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SCIENTIFIC CANADIAN
MECHANICS' MAGAZINE
AND
PATENT OFFICE RECORD

Vol. 12. MAY, 1884. 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.

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ARCHITECTURE AS A SCIENCE.[*]

(*With special relation to Construction, Engineering and Modern Requirements.*)

BY A. T. TAYLOR, M.R.I.B.A.

(*Continued from page 99.*)

This is unhappily what has been done to a large extent in buildings, especially in the States. I think that for buildings for commercial purposes, for exhibitions, and such like, and in crowded cities where space is valuable and light precious, entire iron construction will be more and more used. I cannot see that it will even be wholly successful artistically, as there will be none of that substantial appearance or breadth of effect, which is so necessary, but if such buildings are designed in a common-sense way, *i. e.*, recognizing the fact that the material is wrought and cast-iron and obtaining such embellishments as may be desired, in a way to bring out the legitimate capabilities of the material, then a certain amount of success will be achieved.

One great objection to such buildings is they are not fireproof—if they are cast-iron they get heated, and when cold streams of water are thrown on them they crack and break, or if of wrought-iron, they bend and twist under great heat, and even in ordinary circumstances the metal is so affected by the changes of temperature, in the way of expansion and contraction. that it is much more difficult in a building to allow for this than in a bridge or railway station roof.

Iron columns, girders, etc., in internal construction, ought, as a rule, to be encased in some non-conducting material, such as terra cotta, plaster of Paris, etc., and if they can be kept from rusting, they are otherwise safe.

In arranging one's materials for the construction of a building, it is necessary that not only must each be sufficient for its purpose and the weight it has to carry, but it must also convey the impression to the beholder that it is sufficient, otherwise there is left on the mind a feeling of insecurity and dissatisfaction which is fatal to the artistic success of a building. It is no uncommon thing to see a high block of heavy stone buildings apparently standing on the edge of a few sheets of plate glass in the windows of the shops below. It is not sufficient for us to reason thus and say:—Now, I know behind that plate glass there must be iron columns, or uprights, with cross girders on top to carry that immense weight. To satisfy the artistic needs of such a building it is necessary that there be *visible* a sufficiency of pier or support to carry the superstructure; and this can generally be obtained (but it takes a little more trouble to design), without materially reducing the clear space, which is such a desideratum to the modern shopkeeper and salesman, in order that he may by the exhibition of the latest fashions in his windows, or the announcement of great bargains at ruinous prices, allure those not over-wise people who are ever on the watch for bargains, even if they be of things they have no possible use for.

To see an elephant going on high and slender stilts would not be more preposterous than are some of the modern buildings. In what I am saying I trust you will not misunderstand me and think I am alluding to Montreal buildings. I am rather referring to what is too common in England and other countries.

If the engineer, but especially the architect, will be but content to sit humbly at the feet of Nature, and watch her methods and principles, whether it be in the construction of animal or plant life, or in the wonderful instinct with which many of the creatures are endowed, it will be the best training college, and there they will obtain the noblest degree. The cells of the honey bee are marvels of mathematical accuracy (without these little mathematicians having had the advantage of a course of lectures in applied science at McGill College), and the shape of these cells are so adapted as to unite the strongest form, with the greatest capacity for storage.

The web of the despised and much persecuted spider is a magnificent engineering work, where the little engineer not only designs the structure and executes

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[*] A lecture delivered before the Faculty of Applied Science, McGill University.

the work, but supplies the material also, so that there is no chance of scamped work, or jobbery. Long before suspension bridges were dreamed of, every spider had his aerial suspension bridge rocking in the breeze and spanning gulfs, to which in proportion those spanned by man's work were puny.

The mole is proverbially blind, but is a splendid mining engineer, and it had its underground railways and a Mont Cenis tunnel long before these works were thought of by the most visionary and enterprising traveller.

The dams and sluices and locks of our canals and waterworks were all anticipated ages ago by our friend the beaver, whose form and features grace the Dominion arms, and so I could go on adding to the list of man's teachers, but, perhaps, after all, man has in his own body the best model for the mechanic, the constructor, and the architect: such marvellous adaptability of means to end, such grace and elegance, such strength and flexibility. The smallest and most delicate piece of workmanship or machinery is clumsy beside such a part of man as the eye or the ear. Every part of our bodies is designed by the great Creator to be exactly and perfectly suited for the functions it has to perform.

And as in the body, the framework or skeleton is not visible, but is covered with tissues and flesh and skin, and yet the construction is all expressed, so in a building we do not want to see the rough timbering and stonework, but it must be sufficiently outwardly expressed, and after that you may beautify it as much as you please, as long as the ornament emphasises the construction and is not indiscriminately plastered all over the building as if thrown on at haphazard.

The element of *Durability* is an important one to be considered by all who are engaged in the work of construction.

Cynics are never weary of reiterating that superficiality and flimsiness are the characteristic features of the age, and I am afraid there is only too much truth in the statement.

We do not build as the old Builders used to do. Had they constructed as we do, there would have been to-day no Pyramids of Egypt, no rock-cut Temples of Petra, no Greek Parthenon, no Roman Amphitheatres, Triumphal Arches and Baths, no Aqueducts or Roads, no Gothic Cathedrals with "long drawn aisles and fretted vaults;" no heritage of the past centuries would have come down to us. Imagine all these blotted out of existence and only the faint memory of them kept alive by descriptions in literature, how infinitely poorer we should be! We also have our duties to Posterity; even through as a writer has facetiously remarked,—"They have done nothing for us." We have no right to leave them ruins, which Time has not delicately fingered, but our own carelessness and culpability brought about.

There is often a desire for show at the expense of soundness, and engineers and architects are not always able to withstand the clamour; but I would like to urge upon those of you who are or may be in such positions to set your faces like a flint against such suggestions. They are without doubt emanations from the evil one.

I know, I have experienced, that clients expect grandeur, without duly considering that this cannot be obtained without being paid for, and one is sometimes sorely tempted to sacrifice before this heathen altar.

Hence the numerous accidents, which are so often occurring in defective railway bridges and in buildings of various kinds.

If the alternative is inevitable,—then, better a perfectly plain structure and *sound*, than one with the whole "five orders" on it, and flimsy.

And while I am on the subject of a false and flimsy pretentiousness, I would greatly depreciate the system which alas, is too common everywhere, of putting all the money on the front of the building and leaving the sides and back go bare. It used to be the custom in England with certain churches, and the Dissenting brethren were often the greatest offenders to put up a gorgeous front of cement or compo, with porticos and colonnades and pillars and pediments,—all sham-and if you just looked or stepped round the corner you found a mean, shabby, miserable brick wall, and as this side view was often as prominent as the front, you can imagine the result.

It was as if all beholders were to be brought to one point in the centre of the front and were told to look at, and judge of it, from that point only and to shut their eyes at every other point of view.

Not thus did the great mediæval builders build;—each part was fashioned with care and love's labour was spent on the sides and the back and parts out of sight, for they said—"The gods see everywhere!"

Not that they put equal labour on parts out of sight as on parts prominent and near the eye—not so, but every part was in harmony with the other,—near the eye the mouldings and carvings were delicate and refined, higher up they were bolder and less delicate, and on highest heights they were often but blocked out. Delicate work would have been thrown away and would not have given the effect desired. But in all they were true and faithful to noblest traditions. They were able to hang the Lamp of Truth up, and the searching light fell not on foul falsehood or deceit. Would that I could say the same of all of our modern architecture! The lamp of truth reveals much of sham and petrified falsehood, structure of wood and galvanized iron painted to resemble stone, with sham masonry joints carefully drawn on as if to deceive the very elect. Common pine grained with all the skill and art of the grainer to pass itself off for oak or walnut, or maple, cement splotched all over with the dregs of the paint pots to resemble granite, or costly Italian or Tennessee marbles, and made very glossy with varnish to give the shininess.

These Philistinish deeds are still practiced, but latterly there has been a great revulsion againt all such methods, and a "more excellent way" has been adopted and I trust that before long men will wonder how they could have done such things. We are indebted beyond all others to the prince of art critics—Mr. Ruskin—for this return to sound principles, and all honour is due to him for his long and unceasing advocacy of his views at a time when he stood almost alone.

I had intended to have touched on Heating, Ventilation and Sanitary matters, but the subjects are so important and extensive that I must reserve them for some other occasion.

In my next remaining lecture I hope with your permission to view architecture as a Fine Art, and endeavour to show its relation to Painting and Decoration, Sculpture and Carving, and generally treat of the *Poetry of Architecture.*

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THE ATLANTIC AND PACIFIC SHIP RAILWAY.

The railway for carrying ships between the Atlantic and Pacific Oceans, projected by Mr. James B. Eads, across the Isthmus of Tehuantepec in Mexico, unquestionably takes a foremost place among the engineering and commercial enterprises elaborated during this century, and as the work was formally commenced last year at Minatitlan, its northern terminus on the Coatzacoalcos river, some account of its leading features will possess unusual interest.

Tehuantepec is the most northern of the several isthmuses which, with the States of Central America, form the connecting link between North and South America. Being twelve hundred miles nearer the former continent than Panama, the route over it possesses immense climatic as well as geographic advantages over the latter one. No less than five states of Central America lie between these two rival routes, viz., Yucutan, Campeachy, Guatemala, Nicaragua, Costa Rica, and also parts of the Mexican states of Oaxaca and Vera Cruz, and the Columbian state of Panama. In considering, therefore, the great superiority of the Tehuantepec route for all commerce between the British Islands and the North Pacific Ocean, Japan, China, and the Orient, the fact should be kept in mind that between the locality where M. de Lèsseps is striving to cross the American isthmus, and that where Mr. Eads has commenced to construct the ship railway, there exists a territory twice the length of Great Britain. To go by the ship railway to California, British Columbia, Japan, the Phillipine Islands, or China, we would pass through the Gulf of Mexico, but to go by Panama we must sail south to the Carribean Sea, cross the lower end of the isthmus, and then sail 1200 miles along its Pacific Coast to the Bay of Tehuantepec where the ship railway crosses it.

That the ship railway project is one fraught with the most stupendous results, may be readily seen when we consider the fact that the American isthmus separates about 100,000,000 of the most enterprising, industrious, and enlightened people on the earth, inhabiting the North Atlantic Coast of Europe and America, from 600,000,000 souls who inhabit the Orient and islands of the Pacific.

It is true that the sailing distances which separate England, France, Germany, and Italy from India, China, and other Oriental nations, have been greatly lessened by the Suez Canal, but these distances are almost insignificant when compared with those which the ship railway will annihilate. For instance, the greatest saving effected by the Suez Canal between London and Calcutta is about 4500 statute miles; whereas the sailing distance by the ship railway from London to every port on the Pacific Coast of North America will be lessened by nearly twice this vast distance, or about 8250 miles.

The Suez Canal brought London and Canton about 3500 miles nearer together by sea. The ship railway will save more than three times this distance between the Great American metropolis and every port in British Columbia. It will lesssen the sailing distance which to-day separates the Atlantic and Pacific ports of British America by a distance but little less than half of the circumference of the world, and give a sea route between the Gulf of St. Lawrence and Vancouver's Island only 50 per cent. longer than the railway across the American continent.

The American isthmus and the Cordilleras of North America constitute a narrow but almost impassable barrier to the interchange of the manufactures and productions of 40 millions of people in the Mississippi Valley and Atlantic States, not only with those of 10 millions of their countrymen to the west of them, but with the products of nearly a hundred million others on the islands and coasts of the Pacific, who are seemingly their nearest neighbours.

The ship railway will give to these descendants of the British Isles a sea route between their Atlantic and Pacific ports scarcely a thousand miles longer than the railway between New York and San Francisco, and it will give to the vast valley of the Mississippi a gateway equivalent to the discharge of its mighty river directly into the Pacific.

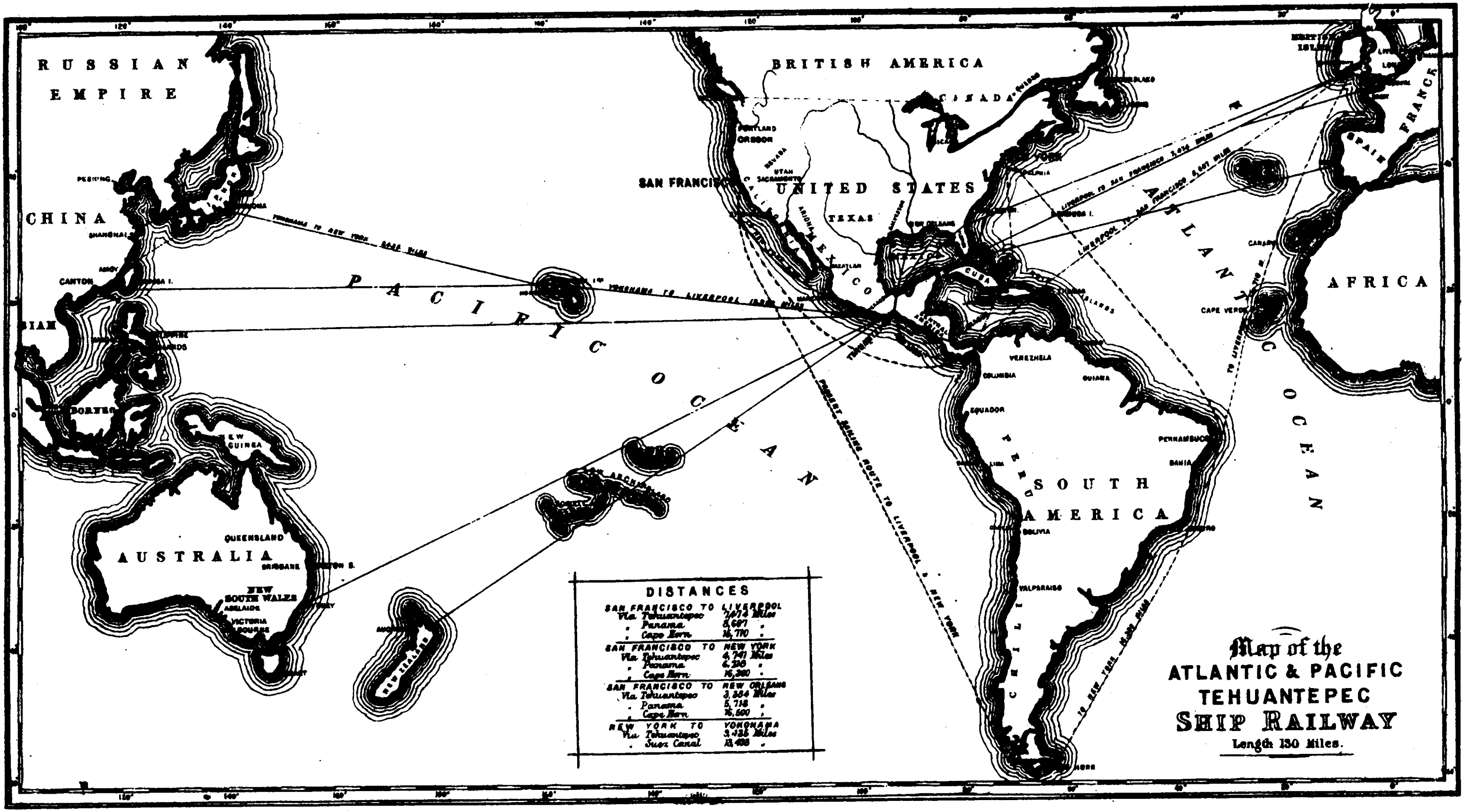
A work designed to effect such enormous benefits to the commerce of the world should commend itself with especial force to this country, which to-day is carrying more than 60 per cent. of that commerce. We learn, therefore, with great pleasure that Mr. Eads intends within a brief period to present this subject to the attention of British capitalists and shipowners, with a view to soliciting their aid in carrying out this great work. Of course the difficulty which stands in his way lies in the fact that large ships have never been carried any considerable distance overland, although ancient history refers to the fact, we believe, that the Athenian fleet was carried over the Isthmus of Corinth more than 2000 years ago, whilst numerous instances of similar achievements are authentically recorded since then, and to-day canal boats and small steamers weighing between 100 and 200 tons are being transported by rail in America and Prussia.

The voluntary endorsement of the entire practicability of Mr. Eads' plan of ship railway transportation, by the most eminent engineers and shipbuilders in England and America during the last two years, the exhaustive examination of the subject by the United States Senate Committee, and its unanimous report in favour of it, have commended the enterprise to the confidence of a number of capitalists who have formed a syndicate or provisional company and supplied the necessary funds to make a thorough examination of the route from ocean to ocean, and to execute such portions of the road as are required by the terms of the concession which they hold from Mexica. This is one of the most liberal ever granted by any Government, and gives practically the entire control of the isthmus for ninety-nine years to the company which Mr. Eads is authorised to form.

Under the direction of Mr. Eads, president of the provisional company, a number of distinguished engineers have been engaged on surveys of the route, and they are now preparing estimates of the entire cost of the work, so as to enable the enterprise to be presented intelligently and reliably to capitalists and the public. Mr. E. L. Corthell is the chief engineer of the provisional company, and Mr. M. Van Brocklin its resident engineer. Mr. Corthell was Mr. Eads' chief assistant at the Mississippi jetties; he has examined the entire route across the isthmus, and has given especial attention to the harbours, making at the time a careful hydrographic survey of the Coatzacoalcos river. The first surveys made for Mr. Eads were conducted by Mr. Garay, a distinguished Mexican engineer, educated in France, and who was sent by the Mexican Government to present the merits of the Tehuantepec route in 1869 to the international canal convention at Paris. Mr. J. J. Williams was engaged by Mr. Eads on another part of the line with Mr. Garay. Mr. Williams surveyed the Panama route for the Panama Railway Company, more than twenty years ago and discovered the lowest summit on that isthmus, over which the railway is now located. Thirty years ago he assisted General Barnard of the United States Army in surveying the isthmus of Tehuantepec for a canal, and has since devoted several years in making surveys of that isthmus. The resident engineer, M. Van Brocklin, spent over two years on the isthmus as chief engineer of the railroad commenced in 1880, under the concession to Mr. Learned. Guided by the results of the surveys of other engineers, and the knowledge he had then acquired, Mr. Van Brocklin undertook the survey last March of a new route across Tehauntepec, which he completed recently, from harbour to harbour, with greatly improved results.

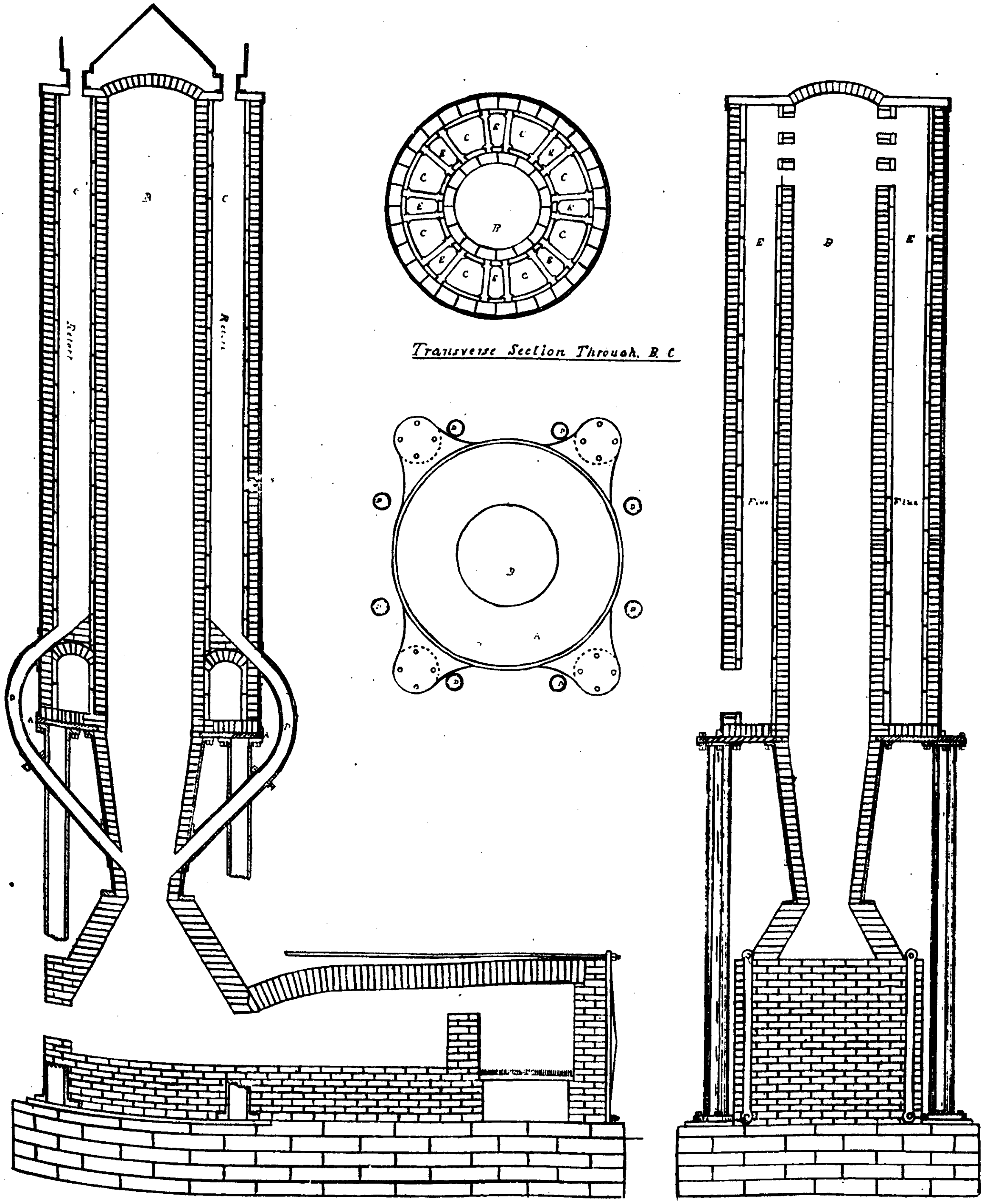
This engineer was also four years engaged on the celebrated railroad in Peru, which cross the Andes at an elevation of 15,600 ft., the highest railway in the world. He was assisted in the recent survey of the isthmus by Mr. Deming J. Thayer, a young American engineer, who built a railway in Columbia from the Pacific ocast to the Cauca Valley. We mention these facts to show that Mr. Eads has had the good fortune to secure the aid of very experienced engineers in his great work. All of these gentlemen speak in glowing terms of the healthfulness of the Isthmus of Tehuantepec. Mr. Van Brocklin had four surveying parties in the field from March last until November, not one of whom was sick at any time, and none of his assistants or men were invalided during his previous surveys. Mr. Williams, Mr. Garay, and Mr. Corthell all give similar testimony.

The heaviest gradient on the Atlantic side does not exceed 42 ft. per mile, while that on the Pacific is only 52 ft. for about eight miles, the remainder of the route will have no grades exceeding 26 feet per mile. No exceptionally heavy work will be encountered either in cuts or embankments, and the entire road from the Coatzacoalcos river to the Pacific harbour will be only 134 miles long.



DISTANCES

SAN FRANCISCO TO	LIVERPOOL
Via Tehuantepec	7,674 Miles
" Panama	8,687 "
" Cape Horn	16,770 "
SAN FRANCISCO TO	NEW YORK
Via Tehuantepec	4,741 Miles
" Panama	6,216 "
" Cape Horn	15,380 "
SAN FRANCISCO TO	NEW ORLEANS
Via Tehuantepec	3,384 Miles
" Panama	5,718 "
" Cape Horn	15,600 "
NEW YORK TO	YOKOHAMA
Via Tehuantepec	9,435 Miles
" Suez Canal	13,488 "



Transverse Section Through. B C

Appreciating the difficulty which engineers encounter when explaining by mere drawings any novel devices required to meet the ever increasing demands of commerce, Mr. Eads has wisely determined to construct a working model of the ship railway, which shall illustrate in miniature every detail of the work. By it will be clearly seen the great simplicity of the devices needed for raising and lowering the ships at the harbours, distributing their weight equally upon all the wheels of the cradle on which they will be borne, the precautions for supporting every part of them to avoid injury during their journey by rail, and the safe and rapid method by which they may be shunted to permit of their passing each other, or to change their direction so as to avoid curves in the railway tracks, or to enable them to be run out of the way for painting or repairing.

The ship will be 7 ft. in length, the car or cradle on which the ship is carried will be 6 ft. 4 in. long. The floating dock will be 7 ft. 6 in. long, and 30 in. wide, and the basin in which it floats will require about two tons of water to fill it. By this means the public will become familiarised with the method proposed by Mr. Eads for working the traffic upon this gigantic line of railway.—*Engineering.*

◆

A PROCESS FOR MAKING WROUGHT-IRON DIRECT FROM THE ORE.*

By Willard P. Ward, a.m., m.e.

The numerous direct processes which have been patented and brought before the iron-masters of the world, differ materially from that now introduced by Mr. Wilson. After a careful examination of his process, I am convinced that Mr. Wilson has succeeded in producing good blooms from iron-ore, and I think that I am able to point out theoretically the chief reasons of the success of his method.

Without going deeply into the history of the metal, I may mention the well-known fact, that wrought-iron was extensively used in almost all quarters of the globe, before pig or cast-iron was ever produced. Without entering into the details of the processes by which this wrought-iron was made, it suffices for my present purpose to say that they were crude, wasteful, and expensive, so that they can be employed to-day only in a very few localities favored with good and cheap ore, fuel, and labor.

The construction of larger furnaces and the employment of higher temperatures led to the production of a highly carbonized, fusible metal, without any special design on the part of the manufacturers in producing it. This pig-iron, however, could be used only for a few purposes for which metallic iron was needed; but it was produced cheaply and with little loss of metal, and the attempt to decarbonize this product and bring it into a state in which it could be hammered and welded was soon successfully made. This process of decarbonization, or some modification of it, has successfully held the field against all, so-called, direct processes up to the present time. Why? Because the old-fashioned bloomeries and Catalan forges could produce blooms only at a high cost, and because the new processes introduced failed to turn out good blooms. Those produced were invariably "red-short," that is, they contained unreduced oxide or iron, which prevented the contact of the metallic particles, and rendered the welding together of these particles to form a solid bloom impossible.

The process of puddling cast-iron, and transforming it by decarbonization into wrought-iron has, as everybody knows, been in successful practical operation for many years, and the direct process referred to so closely resembles this, that a short description of the theory of puddling is not out of place here.

The material operated on in puddling is iron containing from 2½ to 4 per cent of carbon. During the first stage of the process this iron is melted down to a fluid bath in the bottom of a reverberatory furnace. Then the oxidation of the carbon contained in the iron commences, and at the same time a fluid, basic cinder, or slag, is produced, which covers a portion of the surface of the metal bath, and prevents too hasty oxidation. This slag results from the union of oxides of iron, with the sand adhering to the pigs, and the silica resulting from the oxidation of the silicon contained in the iron.

This cinder now plays a very important part in the process. It takes up the oxides of iron formed by the contact of the oxidizing flame with the exposed portion of the metal bath, and at the same time the carbon of the iron, coming in contact with the under-surface of the cinder-covering, where it is protected from oxidizing influences, reduces these oxides from the cinder and restores them to the bath in metallic form. This alternate oxidation of exposed metal, and its reduction by the carbon of the cast-iron, continues till the carbon is nearly exhausted, when the iron assumes a pasty condition, or "comes to nature," as the puddlers call this change. The charge is then worked up into balls, and removed for treatment in the squeezer, and then hammered or rolled.

In the Wilson process the conditions which we have noted in the puddling operation are very closely approximated to. Ironore, reduced to a coarse sand, is mixed with the proper proportion of charcoal or coke dust, and the mixture fed into upright retorts placed in the chimney of the puddling-furnace. By exposure for twenty-four hours to the heat of the waste gases from the furnace, in the presence of solid carbon, a considerable portion of the oxygen of the ore is removed, but little or no metallic iron is formed. The ore is then drawn from the deoxidizer into the rear, or second hearth of the puddling-furnace, situated below it, where it is exposed for twenty minutes to a much higher temperature than that of the deoxidizer. Here the presence of the solid carbon, mixed with the ore, prevents any oxidizing action, and the temperature of the mass is raised to a point at which the cinder begins to form. Then the charge is carried forward by the workmen into the front hearth, in which the temperature of a puddling-furnace prevails. Here the cinder melts, and at the same time the solid carbon reacts on the oxygen remaining combined with the ore, and forms metallic iron; but by this time the molten cinder is present to prevent undue oxidation of the metal formed, and solid carbon is still present in the mixture to play the same *rôle*, of reducing protoxide of iron from the cinder, as the carbon of the cast-iron does in the ordinary puddling process. I have said that cast-iron used as the material for puddling contains about 3 per cent. of carbon; but in this process sufficient carbon is added to effect the reduction of the ore to a metallic state, and leave enough in the mass to play the part of the carbon of the cast-iron when the metallic stage has been reached.

It would be interesting to compare the Wilson with the numerous other direct processes to which allusion has already been made, but there have been so many of them, and the data concerning them are so incomplete, that this is impossible. Two processes, however, the Blair and the Siemens, have attracted sufficient attention, and are sufficiently modern to deserve notice. In the Blair process a metallic iron sponge was made from the ore in a closed retort, this sponge cooled down, in receptacles from which the air was excluded, to the temperature of the atmosphere, then charged into a puddling-furnace and heated for working. In this way (and the same plan essentially has been followed by other inventors) the metallic iron, in the finest possible state of subdivision, is subjected to the more or less oxidizing influences of the flame, without liquid slag to save it from oxidation, and with no carbon present to again reduce the iron-oxides from the cinder after it is formed. The loss of metal is consequently very large, but oxides of iron being left in the metal the blooms are invariably "red-short."

In the Siemens process pieces of ore of the size of beans or peas, mixed with lime or other fluxing material, form the charge, which is introduced into a rotating furnace; and when this charge has become heated to a bright-red heat, small coal of uniform size is added in sufficient quantity to effect the reduction of the ore. The size of the pieces of the material employed prevents the intimate mixture of the particles of iron with the particles of carbon, and hence we would, on theoretical grounds, anticipate just what practice has proved, viz., that the reduction is incomplete, and the resulting metal being charged with oxides is red-short. In practice, blooms made by this process have been so red-short, that they could not be hammered at all.

It would be impracticable in this process to employ ore and carbon in as fine particles as Wilson does, as a very large portion of the charge would be carried off by the draught, and a sticking of the material to the sides of the rotating furnace could scarcely be avoided. I do not imagine that a division of the materials into anything like the supposed size of molecules is necessary; we know that the graphitic carbon in the pig-iron employed in puddling is not so finely divided, but it is in much smaller particles than bean or pea size, and

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* A paper read at the Cincinnati meeting of the American Institute of Mining Engineers.

by approximating the size of the graphite particles in pig-iron Wilson has succeeded in obtaining good results.

If we examine the utilization of the heat developed by the combustion of a given quantity of coal in this process, and compare it with the result of the combustion of an equivalent amount of fuel in a blast furnace, we shall soon see the theoretical economy of the process. The coal is burned on the grate of the puddling-furnace to carbonic acid, and the flame is more fully utilized than in an ordinary puddling-furnace, for besides the ordinary hearth there is the second or rear hearth, where additional heat is taken up, and then the products of combustion are further utilized in heating the retorts in which the ore is partly reduced. After this the heat is still further utilized by passing it under the boilers for the generation of steam, and the heat lost in the gases, when they finally escape, is very small. In a blast-furnace the carbon is at first burned only to carbonic oxide, and the products of combustion issue mainly in this form from the top of the furnace. Then a portion of the heat resulting from the subsequent burning of these gases is pretty well utilized in making steam to supply the power required about the works, but the rest of the gas can only be utilized for heating the blast, and here there is an enormous waste, the amount of heat returned to the furnace by the heated blast being very small in proportion to the amount generated by the burning of that portion of carbonic oxide expended in heating it, and the gases escape from both the hot-blast and the boilers at a high temperature.

In the direct process under consideration the fuel burned is more completely utilized than in the puddling process to which the cast iron from the blast-furnace is subjected to convert it into wrought-iron.

The economy claimed for this process, over the blast-furnace and puddling practice for the production of wrought iron, is that nearly all the fuel used in the puddling operation is saved, and that with about the same amount of fuel used in the blast furnace to produce a ton of pig iron, a ton of wrought-iron blooms can be made. I had no opportunity of weighing the charges of ore and coal used, but I saw the process in actual operation at Rockaway, N.J. The iron produced was hammered up into good solid blooms, containing but little cinder. The muck-bar made from the blooms was fibrous in fracture, and showed every appearance of good iron. I am informed by the manager of the Sanderson Brothers' steel works, at Syracuse, N.Y., that they purchased blooms made by the Wilson process in 1881—1882, that *none* of them showed red-shortness, and that they discontinued their use only on account of the injurious action of the titanium they contained on the melting-pots. These blooms were made from magnetic sands from the Long Island and Connecticut coasts.

The drawing page shows the construction of the furnace employed. I quote from the published description.

"The upper part, or deoxidizer, is supported on a strong mantle plate, resting on four cast-iron columns.

"The retorts and flues are made entirely of fire-brick, from special patterns. The outside is protected by a wrought-iron jacket made of No. 14 iron. The puddling-furnace is of the ordinary construction, except in the working-bottom, which is made longer to accommodate two charges of ore, and thus utilize more of the waste heat in reducing the ore to metallic iron.

"The operation of the furnace is as follows: The pulverized ore is mixed with 20 per cent. of pulverized charcoal or coke, and is fed into an elevator which discharges into the hopper on the deoxidizer leading into the retorts marked C. These retorts are proportioned so that they will hold ore enough to run the puddling furnace twenty-four hours—the time required for perfect deoxidization. After the retorts are filled, a fire is started in the furnace, and the products of combustion pass up through the main flue, or well B, where they are deflected by the arch, and pass out through suitable openings, as indicated by arrows, into the down-takes marked E, and out through an annular flue, where they are passed under a boiler.

"It will be noticed that the ore is exposed to the waste heat on three sides of the retorts, and owing to the great surface so exposed, the ore is very thoroughly deoxidized, and reduced in the retorts before it is introduced into the puddling-furnace for final reduction. The curved cast-iron pipes marked D are provided with slides, and are for the purpose of introducing the deoxidized ore into the second bottom of the furnace. As before stated, the furnace is intended to accommodate two charges of ore, and as fast as it is balled up and taken out of the working-bottom, the charge remaining in the second bottom is worked up in the place occupied by the first charge and a *new* charge is introduced. As fast as the ore is drawn out from the retorts the elevator supplies a new lot, so that the retorts are always filled, thus making the process continuous."

The temperature of the charge in the deoxidizer is from 800° to 1000° F.

THE ELECTRIC TRANSFER OF ENERGY. (*Electric Review.*)

RESEARCHES OF M. MARCEL DEPREZ.

Summary of Experiments.

(*For illustrations see pages* 136, 137, 140, 141 *and* 145.)

To the theoretical explanation which has just been put forward, it is necessary, in order to give the reader a complete idea of the researches of M. Marcel Deprez, to append a radid sketch of his experimental studies—the trials which have been successively made, and which have taken up the years 1881, 1882 and 1883.

The starting point of these labours may be, perhaps referred to the Electric Exhibition of 1881. Doubtless M. Marcel Deprez had experimented before this date, but it was in his laboratory, on a limited scale. Several persons have, indeed, had the opportunity of seeing an instance of distribution effected in his laboratory, but it was at the Palace of Industry that he displayed his results for the first time to the public.

The installation which he erected there was an instance of the electric transfer and distribution of energy. As regards the transfer, it does not differ widely from what had been effected by others. The total length of the cable was about 1,800 metres; very well at that date, but not exceptional. The power collected was not measured, but about four horse-power was expended. It may be said, further, that at that date there was no great interest felt in measuring, with precision, the power and the result, an affair which shortly afterwards became of such importance. To succeed in transferring power under any conditions seemed then an interesting result. From this point of view the installation of M. Marcel Deprez seemed about as good as any other. The feature in which it was unrivalled and altogether exceptional was, that not content with merely transmitting power, it distributed such power among numerous distinct machines, each acting independently of the others; in a word, it worked with distribution. This was the first realization of the principles which have been already expounded. We reproduce here, fig. 1, the two dynamo machines which produced the current. The double cable conveying the current went entirely round the Palace of Industry, with derivations both on the ground floor and on the first storey, to 27 distinct apparatus, some detached, and others arranged as in a worshop, and comprising sewing machines, folding machines, machines for ribbon sawing, for wire weaving, arc and incandescence lamps, and, lastly, a printing press. Each apparatus had its electro-motor, most of them a magneto-electric motor on the Marcel Deprez system; some, among others the press, had small Siemens dynamo machines.

This was certainly a mere experiment, but on a large scale, approaching to practical dimensions. At any rate it was very novel, and, as was generally remarked, it was at least a brilliant departure which promised well for the future.

In the International Congress of Electricians, in 1881, M. Deprez had explained his ideas and the general theory of the transfer of power such as he had conceived it; this theory, we may remember, has encountered much contradiction. The application, as it was said, was limited both as to the distance and the quantity of power. It was necessary to go further—to confirm the theory by precise experiments, and to carry out its application on a scale of industrial utility.

It is true that the author was not obliged himself to undertake these tasks. Many men of science, having announced an idea, stop, and do not consider themselves called upon to carry it personally into practice. This is doubtless allowable, and they have, after all, fulfilled their duties as savants and theorists. But if we cannot blame them, we should praise those who do not recoil from the arduous task of giving a material form to their ideas—an arduous task which demands, besides the attributes of the savant, others lower perhaps, but not less rare, among which must rank first and foremost a persistence which nothing can weary.

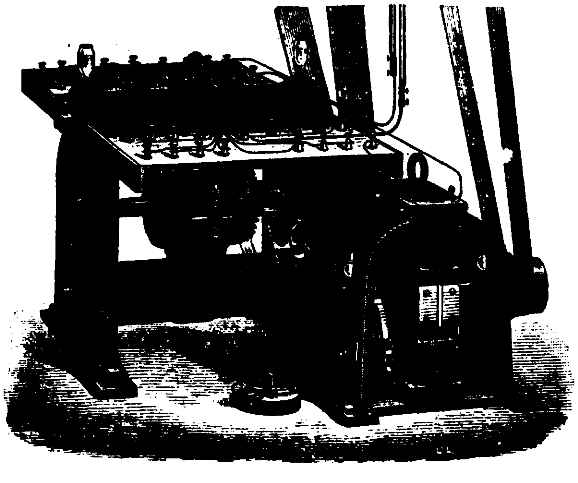

FIG. 1.

The first step on entering upon this experimental career was to verify, fundamentally and completely, the various bases upon which rests the theory proclaimed at the Congress, explained, afterwards, before the Academy, and produced before the public in *La Lumière Electrique*.

The details already given embody the most striking results of these experiments. As may be supposed, these are merely instances selected from a great many others. Especially as regards the characteristic curves, it was established by means of machines as numerous and as different as possible. Thus a very complete knowledge of the various types are acquired; the instruction collected was very precious for future improvements, and for preparing designs of machines which may be constructed hereafter.

In the meantime, everything was being prepared for experiments on transmission to a great distance. It will be remembered that one of the first theoretic researches of M. Deprez (*La Lumière Electrique*, Aug. 24th, 1881) consisted in showing that with existing types of machines we might, by the aid of a transformation mathematically calculable, succeed in effecting a transfer to a great distance. The calculations were based on experiments made by English Engineers at Chatham with electric light machines. The data furnished by these experiments were very vague, as they had not been undertaken for the object aimed at by M. Deprez. The first experiments, however, carried out in the laboratory permitted them to be completed, and a transformation could be undertaken conformably to theory, and which must effect the purpose aimed at.

The utility of this experiment may be conceived. Of course, it cannot completely answer the conditions to be fulfilled, and can yield result only with difficulties, in a troublesome manner, and liable to accidents. In order to succeed fully it was necessary to construct new machines. This fact was not overlooked, but this construction presupposed long studies. It was necessary to examine separately the influence of each part. Then, when the type was determined, time was still needful to effect any required correction. The use of these machines allowed of rapid experiments at a moderate cost, and had the immense advantage of placing the principle beyond doubt, of replying to objections, and of securing the future by establishing a firm point of departure.

The machines selected for conversion were two Gramme machines of the workshop model. They were fitted with new coils of finer wire, were modified in several of their parts, and were finally used in the experiments. On February 13th, 1882, M. Marcel Deprez was able to announce to the Academy that he had succeeded in transmitting 27 kilogrammetres against an artificial resistance of 786 ohms, representing a

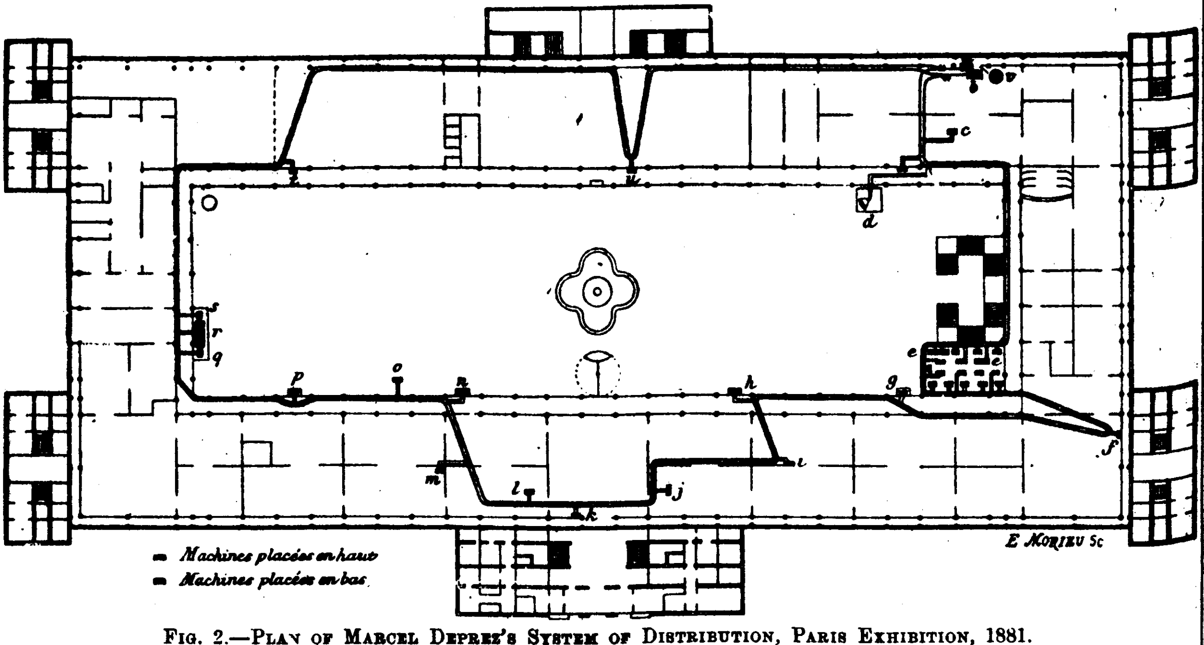

FIG. 2.—PLAN OF MARCEL DEPREZ'S SYSTEM OF DISTRIBUTION, PARIS EXHIBITION, 1881.

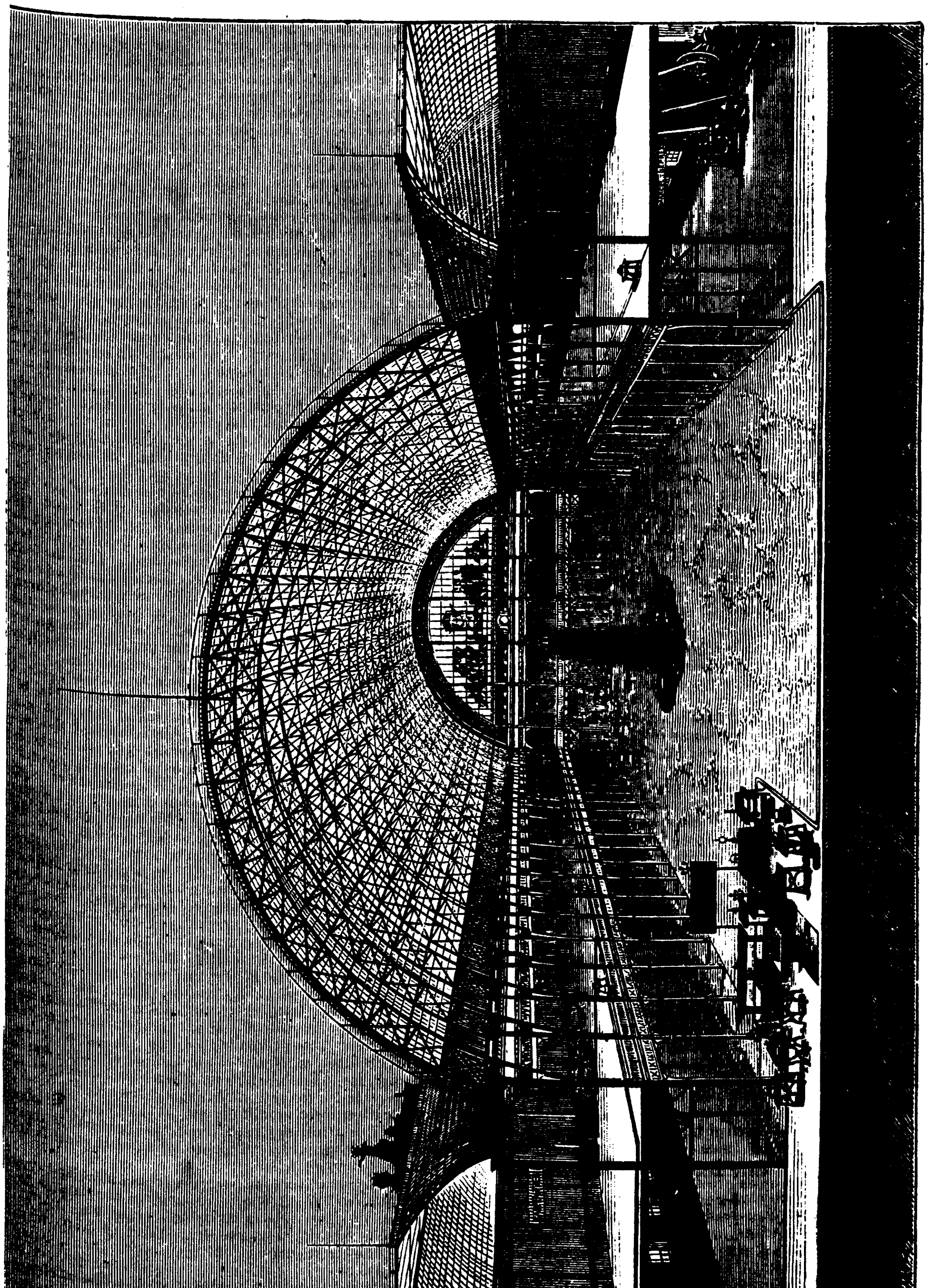

Fig. 3.—General View of the Deprez Arrangement, Paris Exhibition, 1881.

length of 78·6 kilometres of telegraph wire. The return was estimated approximately at 25 per cent.

It must not be believed that the affair proceeded with the convenient rapidity which this brief account might lead the reader to suppose. Many obstacles were encountered, but not those which had been announced. We are not speaking here of M. Deprez and his friends, who knew approximately what might be expected. But, in the electrical world, it was said on all sides that this would never work. Each one had his reason. At the first trial the machines, it was said, were to melt, burn, and be destroyed by the heat. Not only did nothing of the kind occur, but no machine had ever been so cool. The most ordinary light machines heated incomparably more than these. The real difficulties encountered lay, as was known to those who had studied the question, in the novel use of high tensions. It was necessary to employ great care in insulation; to arrange commutators of new forms to prevent the origination of voltaic arcs, very difficult to extinguish at the moment of interrupting the current. It was even needful to employ especial methods for effecting the interruption, as any sudden break was seriously injurious. Thus, as we advanced, difficulties presented themselves, inherent in the use of electricity in this novel form, and successively they were overcome.

It was about the beginning of 1882 when the Technical Commission charged with organizing the Electric Exhibition at Munich, placed itself in communication with M. Deprez. The question of transmission had been already raised at the Paris Exhibition, and it was decided to render it one of the main features of the Munich Exhibition. But, as may be understood, it was decided to present the transmission under novel forms and to show results which had hitherto not been seen. The Commission addressed itself to various German firms, asking their assistance. Messrs. Siemens & Halske declined the proposal, doubtless being able to do merely what they had done previously and not wishing to repeat themselves. Messrs. Schukert accepted, and effected a transfer to to the distance of five kilometres. The motor machine was impelled by a fall of water on the river Isar, at Hirschau. The conducting wire was of copper, and presented a total resistance of 12·61 ohms.

It is necessary to insist upon this point. We must carefully note that in transfers the distance does not act strictly by its length but by the resistance of the conducting wire necessary to connect electrically the two machines. Doubtless, we may diminish this resistance by selecting a good conducting metal and increasing the diameter of the wire. But this can only be done by increasing the expense. Now, we must remember that the transmission of power is not merely a scientific question, but should admit of an industrial application. Hence, economic considerations play an important, and even a preponderating part. If the transfer is to have any interest, the distance must be considerable and it must be traversed by means of a cheap conductor, that is, a wire relatively slender and therefore having a considerable resistance. As will be seen directly, the experiment of Messrs. Schukert responded very imperfectly to these conditions, the distance being small and the conductor very thick. Hence this transfer did not differ essentially from former experiments, and especially from what had been done at the Palace of Industry in 1881. For the rest, no measurements were made with this transfer, which is the more singular as the Munich Exhibition was got up for the very purpose of securing precise data, and the apparatus were generally submitted to a thorough examination.

We will say nothing of an alleged transfer effected at Munich by the Edison Company, the generating and the recipient machines being placed only at a distance from each other of 10 metres!

On the contrary, it is necessary before coming to the principal experiment, to say a word on a transfer of a peculiar kind exhibited by M. Deprez. As regards the distance of the transfer, properly speaking, it offers no novelty. But it displays an interesting manner of utilizing electric action for the production of mechanical work. In the course of the experiments, the solenoids have been studied, and it has been found that the attractions developed in these apparatus are very energetic. But in their ordinary arrangement they cannot give great displacements, nor, consequently, much work. By an ingenious arrangement, M. Deprez constructed a solenoid of a series of small, very flat solenoids, superimposed. Each of them is connected to the preceding one so as to form a continuous whole. But at the junction of two sections there is a stop of copper and these stops together form a collector, like those of the Pacinotti-Gramme machines.

Two rubbers convey the current, comprising between them a certain number of contacts, for instance, 10. There is, then, in the column forming the solenoid an acting portion traversed by the current, formed of 10 sections. By causing the brushes to travel along the commutators we cause at the same time the active portion to move along the solenoid and the iron core will follow it. We may thus raise it rapidly, cause it to descend in the same manner and make it act like a steam hammer. The power produced has been brought up to 180 kilos; at Munich it was 70 kilos.

We now come to the most important experiment.

M. Deprez having announced that he purposed working to great distances, the Commission immediately proposed to him to go to 50 kilometres, and offered him as conductor, an ordinary telegraph line. Here were certainly conditions quite exceptional, nothing of a similar kind having yet been attempted. As to the resistance to be overcome, M. Deprez was prepared; we have described one of his experiments in which he traversed in his laboratory resistances greater than the 500 ohms of a line of 50 kilometres. But there remained a doubtful point—to know how a telegraph line would behave, if its insulation was sufficient, if atmospheric disturbances had any influence. Experience alone could answer. To accept the investigation thus publicly, at so great a distance and under such conditions, was certainly bold. M. Deprez was bold enough, and he was justified by success.

It must be added that at this time he had no dynamos furnishing high tensions save the two transformed Gramme machines which have been previously mentioned. These apparatus were originally imperfect, and were already a little injured by the experiments for which they had served. These he sent on to Munich. The first project was to effect a transmission between Augsburg and Munich, but a Bavarian manufacturer, M. Fohr, who had works at Miesbach, a small town at the distance of 57 kilometres from Munich, urged that the generating machine should be placed there, and undertook to supply the necessary power. The distance was about the same.

As a conductor, the existing telegraph line was employed without alterations. It was at first intended to effect the return by the earth, but on further reflection this idea was abandoned and a second telegraphic wire completed the circuit. This arrangement certainly doubled the resistance of the line and, consequently, the difficulty of transport, but it was thought necessary to avoid danger. The effect of high electric tensions was then excessively dreaded; and if the earth was used for a return, the body of any person touching any point of the line would form at once a derived circuit.

It was subsequently found that high tensions were less formidable than had been supposed. Still, it is certainly imprudent to play with them, and a return wire seems a necessary precaution. It seemed still more important at the time in question. Thus arranged, the line offered a total resistance of 950 ohms according to the measurement of the Commission.

It must be said that, whilst inviting M. Deprez to carry out his experiment, it does not appear that the Munich Commission had much confidence in his success. Thus, on the day when M. Sarcia, the engineer employed by M. Deprez, announced that he would make his trial, many members of the Commission were present, and when, on the signal being given, the obedient machines began to move, there was a burst of applause. The machine at Munich was employed to work a rotary pump, feeding an ornamental cascade.

The success was clearly and fully proved, but, as might have been expected, a number of small accidents interfered to limit its duration. On this subject it is best to quote the certificate given by the Commission:—

"The dynamo machines were set in motion for the first time on Sept. 25th, at 7 p.m., and, according to the data of M. Datterer, the engineer appointed by the committee, the receiver placed at Munich revolved at the speed of 1,500 turns per minute, the brake, serving to measure the work, being loaded with 1·5 kilog.

"A series of accidents, due to the fact that the machines were constructed for laboratory experiments and not for practical work, arrested, after eight days, the progress which up to that time had been completely satisfactory. The circles surrounding the ring of one of them broke, consequently the wires of the ring of 0·4 mm. in diameter were damaged, and had to be insulated afresh. In the remote town of Miesbach these repairs were effected wtth great difficulty, and required, on the part of the assistants of M. Marcel Deprez, much patience and perseverance.

"On Oct. 9th and 10th, when the Commission of Investigation commenced its measurements, the greatest speed attained at Miesbach with the repaired machine was 1,600 revolutions per minute; the results were consequently much less favourable than they had been with the normal velocity of 2,000 revolutions per minute obtained at first.

"During a few moments only it was found possible to reach. during the measurements, the speed of 2,000 revolutions per minute, and quite at the beginning of the experiments one of the brushes of the machine became detached, which produced an extra current and destroyed the machine."

It will be seen from these extracts that the results were obtained under disadvantageous conditions.

They are not, moreover, perfectly exact, especially from the transmission dynamometer at Miesbach having been made for 15 horse-power, was ill adapted for the measurement of small forces.

The results were the following: work received 0·25 horse-power, electric return 38·9 per cent. The machanical return was not measured, but it is estimated at about 30 per cent.

All this, doubtless, was but a beginning; but it differed so widely from the attempts previously made, that a great outcry was raised. There was a brisk, indeed a violent, discussion on the results, the procedures, and everything which seemed open to attack. However, as was said by M. Cornu in a report to the Institute, to which we shall have to return below:—"The very violence of the polemic which has arisen on this question suffices alone to show that the author, if he has not solved the problem, has at least approached it very closely."

It was impossible to stop on so open a road. Along with these public trials, laboratory experiments were also advancing, and M. Deprez succeeding in deciding on the construction of his permanent machines.

On account of particular circumstances and of a special application which was projected at this time, it was not proposed to adapt the first machine to a distant transmission, but it was thought desirable to receive a quantity of work of practical importance.

A beginning was made with a single apparatus; prudence demanding that in novel regions we should advance only step by step. The machine was completed about the end of January, 1883; it was tried, at first, in the laboratory, and appeared to answer all expectations, but it was necessary to try it in a more practical manner, and on a real line.

A telegraphic line is not an easy thing to find. It is true one was urgently offered, but it was in Bavaria. As a sequel to the success of the first former experiment, the administration of Munich had urged upon M. Deprez to repeat it with the machines which he subsequently constructed. He might have accepted this offer, but it implied going to a distance, leaving France, and carrying his performances abroad. This did not please the inventor. Among the French telegraphic lines there are some which the Administration often devotes to experiments. But these are more especially reserved for telegraphy. Besides, it must be said that the Administration had an exaggerated fear of high tensions, and was reluctant to see them upon its lines. M. Deprez addressed himself, therefore, to the Companie du Nord. The engineer of the telegraphic service, M. E. Sartiaux, with great kindness, found a line which it was possible to withdraw from the general service for a few days. The engineers of the depots, MM. Delebecque and Sauvage, found in their work rooms a corner and driving gear; the working service and its engineer, M. J. Sartiaux, took the experiment under their charge, and occupied themselves with the details. In a word, the company showed a good will, for which M. Deprez is exceedingly grateful.

As it was necessary to know exactly all the circumstances, and to take as many measurements as possible, M. Marcel Deprez made the most suitable arrangements to facilitate such studies. To this end the two machines, the generator and the recipient, were placed near each other in the work-rooms of the company, connected on the one hand by a wire of trifling resistance, and on the other hand by a double telegraphic line going to Bourget and returning. The distance was 8·5 kilometres, and the total length of the wire about 17 kilometres. Of the two machines, the one which served as generator was the dyname recently constructed, of which we give a representation in fig. 8.

As will be seen, this machine has two induced rings, each turning in a distinct magnetic field. The inductors have the form of horseshoe electro-magnets, which has been found the most advantageous to produce the magnetic field with a small outlay of energy. The numerous terminals on the upper table are intended for effecting combinations, and for modifying the effects of the machine, which was thus adapted for study and experiment. The recipient was a Gramme machine, of the model. D, transformed. It was not unknown that this machine was inferior to the other, but we must add that the experiment was attended with all sorts of unfortunate circumstances. The recipient had suffered in recent experiments; the days for the experiment being fixed, there was no time for repairing it, and it had to be taken away as it was, with full knowledge that it was faulty in several places, but to what extent was not entirely known. To crown all, the generator, which was in very good condition, was drenched in a heavy shower whilst being taken down from the truck. It was thought at first that the damage was slight, but it had to be taken into account. To gain its electromotive force, this machine had to be revolved at a velocity of 1,000 to 1,500 revolutions. When set in motion, it was impossible to bring it to more than 500 revolutions. At this speed the insulators, soaked in water, allowed the electricity to pass, and sparks flew off continually. It was necessary to begin under these wretched conditions, and it was only by degrees, as the machine dried slowly, that it was possible to attain proper velocities. Still 1,000 revolutions, which ought to be a normal velocity easily exceeded, remained a maximum, which was not reached without difficulty, and which could not be kept up for any length of time. These experiments introduced quite a new feature into the question of the electric transmission of power. They attracted very strongly the attention of the scientific world, so much so that the Academy of Sciences, to whom communication had been made, wished to be completely enlightened on the subject, and nominated a Commission, composed of M. Bertrand, the perpetual secretary, as president, and MM. Tresca, De Freycinet, De Lesseps, with Cornu, as reporter.

The work expended at the generating machine was measured by means of a Morin taansmission-dynamometer, obligingly lent by the Commission of Arts and Trades. The work received was absorbed and measured by a Prony brake. The electric elements were determined in duplicate by M. Cornu with Deprez galvanometers, and by Dr. Hopkinson with the instruments of Sir William Thomson.

It must be added that these instruments had had to be arranged in a special manner to measure very high potentials, for which they had not been constructed, and for which, indeed, no apparatus exists. Thus the Deprez galvanometer acted in a circuit into which a resistance of 50,000 ohms had been introduced. All the details, and the procedures for aauging and verifying are explained with great care in the report made to the institute by M. Cornu, and have appeared in the *La Lumière Electrique* (April 14th, 1883). A series of experiments was made at different velocities, and the following values were obtained (see following table extracted from the report). Among these experiments, one, No. 5, might be the subject of a certain doubt. This experiment was marked by an accident, fortunately unattended by serious results, but which greatly alarmed the observers. Whilst taking electric measurements, M. Cornu, wishing to move the commutator, grasped it by mistake by the metal instead of by the insulating handle, and thus found himself in a derived circuit taken from the extremities of the generator, the experiments showing at that moment that the difference of potential was at least 1,900 volts. M. Cornu was violently projected to the distance of some paces, but without falling. The two fingers which had touched the metal received two burns, not very serious, but rather deep. This injury was accompanied by stupefaction for some seconds. Such were the only results of this accident, but the general sensation may be conceived. Misfortune is not without its uses, and M. Cornu, on recovering after a few minutes, remarked that it was an interesting experiment. Currents of high tension were much dreaded; it had even been announced that their effects were like those of lightning, such alarming assertions being based upon accidents which had occurred with light machines.

(*To be Continued.*)

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Spanish Minerals.—Veins of argentiferous lead are said to have been recently discovered at Argentera, in the province of Tarragona (Spain).

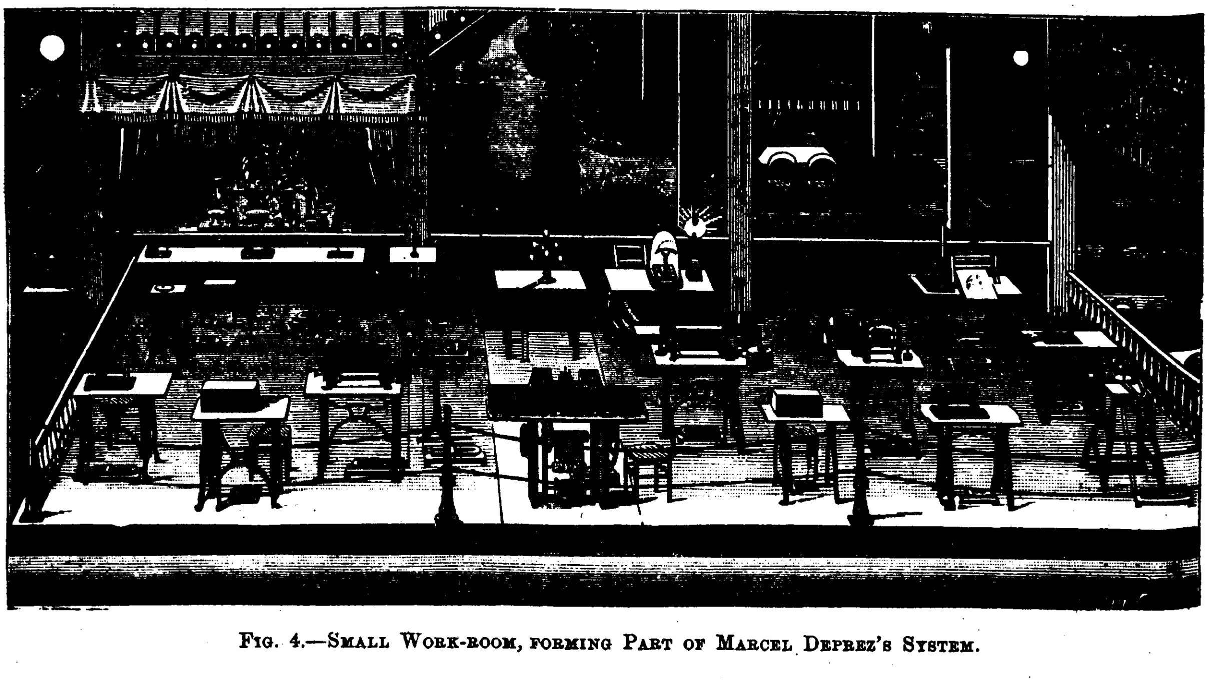

FIG. 4.—SMALL WORK-ROOM, FORMING PART OF MARCEL DEPREZ'S SYSTEM.

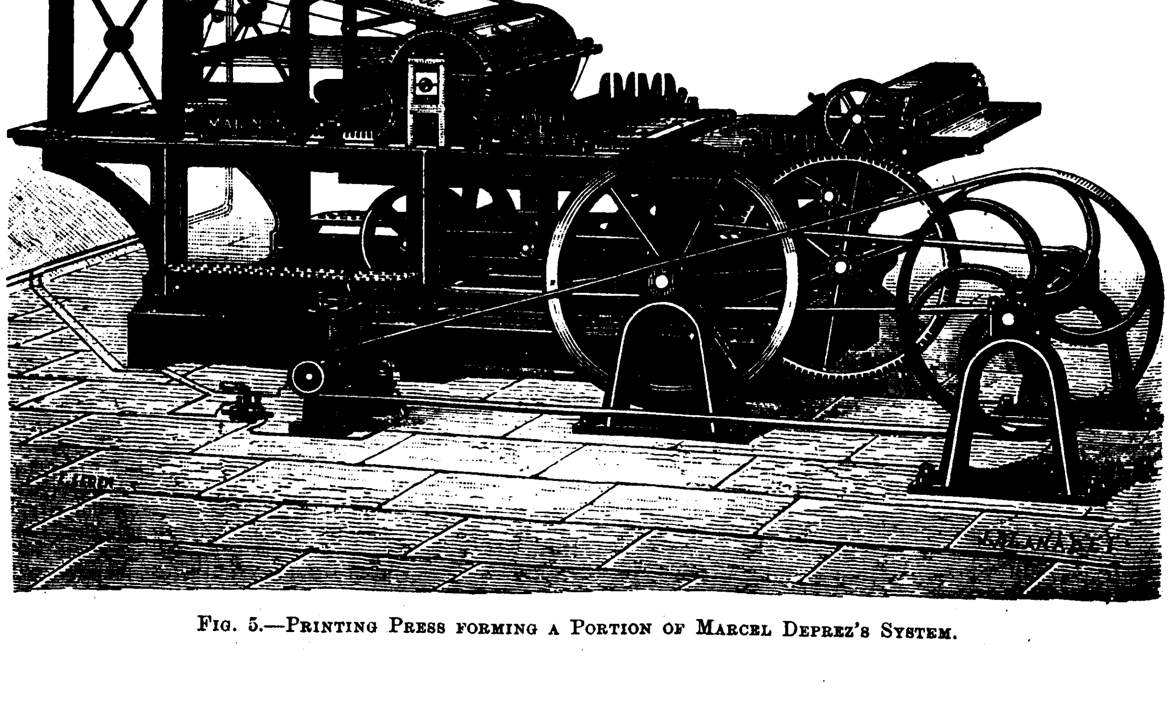

FIG. 5.—PRINTING PRESS FORMING A PORTION OF MARCEL DEPREZ'S SYSTEM.

Fig. 6.—Installation at Miesbach.

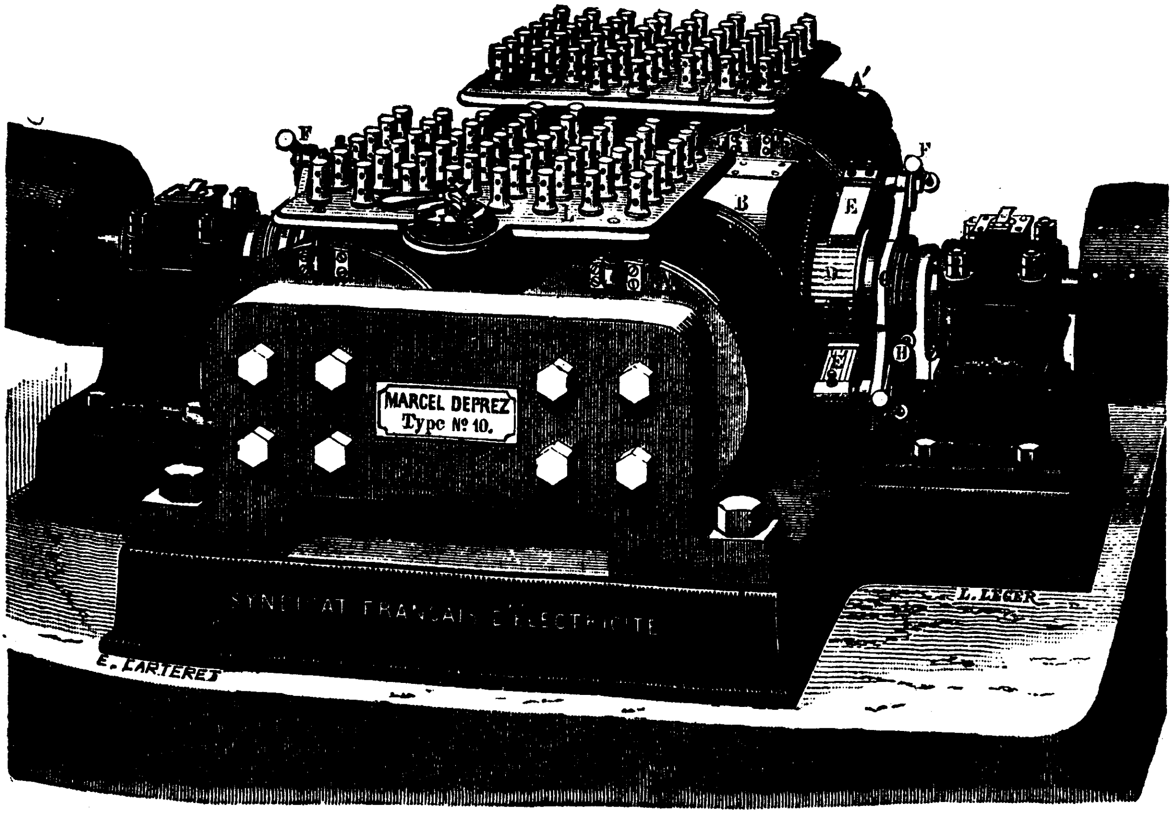

Fig. 8.

TEMPERATURE OF WATER AT VARIOUS DEPTHS IN LAKES AND OCEANS.

By Hamilton Smith, Jr., M. Am., Soc. C.E.

Mr. Smith at a meeting of the Am. So. of Civil Engineers expressed the opinion that the temperature of water drawn from a reservoir at a depth of 170 feet would be much more constant during the year than if drawn from a point say 60 feet below the surface. He stated that at one of the North Bloomfield reservoirs in California, formed by a masonry dam about 100 feet in height, the water was drawn from a point about 90 feet below the top of the dam. In July, when the temperature of the air is often above 90 degrees, the water near the surface is too warm for drinking, and not too cold for bathing, while the water from the deep point is almost icy cold. In the winter months, with a depth of 50 to 60 feet of water, that drawn from the bottom is from 5 to 7 degrees warmer than the stream water in the neighborhood; this fact being of great practical advantage, as the comparatively warm water enters the open canal of the Company and retains more or less of its high temperature for a distance of 15 miles, even during snow storms, while in other canals of that neighborhood, whose water comes from running streams, the flumes soon become choked by snow unless they are covered.

A number of observations upon the temperature of water were given. Those made by F. A. Forel, at the Lake of Geneva, Switzerland, showed a surface temperature varying from 41 degrees to 71 6-10 degrees, and a constant temperature of 41 4-10 degrees at the depth of 984 feet. The range at the depth of 164 feet was only from 43 3-10 to 44 8-10. This lake rarely freezes. Observations upon other Alpine lakes were given with the same general results. Prof. Wm. Ripley Nichols found the temperature of Fresh Pond at Cambridge, Mass., with a range of from 82½ degrees to 33½ degrees at a depth of 2 feet below the surface, while at a depth of 35 feet the variation was only from 51 degrees to 34½ degrees.

Prof. J. LeConte found the temperature of Lake Tabac, California, at 1506 feet below the surface to be 39 2-10 degrees, when at the surface it was 67 degrees. This lake has never been frozen across. In ocean soundings the *Challenger* found in latitude 37° 31' south, longitude 36° 37' west, a temperature of 30 9-10 degrees at a depth of 16,050 feet, and in several other soundings temperatures of 31 3-10 and 31 5-10. The *Blake* found north of St. Thomas, in the West Indies. 36½ degrees, at a depth of 27,366 feet, which is notable as being the deepest sounding thus far made. At this point the surface temperature practically remains constant at 80 degrees. The *Blake* soundings also show that in this heated current rapidly moving northward from the tropics there is a very rapid diminution of temperature, even at very small depths. The explanation of these low summer temperatures at considerable depths in bodies of fresh water is that water being most dense at about the temperature of 39 2-10 degrees, the surface water, which becomes cold in the winter, gradually sinks, and, water being a poor conductor, the strata, at depths of 200 feet or more, will retain during summer this lower temperature with but slight variations, although the surface may become heated up to 82 degrees, as at Fresh Pond, and perhaps even higher at other points. This theory does not seem to account for the very low temperature of 30 9-10 degrees recorded by the *Challenger*, or that of 36 2-10 degrees by the *Blake*. Possbly pressure may be a factor in this problem. There are great practical difficulties in determining accurately temperatures at such enormous depths. In the soundings near St. Thomas, the pressure of water amounts to near 12,000 pounds per square inch. Comparative tests, however, of the latest models of thermometer used by the United States Coast Survey, show satisfactory results. It is evident, therefore, that in a reservoir near this locality the surface temperature may reach 85 degrees in July and August, and go to 33 or 34 degrees in winter, while at a depth of 170 feet it will not vary greatly during the year from 45 degrees; this being on the assumption that the reservoir remains full. Where water can be obtained from depths of 60 to 170 feet. this consideration should have weight in determining the point from which it can be most advantageously drawn. On account of this lower temperature the water will probably be more free from organic matter or organisms. Of course, bottom temperature will become elevated as heated strata from near the surface find their way towards the bottom.

In the discussion of the paper, Mr. N. S. Keith described the construction and operation of the electrical apparatus used for ascertaining temperature at great depths. The paper was further discussed generally.

Miscellaneous Notes.

Gas Leakages.—An indicator of gas leakages has been constructed by Mons. C. V. Jhan, and is described in the *Revue Industrielle.* The apparatus consists of a vessel of porous earthenware, such as the porous cell of a galvanic battery, set upside down, and closed by a perforated india-rubber stopper. Through the hole in the stopper, the inside of the vessel is connected with a pressure gauge containing a little colored water. The vessel can be exposed to the air of an apartment where a leak of gas is suipected; or a sample of the air may be contained in a bell glass inverted over the porous cell. The diffusion of gas through the earthenware raises the level of the water in the pressure gauge, and when the latter is properly graduated and proportioned to the capacity of the cell axact and delicate indications may be obtained in a simple manner. This species of diffusiometer is so sensitive that when an Argand burner if gradually turned down until it is extinguished, the instrument, if held above the burner, will show a considerable rise of the water in four or five seconds. If held over an ordinary burner, turned on just sufficiently to be ignited, the liquid rises verw rapidly. When the instrument is graduated in millimetres a volume of one-half per cent. of gas in a room may be distinguished by it. An example is afforded by a case of sickness, wnich, in the opinion of the medical attendant, was due to gas poisoning. Some doubt arose on the point, because gas was not laid on to the house. The diffusiometer was brought into requisition, and showed the prhsence of gas, the source of which was afterward found in a broken main three metres distant from the house. A modification of the same instrument is made, whereby the sensitive portion is adapted for permanent exposure in any place difficult of access—such as the ceiling of a theatre or public building, where gas might be expected to collect, the indicating portion being fixed anywhere within view.

Consumption of Pig Iron in 1883.—From a comparison of the figures showing the production, imports, exports and stocks in hand, it appears that the consumption of pig iron for the year 1883 was 4,825,881 gross tons. It is a notable fact also, that, in spite of the general falling off of business, the figures of production and consumption of pig iron for the past three years show very little change. Thus, the consumption of 1881 waf 4,982,565 tons; that of 1882 was 4,956,171 tons; and that for 1883 was 4,825,881, a comparatively insignificant decline. The figures of production, imports and of stocks in hand, for the years 1883 and 1882, exhibit a remarkable uniformity, as will be observed from the following tabulation.

	1883. Gross tons.	1882. Gross tons.
Production	4,595,510	4,623,323
Importation	322,648	540,159
Makers' stocks, Jan. 1	383,655	188,300
Warehouse stocks, Jan. 1	14,356	9,953
Total	5,316,169	5,361,735

How Galvanized Iron is Made.—The iron to be covered is deprived of its coating of oxide by an acid bath composed of sulphuric acid and water, or of hydrochloric acid, in which it is immersed for a short time. It is then scrubbed with sand until the surface is cleansed; after which it is immersed in a concentrated solution of chloride of ammonium, taken out, and subsequently put into a bath of melted zinc, covered with fatty matter, or colophony, to prevent oxidatron, and stirred in it till the zinc forms an alloy at its surface. The coated metal is then, in some instances, introduced into a second bath consisting of melted tin, such as is used for tinning thin sheet-iron, when a slight coating of tin is formed on the exterior of the plate or bar. Of late years this second bath is generally dispensed with, a few pounds of tin being added to the zinc bath to produce the same effect.—*Mechanical Engineer.*

The Berryman Feed Water Heater.—Messrs. Wright & Co., of Tipton, Staffordshire, are erecting for a Manchester firm a number of Berryman feed water heaters of the largest size, over 33 ft. high, the whole weighing over 110 tons. They are equal in power to about six double-flued Lancashire boilers 7 ft. in diameter by 27 ft. long, and are designed to supply hot purified feed water to eleven boilers, and also hot water for washing purposes throughout the works, their delivery being calculated at 12,000 gallons per hour. They will be heated by the exhaust steam from sixty-seven steam engines. By their application it is expected that a saving will be effected of about 6000 or 8000 tons of coal per annum, besides £800 in soap, and the further economies which these reductions will bring about.

A **Gold Colored Surface on Brass** may be produced with a liquid prepared by boiling together for about fifteen minutes, 4 parts of caustic soda, 4 parts of milk sugar, and 100 parts of water, to which 4 parts of a concentrated solution of sulphate of copper should then be added with constant stirring. The mixture is then cooled to 75° C. (=167° Fah.), and the well-cleansed orticles are immersed in it for a shart time, when the gold color will appear. A longer immersion results in the formation of a bluish-green tint, and a still more prolonged action causes the formation af iridescent colors.

◆

THE ELECTRIC LIGHT ON SHIPBOARD.—*Engineering.*

As the result of Messrs. Siemens' experience and practice, we note the following points as essential elements in the system which has led to success at sea, and which may produce equally satisfactory results on land.

1. *Motive Power.*—A strong plain engine, with very large wearing surfaces especially on the crank-pin; a crosshead with perfect arrangements for continuous lubrications of the moving parts; and a highly sensitive governor controlling a throttle valve, the expansion valve, if any, being regulated by hand.

2. *Transmission*—Rope gear with ample provision for tightening the rope whilst running, or friction gear with a large margin of safety and complete arrangements for lubrication. These systems are quite free from the slight pulsations in the strength of the lights which are often visible with strap driving, owing either to thick or thin places in the belt, or to waving or flapping of the belt where the centres are far apart.

3. *Safety.*—Duplicate machines, each driven by a separate engine with hand adjustment to the governor, so that the speed and consequent electro-motive force may be adjusted accurately by the test lamps or voltmeter before changing from one machine to the other.

4. *Circuits.*—Complete arrangements on the key-board for changing to or from any circuit or machine whilst running without stopping or sparking, and for coupling machines parallel prior to changing from one to the other, so that the act of changing may not affect the strength of the light. To carry this out successfully the keyboard should be close to the engines, and every key should be properly labelled to avoid mistakes.

With machinery arranged on this system a steady light may be maintained for any length of time without fear of failure, even on vessels without duplicate machines. On the *City of Rome* and *Alaska* the engine-room and some other lamps are maintained without stoppage from Liverpool to New York and *vice versa*. The system of using the hull of the ship as "return," which is now known as "the single wire system," originated with Messrs. Siemens Brothers & Co., and possesses the following advantages:

1. With a given sectional area of conductor the resistance is one-half and the cost one-half compared with the double wire system, or if the same weight of copper be used, the resistance of the single wire system is only one-fourth of that of the double wire.

2. The cost of laying the wires is very small.

3. The extreme simplicity of the fittings and attachments makes it easy to guard against short circuits in the keys and lamp-holders.

4. The average distance of the conductor from the metal of the ship is very much greater than the distances between the double conductors under ordinary circumstances.

The next point worthy of notice in the Siemens system is the large number of branch of sub-circuits. No lamps are coupled direct to a main directors, but branch wires are taken from the main, each forming a section of ten or twelve lamps. At every junction with the main conductor there is a safety bridge and key, and a descriptive name-plate. This arrangement reduces the effect of an accident to the smallest proportion and makes it a simple matter to trace and rectify faults. By a judicious selection of two or three places from which to start branches, the main conductor may be kept almost free from joints, and we are informed that in consequence of a strict adherence to this principle, there has not up to the present time been a single instance of trouble with a main conductor. This possibly is due, to some extent, to the use of a wire specially insulated, and served with jute for use on ships, or, in other words, to the fact that the single wire has got the insulating material of two ordinary wires and the jute in addition.

The section safety bridges mentioned above are not arranged to protect the lamps as is commonly supposed, but are made thick enough to stand a current much stronger than the normal, but they will melt with less current than is necessary to damage the smallest single-light wire in the section. The section keys break the circuit at two points to prevent arcs forming, and they make a very tight and clean contact.

The fittings, or brackets, pendants, &c., which carry the incandescence lamps are chiefly noticeable for their simplicity and strength. Referring to our illustrations, Fig. 1 is a bracket suitable for state-rooms and officers' cabins and with slight modification can be used in many positions. For instance, instead of the curved arm it may have a straight one rising from the top of the globe for attachment to the deck or ceiling. It is usually supported by an iron screw tapped into the iron deck, and serving also as the metallic contact required for the "return." Fig. 2 is a strong guarded lamp, specially adapted for steerages; it is fixed up with a "bayonet joint," so that it may be easily removed for stowage of cargo. The act of replacing it in position makes the connexion to the electric circuit. Fig. 3 is a bracket designed principally for engine-rooms. It carries a Swan lamp protected by a strong glass shade; it also serves as a socket for connecting the end of a flexible double wire in connexion with a hand lamp, Fig. 4, which is chiefly used in repairing or examining the main engines. These hand lamps are attachable to any of the engine-room brackets, and are provided with about 20 feet of flexible wire.

The whole of these fittings have similar internal parts, consisting principally of a central taper peg, which forms the terminal of the positive conductor, and which makes contact with the lamp-holder by fitting tight in a brass socket in the lamp-holder. The method of securing the glass globe is extremely simple and ingenious. Three brass fingers, each about ¼ inch longer than the radius of the hole in the globe, support the weight of the globe, and a brass cover sliding on the central tubes sits on the flange of the globe and holds it in a central position. To remove the globe it is necessary to raise the brass cover with one hand and with the other hand to push the globe to one side, when it falls off one of the fingers, and may then be drawn sideways off the other two. This device has been in use since February, 1882, and has nearly stopped the breakage of globes, which before that time was a serious item, partly owing to screws jarring out and partly to over-screwing. The globes are all made in one mould, and are therefore interchangeable on every ship.

The lamp-holder, or device for making connexion to the platinum loops of the Swan lamp, has two noticeable points; it can be removed easily from its socket when a new lamp has to be fitted, thus enabling the attendant to effect the operation carefully without damaging the loops; and the supports and connexions of the lamp are perfectly elastic, which protects the filament from injury from the vibration of the ship and maintains good electric contact under all circumstances.

We have given a full description of Messrs. Siemens' system, principally because it is a system which may be traced as plainly in the first installation as in their latest, consequently every addition has been a progressive step towards that perfection which, it is hoped, will ultimately make the electric light not only as cheap but as reliable as gaslight. It is pleasing to note the support which Messrs. Siemens Brothers & Co. have given to their competitor, or rather coadjutor, Mr. Swan. They adopted his incandescence lamp at the outset, and have probably been his largest customers down to the present time. We are informed by Mr. J. S. Raworth, of Manchester, who, representing Messrs. Siemens Brothers, has had charge of the principal installations on shipboard, that the renewal of Swan lamps which at first was a most serious item, is now reduced to about 10 per cent. per voyage to New York and back.

FITTINGS FOR ELECTRIC LIGHT ON SHIPBOARD.

CONSTRUCTED BY MESSRS. SIEMENS.

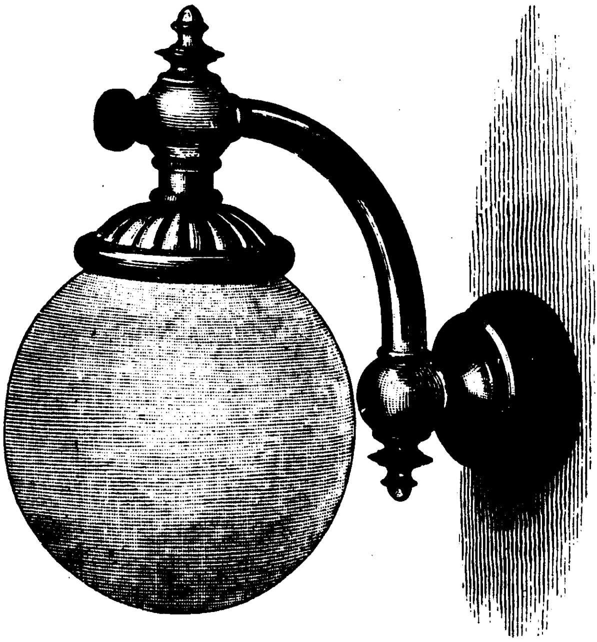

FIG. 1.

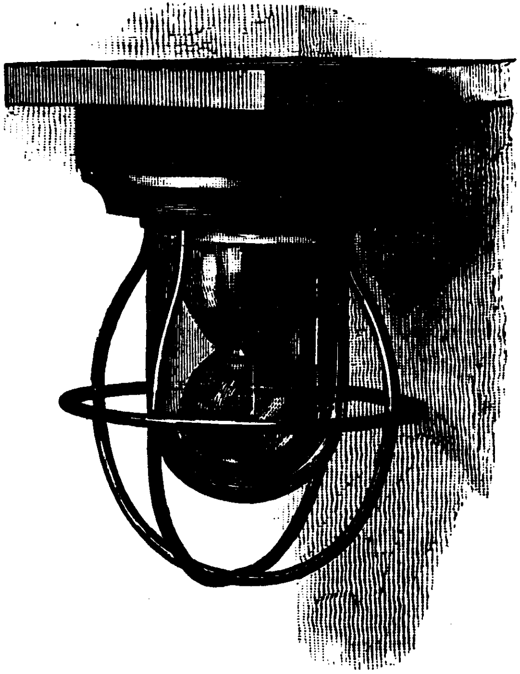

FIG. 2.

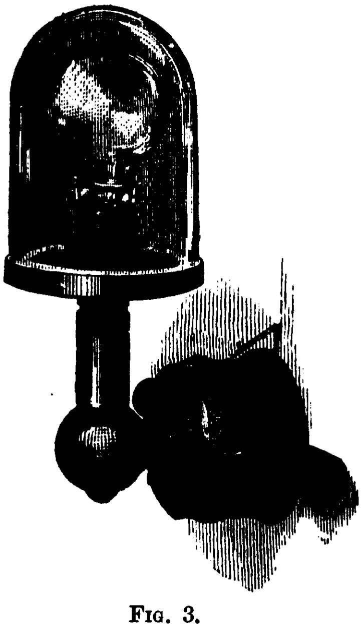

FIG. 3.

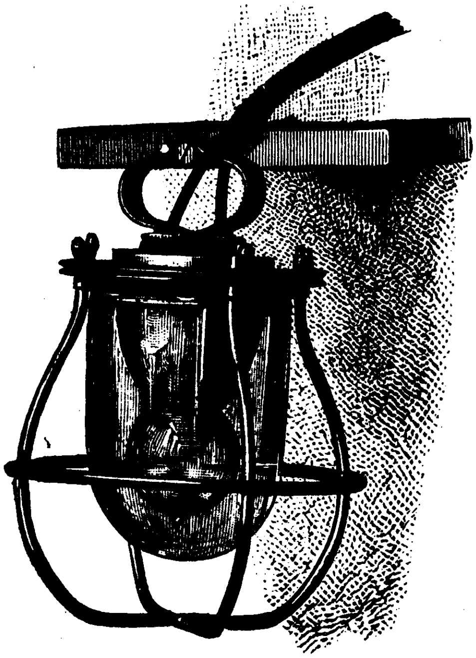

FIG. 4.

DEPREZ'S EXPERIMENTS.

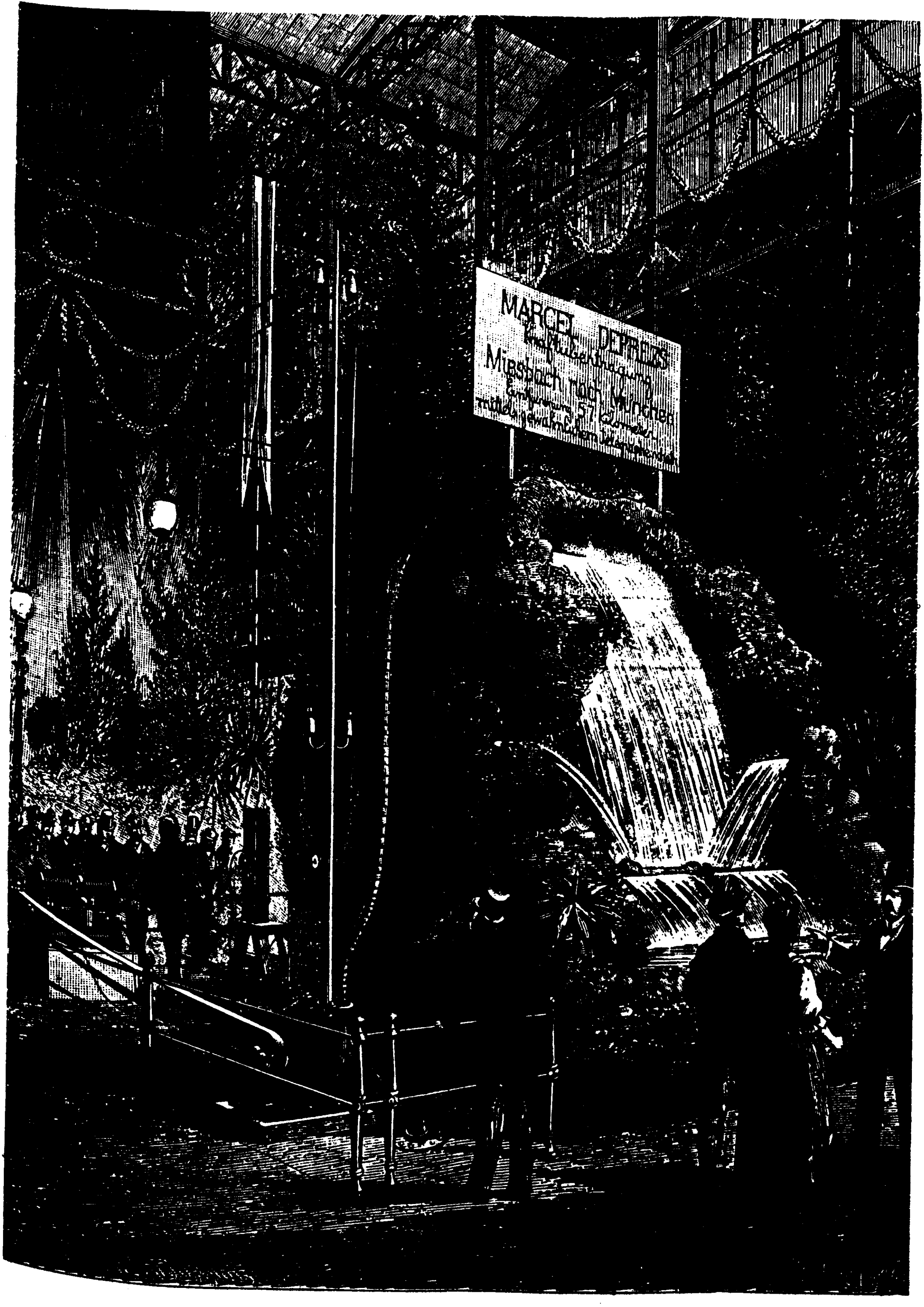

Fig. 7.—Installation at Munich.

NOTES ON ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

(*Continued from page* 127.)

The first measurements of specific inductive capacity were made by Faraday, who constructed two precisely equal condensers, each consisting of a sphere insulated within a larger hollow sphere, the latter having an aperture for the passage of the electrode of the inner sphere. Faraday first proved the equality of the capacities of the instruments when the space between the spheres was occupied by air by charging one condenser, measuring its potential by Coulomb's torsion balance, then connecting it with the second condenser, and again measuring its potential, when it was found that the potential was reduced to one half its former value. Hence the charge was reduced to one half, and the capacities of the condensers were therefore equal.

Faraday then half filled the space between the spheres in one condenser with shellac, charged the air condenser, and divided the charge between the two, after measuring the potential of the charged condenser. On again measuring its potential it was found to be reduced to about two-fifths of its former value. Hence the capacity of the shellac condenser was one and a half times that of the air condenser. From the Faraday inferred that if the whole space between the spheres had been filled with shellac the capacity would have been doubled, and he therefore concluded that the S. I. C. of shellac was about 2.

DEF. A line of force is a line which, at every point is in the direction of the resultant force at that point.

The direction of a curved line at any point is the direction of the tangent to the curve at that point.

If a number of electrified bodies be immersed in an insulating liquid, such as paraffin oil the directions of the lines of force can be exhibited by throwing into the liquid some fine cotton or linen threads, when the conducting threads will take up the directions of the lines of force between the electrified bodies.

Faraday conceived an electric field permeated by lines of force which always proceed from positively to negatively electrified surfaces, taking their origin when ever there is a positive charge and proceeding to an infinite distance unless they meet with a negatively electrified surface. Faraday not only regarded the lines of force as indicating the direction of the resultant force at every point but he supposed the number of lines of force proceeding from any charged body to be equal to to the numerical value of its charge. Maxwell pointed out the analogy between Faraday's lines of force and the "*stream lines*," or lines of flow, in a fluid, and shewed that, in virtue of the fundamental law of electrical action, *i.e.*, the law of inverse squares, if lines of of force be drawn according to Faraday's system the number of lines passing through unit area of any surface will be proportional to the force at right angles to that surface, and this will be true wherever the surface may be situated in the electric field.

Since no work is done upon electricity when it moves from one point to another along an equipotential surface it follows that the direction of the resultant force is always at right angles to the equipotential surface. Hence the lines of force and the equipotential surfaces cut one another at right angles.

If the surface of a charged body be divided into portions each of which is charged with the unit of electricity, and if lines of force be drawn from every point in the boundaries of each portion of the surface the lines will together form "tubes of force," which will widen whenever they reach places where the force is weak, and contract in places where the force is strong, just as the stream lines in a river widen out when the river widens and the velocity diminishes, but contract when the bed of the river narrows and the velocity of the stream increases, (as in approaching rapids). If the equipotential surfaces be drawn corresponding to unit difference of potential the tubes of force cutting the equipotential surface everywhere at right angles will divide the electric field into a number of rectangular "cells," and Maxwell shewed that each of these cells corresponds to half-a-unit of energy possessed by the electrified system. Thus if all the equipotential surface and tubes of force corresponding to any electrified system be drawn on the above plan and if the electric field be thus divided into 1000 rectangular cells the energy of the electrified system will be 500 ergs. The fact that the energy is proportional to the number of cells suggests the idea that the cells are themselves the receptacle of the energy, that is that the energy of an electrified system resides in the dielectric.

Dr. Kerr succeeded in showing that glass and other dielectrics when exposed to the action of electric forces are thrown into a state of mechanical strain by transmitting a beam of polarised light through the dielectric at right angles to the lines of electric force. When the Nicol prisms of the polariscope were crossed and the field dark to commence with, the light reappeared as soon as the electromotive force attained a certain intensity.

Suppose that a piece of wire gauze is connected with the earth and an electrified body is held near to it. If the lines of forces of this systen be drawn it will be seen that scarcely any of them pass through the gauze. The lines which approach the gauze as though they would pass through the perforations become bent round and finally reach the wire, having passed behind the gauze to a distance which is always small compared with the distances between the wires. Thus, a piece of wire gauze is an effective screen from electric force, and an instrument placed within a wire gauze cage which is in contact with the earth is effectually protected from the direct action of all bodies outside the cage, since no lines of force can find their way through the gauze to the instrument.

It two parallel plates are placed near to one another but maintained at different potentials, lines of force will proceed from the plate at higher potential to that at lower potential and, except very near the edges of the plates, these lines of force will be parallel to one another and perpendicular to the plates, for there is no reason why the lines should bend in one direction rather than another. Hence the electric force will be uniform at all points between the plates which are not very near the edges, and the numerical value of the force will be equal to the difference of potential between the plates divided by the distance between them. At points very near the edges of the plates the lines of force will be curved outwards, their lengths will consequently be increased as well as the distances between them and the intensity of the force will be correspondingly less, but its exact value is very difficult to calculate.

Sir William Thomson took advantage of the uniformity of the force at all points between two parallel plates, which are not very near their edges, in the construction of the various forms of trap-door electrometer. The essential feature of these electrometers is a disk, or trap-door of metal, which very nearly fits a hole made in the middle of a large metal plate which is called the "guard-ring." Near this plate or guard-ring is a parallel plate of metal whose distance from the guard-ring can be altered and measured by means of a screw with a divided circle upon its head. The trap-door is in metallic communication with the guard-ring and is supported, in the absolute electrometer, by springs, and in the portable electrometer by the torsion of a wire, in such a way that its position of equilibrium is a little above the plane of the guard-ring. When a difference of potential is produced between the guard-ring and the attracting disk the trap-door is drawn towards the disk with a force depending on the distance between the plates and on their difference of potential. The distance between the plates is then regulated by the screw until the trap-door is drawn into the plane of the guard-ring in opposition to the action of the springs or wire. The distance between the plates is than proportional to the difference of potential. The idiostatic gauge is similar to the protable electrometer, except that the distance between the plates is fixed, the object of the instrument being to determine when the difference of potential attains a fixed standard.

A magnetic needle suspended within a coil of wire which is so placed that the needle rests in the same plane with the coil constitites a galvanometer. The ends of the coil of wire constitute the electrodes of the instrument. It the conductors of a Voss machine are connected with the electrodes of a galvanometer, and the machine turned the magnet will tend to set at right angles to the coil and will turn through an angle depending on the quantity of electricity which flows through the coil in a second. If the connections of the Voss machine and galvanometer be reversed the magnet will be deflected in the opposite direction.

If a piece of litmus paper be saturated with a solution of sodic-sulphate, and if electricity be allowed to stream from two points attached to the conductors of the machine on to the litmus paper, the paper will be reddened for a small space opposite the point which discharges positive electricity, indicating the presence of an acid, while free alkali will be found opposite the other point. If paper saturated with starch and potassic iodide be employed the blue iodide of starch will be formed opposite the point which discharges positive electricity.

Def. The *electric intensity* at a point, or, as it is sometimes called, *the electromotive force at a point*, is the number of units of force which would be experienced by a unit of electricity placed at that point.

Def. *The electromotive force between two points* is the number of units of work which would be done on the unit of electricity in its passage from the first point to the second.

Hence, the electromotive force between two points is the same as the diff rence of their potentials. It differs from electric intensity or electromotive force *at a point* in the same way as work differs from force.

Def. *The electromotive force round a circuit* is the number of units of work done by the electric forces on the unit of elebtricity in going once round the circuit.

Thus, if Q units of erectricity traverse a circuit in which theee is an electromotive force E, the work done will be EQ ergs.

In 1822, Seebeck found that when a circuit is formed of two different metals, and the junctions of the metals are maintained at different temperatures, an electric current generally flows round the circuit, indicating an electromotive force in a definite direction. If the circuit be formed of antimony and bismuth, the current will flow from bismuth to antimony across the hot lunction, and from antimony to bismuth across the cold junction. If copper and iron be employed at temperatures below 260°C., the current will flow from copper to iron across the het junction. A current so formed is called a thermo-electric current.

Magnus showed that when a circuit is composed of one metal throughout, no variations of temperature between different parts of the circuit are capable of producing a current; but Le Roux showed that this law does not strictly hold when very abrupt changes of temperature are concerned so that "a ssnsible variation of temperature occurs between points whose distance is within the limits of molecular action."

It is possible to arrange the metals in a thermo-electric series corresponding to any given temperature, so that if any two metals be joined in a circuit, and the temperature of one of the junctions be a little below, and that of the other junction a little above the temperature in question, the current will always flow across the hot junction from the metal which stands higher to that which stands lower in the list. At ordinary temperatures bismuth stands at the top, and antimony near the bottom of the list.

In 1823, Cumming discovered several cases in which the thermo-electric order of two metals is reversed when the junctions are heated very highly. Thus, if a circuit is made of a piece of iron aed a piece of copper wire, end one junction is heated while the other remains at, say. 0°C., the current will flow from copper to iron across the hot junction, and will continue to increase until the temperature of the hot junction reaches about 260°C., after which the current will diminish, until it disappears when the temperature of the hot junction is 520°C. If the temperature of the hot junction is still further increased, the current begins to flow in the opposite direction, that is, from iron to copper across the hot junction, and increases as the temperature is raised.

The temperature of 260°C. is called the *neutral temperature* for copper and iron. The current always flows from copper to iron across the junction whose temperature is nearer to 260°C. than the other. Whatever the temperature of the junctions may be, when one of them is as much above 260°C. as the other is below it, there is no current in the circuit. Since the current flows from copper to iron across the junction whose temperature is nearer 260°C. than that of the other, it follows that if one or both of the junctions are heated till their *mean* temperature reaches 260°C., the cerrent will be reversed. The reversal of the current when the mean temperature exceeds the neutral temperature is called *thermo-electric inversion*. For some pairs of metals the neutral temperature is very high or very low indeed.

Tait has shown that the electromotive force in a circuit consisting of two metals may be expressed by the formula—

$$A (T_1 - T_2) \left(T - \frac{T_1 + T_2}{2}\right)$$

where T_1, T_2, represent the temperatures of the junctions. and T the neutral temperature for the two metals. From this formula it will be seen that the electromotive force vanishes when the mean of the temperatures of the junctions is equal to the neutral temperature, and changes sign when it exceeds the neutral temperature.

If the difference of temperature between the two junctions is indefinitely small, the electromotive force divided by the difference of temperature is called the *thermo-electric power* of the combination, or of one of the metals with respect to the other, and that metal is said to have the higher thermo-electric power from which the curreut flows across the hot junction. From Tait's formula, it appears that the thermo-electric power of either metal with respect to the other vanishes at the neutral temperature; in fact, at this temperature the metals behave as one and the same metal.

For a reason to be referred to presently, the metal lead is generally taken as the zero of thermo-electric power, and by the thermo-eleetric power of any metal is generally meant its thermo-electric power with respect to lead.

In 1834, Peltier found that when an electric current is made to flow from one metal to another which has a lower thermo-electric power, the junction is cooled; when the current flows in the opposite direction the junction is heated. This effect is distinct from the ordinary heating of a conductor by the passage of a current. being reversed when the direction of the current is reversed, while the amount of heat generated or absorbed per second is proportional to the strength of the current, the difference in the thermo-electric powers of the two metals, rnd the absolute temperature of the junction. This generation and absorption of heat at the junction is called *the Peltier effect.*

The Peltier effect may be exhibited by soldering together a bar of antimony and a bar of bismuth, and enclosing the junction in the bulb of an air thermometer, while the ends of the bars project through two orifices which are sealed with shellac or sealing wax.

(*To be continued.*)

TELEPHONY AND TELEGRAPHY ON THE SAME WIRES SIMULTANEOUSLY

FOR the last eighteen months a system has been in active operation in Belgium whereby the ordinary telegraph wires are used to convey telephonic communications at the same time that they are being employed in their ordinary work of transmitting telegraphic messages. This system, the invention of M. Van Rysselberghe, whose previous devices for diminishing the evil effects of induction in the telephone service will be remembered, has lately been described in the *Journal Télégraphique* of Berne by M. J. Banneux of the Belgian Telegraph Department. Our information is derived from this article and from others by M. Hospitalier.

The method previously adopted by Van Rysselberghe, to prevent induction from taking place between the telegraph wires and those running parallel to them used for telephone work, was briefly as follows:—The system of sending the dots and dashes of the code—usually done by depressing and raising a key which suddenly turns on the current and then suddenly turns it off—was modified so that the current should rise gradually and fall gradually in its strength by the introduction of suitable resistances. These were introduced into the circuit at the moment of closing or opening by a simple automatic arrangement worked exactly as before by a key. The result of the gradual opening and gradual closing of the circuit was that the current attained its full strength gradually instead of suddenly, and died away also gradually. And as induction from one wire to another depends not on the strength of the current, but on the rate at which the strength changes, this very simple modification had the effect of suppressing induction. Later Van Rysselberghe changed these arrangements for the still simpler device of introducing permanently into the circuit either condensers or else electromagnets having a high coefficient of self-induction. These, as is well known to all telegraphic engineers, retard the rise or fall of an electric current; they fulfil the conditions required for the working of Van Rysselberghe's method better than any other device.

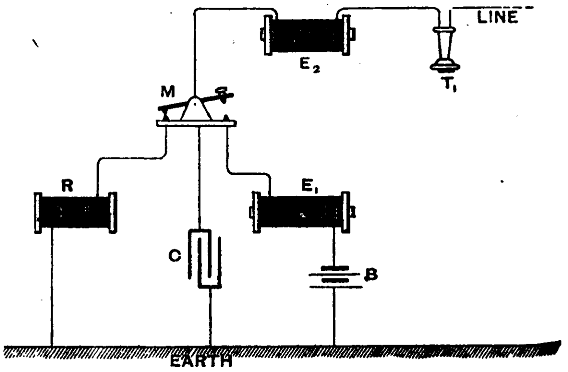

Fig. I

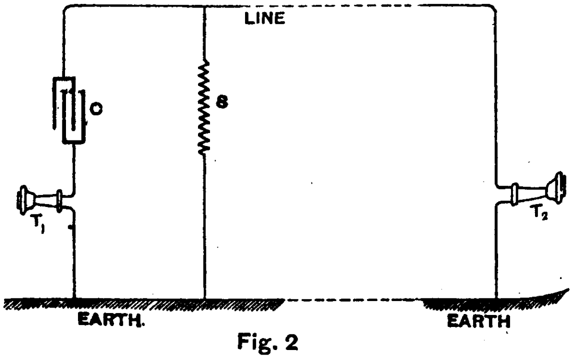

Fig. 2

Having got thus far in his devices for destroying induction from one line to another, Van Rysselberghe saw that, as an immediate consequence, it might be concluded that if the telegraphic currents were thus modified and graduated so that they produced no induction in a neighbouring telephone line, they would produce no sound in the telephone if that instrument were itself joined up in the telegraph line. And such was found to be the case

Why this is so will be more readily comprehended if it be remembered that a telephone is sensitive to the changes in the strength of the current if those changes occur with a frequency of some hundreds or in some cases thousands of times *per second*. On the other hand, currents vibrating with such rapidity as this are utterly incompetent to affect the moving parts of telegraphic instruments, which cannot at the most be worked so as to give more than 200 to 800 separate signals *per minute*.

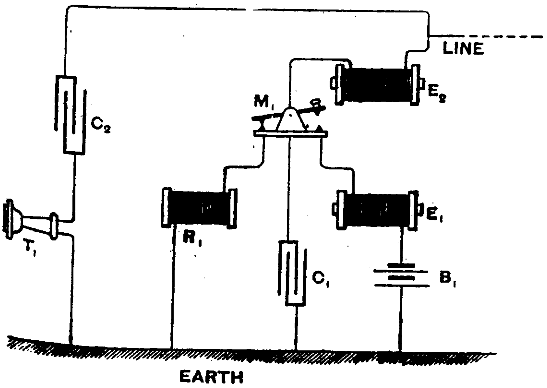

Fig. 3

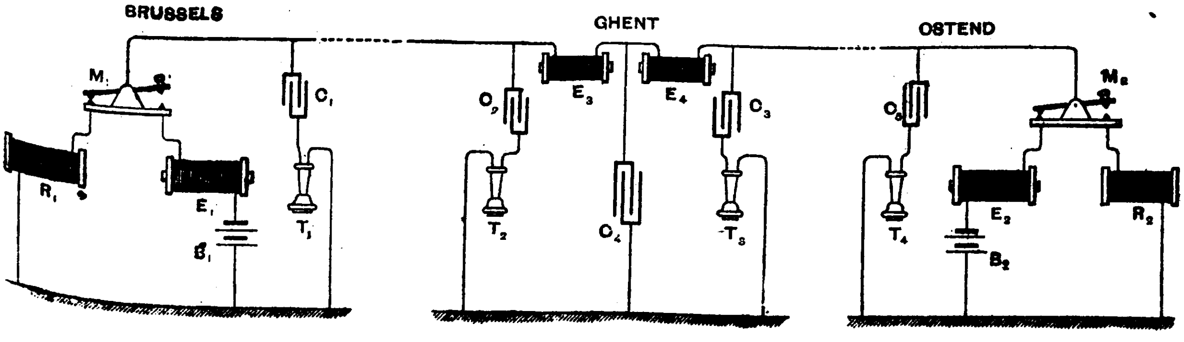

Fig. 4

The simplest arrangement for carrying out this method is shown in Fig. 1, which illustrates the arrangements at one end of a line. M is the Morse key for sending messages, and is shown as in its position of rest for receiving. The currents arriving from the line pass first through a "graduating" electromagnet, E_2, of about 500 ohms resistance, then through the key, thence through the electromagnet R of the receiving Morse instrument, and so to the earth. A condenser, C, of 2 microfarads capacity is also introduced between the key and earth. There is a second "graduating" electromagnet, E_1, of 500 ohms resistance introduced between the sending battery B and the key. When the key M is depressed in order to send a signal, the current from the battery must charge the condenser C, and must magnetise the cores of the two electromagnets E_1 and E_2, and is thereby retarded in rising to its full strength. Consequently no sound is heard in a telephone, T, inserted in the line-circuit. Neither the currents which start from one end nor those which start from the other will affect the telephones inserted in the line. And, if these currents do not affect telephones in the actual line, it is clear that they will not affect telephones in neighbouring lines. Also the telephones so inserted in the main line might be used for speaking to one another, though the arrangement of the telephones in the same actual line would be inconvenient. Accordingly M. Van Rysselberghe has devised a further modification in which a separate branch taken from the telegraph line is made available for the telephone service. To understand this matter one other fact must be explained. Telephonic conversation can be carried on even though the actual metallic communication be severed by the insertion of a condenser. Indeed, in quite the early days of the Bell telephone, an operator in the States used a condenser in the telegraph line to enable him to talk through the wire. If a telephonic set at T_1 (Fig. 2) communicate through the line to a distant station, T_2, through a condenser, C, of a capacity of half a microfarad, conversation is still perfectly audible provided the telephonic system is one that acts by induction currents. And since in this case the interposition of the condenser prevents any continuous flow of current through the line, no perceptible weakening will be felt if a shunt, S, of as high a resistance as 500 ohms and of great electro-magnetic rigidity, that is to say, having a high coefficient of self-induction, be placed across the circuit from line to earth. In this, as well as in the other figures, the telephones indicated are of the Bell pattern, and if set up as shown in Fig. 2, without any battery, would be used both as transmitter and receiver on Bell's original plan. But as a matter of fact any ordinary telephone might be used. In practice the Bell telephone is not advantageous as a transmitter, and has been abandoned except for receiving; the Blake, Ader, or some other modification of the microphone being used in conjunction with a separate battery. To avoid complication in the drawings, however, the simplest case is taken. And it must be understood that instead of the single instrument shown at T_1 or T_2 a complete set of telephonic instruments including transmitter, battery, induction-coil, and receiver or receivers, may be substituted. And if a shunt, S, of 500 ohms placed across the circuit makes no difference to the talking in the telephones because of the interposition of the separating condenser C, it will readily be understood that a telegraphic system properly "graduated," and having also a resistance of 500 ohms, will not affect the telephones if interposed in the place of S. This arrangement is shown in Fig. 3, where the "graduated" telegraph-set from Fig. 1 is intercalated into the telephonic system of Fig. 2, so that both work simultaneously, but independently, through a single line. The combined system at each end of the line will then consist of the telephone-set T_1, the telegraph instruments (comprising battery B_1, key M_1, and Morse receiver R_1), the "graduating" electromagnets E_1 and E_2, the "graduating" condenser C_1, and the "separating" condenser C_2. It was found by actual experiments that the same arrangement was good for lines varying from 28 to 200 miles in length. A single wire between Brussels, Ghent, and Ostend is now regularly employed for transmission by telegraph of the ordinary messages and of the telemeteorographic signals between the two observatories at those places, and by telephone of verbal simultaneous correspondence for one of the Ghent newspapers. A still more interesting arrangement is possible, and is indicated in Fig 4. Here a separating condenser is introduced at the intermediate station at Ghent between earth and the line, which is thereby cut in two independent sections for telephonic purposes a single undivided line between Brussels and Ostend, Brussels can telegraph to Ostend, or Ostend to Brussels, and at the same time the wire can be used to telephone between Ghent and Ostend, or between Ghent and Brussels, or both sections may be simultaneously used.

It would appear then that M. Van Rysselberghe has made an advance of very extraordinary merit in devising these combinations. We have seen in recent years how duplex telegraphy superseded single working, only to be in turn superseded by the quadruplex system. Multiplex telegraphy of various kinds has been actively pursued, but chiefly on the other side of the Atlantic rather than in this country, where our fast-speed automatic system has proved quite adequate hitherto. Whether we shall see the adoption in the United Kingdom of Van Rysselberghe's system is, however. by no means certain. The essence of it consists in retarding the telegraphic signals to a degree quite incompatible with the fast-speed automatic transmission of telegraphic messages in which our Post Office excels. We are not likely to spoil our telegraphic system for the sake of simultaneous telephony, unless there is something to be gained of much greater advantage than as yet appears.—*Nature*

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THE MATRIX OF THE DIAMOND.—Until the South African mines were discovered, the diamond was always found in sands and gravels, different from the minerals in which it was believed to be formed. At Griqualand West, however, the consolidated eruptive mud of the mines was believed by some to be the true matrix of the diamond; but opinions differed on the question, and arguments were found on both sides. M. Chaper, a French geologist, has, however, during a scientific mission to Hindustan, succeeded in finding the diamond in its mother rock. At Naizam, near Bellary, in the Madras Presidency, M. Chaper has found the diamond in a matrix of rose pegmatite, where it is associated with corundum. The tract of country is almost denuded of trees, bare and rocky, and the rains wasting the rocks, every year expose fresh diamonds in the soil. The rock is traversed by veins of feldspar and epidotiferous quartz. Here the diamond is always found, associated with epidotiferous rose pegmatite, The diamond crystals observed are octahedral, but less distinct in line than the stones of South Africa, which seem to have been formed in a freer matrix. It follows from M. Chaper's discovery that diamonds may exist in all rocks arising from the destruction or erosion of pegmatite —for example, in quartzites with or without mica, clays, pudding-stones, &c.—*Engineering.*

A PLATINUM WATER PYROMETER.—An ingenious new apparatus for determining high temperatures above the range of the mercurial thermometer, that is to say, 500 deg. Fah., up to any point not above the melting point of the most refractory metal, has been devised by Mr. J. C. Hoadley, and is described in the *Journal of the Franklin Institute.* It consists of a metal pan with triple sides and bottom, the space between the walls being filled with eider down, or drillings of hard rubber, to prevent radiation. The bottom of the pan is concave, and contains a quantity of water which is agitated by a stirrer. The stirrer is a concave sheet of brass perforated with holes and having a narrow rim or fence all round like a pitcher lid. When the stirrer is raised or lowered the water flows through the holes and is mixed up. Heat is communicated to the water by carriers of platinum, each of which is raised to the temperature of the furnace or other source of heat to be measured and dropped into the water through a funnel in the pan. From the number and weight of these hot balls, and the quantity of water raised by them to a measured temperature, the temperature of the balls and furnace can be estimated. Mr. Hoadley describes the details of construction so fully that the instrument can be made from his account, and tables of specific heat, together with corrections for varying specific heat of water are also given. He also shows how to use the apparatus, and to determine the calorific capacity of the metals of the pyrometer in terms of water. It is worthy of remark that the platinum balls used by him began to melt at 295.0. deg. Fahr., though their specific gravity gives assurance of their being at least very nearly pure.

WEEVILS.—(*Knowledge.*)

By S. A. BUTLER, B.A., B.Sc.

Another creature, black and stumpy, and almost as broad as it is long, infests cabbages and other cruciferous plants. It has a short but slender rostrum, which it is able to bend completely under its body; this is rendered possible, not by any articulation of the rostrum to the rest of the head, but by the extreme mobility of the head itself, which fits into the front of the thorax by a kind of ball and socket arrangement. When the insect has thus tucked its rostrum under its body, it folds up its legs and packs them close to the body, and then looks more like a seed or a little lump of earth than anything animate. In this condition it may, like a ladybird, be handled in any way without manifesting the slightest sign of life. Feigning death is a habit commonly indulged in by beetles, and though not confined to that order of insects, is of more frequent occurrence amongst them than in other groups. Severel genera of weevils manifest this habit in a most striking degree, and the apparent enlargement of the insect as it stretches out its legs again, brings forward its rostrum and opens out its antennæ, is most surprising. The black weevil referred to above is only 1-9-inch long and belongs to a large genus called *Ceuthorhynchus,* containing about forty British species, which affect various plants. The female beetle lays her eggs on the stems of cabbages near the root, in small perforations which she makes with the jaws at the end of her nostrum. Around the grubs which hatch from these, gall-like excresences are formed; the grubs feed on the interior, and the galls increase in size with the growth of the cabbage, thus nourishing the grub at the expense of the plant. The maggot, when fully grown, nibbles its way to the rind of the gall, goes into the earth and there forms a cell in which it changes to a pupa, which, in the course of about two months, yields the perfect insect.

The nut-weevil, *Balaninus nucum,* which is remarkable as having almost the longest and slenderest rostrum to be found amongst British weevils, is covered with greyish or yellowish-brown scales, except the rostrum, which is almost bare. With the tiny mandibles at the end of her long rostrum, the female gnaws a hole through the shell of a young nut, while it is still soft, and then deposits therein an egg, which hatches in about ten days. As the nut grows, the weevil grub gradually devours the kernel, and finally eats its own way through the nutshell, either after the nut has (somewhat prematurely) fallen, or before this takes place. The grub falls to the ground, buries itself, and snugly ensconces itself in the soil in a cell of its own manufacture. In this condition it frequently passes the winter, changing in the following spring to a pupa, whence in due course issues the perfect beetle.

Another insect of a reddish colour, with white bands on its back, treats the flower-buds of apple trees in a similar way, devouring all the central organs of the buds and so rendering them abortive. Instead of falling to the ground, however, it undergoes all its metamorphoses cradled in the bud itself.

A species found commonly on lucerne, makes of a gummy substance it secretes, a delicate oval cocoon of open network, on a leaf of its food-plant; in this it encloses itself, as in a cage, in order to pass through its pupahood.

One of the largest of our British species, the Pine Weevil, *Hylobius abietis,* attacks various trees of the pine family. It is a blackish-brown creature, with yellowish markings. The beetle itself devours the tender bark of young twigs, sometimes completely stripping them. The eggs are deposited in various situations where the larvæ will be able to find easy access to the wood of the trees. The grubs, on hatching, begin to tunnel under the bark, forming galleries, the dimensions of which are increased as the insect grows. In course of time, after many months of mining and depredation, these galleries become partially filled with what is called "worm-meal," the remains of the wood-gnawing of the larvæ, and if the burrow be traced to its end, there will be found a snug little cavity hollowed out amongst the chips, where the pupa nestles. The beetles pass about a month in the pupa state, and then issue as perfect insects to pursue their devastations upon the vegetable products of another season. Many wild plants are particularly liable to the attacks of weevils. The figworts (*Scrophularia*) may sometimes be seen in July and August with their leaves all brown and withered, and riddled through and through with tiny holes, as though they had received charge upon charge of miniature shot. This is the work of some very beautiful insects, the genus *Cionus,* which have a squarish body, handsomely adorned with variegated, hair-like scales.

This paper must not be concluded without a reference to two insects, for the presence of which in Britain we are indebted to our extensive commerce—the corn and rice weevils, *Calandra granaria* and *oryzæ*. These are not truly British insects, but were originally accidentally introduced from abroad with foreign wheat. They feed, not upon growing plants, but upon grain, after it has been stored up. They are small, reddish-brown bettles, about ⅛ in. long. The parent deposits a single egg in each grain ; the larva developed from this lives inside the grain, gradually consuming all the interior, and leaving only the husk which, however, remains intact, so that no trace of the depredator is noticeable. Inside the husk the little being pupates, and when fully developed, it easily ruptures its prison walls and makes its exit, a perfect beetle, on the look-out for a mate, and prepared to renew, probably to a much greater extent than before, the work of destruction. Though individually minute, and making no further call upon the corn merchant's stores than the contents of a single grain for the nourishment of each during its larvadom, these insects are so prolific, and occur in such enormous numbers as to be terribly destructive, and sometimes to entail serious loss upon the owners of the grain.

Owing, however, to improved appliances, and greater care in the shipping and storage of the grain, the damage done now-a-days is much less than formerly. I am informed by a friend who has had much experience in these matters, that the beetles do not readily breed in this country, and that most of the damage wrought by the larvæ is effected before the grain arrives here, the chief depredators after it is actually stored being the perfect insect themselves. These, however, occasionally occur in immense swarms, and there are on record instances of such vast numbers having been screened out of infested corn that they could be weighed only by the hundred-weight ! Weevils are not the only beetles that attack corn in this way. On one occasion, no less than twenty species belonging to several families were obtained in varying numbers from a small collection of granary-sweepings, which yielded in all six ounces of insects, containing over 2,000,000 specimens. Facts like these go far to show the economic importance of entomology, an aspect of the science that, curiously enough, has not until recently attracted much attention in this country ; one reason for this may, no doubt, be found in the fact that unfortunately agricultural and entomological tendencies do not of tenco-exist in the same individual.

MM. NIGNON AND TOUARD, who established the refrigerating service at the Paris morgue, have made experiments with their system on hams infected by trichinæ, and are stated to have proved that these are rendered wholly innocuous by exposure during an hour to a cold of – 20° C. It will be proposed for the protection of consumers from trichinosis to render exposure obligatory in the case of importations from America or Germany.

ICHNEUMON FLIES.

BY E. A. BUTLER, B.A., B.Sc.

The word "fly " is of extremely wide popular application used for all sorts of dissimilar insects, it unfortunately frequently suggests affinities which do not exist. It would be an advantage if its application could be restricted to the flies proper, two-winged insects constituting the order Diptera, several representatives of which are household pests during the summer. The present insects have nothing whatever to do with the true flies, but belong to the Hymenoptera, the order that includes bees, wasps, ants, &c. They form a distinct and most remarkable section of this order, noteworthy for their slender make and strange habits of parasitism. They are the pirates of the insect world, maintaining their own existence by levying blackmail upon their fellow-creatures.

Airy, graceful, and sylph-like, they are yet so thin in body, long in limbs, and restless in habits that one is apt to regard them with some degree of suspicion as creatures possibly dangerous, whose too close acquaintance it may not be desirable to cultivate—an impression which is in some cases deepened by the formidable aspect of a long ovipositor. In slenderness of make they are without rivals in the insect world. They have usually long, narrow bodies ; very long, slender, and tapering antennæ ; long, slender legs ; and four transparent wings, similar in texture and general form to those of bees, but different in the arrangement of the nervures, as will be seen by comparing Fig. 1 with the bee's wing figured in our first paper on Wild Bees. The abdomen is much pinched in at the waist, and attached to the thorax by only a very slender junction, through which all communication has to be kept up between the anterior and posterior parts of the body. It sometimes carries at its apex three thread-like processes, which are occasionally even longer than the body itself (Fig. 2) page 152. These constitute the ovipositor, and consist of a central composite hard and stiff boring organ and its more flexible sheaths. The whole locks a formidable weapon, and the borer is indeed sometimes so hard and sharpointed as to be able to inflict a smart prick, but it is not a sting, *i.e.*, no poison gland is attached to it, and its main function is to make suitable perforations for the lodgment of the eggs and to guide them into their place of deposit. It is scarcely necessary to add, therefore, that it is an appendage to be found only in the females. The head carries the usual two masses of compound eyes, which are of large size, and suggest superior keenness of vision and a general wide-awakeness in excellent keeping with the rapidity of movements so characteristic of the insects. Between the compound eyes are the ocelli, or simple eyes, three small highly-polished knobs, triangularly disposed, and directed skywards.

The majority of these insects are, in their earlier stages, parasitic upon the Lepidoptera, or butterflies and moths, which they usually seek in the caterpillar state. Having found a suitable caterpillar, the ichneumon fly mounts its back, and bending its own body, brings its ovipositor down on the surface of the unsuspecting grub. By a little pressure the sharp point of the borer is driven through the poor creature's skin, producing, however, apparently, no greater discomfort at the time than a slight tickling sensation. The perforation made, an egg is inserted into the body of the victim sufficiently far to prevent the possibility of its removal with the skin when the caterpillar effects its periodical moults. Frequently a large number of eggs are laid in a single caterpillar, but in many cases only one is deposited, the number depending in large measure upon the size of the ichneumons they are destined to produce, a matter requiring careful consideration as the supply of food is limited to what is or will be containsd within the body-walls of the caterpillar. From the moment of the insertion of the egg, the caterpillar is a doomed being, though for a long time there may be no premonitions of its fate. The ichneumon grubs, which soon hatch from the eggs, as soft, white, fleshy creatures which cylindrical bodies and without feet, devour the stores of fat laid up by their host, which it was intended to use in the elaboration of the additional orgains of its own future form. These depredations, however, do not affect any vital part, and the creature goes on living, eating, and growing, while the insidious parasites more feeble until it finally dies of exhaustion, when the parasites eat their way through its skin, and, on reaching the outside, form cocoons to protect themselves while in the pupa state, which they group round the carcase of the caterpillar whose vitality has now passed into their own bodies So the development of the caterpillar is arrested before it can enter the chrysalis stage, and it therefore never fulfils its destiny. More generally, however, the ichneumon maggots do not mature quite so quickly, and the larva manages to pupate before they make their exit from its body. Still the result is in the end the same ; the creature dies prematurely, never reaching the stage in which it can provide for the perpetuation of its race, and so passes away "without issue." Now, as the caterpillars of the Lepidoptera are almost exclusively devourers of vegetable substances, the ichneumon flies, by preventing their too rapid increase, become the saviours of vegetation, and may therefore be welcomed by the agriculturist. It is difficult to discover to how great an extent vegetation is preserved by these means ; comparatively little attention has, until quite recently, been given to the ichneumons that inhabit this country, partly, no doubt, owing to the extreme obscurity of many species and their very close resemblance to one another. It is impossible to give an accurate estimate of the number of species we possess, as large numbers of new ones are being discovered year after year ; still the number already recorded amounts to more than 2,000. Some of these are very abundant in individuals, and if we remember that every single ichneumon amongst the the larger kinds, at least of those that prey upon the Lepidoptera, and every score or so of the smaller ones, means the destruction of a caterpillar. we can see what enormous accessions to their ranks the butterflies and moths would receive if only the ichneumon flies were blotted out of existence. A large proportion of every brood is no doubt exterminated in this way, and the perils of larvadom amongst the Lepidoptera must indeed be great.

ICHNEUMONS FLIES.

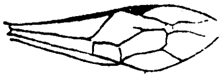

Fig. 1.—Forewing of Ichneumon grossorius.

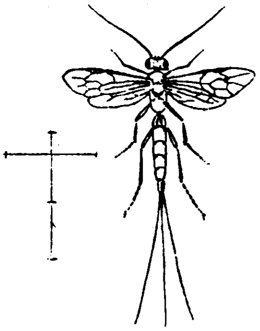

Fig. 2.—Glypta lugnorina.

Ichneumons do not confine their attacks to the Lepidoptero; some are parasitic upon beetles, some upon plant-lice, some upon flies, and some even upon ther hymenopterous insects: they also extend the range of their enmities beyond the pale of the insect world, and, in some cases, live at the expense of spiders, whose eggs their grubs devour; still, the Lepidoptera are the group they principally affect. It must not be supposed that they are indiscriminate in their attacks; they will not take up with any caterpiller they come across, and very frequently each species of caterpillar has its own peculiar foe or foes, ever on the look out for it and ready to pounce upon it without a moment's warning. The elucidation of the life history of these creatures is not an easy task; the collectors of the Lepidoptera, in their efforts to rear their favorite insects from larvadom, are often baffled by the ichneumon, and in their disgust at getting a crop of uninteresting-looking "flies" instead of the handaome moths they had set their hearts upon, too often cast away the parasite as a despicable, worthless thing, and so lose the chance of solving a problem in nature. The determination of the species, moreover, is often an exceedingly difficult matter, so that it needs the combined efforts of a good Lepidopterist and a good Ichneumonologist before the matter can be settled—the former to determine what the caterpillar is, for, be it remembered, there is no chance of seeing the perfect moth, and the latter to decide on the ichneumon. Thus it happens that the hosts of many are still unknown.

Though so intensely carnivorous during their larval existenee, these insects do not appear to have similar tastes in the adult state. They have, it is true, a good pair of jaws, but these they seem to have no great anxiety to use. If seized between finger and thumb, they do not attempt to bite, but wriggle their abdomen about in attempts, which are more often than not abortive, to wound with their ovipositor. Such food as they take seems to be confined to the honey of flowers and other equally simple and harmless kinds of diet; hence many species are attracted to flowers, and the broad heads of Umbelliferæ often form a pleasant-foraging ground for considerable numbers.

Many ichneumons are very active in their movements and some, when running about over the leaves of plants in search of caterpillars. have a peculiar habit of rapidly vibrating their antennæ, as if trembling with excitement at the urgency of their business. Those with short ovipositors seek caterpillars that feed in exposed positions, where they can easily be reached, and such may, therefore, be fornd running over plants, etc., but thase with long ovipositors may be looked for on walls and trunks of trees, where they are on the look-out for caterpillars that shun publicity and lurk in obscure corners and in crevices of brickwork, or that burrow into the solid wood of the tree-trunks; hence the length of the ovipositor, which can be thrust down into burrows far too narrow for the ichneumons themselves to enter. In this way they can feel about till they find the object of their search, whose body is forthwith pierced and an egg inserted. Of course, those with long ovipositors, when intent only on their own delectation, and not engaged in oviposition, may be found on flowers with the other kinds.

There is often great disparity between the sexes; the males are sometimes so utterly unlike their partners as to have been referred not only to different species, but even to different genera. Thus one series have narrow-bedied, yellow-banded, long-winged, long-legged males and broader-bodied, red-banded short-winged, short-legged females. In some again, the males are winged, and the females absolutely apterous (Fig. 3), thus presenting a superficial resemblance to ants, from which, however, they may at once bv distinguished by the fact of their antennæ not being elbowed, as those of ants are. White, yellow, and various shades of red, through deep browns to black, are almost the only colours with which they are adorned, and black, as a rule, forms a more or less important element in the coloration. The yellow is usually distributed in the form of bands on a black body, tus giving these slender creatures a supposed, but certainly very remote, resemblance to the heavy-bodied wasps. It is astonishing how frequently this style of ornamentation is met with among insects; besides the ichneumons, it occurs in bees, wasps, sawflies, flies, beetles, moths, and dragon-flies; but it is specially common amongst some section of the Hymenoptera.

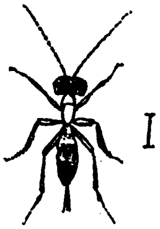

Fig. 3.—Pezomachus transfuga. Female.

Some of the cocoons of ichneumons are marvels of elegance and neatness. They are of various hues—white, yellow, brown, black, and sometimes they are banded with different colours. They are almost always of an elongate oval shape. Sometimes the silk of which they are composed is so closely spun up together that the outside is almost as smooth as the inside, which is saying a great deal, and the whole has a paper-like consistency; the white ones having a lustre like satin; but on the other hann, the outside sometimes has a certain amount of loose silk hanging about it like that of the silkworm, and occasionally whole clusters of cocoons are bound together in a common mass of silk. Some of these objects are probably familiar to most people, as groups of them are often found on walls towards the ends of summer, enveloping the shrivelled carcases of the caterpillars of the common white butterflies that work such havoc among cabbages.

There are two large families of Hymenoptera to which the name Ischneumon Fly is usually applied, though these do not by any means include the whole of the insects that have similar parasitic habits. These families are the Ichneumonidæ and the Braconidæ. They may be easily distinguished from one another—at least, those that are not apterous—by the neuration of the wings, which very constantly follows, with only slight variations, a distinct plan in each group. Fig. 4 represents the wing of a Braconid, and may be compared with the wing of an Ichneumonid shown at Fig s in the former part of this paper. The species are uneuolly divided between these families, the Ichneumoninæ being by far the more numerous of the two. Many of the Braconidæ are very small, and it is to this family that the insect belongs which makes the cluster of tiny oval cocoons referred to above as forming a shroud for the mangled remains of the caterpillars of the cabbage butterflies. In escaping foom their cocoons, these little creatures detach a small piece at one end which looks like a kind of lid, and generally remains hanging by some silk thread belonging to the outer surface.—(*Knowledge.*)

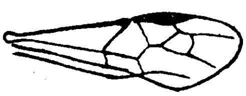

Fig. 4.—Forewing of Zele testaceator.

Scientific Notes.

Meteorological Apparatus—Some interesting information regarding meteorological apparatus was recently brought under the notice of the Royal Scottish Society of arts by Mr. Peter Stevenson, Edinburgh. The apparatus in question was made by him for the late Marquis of Tweedale in the year 1867, when he was president of the Scottish Meteorological Society. Being desirous of conducting experiments with reference to the effects of the sun on the growth of grain crops, the Marquis asked Mr. Stevenson to construct a thermometer which would make a continuous record of temperature in the open field. He did this by mechanical means, but also added a second or wet bulb thermometer, a barometer, and a rain gauge, so that the apparatus recorded continuously time, temperature, pressure, and rainfall. He used an eight-day timepiece and a brass cylinder, round which were wound two sheets of tissue paper, with a sheet of carbon paper between them. By means of a separate apparatus a datum line was impressed on the three sheets, marked in hours, half-hours, and quarters. The timepiece also worked a hammer, which struck a blow on a suspended piece of brass every ten minutes. This made dotted marks on the papers, six every hour, one-twentieth of an inch apart. Two thermometers, constructed alike in every way, were adapted to the apparatus. The barometer was peculiar in having its cistern at the top of the tube instead of the bottom. In order to obtain the continueus registration of a rain-gauge, the rain was conveyed from the gauge into a receiver so proportioned fo the mouth of the rain-gauge, that an inch of rainfall caused the mercury gauge attached to the bottom of the receiver to rise an inch. The tube of this gauge was furnished with a float, carrying the wire with the knob on the top to give a record every ten minutes, at the same time and in the same way as the other instruments. When an inch of rain had fallen into the receiver, the water was discharged in a few seconds by means of a syphon arrangement, and the mercury gauge with the float immediately retuened to zero. The case containing the instruments was made of cast iron, and resembled a post-office pillar letter-box. It was placed in the middle of a large open field on the Yester Home Farm, where Mr. Stevenson believed it was still, but as a wreck. The experiments were carried on for nearly ten years, until the death of the marquis in 1876, and the records during the time had been bound in 38 volumes. Several of the members expressed regret that, in the interests of science, the observations had not been continued, and it was suggested that the society should take some action with the view of having the instruments restored to working order.

Lightning Conductors.—M. A. Callaud has communicated to the French Academy of Sciences a new modification of the cable lightning conductors, such as are made by him for the French Ministry of War. Hitherto the conductors have terminated in holes filled up with coke, but this arrangement, which is good enough if the cable is intact, is defective when oxidation attacks the copper. Doubtlss the copper, coke, and moisture form a voltaic combination resulting in corrosion of the metal, and hence the coke packing of a copper lightning rod "earth," though recommended by a recent learned commission on the subject, is not quite satisfactory. M. Callaud adopts the following plan : Each wire of the cable is surrounded with hemp impregnated with white lead, or with minium. These served wires are wound or cabled round a central naked copper core or wiee, which has no need to be protected. The whole cable is then wound with linen or tape impregnated with white lead or minium. This makes a protective covering for it. M. Colland's plan is no doubt a good protective of the conductor itself from oxidation, but we fail to see how the local voltaic action is to be prevented between it and the coke, unless the minium, being a conductor, serves to shield the metal from electric corrosion while allowing the conducting contact with the carbon or coke to be established. We may add that M. Cochery has presented a report on lightning strokes in France during the last half of 1883 to the Academy.

Artificial Graphite.—Dr. Aron exhibited in a recent meeting of the Electrotechnical Society of Berlin various speciments of vegetable carbon made inductive and incombustible within limits by strong heating *in vacuo*, or in a neutral atmosphere. Heat appears to render carbon first conductive, and then at the highest degrees practically incombustible. Dr. Aron showed incombustible wadding, paper, post-card, and other carbonised specimens. They resist the heat of a Bunsen burner and even that of a gas blow-pipe, so that they might be used for lamp carbons. As high conductivity and incombustibility are characteristic of graphite, carbons prepared in this way may be called artificial graphites, although they do not, under this treatment, assume the crystalline structure of natural graphite. The electric current is of course very suitable for their preparation. Under very strong heat soot becomes a better conductor than graphite, and might thus replace the latter in electro-metallurgical operations. It further results from Dr. Aron's experiments that if the amount of hydrogen in a graphite really determines its combustibility, as is often asserted, the influence can only be due to the amount of combined hydrogen, as carbons did not become more inflammable by being rendered incandescent in a hydrogen atmosphere.

Making Resistance Coils.—Professor S. P. Thompson has introduced a new method of making resistance coils which is likely to prove useful in saving time lost in adjusting the coil to its correct final value, though it may require more wire. The existing method is to cut off a sufficient length of wire to give, say, 2 per cent. more resistance than is required ; then double it on itself, cut the wire at the bight, bare it, and solder a piece of copper across the naked ends. By keeping the solder soft while the wire is being tested, this bridge-piece of copper can be shifted until the required resistance is obtained. Professor Thompson's method, which is best adapted for coils under 10 ohms, consists in first cutting off a length of wire and calculating the resistance which, as a shunt to its resistance (R) will give the final resistance (r) which is required. Let the resistance of this shunt be S then $S = \frac{R\,r}{R - r}$. A second length of wire giving approximately this resistance

(S) (say 2 per cent. more) is then cut off, and the ends of it soldered to the ends of the first piece. The joint resistance is equal to the resistance r required. Professor Thompson also employs a new form of "metre bridge" in his measurements. There are two wires, one having several times the resistance of the other; and both are 2 metres long. One or other can be used as desired, and the same sliding contact serves for both. This arrangement makes the bridge far more useful and widens its range. When Foster's method is used to give very accurate tests, the interchangeable coils are transposed by means of a mercury cup switch, which can be attached to the bridge. By simply shifting four copper connecting pieces in the mercury cups the transposition is effected. We may add that Mr. Shaw, of Cambridge, has designed a special key, whereby the same transposition can be effected by turning an axle, which by a series of cams makes and breaks the contacts necessary for the purpose.

At a Meeting of the Philadelphia Society of Engineers.—Mr. Wm. P. Osler presented, for Mr. J. Godolphin, an count of the Pocahontas Mine Disaster, and the subsequent steps taken for the recovery of the bodies and the resumption of mining. He submitted the March number of the *Virginias*, as containing an accurate detailing description of the mine and plan of the workings, from data by Mr. W. A. Lathrop, Supt. He then showed how probable it was that gas would have been detected by the engineers, had it existed; explained Mr. Lathrop's theory, afterwards verified, of the location of the fire; the method of damming and flooding the mine with 17,500,000 gallons of water to extinguish it—the latter being accomplished in 16 days, 1 day being lost in repair of a dam; and the recovery and identification of the bodies. He states that the mine itself is but little damaged, that the cause of the explosion is, as yet, unknown, and, in conclusion, refers to the ridiculous and imaginary statements that have been published.

Mr. E. S. Hutchinson supplemented the above by an account of his recent visit to the mine, confirming, as far as he had observed, Mr. Osborne's opinion of damage to the mine; timbers were displaced, cars demolished, etc., but there was no fall of roof except in the fan-entry, where much slate had fallen, but where a week's work would repair damage. He attributes the safety of the roof to the fact that from 12 to 18 in. of coal have been left as an elastic support to the treacherous slate above. He considers the presence of 5 or 6 inches of fine, dry coaldust on the floor, a phenomenon of special interest, and, while withholding a positive opinion in view of pending investigations by a committee of the Am. Soc. Min. Engrs., he refers to a number of authorities to show the important bearing dust explosions have upon safety in mines, like this, apparently free from fire damp.

Mr. J. Foster Crowell announced that the new bridge of the Pennsylvania Schuylkill Valley R.R. over the Schuylkill River at Manayunk had just been completed, and noted, as a remarkable illustration of the vast strides made in American Bridge Construction during the past few years, that so large and important structure as this is, being one-third of a mile in length and 90 feet high, can be reared and come into use without exciting special interest or even deserving particular mention from an engineering point of view. There were, however, certain structural features, arising out of some peculiarities of location, which might prove instructive, and these were briefly described and illustrated by blackboard sketches.

Heating of Iron Cores.—It is remarked that in certain dynamos the cores of the electro-magnets gradually heat up, and their temperature continues to rise after the machine has stopped working. Various explanations have been offered for the latter peculiarity, one being that the draught created by the machine in working keeps the temperature down by carrying off heat, whereas when the machine stops the draught ceases. Others suppose that the Foucault currents, or the magnetic friction causing heat, do not cease to operate on the stoppage of the machine. The cause of the heat, whether magnetic friction or Foucault currents, is a moot point, and MM. Warburg and Hönig have recently made experiments which lead them to conclude that it is mainly due to magnetic friction. A core of iron was carefully magnetized by a coil, and the heat generated was exactly measured in an ice calorimeter. If the heat depended only on the electrical resistance of the iron to the circulation of Foucault currents, and if the coercive force of the iron was zero, the authors argued that they could calculate the heat generated by two cycles of magnetisation. This they did; but the calorimeter showed a very different result, and MM. Warburg and Hönig have been led to the conclusion that nearly 75 per cent. of the heat generated is due to magnetic friction.

Hall's Effect.—Mr. Shelford Bidwell has made a very careful study of the curious phenomenon observed by Mr. Hall in America, and now known as Hall's effect. Mr. Hall observed that when a thin strip of metal traversed by an electric current was placed between the poles of an electro-magnet so as to cut the lines of force at right angles, and when (before the helix was magnetized) two points were found across the strip which when connected through a galvanometer showed no current, then, on suddenly making the magnet, a current (+ or −), would be found to flow through the galvanometer. Mr. Bidwell seeks to explain this effect by well-known facts. He shows by several ingenious experiments that mechanical stress in the strip produces similar currents, and combining this observation, due in the first place to well-known experiments of Sir William Thomson on stretched wires, with the equally well-known Peltier effects, he demonstrates that the so-called Hall effect can be satisfactorily explained on these grounds. One anomaly between his results is in the case of aluminium, which Mr. Hall classes as + (like iron), whereas Hall classed it as −. The discrepancy may be due to differences of quality in the aluminium used. To illustrate the effect of magnetic stress on a conductor, Mr. Bidwell inclosed some mercury in a cup and placed it between two magnetic poles, one above the other below mercury. On making the magnet the mercury was seen to break up into two separate whirpools revolving in opposite directions.

A Phosphorescent Eye-Piece.—Herr Lommel, the well-known German Physicist, has applied the luminous paint of Balmain to spectroscopy. In the plane of the cross hairs of an ordinary spectroscope a piece of microscopic slide glass is placed, one portion being covered with Balmain's paint or other phosphorescent substance. The slit of the spectrum is so modified that the solar spectrum is thrown on the phosphorescent slide after it has been rendered self luminous by exposure to daylight or a lamp. Becquerel's phenomenon can then be studied. The dark bands in the ultra red are shown to be true absorption bands due to the phosphorescent substance employed. A greenish blue phosphorescing sulphide of calcium gives a more vivid spectrum than Balmain's paint. A plate covered with it and kept four day in the dark will show the bright phosphorescent ultra red spectrum in a beautiful manner, while Balmain's paint hardly shows it after being two days in the dark. This application of phosphorescent bodies to spectroscopy was, if we mistake not, suggested a year or two ago by Abney.

Measuring the Magnetic Field.—It being useful to measure the intensity of the magnetic field of dynamos, and the ordinary method by vibration of magnetic needles being inconvenient, Mr. J. E. H. Gordon has devised a small instrument for the purpose. It consists of a very small dynamo having its coil mounted with a spring action so that on the release of a detent the coil suddenly makes a quarter turn. The pulse or current generated by this movement is indicated by a galvanometer in circuit with the coil, and at a distance where the magnetism does not affect it. The intensity of the field where the coil is situated may be regarded as equal to the throw of the galvanometer needle. In order to explore the field properly and get its intensity at different points, the coil slides on a vertical stem, which can be given a motion on two horizontal lines at right angles to each other, thus placing the coil at any point compassed by three co-ordinates.

Novel Cure for Noisy Bridges.—The Osnabruck Steel Works have recently been manufacturing steel rails eighty-eight feet six inches long, which have been laid down on railroad bridges crossing the City of Hanover, Germany. It was found that the noise caused by passing trains was becoming such a nuisance that a remedy had become a necessity. The cause of it was the violent vibrations at the rail joints, and the engineers hit upon the expedient having the rails made long enough to cover the whole length of the bridges. Since they were laid down the nuisance caused by the rail joints has ceased. The use of rails of the length stated is, as far as we know, without a parallel in the history of railway construction, and reflects credit alike on the engineers who suggested it and the manufacturers who made them.

Suspension Bridges are generally adopted for long spans. When above 200 feet they compare favourably in cost with girder bridges. They are most useful for spanning ravines. For light traffic on short spans they are sometimes very advantageous. The cost depends greatly on having a firm anchorage for the chains. Among the bridges made in Derby are some of the most important structures put up, including the Kistna Railway Viaduct for India, 3,600 ft. long, and many for Spain, Australia, Hungary, and other purts. The following are the chief points on which full information, accompanied by drawings, should be given to enable an estimate to be made for the most suitable kind of bridge:—1st. The length of the bridge and width of roadway; and if to span a river, the headway, depth of water at lowest and highest level, height of the river banks, and the nature of the river bed. 2nd. The purpose for which the bridge is required. If for a railway, whether single or double line of rails, width of gauge, and weight of the heaviest locomotive. If for a roadway, state the kind of traffic and the heaviest loads, the kind of road surface required. 3rd. What facilities for transporting the bridgework to the site, whether skilled workmen can be got, and what materials are easily and cheaply available near the site.

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THE EVOLUTION OF FLOWERS.—(*Knowledge*)

BY GRANT ALLEN.

V.—*True Lilies.*

The flowering rush and the arrowgrass brought us so very near the true lilies in every important particular that we scarcely feel we have made any transition worth speaking of when we arrive at the simplest and most primitive existing of the restricted lily family—the Liliaceæ of technical botanists· Of these simplest kinds we have two or three excellent representatives in our own country, quite as good as any we could get if we were to search the whole dried specimens of the Kew herbaria. The best of these for out present purpose is that rare little field lily, the yellow gagea (*Gagea lutea*).

In a few sandy meadows of Egland and Scotlands, some straggling colonies are found of a pretty little golden lily, whose proper habitat stretches over the great central plains of Europe and the warmer portions of the Siberian slope. Like most other true lilies, this little plant is a dweller in the fields, while the Alisma-like kinds with which we have hitherto been dealing are all of them denizens of the ponds and marshes. Such a fact is in itself a singnificant one: the more advanced type has overrun the wide plains and uplands of the entire world, while the lower types have everywhere been crowded out into the less desirable habitats, such as water-courses, swamps, and hilltops. Like most other meadow-plants, too, our gagea has been forced, in competition with the grasses, to acquire long and narrow blade like leaves, so as to reach the air and light among the tall plants with which it has to struggle. Furthermore, it shares one common habit of a great many lilies in the fact that it possesses a bulbous root-stock. In this root-stock the starches and other food-stuffs laid by in one season are stored away for the use of the flower in the succeeding spring; and, as a general rule, it may be said that most bulbous lilies and other lily-like monocotyledons (including the very closely-allied iris and amaryllis families) are spring-flowering plants. There can be very little doubt that the prevalent bulbousness of the lilies is one of the points which has chiefly aided them in establishing themselves so widely and firmly as they have done in the very best situations over the entire world.

These, however, are not the peculiaries of the true lilies which chiefly strike the classificatory botanist. As a matter of structural development, the important particulars to note about the gagea, as compared with the flowering rush and the water-plantain, are chiefly these. The carpels, reduced to a single whorl of three, as in marsh arrow-grass, are here firmly united into a single solid ovary, which never at any time dividied into its component parts, but opens in the centre of each carpel to shed the seeds. The stigmas (or summits of the carpels) are combined into a single style, which, however, in most lilies bears three separate stigmas at its top, as a last witness to their original distinctness. Each carpel contains several seeds—an advance which we already noted in the flowering rush. The stamens, instead of being numerous, as in arrowhead, or nine, as in flowering rush, are six in number, as in water-plantain. The general formula for the lily family (though subject to a few exceptions) is about as follows:—Perianth, of six divisions petal-like; stamens, six; ovary, free, three-celled; styles, single, with a solitary or tripartite stigma; seeds, usually many in each cell, sometimes solitary.

Now, what is the practical meaning of all this in its evolutionary aspect? Simply that the lilies have taken, for greater security of fertilisation, to running their three carpels together, and especially to uniting their three stigmas or sensitive surfaces into one, so that a single act of fertilisation suffices for the whole lot. Being all (in the main—about the exceptions we will speak hereafter) insectfertilised, they have conspicuous-coloured flowers; and the sepals as well as the petals share in the attractive display. The lower lilies bear capsules with many seeds; in the higher ones, as we shall soon see, the development of berries has allowed the number of seeds to be still further reduced to three, or one in each carpel—called, in the case of united ovaries, a cell.

Our gagea thus possesses all the most important distinctive lily features, as compared with the flowering rush, the water plantain, and the other alismaeeæ; but, in certain minor respects, it shown many signs of being a very primitive lily indeed. One need only compare the present illustration with the illustration of the flowerlng rush in order to see how markedly like the two plants are in the most notable external features. The flowers here are several in number, with leaf-like bracts beneath each flower-stalk, and the sepals and petals, instead of being bell-shaped, as in the tulip and wild hyacinth, or combined into a single piece, as in the lily of the valley and the garden hyacinth, are quite distinct and broadly spreading, as in the flowering rush. In fact, whilst most other lilies display the common lily features, with some special modifications and additions, such as tubular corollas, fleshy-coloured berries, flattened stamens, abortive leaves, and so forth, the gagea displays them almost in their uncompounded purity, without any complications or additions of any sort. It thus shows itself to be a survival from a very primitive and simple form of the common liliaccous stock. There are, however, a few other lilies which, while more advanced in some ways than gagea, yet preserve some more antiquated or orignal features which this little plant has entirely lost.

Indeed, the Scottish asphodel (*Tofieldia palustris*) perhaps still more closely resembles the earliest lily ancestor in most important respects, especially in the fact that, like the arrowgrass, it has three distinct and separate styles—a very archaic characteristic, certainly; but, for some other reasons, I incline to consider the Tofieldia genus as a degenerate one, and so have not chosen it as my first representative of the true lily group.

I haven't yet mentioned the most interesting particular of all about our little gages, and that is the peculiar colour of its sepals and petals. In common with all the other members of its genus, it has yellow flowers; and I have already tried to show on several occasions that yellow was the original colour of all blossoms—white, pink, and blue being successively later acquisitions. Moreover, gagea bears a very striking resemblance in hue and general appearance to several buttercups, especially to the lesser celandine *Ranunculus ficaria*); and buttercups, as we know, are very primitive dicotyledons. Curiously enough, too, the petals and sepals are yellow on the inner (or exposed) side only; the outer side is green, so that the colour looks almost as if it had been daubed on with a brush upon one surface of a small green leaf. I have very little doubt that we see here a relic of an extremely early stage in the acquisition of colour by the petals of insect-fertilised flowers. And it is a significant fact that the other primitive genus of lilies, Tofieldia, has likewise greenish-yellow blossoms. Gagea is mainly impregnated by bees and flies. It seems to increase for the most part, however, by means of the bulbs, each old bulb producing two new ones in the course of every season, one on either side. These two bulbs are the store-houses in which the old plant lays by material for the flowering of its two successors in the following spring. Perhaps this practical comparative neglect of true reproduction by fertilized seeds, and substitution of the essentially non-reproductive method of increase by means of bulbs, may account for the numerous early characteristics displayed by gagea; for in reality each bulb is not a new plant, formed by genetic union between two old ones, but merely a bud from the old plant, springing afresh just as a cutting or sucker might do. Thus many existing gageas may really be parts of the very same plant that flourished innumerable generations since, a contingency which would bring them far nearer the original ancestor than other lilies which have been almost yearly reproduced from seed for countless ages.

Gagea lutea.

VI.—TULIP AND FRITILLARY.

THE simpler and earlier lilies, well represented by our English Gagea, have bunches of small flowers at the end of a tall stem; and familiar examples of this type are afforded us by the Star of Bethlehem and the common wild garlic. But the more advanced lilies, especially in northern climates, often bear a single larger flower only, the increased attractiveness of the big petals making up, apparently, for the diminution in the blossoms, according to the usual principle that every gain in effectiveness is accompanied by a corresponding loss in number. Of these higher lilies we may take as typical specimens the garden tulip, and the fritillary.

So far as regards structure, the tulip does not differ essentially from the little yellow Gagea. Its points of variation are all adaptive in the simplest degree, and have reference almost entirely to its increased attractions for the larger insects. The tulips, however, are altogether finer, heartier, and more successful plants than the little Gagea, and have consequently throughout a decidedly bolder and more succulent growth. They inhabit naturally richer soils, where they can spread themselves more freely to the sun and air. Hence their leaves are not usually narrow and grass-like, as is the case with Gagea, but broad and thick, or sometimes almost fleshy. Their bulbs, stems, and blossoms are also larger, and their appearance more generally prosperous. But the great distinction which marks them off from Gagea and its allies is the fact that their petals and sepals, instead of spreading out horizontally, so as to form a flat open flower, converge together into a bell, thus producing a sort of cup or goblet for the fertilising bees. Still, the sepals and petals remain distinct from one another, and do not actually unite into a single solid bell or tubular corolla, as in the garden hyacinth: that last advance in integration is one which we shall only meet on a somewhat higher level. In our garden tulips (varieties of *Tulipa gesneriana*), and in most other species, the flower stands upright on the top of the stalk, instead of turning downward, after the common fashion of tubular blossoms. This is a trick which it shares with a whole host of similar large handsome flowers, like the crocuses and colchicums: and everybody who has ever watched a bee at work among them, bustling about at the bottom of the deep enclosing well, must have observed how very effectually it conduces to the proper fertilisation of the stigma. Garden tulips have only one flower on each plant, but some few other species have occasionally two, a last relic of the large bunch produced by their lower relatives.

We have on a few Welsh mountain-tops some little colonies of a very interesting intermediate form—*Lloydia serotina*—which combines some features of the true tulips with some features of the simpler type represented by Gagea. This pretty little plant, a mountain and arctic lily widely spread over Europe, Asia, and America, is a tulip in all its technical characters, but bears a single small white flower with spreading and open petals, like those of wild garlic. It is, in short, a simple lily of the Gagea type, verging in the direction of a tulip, but still preserved for us under its comparatively primitive shape in the extreme north or on the chilly mountain-tops; while its relatives in more favoured climates have developed under happier conditions, and by stress of more advanced insect selection, into the large and handsome Asiatic tulips.

Tulipa gesneriana (Garden Tulip).

Even more characteristic, in some ways, of the higher lily type, is the common English fritillary or snake's head (*Fritillaria meleagris*), which grows abundantly in swampy meadows about Oxford, and in many other parts in the southern and eastern counties. The fritillaries are a group of handsome bell-shaped blossoms, with their sepals and petals still quite distinct, but with a very large and well-marked nectary near the base of each, thus testifying at once to their attractiveness for the honey-sucking insects. Unlike the tulips, their flowers droop downward, so that the bee has to approach them from the under-side. Our English species has only one blossom to each stem, but some South European kinds have two, and the crown-imperial of our gardens has a whole cluster of them, thus rendering it exceptionally conspicuous and brilliant. The colour of these flowers gives us an excellent lesson in the principles of floral colouration. Unlike the Gagea, which is primitive yellow, and the Lloydia, which is white with a yellow spot at the base (a great many other flowers have this same intermediate arrangement) the English snake's-head is usually a dull lurid red, curiously marked inside with very remarkable chequered spots. Now, there is reason to believe that the general progress of colouration in flowers runs from yellow, through white and pink, to red, purple, and finally blue. The snake's-head has thus got about half-way up the ladder; but, as often happens, every now and then it begins to tumble down again part of the distance, or even the whole of it. White fritillaries are intermixed with red ones in the Oxford meadows, and here and there one may even come across a yellow specimen. At the same time, it is interesting to note that in some species of fritillaries this relapse in colouration, which occurs only occasionally in our English snake's-head, has become normal or habitual, no doubt owing to some change in the particular insect visitor by whose aid they are usually fertilised. It is well known that different kinds of insects have very different tastes in the matter of colour, and they select accordingly those variations which best suit their own peculiar æsthetic ideas. But what is most important of all is the curious fact that most yellow fritillaries show unmistakable signs of having been descended from red chequered ancestors, just like our own snake's-head, for though yellow is their prevailing colour, they are loosely sprinkled over with reddish-brown marks, exactly similar to those of the English species. Moreover, in all cases that I have observed (for example, in the yellow *Fritillaria delphinensis* of the Riviera, and the *F. lutea* of the Caucasus) the nectaries and base of the petals are still red, as are also the edges in many instances. This clearly points back to an original red ancestor, and shows that the yellowness of the flowers is not like the primitive yellow of Gagea or of the buttercups, but an incomplete reversion from a higher stage. By far the greater number of fritillaries are purplish red, and the yellow ones always bear marks of having fallen from their high estate. Our own snake's-head is chiefly fertilised by bees, both hive-bees and bumble-bees, as well as by a few other insects. Its secretion of honey is exceptionally abundant.

Lloydia serotina.


Fritillaria meleagris.

It is curious to observe in this same connection that a wild yellow tulip (*Tulipa sylvestris*), not, perhaps, truly indigenous to Britain, has established itself in some of the eastern counties. The group, as a whole, is a southern one, and its prevailing colours are scarlet and pink, often with a dark purple or almost black base to the petals; but in this more northern European species there is the same sort of reversion to yellow as in the Caucasian fritillaries. As a rule, the yellow of such reverted flowers is paler and less golden than in the more primitive buttercup and potentilla types.

At a Meeting of the Philadelphia Society of Engineers, Mr. S. N. Stewart, described a Cushioned Pier and Rolling Trunnion Draw-Bridge. With a working model he showed that a 6 lb. draw could be turned by a pennyweight pressure or a breath, and claimed that, with a leverage six times as great as that of the model, 20 lbs. pressure would turn a 100 ton draw. He also claims that a pivot-bridge, swinging in a horizontal plane, is a trap into which men, teams and railroad trains fall every year, while a Bascule-draw, rising in the air, closes the approach and serves as a signal and warning. Referring to his project for a bridge across the Delaware, he said: "Hitherto the restrictions imposed by the authorities have been practically prohibitive, but the land interests are as much to be considered as those of navigation, for rivers were not made for mariners alone; and the land interests are really greater than the interests of those who go down to the sea in ships. A compromise should be effected, for a bridge has already become a pressing need and will soon be a positive demand." Mr. Stewart claimed that a bridge only 20 feet wide would accommodate two continuous streams of vehicles and still leave a wide foot-way.

ON THE COMPARATIVE MERITS OF VERTICAL AND HORIZONTAL ENGINES, AND ON ROTATIVE BEAM-ENGINES FOR PUMPING.*

By Mr. Wm. E. Rich, M. Inst. C.E.

The author commenced by enunciating the principles that "no single pair of brasses forming a bearing should be subjected to wear on two or more axes at right angles to one another, and all bearings should be adjnstable in the direction in which they wear." He pointed out the several ways in which a horizontal engine almost of necessity departed from these principles, while it was easy to observe them in vertical engines, whether they were direct-acting or of the beam type.

The main bearing of a horizontal engine necessarily had to withstand the alternate thrust and pull of the connecting-rod horizontally, and at the same time the load of the fly-wheel and crank-shaft vertically, and possibly the resistance of some driving-gear in another direction. This bearing ought, therefore, to be made in four or in three pieces, as was usual in good portable-engine practice; but in large engines, for the sake of simplicity, it was more frequently made with two brasses, inclined at an angle of 45°, which could not possibly be kept in perfect adjustment. The wear of the cylinder, piston, and glands vertically, and the necessity for supporting the weight of the piston and rod by means of blocks working on guides, both fore and aft of the cylinder, were also alluded to.

An objection to a tandem arrangement of two or more cylinders and pumps in line, was the difficulty of disconnecting their working parts, and a horizontal was not so efficient as a vertical treble-valve air-pump, and sometimes caused accident in starting, in consequence of the condenser overflowing into the cylinder. To drive any sort of vertical pump off a horizontal engine, some complicated driving-gear was necessary. Usually this was a bell-crank, which also wore its brasses, both vertically and horizontally.

A horizontal engine of the ordinary type, not steam-jacketted, lodged water at both ends of the cylinder, especially if the valve-chest was on the top of it. Messrs. Donkin avoided this by keeping the valves low down on the side, while in Corliss engines separate exhaust-valves were provided at the bottom of the cylinder. Some compound horizontal engines, with two cylinders working on cranks at right angles, with Cowper's re-heater, made by Messrs Easton and Anderson for Messrs. Siemens, and a three-cylinder compound horizontal engine working sixteen pumps for the Ship-Lift at the Victoria Docks, were then illustrated and described. The compound horizontal pumping-engines, made by Messrs. Simpson for the Odessa Waterworks, were next referred to. These were of the same type as those for Messrs. Siemens, but were much larger and fitted with a double-acting pump behind each cylinder.

The author argued that most of the above blemishes were avoided by adopting vertical instead of horizontal engines. The several bearings required vertical adjustment only, the pistons and cylinders were free from all load, except that due to the spring rings, and they wore uniformly round their circumferences, and the air-pump was on the vertical principle. The engine could be easily made self-contained on a compact bed-plate; it occupied little floor space, and the foundations were simple. In many winding and factory driving-engines, and in several centrifugal pumping engines, the crank-shaft was above the cylinders; but vertical marine and blast-furnace pumping-engines were generally of the inverted cylinder type.

Beam-engines were specially suited for pumping, as they permitted a high piston-speed and a low pump-speed at the same time, and several vertical pumps could be driven from one engine. They were also easily balanced, and were convenient for the introduction of the Woolf Compound principle. Their longevity and steadiness of working, when properly balanced, also kept them in favour for factory driving in many parts of England, and in Rouen and Ghent on the Continent; though in consequence of the lower first cost and greater working speed of horizontal engines, they were almost universally adopted on the Continent for such duties.

The universal adoption of the vertical engine in the mercantile marine, and the recent introduction of it in the Royal Navy, even at the cost of additional armour-plating to protect it, in order to obtain the advantages which vertical engines possessed over the horizontal engines formerly used, were then discussed; and allusion was made to the extravagant wear of the largest class of horizontal engines on long voyages. In concluding this section of the Paper, discussion was invited, as to whether the modern continental Engineers were right in adopting horizontal engines for nearly all purposes, or was the Author right in advocating a much larger use than hitherto of vertical engines for land purposes, and using them almost invariably where large pumping-power was required. He admitted the very low first cost of the horizontal engine in its simplest form, and that for small high pressures engines it was frequently the best type to adopt; but if it was condensing and fitted with quadruple or triple main-bearing brasses, it became as dear as a vertical engine, and not so enduring; and it it was also on the compound principle, and fitted for working pumps in a well, the cost of it, with its buildings and boilers, would be very nearly, if not quite, as much as a Woolf beam-engine with similar belongings, and the maintenance of it would cost twice as much.

The Author then proceeded to describe the type of Beam-Engine constructed by Messrs. Easton and Anderson in recent years. Their aim had been to make it, as far as possible, self-contained, on a massive cellular bed-plate, cast in one piece, and to carry the cylinders, valve-gear, main-bearing, beam-carriages and engine-entablature entirely on this foundation-casting, so as to leave the whole engine nearly, or entirely, free from the engine-house walls, which could then be of a much lighter construction than was necessary when the entablatures were supported by them. The bed-plate took the place of the expensive ashlar work required in most engine-foundations, and shallow pumps could be bolted direct to the underside of it. The general effect of the self-contained principle was to add to the cost of the engine proper, but to reduce that of the engine-house and foundations to a greater extent, so that the total cost of the pumping-station was reduced. In the earlier engines of this type the entablature was carried on six round vertical columns; but the angularity of the connecting-rod caused vibration longitudinally of the superstructure, and the two centre columns were therefore replaced by ornamental A frames, which in the most recent examples had given way to cellular A-frames of a very stiff box-section. In all first-class engines the cylinder were steam-jacketted, and usually the high and low-pressure cylinders were placed side by side on the same bed-plate with adjustable expansion-slides of the Meyer type, improved by the Author, on the high-pressure cylinder. The cylinder capacity ratios were usuallly from 3½ to 4 to 1; but if steam-jackets were not adopted, it was useless to make the low-pressures more than three times the size of the high-pressure cylinder, as, if larger, the diagrams would be very attenuated, and almost valueless, in consequence of the lodgment of water, especially at the upper end. The details of some experiments were then given showing the slow rate at which an unjacketed low-pressure cylinder warmed. At one hour and a half after starting, water was present in it during steam admission at a temperature of only 150°; at three hours it was 175°; and only after about five hours did it reach 192°. Diagrams taken during the trials were exhibited.

The necessity for the accurate adjustment of governors when adopted was then referred to, and the cases in which governors were frequently dispensed with when an attendant was always close at hand in the engine-room. The regulation of the expansion by the governor was rarely necessary or desirable in pumping-engines, which had usually tolerably uniform work. When an engine pumped through a long main, it was best to keep the stop-valve wide open and to regulate the engine by the expansion-gear alone.

The Hartley Colliery disaster led to the adoption of wrought iron beams, but they were costly and not entirely satisfactory. Latterly, beams of a mixture of cast iron and steel had been preferred.

It was a mistake to burden a pumping-engine with an abnormally heavy fly-wheel. If only carefully balanced, and the work indicated and work to be done on the up and down strokes respectively were carefully equalized, a light fly-wheel was really better than a heavy one. At a large pumping-station it was better to have several engines of moderate dimensions than one or two of colossal proportions. As regarded engine-speeds, beam-engines might be worked faster than had been the usual practice, if they were well balanced, were not unnecessarily heavy in their working parts, and were fitted with pumps having large valve area. With shallow pumps they could be worked faster than with deep-well pumps. The Brighton engines worked at 14 revolutions, the Winchester at 24, the Lambeth, Antwerp and Sutton

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

at 22, and the Portsmouth at 22 to 26 revolutions per minute.

It was not only necessary that engines should be economical in their steam-consumption, it was equally important that as much as possible of the power indicated should be utilized for useful work. The position of the pump under an engine-beam had much to do with the loads on, and friction of, the working parts. The principles on which air-vessel capacities should be proportioned were then discussed, with the assistance of diagrams showing the variations in the discharges of various types of pumps, the practical result being that 23 gallons of air-volume for a set of three-throw pumps, throwing 100 gallons of water per revolution, or 42 gallons for four-throw pumps, were as effective as 2,200 gallons in a single-acting pump.

The Author considered that all machinery was impaired rather than improved by the introduction of ornamentation in the shape of architectural features burrowed from structures of wood and stone, and that symmetry with such outlines as conveyed the impression of stability and strength, together with good castings and workmanship, constituted the elements of beauty in such works. If decoration was desired it was better to bestow it on the engine-house and chimney, and to call in the architect to assist in designing those structures which were essentially different from the machinery. At the same time if economy of first cost was important, it was better to have an undecorated engine-house and high-class machinery within it, than to limit the perfections of the engines, in order to get means for ornamenting the buildings. Sound engine and boiler-houses could be built for about one-third the cost of the machinery, but not unfrequently they cost considerably more than their contents.

Illustrations were then given of various examples of Beam-pumping engines, constructed by Messrs. Easton and Anderson and their predecessors, commencing with the four Woolf Engines at the Brighton Waterworks. Each of these worked two 33½-inch deep-well low-service pumps, a 24-inch high-service pump, and a middle-service 'pump, the water-supply of that town being divided into three zones at different levels. The four engines at the Portsmouth Works had each a double-acting piston-pump, 20 inches in diameter. with a length of stroke of 3 feet. The South Eessex Waterworks engine had two 16-inch high-lift pumps. All of these depended on the engine-house walls for their stability. Then follow the self-contained Doncaster Sewage and Saratoff Waterworks engines, each with six columns supporting the entablature, and a double-acting pump between the engine centre and the crank. In the Winchester No. 2 Engine, working two deep-well pumps, two A-frames replaced the centre columns in the last-named examples. The Lambeth Waterworks engines had the high and low-pressure cylinders on separate bed-plates, each working a double-acting pump, placed between the cylinder and beam-centres and cranks at right angles. The pumps sucked their water through a surface-condenser, and the condensed water from the steam-jackets passed direct into the feed-pump suction. There were two pairs of such engines in the same engine-house, and they were supplied with steam by five double-flue boilers. The steam in its passage from the high to the low-pressure cylinder was re-heated, as in the Cowper system, by an inclined tubular heater. The beams were of wrought-iron, and were surrounded with entablatures forming chequered plate-platforms, which were supported by A-frames and polished wrought-iron columns, and were entirely independent of the walls. A basement floor, 10 feet below the main engine-house floor, gave free access to the surface condenser and all the pumps without artificial light. In the first trial of these engines they worked with 17lbs weight of steam per indicated horse-power per hour, and a mechanical efficiency of 90 per cent. The temperature of the water in passing through the condensers rose about 1° Fahrenheit per 100 feet of lift. The Antwerp Waterworks engines were to the same centres as those at Lambeth; but they had both a high and a low-pressure cylinder on each bed-plate; the beams and connecting-rods were of cast-iron and the main bearings were cast on the bed-plates. No. 3 Sutton engine was an example of one fitted with three pumps, all sucking from the same well, and working under lifts of 182, 291, and 526 feet respectively, and interchangeable in their duties. The Buenos Ayres sewage pumping-engines consisted of two coupled pairs, each capable of raising a maximum of 17,500 gallons of sewage on a lift of 50 feet in one minute. The A-frames were extended to include the beam-carriages, and together with the bed-plates, were of very stiff box-sections. The beams were constructed of a mixture of cast iron and steel, having a transverse strength 65 per cent. greater and an ultimate deflection 54 per cent. greater than ordinary cast iron. There were two lift pumps 41 inches in diameter, 46 inches stroke under each engine. One of these was worked from a prolongation of the high pressure piston-rod, and the other by a rod from the beam, which was turned upwards at its outer end, to enable a single rod to be introduced for the pump, without fouling the engine connecting-rod. There were four boilers in the adjoining house, and the engines were guaranteed to give a duty of 100 millions of foot-lbs. in water raised per cwt. of coal. The four beam engines at the General Post Office, for the Pneumatic Despatch System, each had two bed plates, one above the other, the lower one supporting two 35-inch double-acting air-pumps, which might be worked separately, pressure and vacuum respectively, or together for either puopose. Two engines of simple design, and smaller dimensions, for a similar duty at the Prudential Assurance Office, were also described. Finally, an example of small compound beam engines working at 45 revolutions per minute, to drive, by means of gearing, two sets of three-throw pumps at 24 revolutions per minute, was given in those at the South Hants Waterworks, where the Clarke softening process was carried out.

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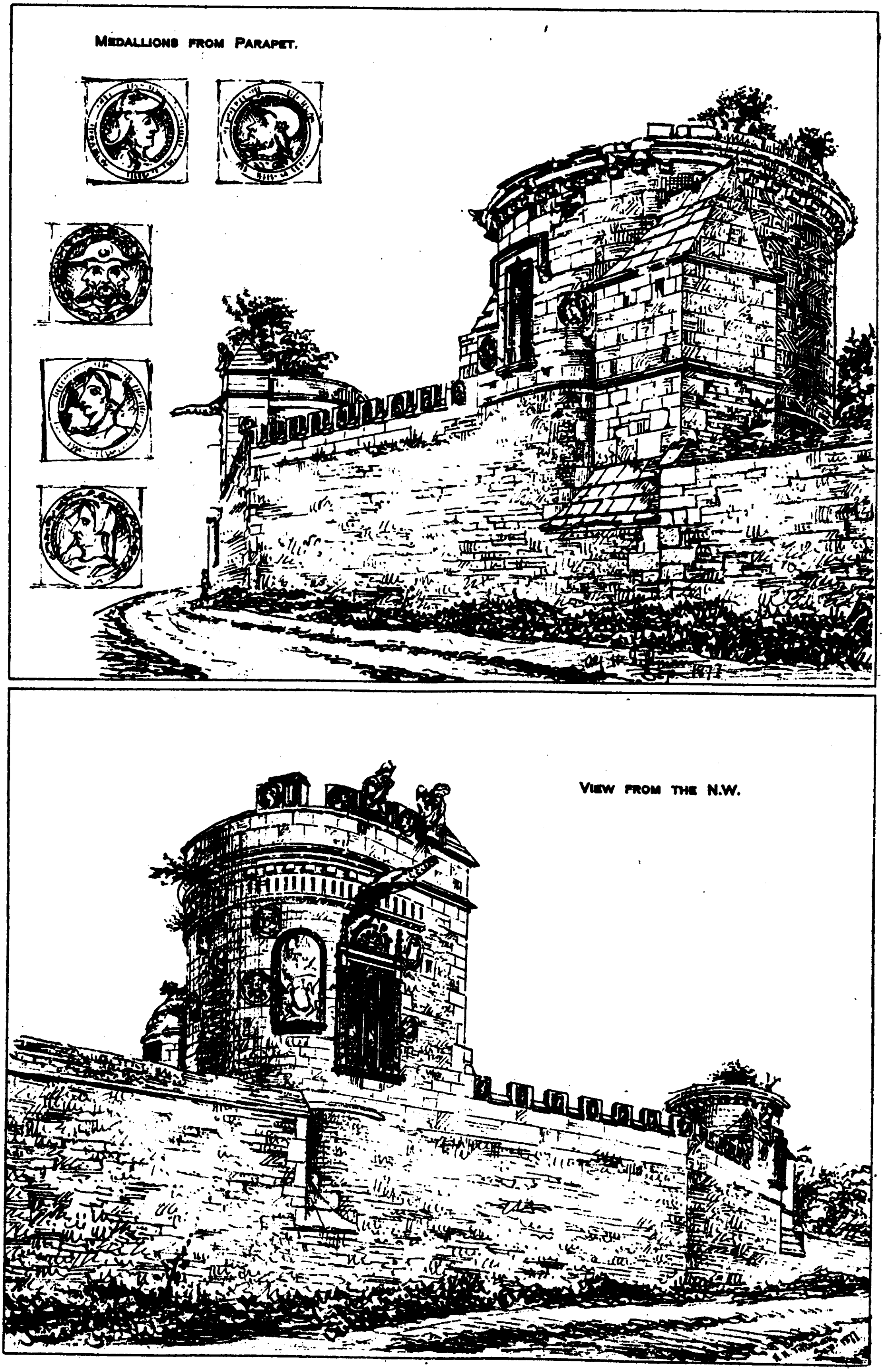
Buck and Hickman's Soldering Apparatus.—This apparatus is intended to supersede the use of the ordinary soldering copper bit and fire pot, for jointing telegraph wires. It consists of a small furnace formed by a spirit lamp with several wicks, enclosed in a perforated copper box; the flame plays beneath a shallow trough of copper, in which the solder is placed and in whioh the joint is dipped. The furnace will work well in windy and wet weather, and is quite adapted for the purpose for which it was designed.

Electric Light.—The electric light is now finding its way into cargo-carrying steamers as well as into first-class passenger steamers. One of the best examples of this is the German steamer *August*, which arrived at Granton with a cargo of staves from Memel on Monday, the 24th March. In the installation fitted into this steamer there is a dynamo which is supplied with motive power from the ship's machinery, and the lamps are so fitted up that the light from one can be shown from the mast head, while the other can be conveyed to the wharf for lighting up the warehouse alongside into which the cargo is being stored. The light has been fitted abroad at a cost of about £300. Messrs. Sartori and Berger, of Kiel, the owner, of the *August*, have a fleet of 22 steamers, 12 of which are fitted with electric light apparatus.

An Easy Test for Lubricants.—The manager of any mill may, at very little expense, determine for himself all the conditions of safety and economy in lubricants as indicated by the standard of heat developed upon any given shaft. The apparatus required for this purpose is merely a thin brass tube closed at the lower end, and two thermometers. The method of using this apparatus is as follows:—Place enough water in one of these tubes so that the bulb of the thermometer will be immersed; insert the tube in one of the holes in the cap of the journal, so that the lower end of the tube will be in actual contact with the shaft, hang the other thermometer free alongside, then gauge the relative heat developed with oils and with greases. Each man may thus satisfy himself as to which is best and safest.

The Crushing Strength of Ice.—Mr. W. Ludlow, President of the Engineers' Club of Philadelphia, has made a series of tests upon the crushing strength of ice to learn approximately the strength required for an ice harbour of screw piles in mid-channel at the head of Deleware Bay. Eighteen pieces were tried with Government testing machines; the specimens were carefully prepared, 6 in. and 12 in. cubes, and roughly-cut slabs about 3 in. thick, of different qualities and from different localities. For pure Kennebec ice the lowest strength shown was 327 lb., and the highest 1000 lb. per square inch. For inferior qualities the strength varied from 235 lb. to 917 lb. The higher results were obtained, generally, when the air temperature in the testing room was from 29 deg. to 36 deg. Fahr., as against 55 deg. to 68 deg. for the lower results. The pieces generally compressed ½ in. to 1 in. before crushing.



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