Exhibition open.

Shooting out at right angles are the Spanish annexe, and the building shared by India and Ceylon, China and Japan, and New South Wales: while corresponding to these at the western end are the Russian annexe and a shed allotted to several countries and colonies. The Isle of Man, the Bahamas, Switzerland, Germany, Hawaii, Italy, and Greece—all find their space under its roof.

After all the buildings were planned, the Governments of Russia and Spain declared their intention of participating; and accordingly for each the countries a commodious iron building has been specially erected.

The Spanish collection will be of peculiar interest; it has been gathered together by a Government vessel ordered round the coast for the purpose, and taking up contributions at all the seaports as it passed.

Of the countries whose Governments for inscrutable reasons of state show disfavour and lack of sympathy, Germany is prominent; although by the active initiative of the London Committee some important contributions have been secured from private individuals · among them, we are happy to say, is Mr. Max von dem Borne, who will send his celebrated incubators, which the English Committee have arranged to exhibit in operation at their own expense.

Although the Italian Government, like that of Germany, holds aloof, individuals; especially Dr. Dohrn of the Naples Zoological Station, will send contributions of great scientific value.

France, the other day only, consented to the official appointment of her Consul to look after the interests of the oyster cultivators who are contributing an important feature.

In the Chinese and Japanese annexe, on the east, will be seen a large collection of specimens (including the gigantic crabs) which has been collected, to a great extent, at the suggestion of Dr. Gunther of the British Museum.

It is at the same time fortunate and unfortunate that a similar Fisheries Exhibition is now being held at Yokohama, as many specimens which have been collected specially for their own use would otherwise be wanting; and on the other hand, many are held back for their own show.

China, of all foreign countries, was the first to send her goods, which arrived at the building on the 30th ultimo, accompanied by native workmen, who are preparing to erect over a basin contiguous to their annexe models of the summer-house and bridge with which the willow-pattern plate has made us familiar; while on the basin will float models of Chinese junks.

Of British colonies, New South Wales will contribute a very interesting collection placed under the care of the Curator of the Sydney Museum; and from the Indian Empire will come a large gathering of specimens in spirits under the superintendence of Dr. Francis Day.

Of great scientific interest are the exhibits, to be placed in two neighbouring sheds, of the Native Guano Company at the Millowners' Association. The former will show all the patents used for the purification of rivers from sewage, and the latter will display in action their method of rendering innocuous the chemical pollutions which factories pour into rivers.

In the large piece of water in the northern part of the gardens, which has been deepened on purpose, apparatus in connection with diving will be seen; and hard by, in a shed, Messrs. Siebe, Gorman & Co. will show a selection of beautiful minute shells dredged from the bottom of the Mediterranean.

In the open basins in the gardens will be seen beavers, seals, sea-lions, waders, and other aquatic birds.

From this preliminary walk round enough has, we think, been seen to show that the Great International Fisheries Exhibition will prove of interest alike,to the ordinary visitor, to those anxious for the well-being of fishermen, to fishermen themselves of every degree, and to the scientific student of ichthyology in all its branches.

The economic question of the undertaking we have left untouched.

ELECTRICITY APPLIED TO EXPLOSIVE PURPOSES.

The fifth of the series of *Six Lectures on the Applications* of Electricity, was delivered at the Institution of Civil Engineers, on Thursday Evening, the 19th of April 1883, by Professor F. A. Abel, C.B., F.R.S., *Hon. M. Inst. C.E.* The following is an abstract of the lecture:—

In introducing the subject, the Lecturer indicated the principal advantages which it had been early observed would result from a certain mode of firing explosive charges by electric current instead of by the ordinary fuzes, the best of which had inherent defects, greatly limiting their use for any but the simplest operations. He traced the history and development of electric firing from the crude experiments of Benjamin Franklin, about the year 1751, through the various stages in which frictional electricity, volta-induction apparatus, and magneto electric machines had supplied the means of generating the current, the tendency of late years being to revert to a modified form of voltaic battery for one class of work, and to employ dynamo-electric machines for another class. The history and development of the low tension, or wire fuze, and of the various fuzes employed with electric currents of high tension, were also discussed, and their relative advantages, defects and performances were described.

The only sources of electricity which at present thoroughly fulfilled the conditions essential in the exploding agent for submarine mines, were constant voltaic batteries. They were simple of construction, comparatively inexpensive, required but little skill or labour in their production and repair, and very little attention to keep them in constant good working order for long periods, and their action might be made quite independent of any operation to be performed at the last moment.

When first arrangements were devised for the application of electricity in the naval service to the firing of guns and so called outrigger charges, the voltaic pile recommended itself for its simplicity, the readiness with which it could be put together and kept in order by sailors, and the considerable power presented and maintained by it for a number of hours. Different forms of pile were devised at Woolwich for boat and ship use, the latter being of sufficient power to fire heavy broadsides by branch circuits, and to continue in a serviceable condition for twenty four hours, when they could be replaced by fresh batteries, which had in the meantime been cleaned and built up by sailors.

The Daniell and sand batteries first used in conjunction with the high tension fuze for submarine mining service were speedily replaced by a modification of the battery known as Walker's, which was after some time converted into a modified form of the Leclanché battery.

The importance of being able to ascertain by tests that the circuits leading to a mine, as well as the fuzes introduced into that circuit, were in proper order, very soon became manifest; and many instances were on record in the earlier days of submarine mining of the disappointing results attending the accidental disturbance of electric firing arrangements, when proper means had not been known or provided for ascertaining whether the circuit was complete, or for localising any defect when discovered.

The testing of the Abel fuze, in which the bridge, or igniting and conducting composition, was a mixture of the copper phosphide and sulphide with potassium chloride, was easy of accomplishment (by means of feeble currents of high tension), in proportion as the sulphide of copper predominated over the phosphide. Even the most sensitive might be thus tested with safety; but when the necessity for repeated testing, or even for the passing of a signal through the fuze, arose, as in a permanent system of submarine mines, the case was different, this fuze being susceptible of considerable alterations in conductivity on being frequently submitted to even very feeble test currents, and its accidental ignition, by such comparatively powerful test or signal currents, as might have to be employed, became so far possible as to create an uncertainty which was most undesirable.

Hence, and also because the priming in these fuzes was liable to some chemical change detrimental to its sensitiveness, unless thoroughly protected from access of moisture, another form of high tension fuze, specially adapted for submarine mining service, was devised at Woolwich. This, though much less sensitive than the original Abel fuze, was sufficiently so for service requirements, while it presented great superiority over the latter in stability and uniformity of electric resistance; and, though not altogether unaffected by the long continued transmission of test currents through them, the efficiency of the fuze was not affected thereby.

Although high tension fuzes presented decided advantages in point of convenience and efficiency over the earlier form of platinum wire fuze, the requirements which arose, in elaborating thoroughly efficient permanent systems of defence by submarine mines, and the demand for a battery for use in ships which would remain practiclaly constant for long periods, caused a very careful consideration of the relative advantages of the high and low tension systems of firing to result in favour of the employment of wire fuzes for these services. In addition to the disadvantages pointed out there was an element of uncertainty, or possible danger, in the employment of high tension fuzes, which, though fully eliminated by the adoption of voltaic batteries, in place of generators of high tension electricity, might still occasionally constitute a source of danger, namely, the possibility of high tension fuzes being accidentally exploded by currents induced in cables, with which they were connected, during the occurrence of thunder storms, or of less violent atmospheric electrical disturbances.

Experiment, and the results obtained in military service operations, had demonstrated that if insulated wires, immersed in water, buried in the earth, or even extended on the ground, were in sufficient proximity to one another, each cable being in circuit with a high tension fuze and the earth, the explosion of any of the fuzes by a charge from a Leyden jar, or from a dynamo-electric machine of considerable power, might be attended by the simultaneous ignition of fuzes attached to adjacent cables, which were not connected with the source of electricity, but which become sufficiently charged by the inductive action of the transmitted current. It therefore appeared very possible that insulated cables extending to land or submarine mines, in which high tension fuzes were enclosed, might become charged inductively during violent atmospheric electrical disturbances to such an extent as to lead to the accidental explosion of mines with which they were connected. In a Report by von Ebner on the defence of Venice, Pola, and Lissa, by submarine mines, in 1866, he refers to the accidental explosion of one of a group of sixteen mines during a heavy thunderstorm, as well as to the explosion of some mines, by the direct charging of the cables, through the firing station having been struck by lightning. Two instances of the accidental explosion of tension fuzes by the direct charging of overhead wires during lightning discharges occurred in 1873 at Woolwich.

Subsequently an electric cable was laid out at Woolwich along the river bank below low water mark, and a tension fuze was attached to one extremity, the other being buried. About eleven months afterwards the fuze was exploded by a charge induced in the conductor during a very heavy thunderstorm.

In consequence of such difficulties as these experienced in the special application of the high-tension fuzes to submarine purposes, the production of comparatively sensitive low-tension fuzes, of much greater uniformity of resistance than those employed in former years, was made the subject of an elaborate experimental investigation by the lecturer. Different samples of comparatively thin wires, made from commercial platinum, showed very great variatoins in electrical conductivity. Very considerable differences in the amount of forging to which the metal, in the form of sponge, had been subjected, did not importantly affect either its specific gravity or its conductivity, and the fused metal had only a very slightly higher degree of conductivity than the same metal forged from the sponge.

(To be continued.)

THE SHAPES OF LEAVES. "*Nature.*"

BY GRANT ALLEN.

III.—*Origin of Types.*

The two most general and distinctive types of foliage among angiosperms are those characteristic of monocotyledons and dicotyledons respectively. They owe their principal traits of shape and venation to the manner in which these two great fundamental classes have been separately evolved from lower ancestors.

Mr. Herbert Spencer has shown that there are two chief ways in which a central axis or caulome *may* conceivably be developed from an integrated series of primitive stalkless creeping fronds. The *first* way is by the in-rolling or folding of the fronds so as to form a complete tube, often with adnate edges, as represented in the accompanying diagram (Fig. 20) modified by Mr. Spencer's kind permission from the "Principles of Biology." For details of the explanation, the reader must be referred to that work (vol. ii. part iv. chap. iii.); it must suffice here to note that as in such case each frond must envelop the younger fronds within it, the process is there shown to eventuate in an endogenous stem and a monocotyledonous seed—two characteristics found as a matter of fact constantly to accompany one another in actual nature. The *second* way is by the thickening and hardening of a fixed series of midribs, as shown in the next diagram (Fig. 21), also modified after Mr. Spencer; and this method must necessarily result in an exogenous stem and a dicotyledonous seed. The diagrams in Figs. 22 and 23, which represent according to Mr Spencer (slightly altered) the development of the monocotyledonous and dicotyledonous seedlings respectively, will help further to illustrate the primitive characteristics of the two types.

The monocotyledonous type of foliage is for the most part extremely uniform and consistent, in temperate climates at least, for in the tropics the presence of large arborescent forms, such as palms and screw-pines, as well as of gigantic lilies, amaryllids, and grasses, such as the bananas, yuccas, agaves, and bamboos, gives a very distinctive aspect to the *ensemble* of the class. Being in principle a more or less in-rolled and folded frond, every part of which equally aids in forming the caulome or stem, the monocotyledonous leaf tends as a rule to show little distinction between blade and leaf-stalk, lamina and petiole. For the same reason, the free end also tends to assume a lanceolate or linear shape, while the lower part usually becomes more or less tubular or sheathing in arrangement. Again, for two reasons, it generally has a parallel venation. In the first place, since the leaves or terminal expansions are *mere* prolongations or tips to the stem-forming portion, it will follow that the vascular tissues will tend to run on continuously over every part, instead of radiating from a centre which must in such a case be purely artificial. *In the second place* it is clear that parallel venation is the most convenient type for long narrow leaves, as is plainly shown even *among dicotyledons* by such foliage, as that of the plantains, descended from netted-veined ancestors, but with *chief ribs now parallel.* Still better are both these principles illustrated in those cases among dicotyledons where the lamina is suppressed altogether, and, the flattened petiole assumes foliar functions, as in *Oxalis bupleurifolia* and *Acacia melanocylon* (Fig. 24). These phyllodes thus resembling in their mode of development the monocotyledonous type, and continuous throughout with the caulome-portion of the primitive leaf, exhibit both in shape and venation the chief monocotyledonous characteristics. A typical monocotyledon in shape and venation is represented in Fig. 25.

The dicotyledonous type, though far more varied, is equally due in its shape and venation to the original characteristics implied by its origin. Only the midrib instead of the whole leaf being here concerned in the production of the stem, there is a far greater tendency to distinctness between petiole and lamina, and a marked preference for the netted venation. The foliar expansion is not here a mere tip; it becomes a more separate and decided element in the entire leaf. And as the petiole joins the lamina at a distinct and noticeable point, there is a natural tendency for the vascular bundles to diverge there, making the venation palmate or radiating, so as to distribute it equally to all parts of the expanded surface. Fig. 26 shows the resulting characteristic form of dicotyledonous leaf. Its variations of pinnate or other venation will be considered a little later on.

Among monocotyledons, the central type is perhaps best found in the mainly tuberous or bulbous orders, such as the orchids, lillies, and amaryllids. These orders, having rich reservoirs of food laid by underground, send up relatively thick and sturdy leaves; but their shape is decided by the ancestral type, and by their strict subordination to the central axis. Hence they are usually long, narrow and rather fleshy. Familiar examples are the tulips, *hyacinths, snowdrops, daffodils,* crocuses, &c. Those which have small bulbs, or none, or grow much among grass, like Sisyrinchium, are *nearly* or *quite* linear; those which raise their heads higher into the open, like Listera, are often quite ovate. Exotic *forms (bromelias,* yuccas, agaves) frequently have the points sharp and piercing, as a protection against herbivores. In *the* grasses *there* is generally no large reservoir of food, and their leaves accordingly show the central type in a stringy drawn-up condition. So also in sedges, woodrushes, and many others. But where the general monocotyledonous habit has been more lost, and something like the dicotyledonous habit acquired, the leaves become more like those of the opposite class. Thus the Arums, with their very unlilylike mode of growth, and their long petioles rising high into the open air, have usually a very *distinct broad lamina, and have the veins accordingly* branched or netted, almost as in dicotyledons. Very much the same type recurs under similar circumstances in *Sagittaria sagittifolia* (Fig. 27). Still more markedly dicotyledonous-looking are the leaves of certain very aberrant Amaryllids, such as *Tamus* and the other Dioscorideæ, *which have taken to climbing, and have therefore* acquired broader leaves with netted veins between the ribs. Compare with these the like result in *Smilax;* and then look at both side by side with such dicotyledons as *Convolvulus.* The influence of the ancestral type is here seen in the arrangement of the main ribs; the influence of environment is shown both in the approximation of general shape, and in the netting of the minor veins. Once more, the ovate type of Listera leads on readily enough to the whorled leaves of *Paris* and *Trillium,* where the venation has become similarly netted. A bushy type, like *Ruscus*, develops broad leaf-like peduncles, which closely simulate the true leaves of dicotyledonous bushes with like habit, such as box or privet.

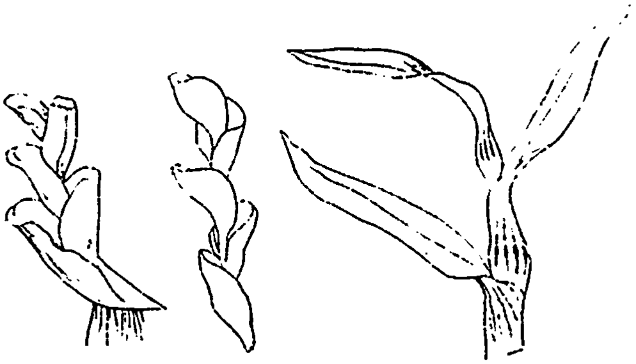


FIG. 20.—Development of Monocotyledonous stem.

FIG. 21.—Development of Dicotyledonous stem

But the widest departure of all from the central monocotyledonous type is found in leaves like those of the tropical arborescent forms—the palms, screw-pines, &c. Most of these have long pinnate foliage, whose origin may best be considered when we come to examine the chief dicotyledonous types; meanwhile such forms as the cocoanut or the date-palm may be advantageously compared, as to conditions and general shape, with the tree-ferns in one direction, and the cycads in another. The bananas cast much analogous light upon the origin of these tropical pinnate forms. Where the plant is less arborescent, as in *Chamærops*, the leaf assumes rather a fan-shaped than a pinnate development.

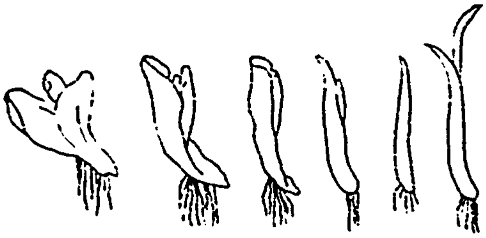


FIG. 22.—Development of Monocotyledonous seedling

Among dicotyledons it may be fairly assumed that the earliest form of leaf was simple, ovate, and nearly ribless, or with faint digitate venation. This is shown both by the nature of the earliest leaves in most seedlings, and the constant recurrence to such a type wherever circumstances are favourable for its reproduction. Hence, as a whole, digitate venation seems the commonest in most humble dicotyledons; and the only problem is how pinnate venation came to be substituted for it in certain cases. The answer seems to be that wherever circumstances have caused leaves to lengthen faster than they broadened, and so to assume a lanceolate rather than an ovate shape, the tendency has been for the main ribs to be given off, not from the same point, but a little in front of one another. If the technical botanists will pardon such a phrase, the internodes of the midrib, usually suppressed, seem here to have been fully developed. Figs. 28, 29, and 30 show the stages by which such a change may be brought about. Figs. 31, 32, and 33 exhibit a slightly different form of the same tendency.

That this is the real origin of pinnate venation seems pretty clear on a comparison of a good many otherwise closely related forms. Look for example first at the rounded, almost orbicular leaf of *Geranium molle* and its allies, with palmate ribs; and then look at the long, narrower, doubly pinnate, and pinnately-ribbed leaves of *Erodium cicutarium*. Or again, look at the common cinquefoil, erect and palmate; and then at silver-weed, long, creeping, closely pressed to the ground, and with numerous pinnate leaflets. Once more, compare *Alchemilla* with *Poterium* and *Sanguisorba*. As a still simpler instance, where we get the difference in its first beginning, contrast *Ranunculus acris* with *R. repens*, or the least compound leaves of the blackberry bramble with its own most compound foliage. As a rule the most pinnate groups, such as the lesser crucifers, the peaflowers, &c., have very long leaves.

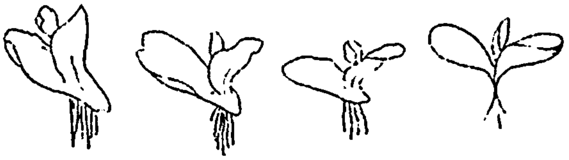


FIG. 23.—Development of Dicotyledonous seedling.

FIG. 24.—*Acacia melanoxylon.*

FIG. 25.—Typical Monocotyledonous leaves and venation.

This suggested origin of pinnate venation in dicotyledons becomes even more probable when we look at the pinnate members of other classes. Among monocotyledons the long-leaved arums, though their venation is fundamentally parallel in type, have yet acquired a branching and practically pinnate set of ribs. The plantains and bananas, with very long and broad foliage, carry the same tendency yet further; for their leaves are pinnately ribbed from a stout midrib. The lower shrubby or bushy palms, like Chamærops, have fan-shaped leaves, with veins diverging in rough parallelism from a common centre; that is to say, they are in fact palmate; but in the taller arborescent palms, with their long leaves, the internodes of the midrib (to use the same convenient phrase once more) are fully developed, so that the leaf becomes pinnatifid. In this case the subdivision into leaflets is probably protective against tropical storms. The broad-leaved plantains and the Chamærops, though so much shorter than the pinnate palms, are often torn by the wind, and a plantain leaf so torn into ribbons closely resembles a cocoanut leaf: in the taller palms this disruption between the ribs becomes normal. Compare Zamia and the other cycads among gymnosperms.

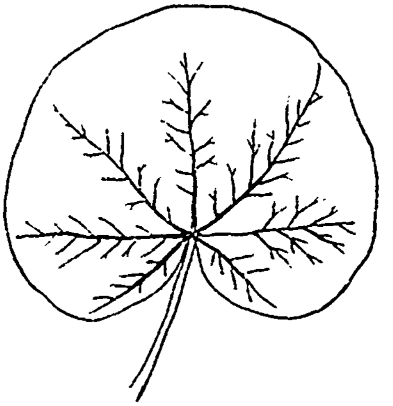


FIG. 26.—Typical Dicotyledonous leaf and venation.

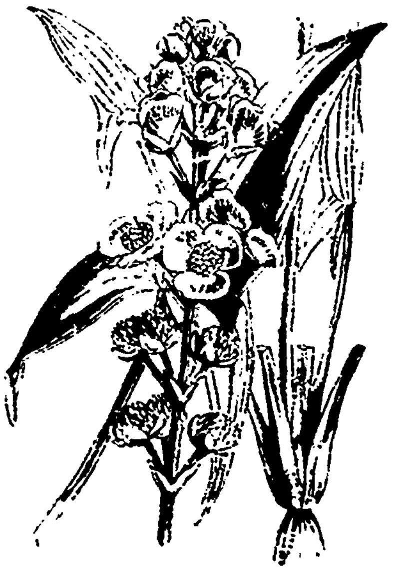


FIG. 27.—*Sagittaria sagittifolia.*

Once more, the ferns are a class with long lanceolate fronds as a rule, and their venation is almost always pinnate; the only ferns that vary much from the central type being some like the Maidenhairs, which are tufty and rather ovate in general form, and have so modified their venation as closely to approach the herb Roberts and other hedgerow plants in the outer effect. We may fairly conclude, therefore, that pinnate venation is best adapted to very long leaves, both because of the support it gives to the celllular mass and because of the easy manner in which it distributes sap to every part alike.

It seems also probable that pinnate ribs are especially adapted to forest trees. Most of these indeed have their leaves rather long in outline—like the ash, the oak, the chestnut, the walnut, the mountain ash, the laurels, the hornbeam, and the willow—while others in which the primary ribs are palmate—like the horse-chestnut and the plane—have their secondary ribs pinnate and their lobes or leaflets very long, so that the total effect is in the end pretty much the same. But even when the leaf is rather shortened in general outline, as in the elm, the beech, the alder, and the poplar, the venation is still pinnate. Doubtless this form of ground plan protects the leaves of these exposed trees best against the wind; and where the leaflets are much subdivided, as in the acacias, the subdivision may be regarded as a protection against severe storms.

The shapes of leaves in each particular species of plant thus depend in ultimate analysis upon two factors. first, the ancestrally-inherited peculiarities of type and venation; and second, the actual conditions to which the species is now habitually exposed. Accordingly, under the same conditions, a monocotyledon and a dicotyledon will tend to assume approximately similar general external forms; but their underlying ancestral peculiarities may generally be perceived through the mere analogical resemblance produced by an identical environment. By the interaction of the two factors we must endevour to explain every particular form of leaf. To do this throughout the whole vegetable kingdom would be of course an endless task, but to do it in a few selected groups is both a practicable and a useful botanical study. The ground-plan will always depend upon the ancestral type, the outline, degree of segmentation, and minuteness of cutting, will always depend upon the average supply of carbonic acid and sunlight.

SPECIAL TYPES IN SPECIAL ENVIRONMENTS.

From the previous papers it will be clear that degree of subordination to the stem accounts in large measure for the extent to which leaves vary from the primitive ovate-lanceolate type. Where they are still so most subordinated, there will be a strong tendency towards the long pointed ribbon-like form, and also a marked inclination towards decurrence. This combination of peculiarities is well seen in several thistles, and in comfrey, as also to a less extent in many epilobes and stellarias. Compare *Verbascum thapsus*, and other mulleins. From these extreme cases, in which leaf and stem are not fully differentiated from one another, one can trace several gradations, through square stems with sessile leaves (as in certain St. John's worts) up to merely sessile stem-leaves, or leaves that clasp the stem with pointed or rounded auricles. Wherever lines exist along the stem, they may be observed in pairs up to a point where a leaf is given off, and they are undoubtedly surviving marks of the primitive unity of stem and leaf. The same may be said of rows of hairs, like those of *Stellaria media* and of *Veronica chamædrys*. There can be little doubt that selective causes (protection against creeping insects &c.) have often come into play in preserving or modifying such decurrent wings, stem-lines, auricles, clasping stipules, and rows of hairs; but as a whole they nevertheless point back distinctly to the origin of dicotyledonous stems from superposition of leaves and midribs upon one another. They are rudimentary forms of stem-lamina.

Sessile leaves are particularly apt to be lanceolate. They approach nearest among dicotyledons to the monocotyledonous type. The botanist will readily fill in examples for himself.

On the other hand, it is clear that the conditions under which leaves assume the orbicular and peltate types can only occur where there is least subordination to a central stem. And these conditions must have occurred for immense numbers of generations in order to overcome the ancestral tendency towards the lanceolate or ovate form. For a leaf must first pass through a cordate or reniform stage, like that of the coltsfoots, before it can reach an orbicular shape, like that of our common waterlily, and even when it becomes completely circular, like the *Victoria regia*, it may still retain a mark of junction where the overlapping edges have met without becoming connate. In the case of *Victoria regia* the transformation has been traced during germination. The first leaves produced by the young plant are linear and submerged; the next are sagittate and hastate; the latter ones become rounded, cordate, and orbicular; and even when they assume the peltate form, the line still marks the point of union. This sufficiently accounts for the rarity of perfectly peltate leaves, such as those of *Tropæolum*, *Hydrocotyle*, and *Podophyllum*. Radical leaves growing on long footstalks will be oftenest orbicular cordate; stem-leaves on the same plant may pass from ovate-cordate to ovate, lanceolate, and linear. Large cordate radical leaves will be most frequently produced from perennials with richly stored rootstocks. The sagittate and pointed leaves of *Arum* and *Sagittaria* show the furthest step attained in the same direction of monocotyledonous foliage, starting from the liliaceous form.

Where the stem, or, what comes practically to the same thing, solitary ascending branches, rise high into the air, especially with opposite leaves, we get a common type which may be well represented by the white deadnettle (Fig. 34). Hedgerow plants with perennial stocks frequently assume this type. It reappears almost identically, under the same conditions, in so distant a group as the true nettles; and though it is possible that the causes which produce mimicry in the animal world may here have come somewhat into play, so as to modify sundry *Lamiums* into the similitude of the protected *Urtica*, yet the analogy of other Labiates shows that the circumstances alone have much to do with producing the resemblance. For a great many tall-stemmed hedgerow Labiates closely approximate to the same type; for example. *Lamium galeobdolon*, *Ballota nigra*, *Galeopsis tetrahit*, *Stachys silvatica*, and *S. palustris*. Compare, *mutatis mutandis* for ancestral peculiarities, the other hedgerow plants, *Scrophularia nodosa*, and *Alliaria officinalis*. On the other hand, notice the orbicular long-stalked lower leaves of the latter (especially when biennial) side by side with the lower leaves of some Labiates, such as *Nepeta glechoma*. Indeed, the Labiates as a whole present an excellent study of local modification in an ancestral type, according to habit and habitat. Take as other groups of this family the following. first *Mentha* and *Lycopus*, then, *Salvia pratensis*, *Prunella*, *Marrubium*, radical leaves of *Ajuga reptans*, and lower leaves of *Nepeta glechoma*; finally, the typical form dwarfed in little prostrate retrograde types, such as *Thymus serpyllum* and *Mentha pulegium*. Compare these last with other prostrate or dwarfed types elsewhere, like *Veronica serpyllifolia*, *Peplis portula*, *Hypericum humifusum*, *Montia fontana*, and *Arenaria serpyllifolia*.

As grassy types, the best familiar examples are those of the flaxes, *Stellaria graminea*, Toadflax, Bastard Toadflax, &c.; all of which have been largely influenced by monocotyledonous competition. Even a pea, *Lathyrus nissolia*, has got rid under such circumstances of its leaflets, and has flattened its petiole into a grass like blade. Intermediate forms occur in Southern Europe. The peas, indeed, are papilionaceous plants which have largely cast off their ancestral leaf-type, in order to avail themselves of new conditions. *L. aphaca* has lost its leaflets, and flattened and enlarged its stipules so as to resemble simple opposite leaves; and *L. hirsutus* and *pratensis* have reduced the leaflets to one long most linear pair. Marshy plants have also often been forced into adopting grass-like forms. The great spearwort is a swampy buttercup, whose ancestral leaf has been lengthened out into a long ribbon, with almost parallel ribs, the lesser spearwort shows the same tendency to a less degree, still retaining ovate lower leaves, with lanceolate upper ones; and *Veronica scutellata* is a similar marshy case among the Scrophularineæ.

When the tree-like form is attained, or free access to air is otherwise gained (as by climbers), the supply of carbon, being practically unlimited becomes relatively little important, and the supply of sunlight assumes the first place in the economy of the plant. Under such conditions, the great object must be to prevent the leaves from overshadowing one another. Now this result may be obtained in a great number of ways, and we must not expect that every tree or shrub will solve the problem for itself in exactly the same fashion. It is enough that the shape into which the ancestral form is finally modified should sufficiently answer the purpose in view. As a matter of fact, the suitability of the actual forms and arrangements of tree-leaves to the functions they have to perform can be readily tested by observing any tree in bright sunshine. On the one hand, almost every leaf is in full illumination, no *leaf unnecessarily shading its neighbour; and on the other* hand, there is hardly any interspace between the leaves, as may be seen by the fact that the shadow thrown by the tree as a whole is almost perfectly continuous. In short, there is no waste of chlorophyll, and there is no waste of sunshine.

Mr. Herbert Spencer has called attention to the results of varying exposure to light in the various parts of the same leaves, which often causes them to become unequally developed. In the lime (Fig. 35) such obliquity is normal. In the various *Begonias* (Figs. 36 and 37) the resulting asymmetry *is very noticeable.* In the cow-parsnip (Fig. 38) it is the leaflets of the same leaf which are asymmetrically developed, *so as not to overshadow one another.* In more symmetrical leaves, there is an equal provision for preventing overshadowing, *only here* it takes *the form of indentation of the edge*, as in the oak, or of subdivision into leaflets, as in the horse-*chestnut.* In the latter case, indeed, the two outermost leaflets are habitually asymmetrical. On the whole, however, *the mass of* forest *trees* in temperate climates *have* almost entire leaves; and full exposure to sunlight is secured rather *by their special* specific arrangement at the end of the minor branches. Most often they are more or less ovate, as in the elm, *beech*, alder, birch, and poplar. Where the leaves are divided, the separate leaflets assume the appearance of almost entire *leaves*; compare the leaflet of the horse chestnut with the leaf of the true chestnut; the leaflet of the ash with the *leaf of the hornbeam*, the leaflet of the walnut with the leaf of the beech; and the leaflet of the mountain ash with the leaf of *the blackthorn*. In all these cases, almost identical results are practically produced in the end by similar circumstances acting upon *wholly* unlike original types.

Some minor typical forms exist in certain groups of climbers, which are worth *a moment's* notcie. Take as an example the creeping leaves of ivy. As long as this plant grows, close to a wall or the trunk *of a tree* it assumes the well known shape shown in Fig. 39. But as soon as it branches out its flowering sprays into the *open, acquiring* a tree-like habit, which it often does on the top of a wall, it takes a simpler and totally different form of leaf, as shown in Fig. 40, growing on the same plant. This last type is quite comparable to that of the pomegranate. That both types admirably suit their particular situation can easily be seen by noting how well they fit in with one another without overshadowing. It would be difficult to point out the geometrical grounds for this relation, but the relation itself becomes obvious *on* watching an ivy-plant in broad sunshine. Moreover, the first or truly ivy-like form of leaf tends to recur in many plants which similarly press close to a flat surface. In *Veronica hederæfolia* we get it in a weed that climbs over banks of earth; *Linaria cymbalaria* we get it in a trailer hanging upon stone walls; in *Campanula hederacea* and *Ranunculus hederaceus* we get it in a creeper along the edge of rills or over soft mud. Compare in each case other forms of the typical generic leaf, as seen in germander, speedwell, toadflax, harebell and meadow buttercup.

Another special climbing type, proper to more *open* habits of twining round alien stems, is that of the common bindweed. This, the ordinary convolvulus form, reappears exactly in so distant a plant as *Polygonun convolvulus,* whose habits are exactly similar. Even among monocotyledons we get it closely simulated by *Smilax,* with precisely like condition, and somewhat less closely by *Tamus.* Indeed, this form of leaf may be said to be almost universal among lithe twining creepers.

The hop type belongs rather to mantling than to mere twining climbers. It reappears under identical conditions *in the vine, and less closely in true bryony.* More subdivided into leaflets it produces the Virginia creeper, and many forms *of clematis.*

Among ground plants it is only possible very briefly to refer *to the* succulent types which abound in dry situations. A regular gradation may here be traced from rich forms with *rather thin, flat, ovate leaves, growing in favourable situations,* like *Sedum telephium*, through dwarfish forms, with oblong *leaves, Sedum album,* to forms with knobby, globular leaves, growing in very dry spots, like *Sedum anglicum.* Where *the stem becomes very* succulent, the leaves may be dwarfed out of existence altogether, or reduced to prickles, as in those *dry desert* plants, the cactuses. Compare some tropical Euphorbias. Miscellaneous examples of these dry types are also found among Mesembryanthemums and other Ficoideæ, natives of hot, sandy plains in South Africa. The succulence *here* acts as a reservoir for water. Special precautions are taken against evaporation. We see the first symtoms of such a habit in some English dry-soil saxifrages.

Proximity to the sea, whether the plant grows in sand or mud, also tends to produce succulence. This effect is seen casually in many seaside weeds, and habitually in such cases as samphire, *Inula crithmoides, Spergularig rubra, Cakile maratima*, and common scurvy-grass. *Suæda maritima* is in this group the exact analogue of *Sedum anglicum*, while *Salicornia* is similarly the analogue of the leafless cactuses. Compare also *Salsola kali.* There is a somewhat similar tendency to fleshiness in certain freshwater weeds of moist spots, such as *Chrysosplenium*, and many saxifrages.

In such a brief sketch as the present it is impossible to do more than allude in passing to sundry more special developments of leaves, for protective or other purposes. One development of this character is *seen in the growth of prickly tips* (*Agave, Aloe, Salsola, Juncus acutus, Bromelia pinguin*), or *of* prickly edges (thistles, *Carlina*, holly, *Stratiotes. Dipsacus, Rubia peregrina*). Such prickles may be purely defensive, or they may assist the plant in clambering (*Stellatæ, Smilax,* hop). Again, the leaf as a whole may be reduced to a prickle, *as in gorse, where the very young* seedling has trefoil leaves like its allies, but these give way gradually to entire lanceolate blades, and finally to mere thornlike spines. Another very different development is that of the insect-eating plants, which grow in very boggy spots, and so require animal matter not yielded them by the roots. Our English sundew (Fig. 41) is an example of the first step in such a process; essentially its leaves belong to the obovate tufted or rosetted type represented by the daisy, only a little exaggerated: but they have been specialised for the insect-eating function by the evolution of the little glandular hairs. Even simpler is the type of the butterwort, which belongs to the same foliar class as the London Pride, *Draba aizoides, Samolus Valerandi, Sempervivum tectorum, &c.*, but with the edges folded over so as to inclose its insect prey From these simple forms we progress at last to highly specialized types like *Dionæa* (Fig. 42), *Sarracenia, Darlingtonia, Nepenthes*, and *Cephalotus*. Once more, the connate form in *opposite* leaves (*Dipsacus, Chlora*) or the portfoliate in alternate ones (*Bupleurum*) may be due, as has been suggested, to the facilities these arrangements afford for storing a little reservoir of water, which acts as a moat to protect the flowers *from* climbing ants. But such minor selective actions are too numerous and too diversified to be noticed in full here; it must suffice to point out the general principles upon which the forms of leaves usually depend, leaving the reader to fill in the *details* in every case from his own special observations.

OUR BODIES:" (*Knowledge*).

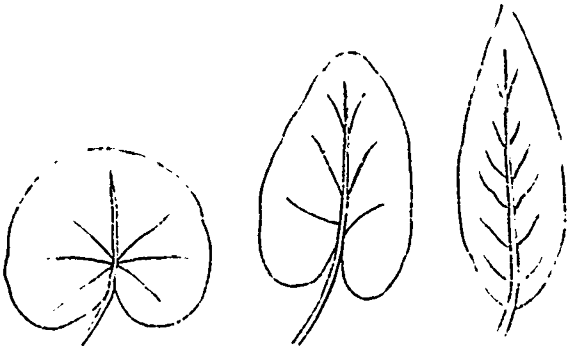
THE PROCESSES OR FUNCTIONS OF THE BODY

BY DR. ANDREW WILSON, F.R.S.E., &c.

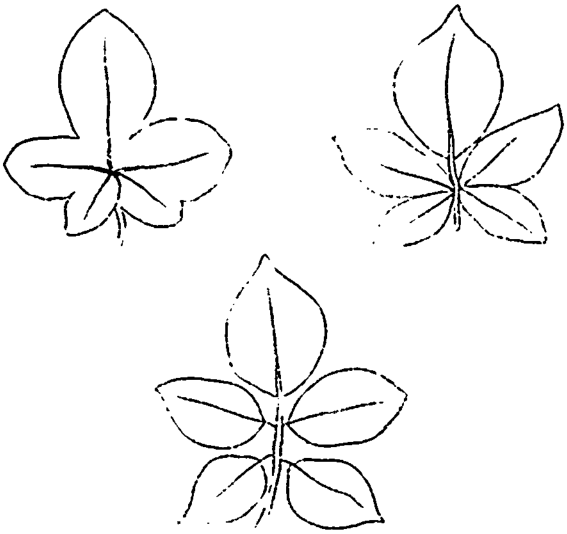
HOW THE BODY'S DUTIES ARE PERFORMED.

In our last paper we saw that the body was a complex machine, within which continual actions were being executed and performed. Life, in one sense, is merely the sum total of these actions. Our existence in the result of their exact and continous performance. It remains, however, that we should look a little more closely at these bodily processes. We must endeavour to ascertain how they are performed, and in what fashion they relate themselves to our daily life.

The world "secretion" is one in constant use in the *mouths* of physiologists. They speak of the liver "secreting" bile, of the salivary glands "secreting" saliva, or the "water" of the mouth, and of the stomach "secreting" gastric juice. What is meant, then, by this word "secretion"? and what is the use or purport of the function which bears its name? To answer these queries we must reflect a little upon the demands *which* life makes upon the body's belongings. In the digestion of food, for example, a considerable number of fluids are poured at intervals upon the food The digestive system, it will be remembered, is merely a tube, opening into which we find certain organs, such as salivary glands, liver, sweet-bread, &c. Now, digestion is largely a chemical process. Certain food-elements are broken down, combined with other elements, and made to assume new forms, in which they can be readily combined with the blood. Hence upon the food there are the fluids already mentioned, which alter and change the food-constituents as nature directs. Take, as an example, the food-changes which occur in the mouth. Saliva—the "water" of the mouth—is poured upon the food at this stage of digestion. This fluid is furnished by three pairs of organs called *salivary glands*, each gland opening into the mouth by a "duct" or tube of its own. When saliva comes in contact with any starchy foods, the latter are transformed by the chemical action of this fluid into dextrin and grape-sugar. When saliva is analysed, it is found to consist of water, certain minerals, and a substance (found nowhere in the body save in this fluid) called *ptyalin*. It is this latter substance which appears to be instru-



FIGS. 28, 29, 30.—Gradation from palmate to pinnate venation.



FIGS. 31, 32, 33.—Gradation from palmate lobes to pinnate leaflets.

FIG. 34.—White Deadnettle (*Lamium album*).

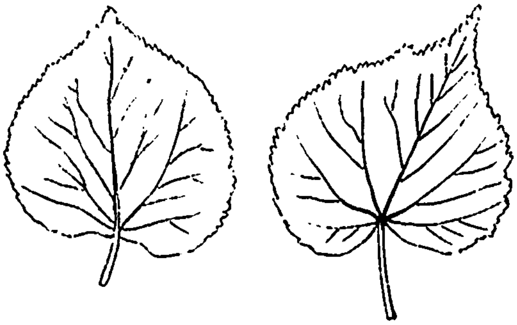
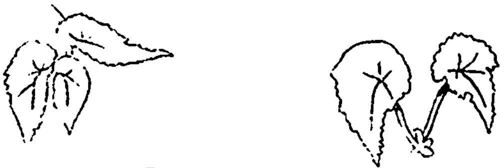


FIG. 35.—Lime.



FIGS. 36 and 37.—Begonias.

FIG. 38.—Cow-parsnip.

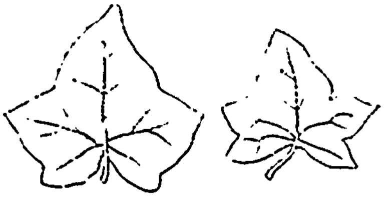


FIG. 39.—Creeping leaves of ivy.

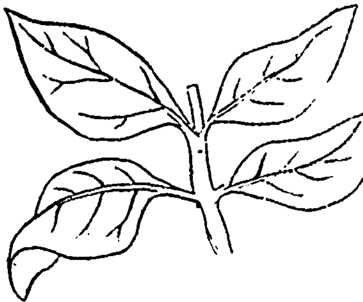


Fig 40.—Ascending leaves of ivy.

Fig. 41.—Sundew.

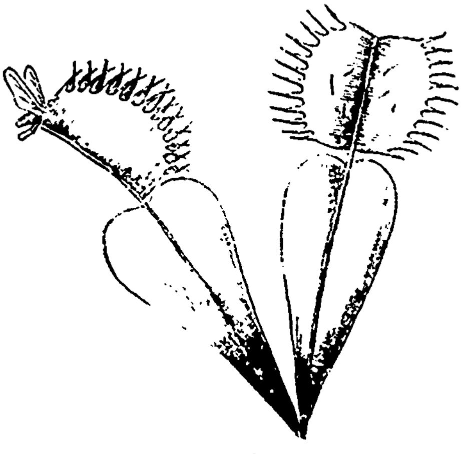


Fig. 42.—Dionæa.

mental in changing starch into dextrin and grape-sugar—in which latter forms starch, itself indigestible, becomes more readily absorbed into the blood. Hence this substance, *ptyalin*, is said to be one of the digestive "ferments"—a name applied to certain bodies which are found chiefly in the digestive fluids, and which produce chemical changes in the foods submitted to their action.

In the stomach, another "ferment," *pepsin*, exists in the "gastric juice." The latter fluid is "secreted" by the little glands that exist in the substance of the stomach itself. This ferment has the power of changing nitrogenous foods or "albuminoids" into substances and called *peptones*. In a word, in the latter form these foods are diffusible, and readily pass into the blood. The liver, as every one knows, is a manufactory of *bile*, which is, perhaps, the most complex fluid in the body. Bile is of a greenish-yellow colour, and when analysed is found to consist of water and solids, amongst the latter being *bilin*, fat, *cholesterin*, &c. There seems little doubt that bile when added to the food (as it is added after the food has left the stomach) acts specially on the fatty parts of the food, whilst discharging other functions. The *pancreas* or "sweetbread" throws *pancreatic juice* on the food, when bile from the liver is also poured upon it. In the sweetbread's secretion we find water, minerals, and a substance called *pancreatin*. Starch is certainly acted upon by this substance, and such starchy foods as may have escaped digestion in the mouth, are changed into dextrin and grape-sugar after leaving the stomach. The sweetbread's "juice" also assists in the digestion of fats, and must in this way aid bile in its work; whilst it is also believed to possess some action upon the albuminous parts of the food, an effect accessory to that produced by the gastric juice of the stomach.

When the food is passing along the tube which succeeds the stomach, and which is called the *intestine* (or bowel), it is thus mixed with bile and pancreatic juice. These fluids are poured upon the food in the first part of the intestine. In total length, the intestine in man measures 26 ft.; the *small* intestine making up 20 ft. of this length, and the *large intestine* about 6 ft. As the food travels along the small intestine, it has also poured upon it the fluids furnished by the glands of the bowel. The glands are of various kinds, and some at least appear to exercise a digestive action on the food.

To sum up our notes on digestion, then, we discover that *the food* is attacked, so to speak, at various *stages of its progress* along the digestive tube by the fluids or "secretions" that are poured upon it; that, secondly, these secretions exert *each a chemical action on the food*; *thirdly, that their effect* is to convert the food into a milk-like fluid (called *chyle*) which contains the concentrated nourishment of the food, and which will be added *in* due course *to the blood*; *and, lastly, that the* fluids which thus accomplish digestion are provided each by an organ or organs called, generally, *glands*. That which remains for us is to enquire, how or by what means the *glands* produce and manufacture the secretions of which we have just spoken.

In a manufactory there are three chief elements which demand consideration at the hands of the economist. The first is the raw material, the second is the workman or workmen, and the third is the manufactured article. Each "gland" in a human body is a manufactory which turns out a manufactured article (bile, gastric juice, saliva, &c.) from raw material. The raw material in the physiological factories is *blood*. Here, however, we come face to face with a very deep physiological problem. From one and the same raw material—blood—which is supplied to the "glands," each factory produces a special product, differing widely from that of other "glands." Bile and pancreatic juice, the "tears" of the eyes, the mucous secretion of the nose, and the saliva, are widely different glands; yet they are manufactured from the same raw material. But what of the workmen which perform the work? Here we come face to face with the microscopic elements of our bodies known as *cells*. In our last paper I spoke of *protoplasm*, the "physical basis of life," as seen in the *Amœba*, or "Proteus-animacule." Now the cells of our bodies, when in an active, living state, consist of protoplasm. The liver is, practically, an agglomeration of *hepatic cells*, each about the $\frac{1}{1000}$th of an inch in diameter. It is "cells" of other kinds that make up the essential parts of the salivary glands; it is "cells" that compose the secreting part of the sweetbread; it is "cells" that make the gastric juice in the glands of the stomach. If, as is certainly the case, the cell is a mass of living "protoplasm;" then it is clear that we have at last tracked the problem of secretion as far as we may. Supply a liver cell with blood, and it makes bile ; supply a cell of the stomach's glands with blood, and it makes or "secretes" gastric juice. The "properties of protoplasm" is a phrase that means much or little, according as we are wise or heedless of life's acts and wonders. *He who is heedless will be apt to say there is no* mystery after all ; he will urge that living protoplasm, because it lives, discharges these functions, and that there is an end of the matter. But he who is wise will not rest here. He will seek to know *why* one bit of protoplasm makes bile, and *why* another makes saliva. He will regard with wonder the fact that all forms of protoplasm appear essentially similar to all scientific tests. He will look below the surface, and see in the adaptations of this one substance to many and varied ends, another proof of the great contention of modern science—that, after all, the evolution of life's ways and works is as discernible in a study of "secretion," and "cells," as in the growth of the complex animal from the simple egg, or of the flower and its variety from the primitive germ that precedes fruition.

THE BLOOD.

When the voice of ancient authority declared the blood of the body to be its "life," the statement was one which the experience of everyday life seemed fully to support. The physiologist of to-day will not quarrel seriously with the ancient rendering. He knows the impossibility of defining this mystic "life" of ours, which appears now as diversity in unity, and then as unity amidst variety of the most complex kind. He also knows that many other parts or components of the body might with equal justice be named the "life"—at least, in the sense in which the blood has been so termed. The top of the spinal cord (or *medulla oblongata*, as this part of the nervous axis has been named) might, perhaps, with greater force than the blood, be named the "life," since we can lose a pint or two of blood and recover perfectly from the depletion, while a prick with a pin in the medulla would cause instant death. Similarly, the heart might quite appropriately be named the "life,". in the sense of the absolute necessity of its action for the continuance of the circulation. The "breath," also, is the "life" in a very plain and unmistakeable sense, since interference with the breathing function means primarily death to the blood itself. But when we consider that the blood-flow is incessant, that it travels to all parts of the body, and that its failure means deprivation of food to the tissues, as well as the want of heat-production, we can readily enough find ample justification for the words of ancient wisdom with which we open this paper.

What is blood ? An important question this, and one which may be answered in at least three ways—firstly, *physically* ; secondly, *chemically* ; and thirdly, *microscopically*. Let us, firstly, endeavour to ascertain the *physical characters* of blood, or those which blood exhibits when regarded merely as a particular kind of fluid. To the naked eye, blood appears of a bright red colour as it flows in the arteries—that is, when it is pure ; whilst it is of a purple colour when, in an impure state, it circulates through the veins. Microscopically, as we shall *presently see, blood is not really red in hue*, but *owes* its colour to the numerous red bodies (or *corpuscles*) which float in it. Blood is feebly alkaline in its reaction, and this alkaline character decreases from the time of the removal of the blood from the body, and until it clots or "coagulates."

When drawn from the body, blood "clots." From two to five or six minutes suffice for this action. At first, the blood appears as a red jelly ; but ultimately, the clot sinks to the bottom of the vessel, leaving a straw-coloured liquid above. Blood thus practically analyses itself before our eyes, into a solid part, the *clot*, and a liquid part, the *serum* or *plasma*. The clot consists of the *corpuscles* or *globules* of the blood (most of them *red*, hence the character of the clot) entangled in a substance called *fibrin*. The liquid, or *plasma*, is the normal liquid or fluid part of the blood itself. This fluid, the microscope shows us, is as clear as water, and owes its apparently red colour, as already remarked, to the red globules that float in it. *It is owing to a few of these red corpuscles remaining* suspended in the plasma, that the liquid part of the blood in the "clot" seems to be straw-coloured If we whip up or switch the blood with a bundle of twigs, just after it has been shed, no clotting takes place. In such a case, we whip out from the blood the fibrin which entangles the red corpuscles, and which adheres in strings or shreds to the twigs.

· The *chemical composition* of the blood may be very shortly dealt with. A fluid which is supplied to every part of the body, and from which each organ or tissue derives the materials wherewith to renovate and repair its substance, might reasonably enough be expected to present us with a fluid epitome of the entire frame. And so, in truth, do we find blood to exhibit a composition of wide and generalised character. We discover, for instance, that blood contains about 784 parts of *water per* 1,000 ; it is rich in *albumen* ; it contains *fatty matters* ; it has a complex list of minerals, such as common salt, chloride of potass, phosphates of lime and magnesium, carbonate of sodium, etc., and it shows on analysis, colouring matter, gases, and a number of substances derived from the waste of the body. *Another fashion of showing the chemical* composition of blood, brings out its elementary constitution as follows : Carbon, 57·9 ; hydrogen, 7·1 ; nitrogen, 17·4 ; oxygen, 19·2 ; ashes, 4·4. From such an estimate, we see that blood contains material adapted for supplying all the tissues of the body in the reparative work which is incessantly being performed.

Under the *microscope*, a thin film of human blood is seen to consist of a clear liquid—the *plasma*—in which float two kinds of bodies. These are the *red* and *white corpuscles* or "globules," as they are often popularly named. The blood derives its red colour from the immense number of corpuscles which float in its liquid The white globules are less numerous; about one white corpuscle existing to 400 or 500 red ones. The microscope enables us to see in between the globules, and thus to perceive the clear liquid. To the naked eye, conversely, the blood appears uniformly red, because the globules are so numerous, *and because we cannot perceive the liquid in which they* float. Each red corpuscle of man measures in breadth about 1-3200th of an inch, and in thickness about 1-10,000th of an inch. In shape it is biconcave, or hollowed on either side, and is coloured red by a substance called *hæmoglobin*. It is this substance which is affected by the *oxygen* we breathe into *the blood, and by the carbonic acid gas* the body and *tissues* at large excrete into the blood. The *white corpuscles* of man's blood measure in diameter, each, about the 1-2500th of an inch. Each contains a central particle, the *nucleus*. It appears to be this nucleus which, when liberated from the outer part of the white corpuscle and coloured red, *becomes* a *red corpuscle*. The red corpuscles of the blood are thus derived from the white ones.

The white corpuscles of the blood are known to possess the curious property of exhibiting movements similar to those seen in the *amœba*-animalcule. These corpuscles (like the *amœba*) can also absorb particles of solid matter, as the animalcule in question takes its food. The white corpuscle is, therefore, a particle of *living protoplasm*, possessing a vitality independent, in a measure at least, of that seen in the body of which it forms part. It is, indeed, a curious fact to ponder over, that rolling about in our veins and arteries ; now worming through the walls *of blood-vessels into our tissues, and now contracting and* expanding their substance, are myriads of minute living specks which, although, part and parcel of our composition, are closely related in structure and life to the animalcules of the pool.

Miscellaneous Notes.

At a Meeting of the Physical Society Berlin, Dr. Konig reported on two optico-physiological researches, which he had carried out in consequence of his optical studies with the leucoscope. In the first he has, with the aid of a special apparatus, examined a number of colour blind persons as to the position in the spectrum of their so called "neutral" point. According to the Young-Helmholtz theory, it is known, there are three primary colours (red, green, and violet), each of which produces its special colour sensation, while all combined give the impression of white. The sensibility for the three primary colours is so distributed over the spectrum that their curves in great part coincide on the abscissa *of wave lengths, and therefore mixed colour sensations* occur everywhere, while the maxima of the separate curves occur at the places of brightest red, green, and violet respectively. In the case of the colour blind one curve is wanting, and the two remaining ones have therefore a point of section where their ordinates are the same. Hence the eye must at this part have the impression of white or grey. For finding this neutral point in the spectrum, an apparatus served, in which the telescope of a spectroscope was so arranged with regard to the non refringent angle of the prism that the spectrum took up only half of the field of vision, while the other half was occupied with the image of the white painted ground surface of the prism. Instead of the eyepiece there was another slit in the telescope, in which one saw only a small section of the spectrum; by micrometric displacement of the collimator of the spectral apparatus any part of the spectrum the colour blind person saw both halves of the field of vision white, while the person with normal vision saw the part of the spectrum in question in its normal colour, and so could determine the wave length at which the neutral point of the colour blind person occurred. Changes of light intensity displaced the neutral point; hence in comparative measurements care must be taken to have the same intensity in the source of light. Such measurements were made by Dr. König with great precision on nine colour blind persons, and it appeared that the neutral points are situated between about 491 and 500 millionths of a millimetre, and (what is of special interest theoretically) that the mean values of the separate observations with different colour blind persons were not equal, but varied in a pretty regular series between the two terminal values. According to the common view that colour blindness depends on the disappearance of one of the normal three curves of colour perception, the position of the neutral point as point of section of the two curves present must be always the same, and for the red and the green blind must be at two quite determinate points of the spectrum. As the experiments have yielded a different result in persons, two of whom were red blind, and seven green blind, Dr. Konig believes that the essence of colour blindness consists not in the absence of one curve, but in the displacement of two curves on one another, which may be more or less complete, and so produces the different degrees of colour blindness observed. In the second investigation Dr. König sought to determine the two remarkable points of section of the three curves that occur, according to the Young-Helmholtz theory, in normal colour perception. From the researches of Prof. von Helmholtz on the wave lengths of the complementary colours, and from those of Clerk Maxwell on colour mixtures, appear values for these points of section which agree pretty well. The same values, approximately, are reached by the researches of several ophthalmologists on the places of quickest change of colour in the spectrum. Dr. König tried to determine the first section point by making the violet curve disappear through the taking of santonin, and when he had thus made himself temporarily violet-blind, he determined his neutral point, the point of section of the red and the green curve. All these determinations and theoretical considerations led to pretty much the same values for the points of section, and the first point is situated not, as is often supposed, in the yellow, but in the blue, between the Fraunhofer lides E and b_1, and nearer the latter.

At a Meeting of the Royal Society, Edinburgh, Mr. Buchan read a paper on the variation of temperature with sun-spots. The comparison was not a direct one, but was based upon the well known phenomenon of the diurnal barometric oscillation viewed in relation to the amount of water vapour in the air. From the observations of the *Challenger* Expedition, Mr. Buchan had concluded that this diurnal variation over the open sea was not the result of changes of surface temperature (for these were very small), but was to be referred to the direct heating effect of the sun open the air, or more strictly upon the water vapour in the air. This view was supported by the fact that over the sea the diurnal variation of pressure was greatest where most vapour was; whereas the contrary held over the land, the temperature of which varied greatly during the day, and the more so when the air above was drier, as more heat then reached the earth. In other words, the increase of moisture in the air increases the barometric oscillation over the sea and diminishes it over the land; and hence it seemed probable that the discussion of these daily oscillations in sun-spot cycles might lead to some definite result. The long continued observations at Calcutta, Madras, and Bombay were combined in this way, and yielded a remarkable result — there being a well marked maximum of barometric diurnal oscillation half way between the minimum and maximum sun spot years, and a minimum half way between the maximum and minimum years. The averages were taken for the five dry winter months. and the effects were explained as due to the accumulated water vapour in the upper southerly winds that exist over India during these months. When the rainfall on the southern slopes of the Himalayas was similarly treated—which rainfall is of course due to the arresting of these upper moist currents—the analogous fact was brought out, viz. minimum rainfall at times of maximum barometric oscillation and *vice versâ*.

Respirators for Mines.—Mr. Dickinson, H. M. Chief Inspector of Mines, made an important communication to the members of the Manchester Geological Society at their meeting on Tuesday. His attention, he said, had been requested to the subject of a respirator and a lamp for penetrating noxious gases in mines; and, after detailing the various efforts which had been made in this direction, he gave a description of the Fleuss exploring respirator, to which, he said, the attention of the Secretary of State had been drawn; and the Government were anxious that the inspectors of mines should make it well known, and that the various colliery districts should participate in its benefits. It was suggested that stations should be organized in mining districts, where the apparatus should be stored in sufficient numbers, and maintained in readiness for immediate use, and where the instruction of the men from the surrounding coal-mines in its use should be systematically carried out, in order that a rescuing party could thus be speedily on the spot after the occurrence of an accident. Satisfactory results had been secured with the apparatus, but with it organisation was required; oxygen gas had to be provided, and men instructed in the use of the apparatus. The diving-dress in connection with the apparatus was acknowledged, and practised now and then in pumping pits; and it was put on when upwards of 200 men were shut up in the Hartly Colliery, and had been proposed for other occasions without, however, much useful effect. The question of safety-lamps was also before the meeting, and it was urged by Mr. Purdy, of Nottingham, that, as it was well known many explosions hab been caused by the faulty construction of lamps, every lamp-maker ought to be made responsible for each lamp he sent out.

To render Linen and other Fabrics Impermeable.—Mr. Janin has discovered that by putting a layer of cellulose on the surface of any kind of fabric, and particularly linen and stuffs, it will become impermeable. The mixture is prepared with pyroxyline, which is obtained by disaggregating some cellulose with paper or with rags, in a mixture of sulphuric acid and azotic acid. This pulpous mass is put in camphorated alcohol, to which is afterwards added a mixture of alcohol and ether. The compound is applied on hard objects with a brush, but stuffs are dipped into a bath of the mixture. It does not, in fact, consist of a new product, but of a new application of a known product. Mr. Janin's mixture is simply celluloid dissolved. The cloth thus obtained, to which Mr. Janin gives the name of *linge parisien* (Parisian linen), differs from the American in the fact that the latter is applied dry.

Weight of Seasoned Timber.—The following is the weight of seasoned timber per cubic foot, in lbs.: Apple tree, 49; ash, 50; bay tree, 50; beech, 51; birch, 48; box, 60: cedar, American, 30, Lebanon, 35; cherry tree, 42; chestnut, 40; cork, 15; ebony, Indian, 70, American, 80; elder, 42; elm, 39; fir, Dantzic, 35, Memel, 38; hazel, 40; hornbeam, 48; larch, 35; lignum-vitæ, 70; logwood, 55; mahogany, Honduras, 40, Spanish, 55; maple, 47; oak, English, 50, American, 47, Baltic, 46; pine, red, 40, yellow, 33; poplar, white Spanish, 32; sycamore, 37; teak, Indian, 41, Moulmein, 45, Johore, 70, African, 60; wainscot, Riga, 38; walnut, American, 35, Spanish, 43; willow, 30; yew, 50.

In the last report of the French Society for Preventing Accidents from Machines—a society founded under the auspices of the Société Industrielle de Mulhuse—a recommendation is made for the avoidance of the use of circular saws in all workshops where practicable. The following are the reasons for this recommendation:—1st, circular saws are dangerous to workmen; 2nd, they require more power than other saws; and 3rd, they cut a broader line and are consequently more wasteful.

PROCEEDINGS OF SOCIETIES.

The Institution of Civil Engineers.—Mr. Brunlees, President, in the Chair. the Paper read was "On the Summit-Level Tunnel of the Bettws and Festiniog Railway," by Mr. William Smith, M. Inst. C.E.

The Author stated that the object of this railway was to afford more direct communication between the slate-producing district of Festiniog and the home markets. The line commenced at Bettws-y-Coed, traversed the valley of the river Conway for about 1 mile, and then followed the valley of the river Lledr. It next passed under the mountainous ridge between Carnarvonshire and Merionethshire in a long tunnel, ran along the Dinas branch of the Festiniog narrow-gauge line, and terminated at Blaenau Festiniog. The total length was about 12 miles, and, except at the stations, the line was laid with a single way. The summit-level tunnel was 3,860 yards in length. It was carried out by the staff of the London and North-Western Railway Company, the greater part of the remainder of the works being executed by contract. The tunnel-works comprised the sinking of three shafts, the driving of eight headings, and opening them out to the full size of the tunnel. The rocks perforated consisted of very hard members of the metamorphic system: and it was stated that at the south end, in passing under the Welsh Slate Company's works, great care was necessary, and a strong casing for lining was required to sustain the heavy weights above and around. The tunnel had an ascending gradient from the north end of 1 in 660 for a distance of 1 mile and 58·4 chains, followed by a level portion at the summit of 0·75 chain, and then a descending gradient of 1 in 660 for a distance of 36 chains to the south end. It was 18 feet 6 inches in height, and 16 feet 6 inches in width. The deepest of the three shafts slightly exceeded 143 yards, and all were rectangular, 12 feet by 6 feet, with the longer side in the direction of the line of the tunnel. The winding-machinery comprised, at each shaft, a boiler of the locomotive type, two small high-pressure engines, with spur-wheel and pinion and winding-drums: the latter were 6 feet in diameter, and the whole could raise a gross load of 30 cwt. at 8 feet per second. The timber head-gearing carried two pulleys, each 8 feet in diameter, and was fitted with Walker's detaching hook to prevent over-winding. The ropes were of steel wire, the breaking-strain being 20 tons. Five air-compressors were constructed to compress, to a pressure of 50lbs. per square inch, sufficient air to supply six rock-boring machines at each face. The compressor steam-generators were second-hand boilers. The pipes for conveying the compressed air to the workings were of wrought-iron, of 3½ inches bore to the bottom of the shafts and of 2½ inches bore from thence to the face of the workings. Superfluous water was raised to the surface, from a sump a the bottom: from two of the shafts by a wrought-iron vessel, attached to the under side of the cage, which filled and emptied itself automatically; but at the other shaft water was in excess, and a force pump had to be employed. The shafts were mainly sunk by hand labour. The Author then proceeded to describe at length the drill-carriages for supporting the machines, the drilling-machines themselves, and the modes of actuating them. At the north end of the tunnel an experimental drill-carriage was employed, in conjunction with electric-firing, with the view of taking out, as one large heading, the full section of the tunnel; but for want of success in electric-firing it was eventually abandoned, and the St. Gothard type of carriage and machine was substituted. It was equipped with six Ingersoll drills, fitted with automatic feed. At the south end a small drill-carriage was constructed, suitable for an advanced heading only, and provided with six Burleigh drilling machines with hand-feed. At the six intermediate faces the carriages were of the type adopted at the St. Gothard Tunnel, with Mackean drilling-machines, four at each face, driven by compressed air. Two forms of drill points were used, the chisel single-cutting edge for solid rock, and the cross-point for jointed rock With regard to the workings at the bottom of each shaft, a top heading was driven in the first instance. Driving the advanced heading comprised three distinct operations, namely, boring the holes at the face, charging and firing, and removing the *débris*. Of the various explosives used, cotton powder or tonite answered well for the removal of rocks in unconfined places: but dynamite and lithofracteur were the most effectual in the advanced headings. The advanced heading was 8 feet square, and usually required from 15 to 30 holes 3½ feet deep, and from 1 inch to 2 inches in diameter, to remove a complete slice off the face. The operation of the drilling-machines mounted on the carriages was then described, a speed of 300 to 500 strokes per minute being attained: also the method of charging the holes and firing by hand, which was somewhat different to that ordinarily pursued. Following in the wake of the advanced heading in the top of the tunnel was the removal of the two sides. This was done principally by hand labour, and changed the section of the opening from a square to a semi-circle. The excavation of the lower portion was effected by driving a gullet along one side of about half the width of the tunnel to the full depth, leaving the other half for a roadway. The remaining portion was then attacked partly by hand, partly by machine-drills at various points. The Author next referred to the progress made at each of the shafts and headings, from which it appeared that the average upon the whole of the eight faces amounted to 14·09 feet per week. The total quantity of water finding its way into the tunnel was about 100,000 gallons per day. The total cost of the tunnel and three shafts complete, including labour, plant, materials and sundries was £302,850, divided as follows, viz., labour £203,000, plant 25,630, and materials and sundries £74,220. Allowing as a credit the half-cost of the plant of the plant, which it was assumed might eventually be realised, the reduced cost would be £75 per lineal yard, and taking the whole cubical contents of rock and other substances actually removed, the cost per cubic yard was £2 8s. 10d. The tunnel was opened for public traffic on the 22nd of July, 1879.

American Society of Civil Engineers.—Regular meeting, April 18th, 1883. Vice-President Perine in the Chair. The deaths of Messrs. John C. James, M. Am. Soc. C. E., of Winnipeg, Manitoba, and Simeon Sheldon, M. Am. Soc. C. E., of Cleveland, Ohio, were announced.

The Secretary stated that arrangements were well advanced for the Convention of the Society to be held at St. Paul and Minneapolis beginning June 20th. The ordinary meetings to be held at St. Paul. One meeting at which the President's address will be delivered to be held at Minneapolis. Members of the Society and their families will be accommodated at the Hotel Lafayette, Lake Minnetonka, and special arrangements have been made for trains to and from that hotel with reference to the meetings of the Convention. A banquet will be tendered by the Citizens of the two Cities at that hotel. It is also expected to make arrangements for a visit to the exposition of Railway Appliances at Chicago during the week previous to the Convention, and the Members of the Society will leave Chicago for St. Paul at a time to be announced on either June 18th or 19th. The attendance at the Convention will probably be very large.

A paper by the late Wm. R. Morley, M. Am. Soc. C. E. was read by the Secretary upon the Subject of the Proper Compensation for Railroad Curves upon Grades. Mr. Morley expresses the opinion that the resistance due to curvature is measured not by the length of radius but by the length of train, or what is the same, by the ruling grade and that while there may be some increased resistance due to radius, that may be largely overcome by the elevation of the outer rail, and that in the location of a railroad, the length of train, or ruling grade should be made the basis of Compensation, and not the radius of Curvature.

He gives examples in his experience where the practice of Compensation with reference to the radius resulted upon steep grades in a decided excess of Compensation, and in a noticeable increase of speed of the train upon curves. He also gives the rules adopted by him in his practice which were as follows:

Rate of max grade	·00 to ·70 per 100 feet	·06	per 100	feet per	degree Compensation.
" "	·70 to 1·60 "	" ·05	"	"	"
" "	1·60 to 3·00 "	" ·04	"	"	"

The paper was discussed by Messrs. Bogart, Chanute, T. C. Clark, Emery Forney, Macdonald, North, Wm. H. Paine, D. Ward, and L. B. Ward.

In the discussion Mr. Chanute referred particularly to the paper by S. Whinery M. Am. Soc. C. E., published in the Transactions of the Society in 1878 on the Resistance of Curves, and the discussion upon that paper, stating that the theoretical resistances determined by Mr. Whinery agreed very closely with the practical results obtained by experiments upon ordinary wheels at low speed, and that the result was an addition of about one half pound per ton, per degree, to the resistance on straight lines, and that the equation for curvature resulting from this was about half of what Mr. Morley has adopted for his lighter grades.

The paper will be published in an early number of the Transactions, and will be discussed with others at the approaching Convention.

Meeting of April 4th, 1883: Geo. S. Greene, jr. in the Chair. As Members,, Thomas Appleton, Council Grove, Kan., O. H. P. Cornell, Schenectady, N. Y., G. H. Elliott, Norfolk, Va., Orville Grove, Houston, Tex., W. G. Williamson, Martinsville, Va.: As Juniors, F. L. Fuller, Boston, Mass., A. McDonald, Nashville, Tenn.

The preliminary arrangements for the Convention were reported by the Secretary. The Convention is to be held at the Cities of St. Paul and Minneapolis, Minn. The party will arrive at St. Paul about noon on June 19th. Full details will soon be announced. It is intended also to arrange for a visit to the National Exposition of Railway Appliances at Chicago before proceeding to St. Paul. The death of Mr. Peter Cooper on the morning of the meeting was announced, and after remarks by Mr. Macdonald, it was ordered that an appropriate notice should be spread upon the minutes of the Society. A paper by G. Y. Wisner M. Am. Soc. C. E. on Geodetic Field Work was read by the Secretary in the absence of the Author and was discussed by Messrs. Haight, Prindle, Orves, and Geo. S. Greene, Jr.

Engineers' Club of Philadelphia.—Record of regular meeting, March 17th, 1883. President Henry G. Morris in the Chair; Mr. Chas. A. Ashburner read a paper on "A New Method of Estimating the Contents of Highly Plicated Coal Beds as Applied to the Anthracite Fields of Pennsylvania," The questions of the future production and ultimate exhaustion of these fields, are of the greatest importance. In 1860 the population of the United States was 31,443,321, and 8,513,123 ton of coal were produced, *i. e.*, actually shipped to market; in 1870 the population had increased 22 per cent (38,558,371) and the production of anthracite was nearly doubled, being 16,182,191 tons. For the year 1880, with a population of over 50 millions, the product was 23,437,242 tons. In 1882 the actual production was over 30,000,000 tons. It has been variously estimated that the 470 square miles containing this coal in Pennsylvania, will be entirely exhausted in from 140 to 204 years. While Mr. Ashburner does not estimate the ultimate exhaustion, he has devised a method for estimating the contents of these fields, from data now being obtained by the careful and practical geological and mining examinations of the State Survey. The exact position and detailed structural shape of the coal beds are first mapped by 50 feet contour lines along the floor of the beds, giving completely and satisfactorily, the geometrical construction and shape. These surfaces are then developed into planes, by the development into straight lines of the line of the bed as cut by parallelled section planes 1600 feet apart. This graphical method is attended with errors which are mathematically discussed, and which have been formulated by Mr. Arthur Winslow, Member of the Club. This method does not give the true area of the surface of a sphere, cone or triangular trough. In the case of a sphere, it gives $\frac{}{4}$ of the true area; in a cone, the error increases directly as the secant of the angle which the pitch of the cone makes with its axis: and in a triangular trough, which more nearly represents the shape of the anthracite basins, the error is very much less. A practical test has been made of this method in the Panther Creek basin, between Mauch Chunk and Tamaqua, and the maximum possible error in estimating the surface area of the coal beds was found to be .905 of 1 per cent. After the areas are thus found, the contents are obtained by careful measurements made in the mines to ascertain the actual number of tons of coal which are contained in a unit (1 acre) of bed area. In this way it has been estimated that the above basin originally contained 1,032,000,000 tons; that the area under development originally contained 92,000,000 tons, out of which latter area 54,000,000 tons have been taken.

The Secretary presented, for Mr. John Marston, an illustrated set of formulæ for railroad turnouts and crossings.

Mr. John T. Boyd exhibited ribbons of phosphor bronze with which he had experimented with a view to its use for tape lines, in mine, shop and other work, where the danger of breaking the ordinary steel lines is very great, and where the contact of the tape with substances, in themselves injurious to it, renders frequent wiping, and consequent scouring off of the figures, necessary. The phosphor bronze ribbon was found to be extremely tough, but, in addition to the difficulty in its manufacture into this shape, it was found that after it was bent at a sharp angle, it would not straighten out, thus decreasing the length of the line. As using the hammer to straighten it would increase the length, the experiment was not prosecuted further.

The Secretary presented a system of reduction tables which he had made to facilitate long and tedious multiplications and divisions.