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

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NEW BOOKS.

Text-Book of Least Squares.—By Mansfield Merriman. (New York: John Wiley & Sons. Montreal: Dawson Bros.)

This is another of the admirable series of text-books which are being issued by Messrs. John Wiley & Sons, of New York. The author, Mr. Mansfield Merriman, is well known as an accomplished mathematician, and this new work on least squares will be welcomed as a valuable contribution to the mathematical literature of students. It is a considerably altered and enlarged edition of the "Elements of the Method of Least Squares," published by Mr. Merriman, in 1877, and is divided into 10 chapters. In Chapters I. to IV. he deals very fully with the mathematical development of the principles, methods, and formulæ, and in Chapters V. to IX. he discusses their application to the different classes of observation. Questions and problems are given at the end of each chapter to test the student's knowledge of the preceding matter.

The True Theory of the Sun.—By Thomas Bassnett. (New York; G. P. Putman's Sons.)

Mr. Thomas Bassnett has been long known as an earnest and diligent investigator of various natural phenomena. In 1854 he published the "Outlines of a Mechanical Theory of Storms," being an exposition of his own speculations, on the subject. Many physical questions, however, he discussed only very briefly. With the object of explaining those more fully and explicitly, Mr. Bassnett now publishes a new work, which he calls the 'True Theory of the Sun,' "which theory," as he claims in his preface, "after 30 more years of observation is proved to be a true theory, and it is of some importance that the history of its origin and development should be preserved, as well of the adverse influence which have elevated the world out of the benefits which might have resulted, had not science emphatically condemned it." How far such claim can be maintained is for the reader to judge. The subjects dealt with are the ethereal medium, the constitution of the solar surface, the character and theories of the solar corona, sun spot theories, cometary phenomena.

THE POETRY OF ARCHITECTURE,

OR

Architecture in its relation to the other Fine Arts.

Architecture has been practically described as "frozen music." In proportion as it is noble it speaks to the spirit of man in elevated and refining strains. Analyze the emotions aroused by hearing a masterpiece of Handel or Beethoven played on a cathedral organ by a Stainer or an Elvey; study a picture such as the marvellous Transfiguration, by Raphael, or a piece of sculpture breathed into being by the genius of a Michael Angelo, or come under the spell of a cathedral interior such as Westminster or York, Amiens, or Chartres, with their "dim religious light," and their "stained windows richly dight," and you will find that they have all much in common. They are all the outward expressions of the infinite in man striving for utterance. They have their fountain in that innate sense of beauty implanted in all of us. They embody the teachings of Nature to the soul of man, and his aspirations after the perfect beauty of a "new heaven and a new earth."

Such being so, it would be doing violence to separate the loving sisterhood, or, at any rate, the three graces—Architecture, Sculpture and Painting. History teaches us that they were intertwined in loving embrace in the early ages of the world, and although it is possible to have noble architecture, without either the aid of sculpture or painting, yet the perfect art is that which combines the three in due proportion and relation.

I therefore crave your company for a short time as we look, first, at architecture alone, from its artistic side, then glance at it in combination with the pictorial art, and then with the plastic. First, then, an essential element in all good artistic architecture is its proportion. Some have professed to reduce this to an inexorable set of rules; but proportion is too subtle to be thus "cribbed, cabined and confined." More stress has been laid upon it in classic architecture than in Gothic. In our first lecture we found that Vitruvius and others had made out a scale for the Greek temples and orders, in which the height of columns bore a certain relation to the diameter of them, in which the capital, the entablature, the frieze, and the cornice were all in a certain proportion to the size of the column and to each other, and any one who departed from these standards was considered a daring, if not an ignorant person. These rules, from being elastic bands became fetters, which kept the original minds from launching forth into new regions of designs, until, as we have seen, the fetters were broken altogether or flung away.

In the Gothic there have been no such hard and fast rules recognized, or even formulated, and yet you will find an unwritten law of proportion in the great cathedrals which was carefully observed,—the height bearing a certain relation to the width of the interiors, the towers and spires to the main building and to each other. The equilateral triangle was a favourite basis of proportion. You may take it as an axiom that a cube is never a satisfactory shape. A square room of equal length, breadth and height, would not be satisfactory to the eye and would be at once felt to be not in good proportion. In practice the best shape of a room is found to be when the breadth is to the length as 3 is to 4, or sometimes even 4 to 5, and in which the height is obtained by taking half the width plus the square root of the length.

In elevation also equal horizontal divisions are never satisfactory, the spaces should either diminish or increase in height. In the famous Palace of the Doges at Venice they increase, but generally speaking, they diminish,—sometimes pretty regularly at other times varied, as two low stages and a high one, or one high one, and a low one as in the common classic form of one order and an attic.

There must also be a grouping of the parts in all good architecture. The most elementary form of design and one which judging by our streets is still greatly in favour, is to build up a plain wall and pierce it with holes for windows at regular intervals. There is no great genius required for that; a step in advance would be, supposing there are 4, to place these windows in pairs but even better still to place the centre two near together, leaving the side ones as wings. In connection with this I may fitly refer to the sky line, *i. e.*, the line which the top of the building makes against the sky. In southern architecture, as a rule, the sky line was very little broken. In the Greek, the comparatively flat pediment rather accentuated the horizontal feeling than otherwise, and in the Venetian and Florentine and Genoese Palaces the unbroken horizontal cornice was very largely adopted.

On the other hand in more northern countries the sky line was more broken—gables, towers, turrets, spires, chimneys, all diversified the outline and gave a picturesque appearance. Much has been written in favour of both styles, but for my own part for town and street architecture, where frontages are narrow and there is difficulty in giving proper individuality and accentuation to each building my sympathies are entirely with the broken skyline. There is a charm in the high pointed gables and roofs, the peaked tourelles or turrets, the boldly defined chimneys and other features which are not compensated for by the tame horizontal top cornice, however well designed.

It is sufficient to name Nuremberg, Antwerp, Bruges, Lisieux, and a host of other places, the very mention of which recall delightful days spent amongst their architectural treasures.

Another element in good architecture is colour. I speak at present only of external appearances. This I venture to think has been somewhat neglected. I cannot admit that a dull leaden or gray monotone is the best colour for a building, or for the prevailing tone of our streets.

We do not find this in nature. An unthinking or unobservant person may say—why!—the grass and the trees are green, and the rocks and stones are gray, and the sky is blue and there's an end of them. But not so. As no leaf or even blade of grass is absolutely identical in form with another, just as no human face out of the many millions of the earth's inhabitants exactly corresponds to another so there is as much variety in their colour.

Just as a black coat is an Englishman's badge of respectability, so with many people a monotonous, dull, uniform stone front is their idea of perfection in architecture.

The adoption of red brick was a revolt against this and a step in the right direction, but as even red brick may be monotonous and harsh, we might do much more by the introduction of different colours or stone, the employment of terra cotta, the judicious use of marbles and granite and tiles, and when wood is used, the painting of it in two or more harmonious colours.

Modern fashion, for the time has laid its veto on the wearing of bright coloured garments, and we walk in sodden grey and solemn black, except on special occasions, but why should an embargo be laid on our buildings also. The local limestone is in some respects a good material, but its colour is distressing, and, unlike the sandstones, it is not influenced by the beautifying touch of time. There is little light or shade about it, but some little variety can be obtained with it by employing it with other stones, or even by the different modes of working it so as to get shades of white and dark grey.

We now know that the Greeks often decorated the exterior of their temples and buildings with brilliant colours to heighten the effect of the mouldings and sculpture, and even the Gothic builders sometimes did this also. I do not advocate this, as we require a more permanent mode of colour, and one which will stand our more rigorous climate.

I do think, however, that we miss something of the joy of life by reason of our dull surroundings, our spirits are unconsciously affected by them, and we take our pleasures more sadly, and possibly less innocently.

I come now to architecture in its relation to sculpture and in the general name of sculpture I include all carving, whether of natural objects or of imagination.

After the mere necessities of a shelter had been satisfied man began gradually to embellish and ornament his dwelling, it might be by but a few notches or markings, yet it enabled him to express his thoughts on things which he was unable to do in any other way. They symbolized great ideas,—just as the untutored savage takes a block of wood or a stone and rudely shapes it into some form, and clothing it with his unexpressible and vague ideas of the supernatural, calls it his god. Every nation and architecture has its own instructive sculpture in which you can trace the thought, the morals, the genius and the aspirations of that nation almost as distinctly as its own literature.

The discovery of ancient sculptures has revealed to us much that was vague and uncertain before. The Assyrian bas-reliefs formerly forming sculptured slabs in their architectures many of which, either originals or copies are now in the British Museum, have been most valuable in throwing light on their modes of construction. It was supposed that they had knowledge of mechanical powers and appliances of which we know nothing, else people asked how could they raise the mighty structures they did. If they had, it is singular that we have no trace or reference to such, but on the other hand in these sculptured bas-reliefs we have representatives of the transporting and raising of immense columns, and huge winged bulls and such like, and how is it done? Simply by the application of the simplest of our mechanical forces, the inclined plane, the roller and lever, possibly the pulley, and brute force.

Hundreds, nay thousands of slaves are there sculptured, dragging at the chains, and kept to their work by the lash of cruel overseers, columns are now raised by the slow process of ramming earth under them until they were got to the perpendicular. Human life was of no importance in those times, and the stones may almost be said to have been cemented with blood.

In Egyptian architecture they embodied some noble sculpture, entwining with the grosser materialism symbolic representatives of eternity, resurrection and notably in those strange majestic Sphnixes, their conceptions of deity, or sovereignty of the universe—the wings of the eagle, the king of birds, the body of the lion, the king of beasts, the head of man—the highest type of intelligence.

In Chinese, Japanese and Indian sculpture you have representatives of the whole hierarchy of their gods as they lived in fabled story.

But it is to Greece that, we turn for ideal sculpture. The Greeks brought the representation of the human form to as nearly perfection as it seems possible to attain as far as its physical aspect is concerned. Their refined and beautiful statuary has been the admiration of the world since. Who that has seen the grace and beauty of the Venus de Milo or of de Medici, the strength and the lithesomeness of the Apollo Belvidere, the half-man half-animal aspect of the marble Gam, the marvellous modelling of muscles as shown in the Wrestlers, the Dying Gladiator, the statues of some of the Cæsars, the frieze of the Parthenon, and many others, but will feel that the men that moulded and chiselled these forms were no ordinary men.

The Elgin marbles, as they are called, or more properly, the horsemen sculptured on the frieze of the Parthenon, and now in the British Museum, are well known. It is said that a riding-master took his class one morning to where they are hung along the walls and said :—" Gentlemen ! Sit down and study the attitude and grace and easy seat of those riders to-day, and you will learn more from them as to what good riding is, than I can teach you !" We found that the architecture of the Greeks was a self-satisfied thing. —elegant, refined, placid, but cold—and such is their sculpture. They never cared to express profound emotion. They preferred to depict life in its easy-going, irresponsible, pleasant, sunny aspect, only here and there as in the powerful group of the Laocoon or in the pathetic 'Dying Gladiator' or 'ancient Briton' as it should rather be called, did they strike a deeper chord. Passion they endeavour to banish, aspirations after the divine they understood not, the worship of humanity was personified in their sculpture as in their temple.

(To be Continued.)

ON THE PHYSICAL CONDITION OF IRON AND STEEL

(Tr. Inst. M. E.)

BY PROFESSOR D. E. HUGHES, F.R.S.

In a paper read before the Royal Society, 5th May, 1879, entitled "On an Induction Currents Balance, and experimental researches made therewith," the author showed that this instrument was extremely sensitive to all molecular changes in metallic bodies. Finding that its powers were remarkably suitable for researches upon the molecular change which takes place in Iron and Steel when tempered, he made it with a series of researches to determine the cause of tempering in steel. The results of these he laid before the Institution of Mechanical Engineers (Proceedings 1883, p. 72) in a paper "On the Molecular Rigidity of Tempered Steel." In that paper he advanced the theory that the molecules of soft iron were comparatively free as regards motion amongst themselves, whilst in hard iron or steel they were extremely rigid in their relative positions.

The author has since widened the field of research so as to embrace all the physical changes which occur in iron and steel through chemical alloys, mechanical compression or other strains, annealing, and tempering. The result of these researches he now embodies in the present paper. Believing it necessary that we should be able to tell the physical state of any piece of iron, without destroying or changing that state, he has sought for and tried several methods which gave any hope of success in this direction. The physical state of iron has a marked influence upon its electric conductivity. The differences thus indicated however are not wide enough to be appreciated except with metal in the form of a wire; and in order to perceive small changes, such as small differences of temper, we should require a wire at least 250 yards in length. The author has found however that by the application of certain phenomena belonging to magnetism we are ennabled to perceive clearly the slightest change in the molecular structure of iron or steel, through all degrees of annealing to the finest differences in tempering, and this with pieces of any form or dimensions.

It is already known that soft iron will take a higher degree of magnetism, and retain it less, than steel; and that tempered steel retains magnetism more than soft steel. Consequently we might expect that, by the aid of an instrument which could give correct measurement of degrees of magnetism, we should be able to include all varieties of iron and steel, between the two extremes of softness as in annealed iron, and hardness is in highly tempered cast-steel. The author soon found that this was not the case when pieces of iron were magnetized to saturation, or even partially so.

In a recent paper upon the theory of magnetism the author said, "During these researches I have remarked a peculiar property of magnetism, viz., that not only can the molecules of iron and steel be rotated through any degree of arc to its maximum or saturation, but that each molecule, whilst it requires a comparatively strong force to overcome its rigidity or resistance to rotation, has a small field of its own through which it can move with excessive freedom, trembling, vibrating, or rotating through small arcs with infinitely less force than would be required to rotate it permanently on either side. This property is so marked and general that we can observe it without any special iron or apparatus."

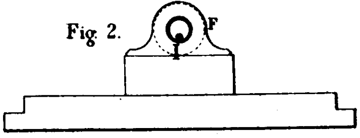
The author has found, by employing extremely feeble magnetizing powers,—such as a weak current of electricity only just sufficient for measurement, or the current from one Daniell cell reduced (as found best for the dimensions of the iron) by passing it through resistance-coils varying from 10 to 100 ohms,—that the following laws hold with every variety of iron and steel :—

1. The magnetic capacity is directly proportional to the softness, or molecular freedom.

PHYSICAL CONDITION OF IRON AND STEEL.

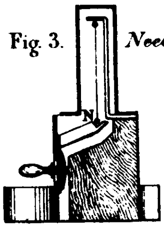
End Elevation of Magnetic Coil.

Fig. 2.



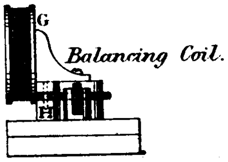
Magnetic Balance.

Fig. 3.



Scale 1/2

Fig. 4.



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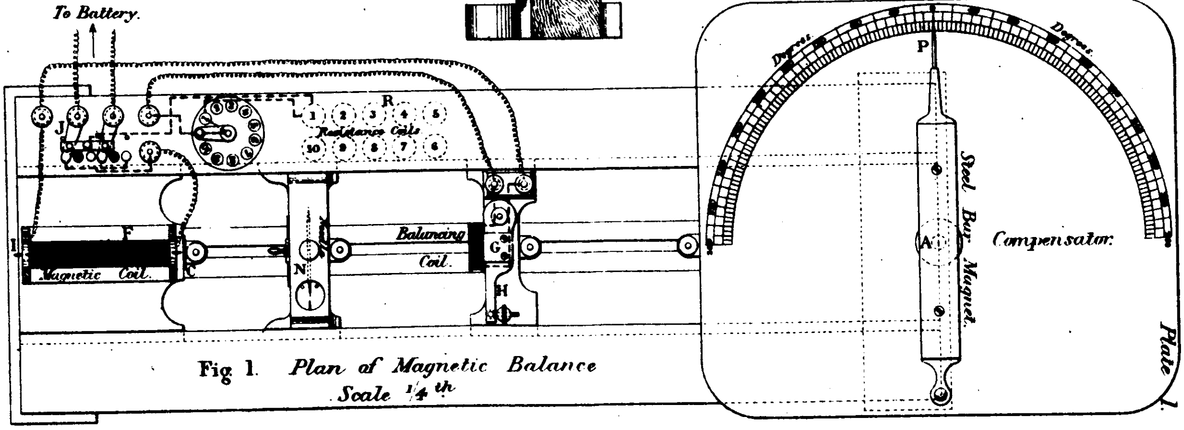

Fig. 1. *Plan of Magnetic Balance*
Scale 1/4 th

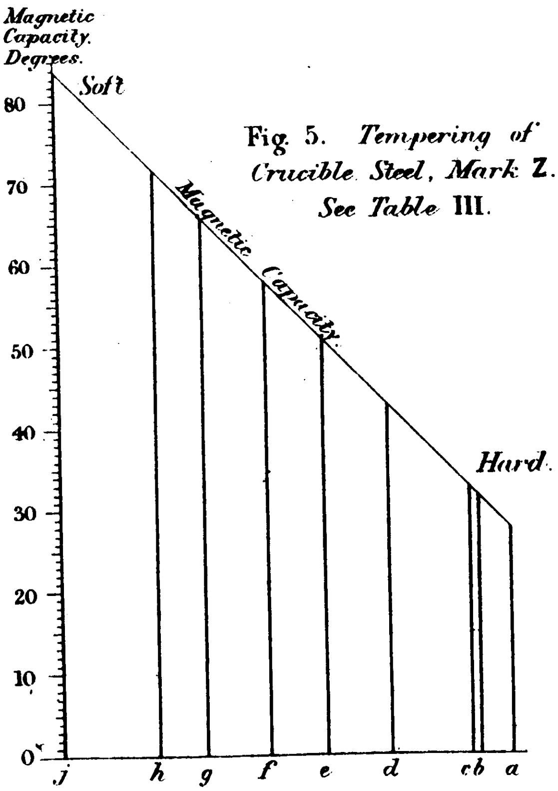

Fig. 5. *Tempering of Crucible Steel, Mark* Z.
See Table III.

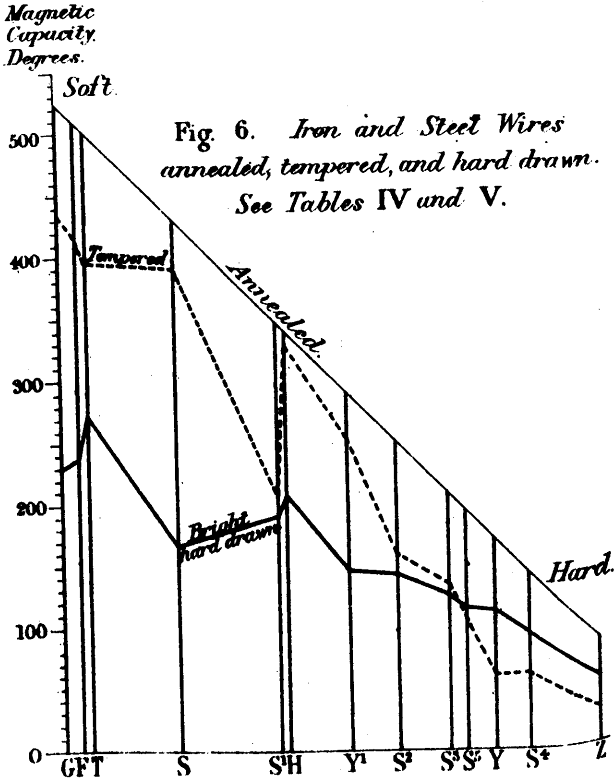

Fig. 6. *Iron and Steel Wires annealed, tempered, and hard drawn.*
See Tables IV *and* V.

PHYSICAL CONDITION OF IRON AND STEEL.

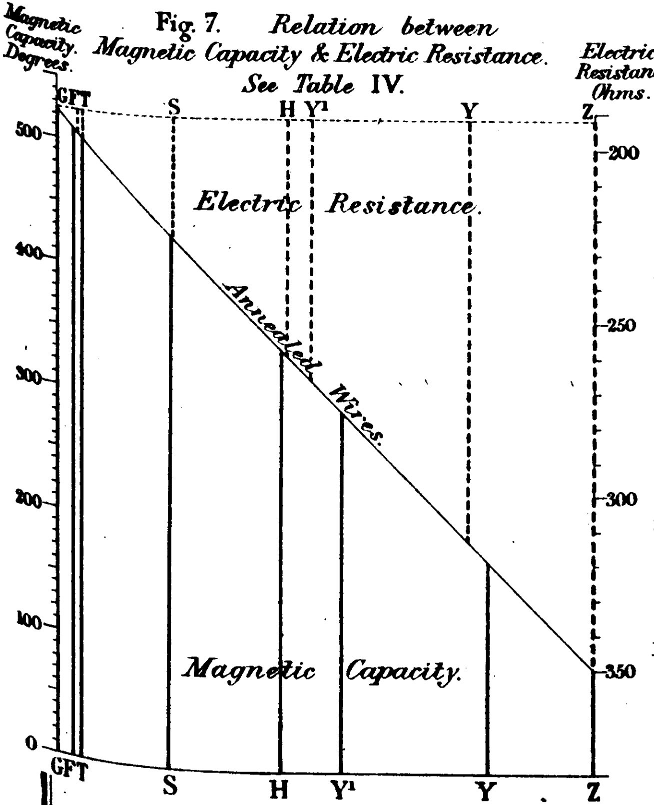

Fig. 7. *Relation between Magnetic Capacity & Electric Resistance. See Table IV.*

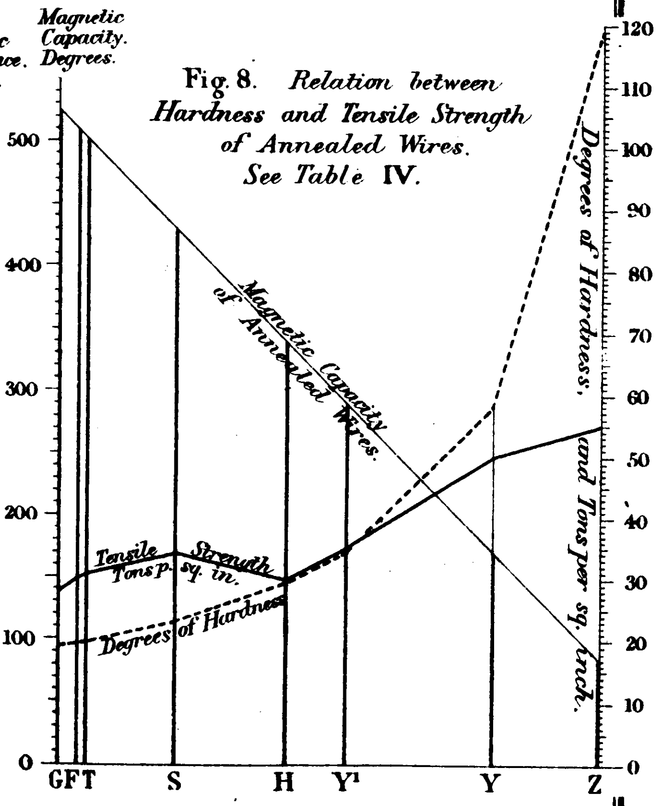

Fig. 8. *Relation between Hardness and Tensile Strength of Annealed Wires. See Table IV.*

TABLE IV.

Mark.	Description of Iron or Steel.	Electric Resistance per Mile of 0.04 in Diameter.	Tensile Strength per sq. Inch.	Magnetic Capacity. Bright Hard.	Magnetic Capacity. Annealed.	Magnetic Capacity. Tempered Hard.	Chemical Analysis Percentages. Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Copper.	Iron.
		Ohms.	Tons.	Deg.	Deg.	Deg.							
G	Best Swedish Charcoal Iron No. 1.	191.52	28	230	525	435	0.09	Trace.	Trace.	0.012	0.06	Trace.	99.69
F	" " " " " 2.	198.40	30	236	510	415	0.10	"	0.022	0.045	0.03	"	99.70
T	" " " " " 3.	199.62	31	275	503	395	0.15	0.018	0.019	0.058	0.234	"	99.44
S	Swedish Siemens-Martin Iron.	226.32	34	165	430	390	0.10	Trace.	0.035	0.034	0.324	"	99.60
H	Puddled Iron, best best.	259.92	30	212	340	328	0.10	0.09	[illegible]	0.218	0.234	0.015	99.11
Y_1	Best Homogenous Bessemer Steel, [soft	266.52	35	150	291	255	0.15	0.018	0.092	0.077	0.072	Trace.	98.74
Y	" " " hard.	312.69	50	115	172	60	0.44	0.028	0.126	0.103	1.296	"	98.20
Z	Fine Crucible Cast Steel.	350.08	55	50	84	28	0.62	0.06	0.074	0.051	1.584	"	97.41

2. The resistance to a feeble external magnetizing force is directly as the hardness, or molecular rigidity.

The author has proved this to be the case with sixty different varieties of iron and steel furnished direct from the manufacturers. And he has found that each variety of iron or steel has fixed points, beyond which annealing cannot soften, nor tempering harden; consequently, if all varieties were equally and perfectly annealed, each variety would have iss own magnetic capacity, or its specific degree of value, by means of which we could at once determine its place and quality.

If in place of several varieties we take a single specimen, say hard-drawn Swedish iron wire, and note its magnetic capacity, we find that its value rises rapidly with each partial annealing, until an ultimate softness is obtained, being the limit of its molecular freedom. We are thus ennabled to study the best methods of annealing, and to find at once the degree of softness in an unknown specimen.

Similarly, when we temper annealed iron and steel, we find that we can follow out each degree of temper up to ultimate molecular rigidity; and we may thus appreciate, in an unknown specimen of unknown temper, the degree of its hardness.

We have thus in each piece of iron or steel a limit of softness and hardness. In soft Swedish iron, tempering hardens it but 25 per cent. on the scale adopted; whilst mechanical compression, such as hammering, hardens it 50 per cent. In cast steel, tempering hardens it 400 per cent., whilst mechanical compression gives but 50 per cent. Between cast steel and Swedish iron, we find a long series of mild steel, hard iron, &c., varying in their proportionate degrees between the two extremes just mentioned.

The theory which the author has advanced, of molecular freedom as in soft iron, and molecular rigidity as in cast steel, fully explains all the changes which we are enabled to perceive and measure; but it is not absolutely necessary to accept the theory, in order to appreciate the results. For, leaving theoretical considerations aside, we have one proved fact: namely that the magnetic power or capacity of a piece of iron, under the influence of an external limited magnetising power, depends upon its softness; and that the retention of magnetism, when the external power is withdrawn, depends upon its hardness. The same degree of temper or annealing, upon the same iron or steel, gives invariably the same readings; but the slightest change—say from a straw-coloured temper to a blue—gives very wide differences.

DESCRIPTION OF APPARATUS.

The instrument which the author has constructed and used n these experiments, and which he has named a "Magnetic Balance," consists of a delicate magnetic needle N, Fig. 1, page 164, suspended by a silk fibre; it is 5 centimetres in length(2 in.), and its pointer rests near an index having a single fine black mark for its zero. The movement of the needle on either side of zero is limited to 5 millimetres (0.2 in.) by means of ivory stops or projections. When the north end of the needle and its zero index are north, the needle rests parallel with its index; but the slightest external influence such as a piece of iron 1 millimetre in diameter (0.04 ins.) placed at 10 centimetres distance (4 ins.) deflects the needle to the right or left, according to the polarity of its magnetism, and with a force proportionate to its magnetic power· If we place on the opposite side of the needle, and at the same distance, a wire possessing absolute the same polarity, of similar name and force, the two balance each other and the needle returns to zero; and if we know the magnetic value required to balance the first piece of iron we know the magnet value of both.

The iron I, which may be in the form of wires, rods, bars, plates, or any shape or size desired, is placed a fixed distance, preferaably 10 or more centimetres (4 ins.) resting against a fixed brass stop C. The centre line of the iron should be in line with the centre on which the needle turns, and it should be placed at right angles to the needles, lying horizontally east and west, so as to be free from the directing influence of the earth's magnetism.

The compensator, placed upon the opposite side of the needle, and at a distance of 30 centimetres (12 ins.), consists of a powerful steel bar-magnet, 3 centimetres wide, 1 centimetre thick, and 15 centimetres long (1·18 × 0.4 × 5·31 ins.), This turns upon its axis A, carrying with it the pointer P to indicate its degree of angular displacement on the graduated circle. Generally this bar-magnet is parallel with the needle, the pointer of the compensator and the needle being both at zero; but when we wish to measure the amount of magnetism in the piece of iron I, the bar-magnet is made to pass through an angular displacement necessary to make it balance this force, and its index reading on the graduated circle is taken as the comparative value. The north pole of the compensator should be opposite the north pole of the needle, in order to render it almost estatic and consequently exceedingly sensitive.

In order to magnetise the iron I, if required, by an electric current, a coil of insulated copper wire F is placed near C, the iron I then becoming the core of an electro-magnet. Now as this coil, independently of its iron core, acts upon the needle, its action must be balanced by an opposing coil G, on the opposite side of the needle. The position and power of the second coil G can be minutely adjusted by means of the lever H, which allows of finding a position where the two coils completely neutralise each other. If we introduce iron in the coil on either side, the balance is destroyed, and we have solely the magnetic influence of the iron core, the value of which we find by an equal opposing magnetism brought into play by the rotating magnetic compensator A

A reversing key J serves to change the direction of the current, and thus any difference between north and south polarity in the iron core I can be observed. One Daniell cell is all that is required as a battery; but great care must be taken that its electromotive force is a constant, otherwise all variations in the battery would be read as variations in the quality of the iron itself; and we need in addition a series of resistance coils R from 10 to 100 ohms, in order to reduce the current sufficiently for bringing into range the whole series, from soft Swedish iron to cast steel. Separate and finer determination can then be made, by an extremely weak force for soft iron, and by full or increased battery power for tempered steel. A series of different sized coils to replace that at F is necessary, whenever we vary greatly the diameter of the iron core. The first size, with an internal core opening of one centimetre (0·4 in.), will test bars and rods of wire from one centimetre diameter down to the finest needle; but for larger bars, plates, etc., coils must be used which allows free passage for the iron into the core opening. Great care and some practice are necessary in the use of the instrument, so as to ensure that the iron is placed in a neutral field; but when we have really obtained the necessary conditions, we can take several readings in a single minute, with an invariable result for the same kind of iron.

All irons and steels have some traces of remaining magnetism; it is therefore necessary that a double reading (north and south) snould be taken by means of reversed currents. In this case the quadrant of the compensator scale is divided into 360° on each side of zero; and the total value of north and south polarity added together is that given in the following tablef of magnetic capacity.

Several methods of observation can be employed with the magnetic balanse, the usual one being that already described; but there are many others, such as magnetising all specimens to the same value and noting the amount of current required. We may also observe the remaining magnetism after the cessation of the current; the influence of a weak current after the passage of a strong one, etc, Nany of these methods give interesting facts, particularly useful to those making researches upon the cause os magnetism.

By means of this instrument the author has tested sixty brands of iron and steel, mostly in the form of wires. A wire 1 millimetre diameter and 10 centimetres long (0·04 in. and 4 ins.) was the standard size used, as we can mora readilp temper small wires than large rods. In all comparative experiments between iron of different grades, we must have one standard form to which all the rest must be similar in form and size. Thus we could not compare a square or flat bar with a piece of wire; but if all pieces have the same form, then any difference observed between them must be due to their comparative softnnss, from which we can deduce the quality and place of each in the range from soft iron to cast steel.

INFLUENCE OF ANNEALING UPON THE MOLECULAR STRUCTURE OF IRON AND STEEL.

The magnetic balance shows that annealing not only produces softness in iron, and consequent molecular freedom, but entirely frees it from all strains previously introduced by drawing or hammering. Thus a bar of iron drawn or hammered has a peculiar structure, say a fibrous one, which gives a greater mechanical strength in one direction than another. This bar, if thoroughly annealed at high temperatures, becomes homogeneous in all directions, and has no longer even traces of its previous strains, provided that there has been no actual separation into a distinct series of fibres.

TABLE I.

Influence of annealing upon Swedish Iron, sample G.

—	Approximate Temperature.		Degrees of softness indicated upon the Magnetic Balance.
	Cent.	Fahr.	
Wire hard-drawn as furnished by makers ..	—	—	230°
Annealed at black heat	500°	950°	255°
" dull red	700°	1300°	329°
" bright red	1000°	1800°	438°
" " yellow	1100°	2000°	507°
" " yellow white	1300°	2300°	525°

From Table I. we see that a regular increase of softness occurs as the temperature at which Swedish is annealed increases, the maximum being at a point under that of fusion.

Some difficulty was experienced in annealing all wires to the same standard. The method employed at first was to place the wires in an iron tube heated to the desired temperature; but the temperature of the tube was extremely variable, and it was also found that an interchange of carbon takes place between the tube and the wires. Steel wires rapidly lose their carbon, and thus become softer at each successive annealing; whilst the purest iron absorbs carbon, until it contains exactly the same proportions as the tube itself. It is well known that iron wires at red heat, placed in a porcelain tube through which a current of carburetted hydrogen is passing, will absorb sufficient carbon to become hard steel.

Experiments regarding the time required for perfect annealing showed that, whilst hard steel required several hours, soft iron might be cooled in a few minutes without losing its degree of softness; consequently, knowing the great value of high temperature, the author adopted the following method. The tube was heated to a white heat or otherwise, the iron wires to be annealed were introduced quickly, and the instant they had the same temperature, they were withdrawn and simply allowed to cool in the air. The wire employed being 1 millimetre diameter (0.04 in.), the whole operation was complete in two minutes. This is not suggested as the best practical method of annealing, although in the case of these wires it produced the best result; but the experiments show that, whatever method is employed, the heating should be as rapid as possible to a high degree of temperature, and the wire should cool in a completely neutral medium or atmosphere.

The facts regarding annealing, as pointed out by the measurement of the magnetic capacity of iron wires, have no doubt been in a great measure perceived by ordinary mechanical methods. The results of the author's researches may be thus formulated:—

1. The highest degree of softness in any variety of iron or steel is that obtained by a rapid heating to the highest temperature less than fusion, followed by cooling in a medium incapable of changing its chemical composition.

2. The time required for gradual cooling varies directly as the amount of carbon in alloy. Thus absolutely pure iron would not be hardened by rapid cooling, as in tempering; whilst steel might require several hours or days for cooling, in order to soften it, even in the case of pieces only 1 milimetre diameter (0·04 in.) Slow cooling has no injurious effect upon iron, when cooled in a neutral field: consequently, where time is no object, slow cooling may be employed in every case.

A wire or piece of iron thoroughly annealed must not be bent, stretched, hammered, or filed; the hardening effect of a bend is most remarkable, and the mere cleaning of the surface with sand-paper hardens that surface by several degrees on the scale.

The following Table II. shows the effect of annealing upon a series of wires, kindly furnished expressly for these experiments by Messrs. Frederick Smith & Co,, of Halifax

TABLE II.

Mark.	Description of Iron or Steel.	Magnetic Capacity	
		Bright as sent.	Annealed.
		Degrees on Scale.	Degrees on Scale.
G	Best Swedish charcoal iron, 1st var.	230	525
F	" " 2nd "	236	510
T	" " 3rd "	275	5s3
S	Swedish Siemens-Martin iron . .	165	430
H	Puddled iron, best best	212	340
Y1	Bessemer steel, soft	150	291
Y	Bessemer steel, hard	115	162
Z	Crucible fine cast steel	50	84

From the above Table it will be seen that annealing had a great effect on the iron wires, doubling their magnetic capacity, and that Swedish iron stands far in advance of puddled iron; consequently, for the cores of electro-magnets in Telegraph instruments—as in fact for all electro-magnets—Swedish iron is the most suitable; and the magnetic balance may find a field of practical utility in measuring each core before it is used in an electro-magnet, and may also aid by its measurements in finding the best methods of annealing.

TEMPERING.

The influence of tempering upon the magnetic retentivety, or molecular rigidity, has been shown in every piece of iron or steel yet examined. Swedish iron hardens but 10 to 20 per cent by tempering, while steel hardens 300 per cent; the molecular rigidity of tempered steel being 18 times greater than that of soft iron. The influence of different methods of tempering on crucible steel is shown in Table III., ranging from its ultimate molecular rigidity to its ultimate softness when annealed.

TABLE III.

Tempering of Crucible Fine Cast Steel, mark R.	Plate 2. Fig. 5.	Magnetic Capacity.
Bright yellow heat, cooled completely in cold water...	*a*	28
Yellow red " " "	*b*	32
Bright yellow, let down in cold water to straw colour .	*c*	33
" " " blue	*d*	43
Bright yellow, cooled completely in oil..............	*e*	51
Bright yellow, let down in water to white.............	*f*	58
Red heat, cooled completely in water..................	*g*	66
" " " oil..................	*h*	72
Annealed...	*j*	84

We may therefore represent graphically a diagram which shall include all methods of tempering; and another diagram which shall include all varieties of iron, from the softest iron to the hardest steel, intermediate qualities of hard iron and mild steel finding their place between the two extremes. The first diagram is shown in Fig. 5, Page 164, in which the figures represented by lines (lettered as in Table III.) erected from points on a horizontal scale, to meet a diagonal line drawn at 45°. Thus the height of each line shows the magnetic value, and their distance apart shows the way in which they gradually approach the maximum. The second diagram is shown in Fig. 6, page 000, where the lines are lettered as in Tables IV. and V.

The numerous specimens of wire tested have been forwarded direct from the manufacturers, at the request of the author's friend, Mr. W. H. Preece, F.R.S., Electrician to the General Post Office. The chemical analyses of most of these wires have not beem furnished; but Messrs. Frederick Smith & Co., of Halifax, not only supplied a beautiful series of wires, but had them specially analysed by Mr. Henry S. Bell, of Sheffield, in order that the results should be as exact as it was in their power to make them. The author therefore neglects in this paper all other samples except those of Messrs. Frederick Smith & Co.: they all stand between, or are included by, the two extremes of Swedish iron and cast steel.

Table IV. on page 165 gives the complete results of the mechanical, chemical, and physical tests upon these wires. The tensile strength and electric conductivity are as furnished by Messrs. Frederick Smith & Co.; the chemical analyses are as given by Mr. Henry S. Bell; and the magnetic capacities of

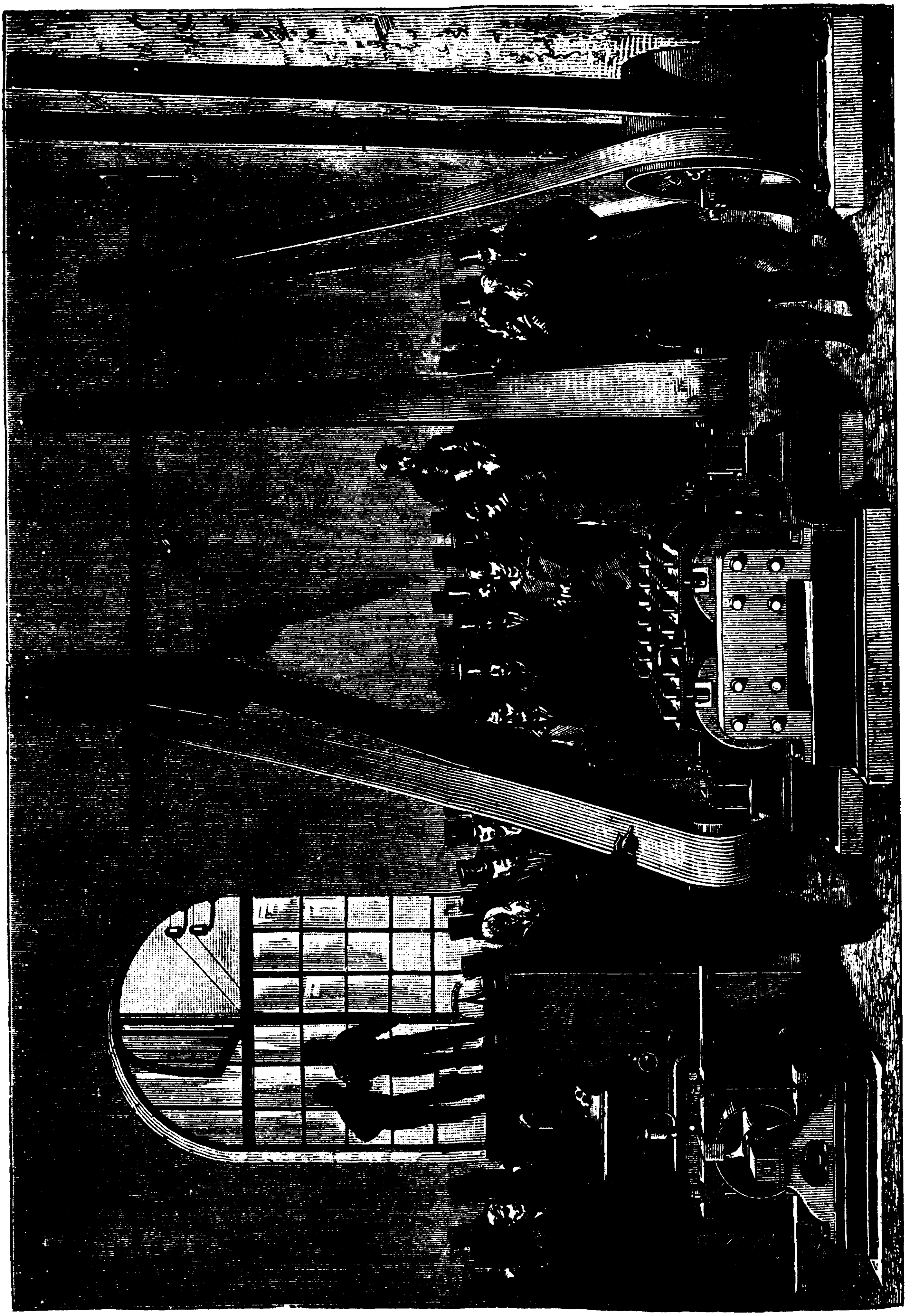

Fig. 9.—Installation in the Work-rooms of the Northern Railway of France

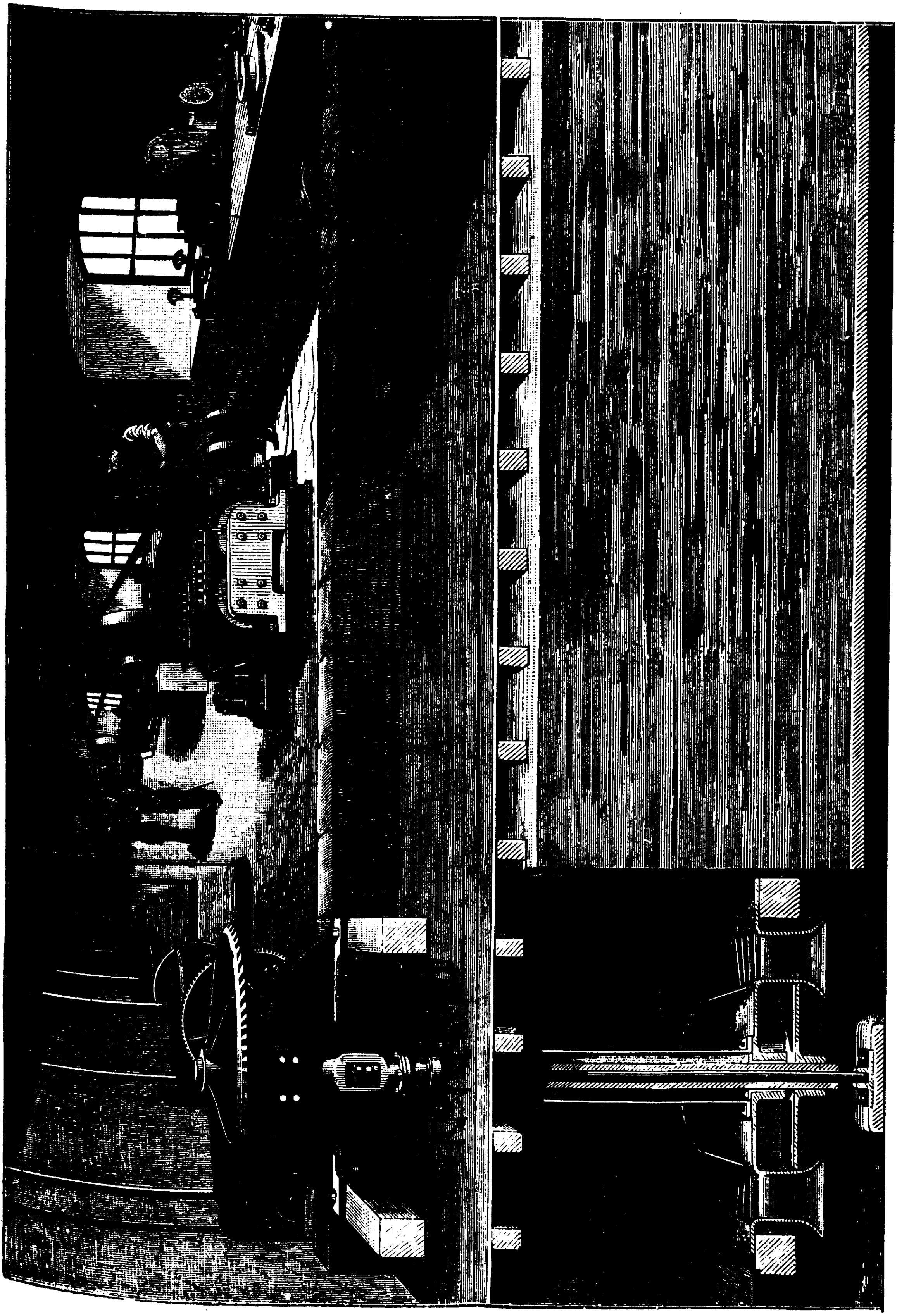

Fig. 11.—Installation at Vizille.

the bright hard-drawn wires, as also of the annealed and tempered wires, were determined by the author with the aid of the magnetic balance.

Table IV. will aid us in drawing several conclusions. Taken in conjunction with Table III., it shows—

1st. That the degree of temper in cast steel is dependent jointly on the heat to which it is raised and on the degree by which this is lowered in rapid cooling ; the extremes in Table III. giving the relative molecula rrigidity of the hardest and softest steel.

2nd. That a peculiar mild and homogeneous temper is obtained in oil.

3rd. That the tempers, or degrees of hardness, when steel is let down through the various colours, vary with the kind of steel tempered, as well as with heat from which it has been let down.

In these experiments the author has noticed that the highest degree of temper has not been obtained with wires containing relatively the highest proportion of carbon. The maximum thus far was obtained with but 0·62 per cent. of carbon ; whilst in a series of steel wires, made expressly for these experiments, but in which the manufacturer stated only the amount of carbon, the results were as in Table V.

TABLE V.

—	Mark.	Magnetic Capacity. Ann'ld	Temp'd	Carbon.
		Degr's	Degr's	Per Cent.
Bessemer soft steel................	Y^1	291	255	0·15
Steel made for these Experiments	S_1	348	206	0·40
" " "	S_2	250	160	0·55
" " "	S^3	209	133	0·60
" " "	S_5	195	107	0·75
" " "	S_4	144	61	0·65
Bessemer hard steel.	Y	172	60	0·44
Fine crucible cast steel...........	Z	84	28	0·62

It will be seen that the hardness, as indicated inversely in the column "tempered," is not directly as the proportion of carbon : a marked example being the wire S5 with 0·75 per cent. of carbon, which is far softer than the wire Z with 0·62. The author might here have doubted the truth of the magnetic balance, if he had not previously verified its results by mechanical tests. In order however to test the accuracy of the results, the wires S5 and Z were bound together, heated together to the same temperature, and plunged together into cold water ; this was repeated several times, with the invariable result that the wire Z with 0·62 carbon was glass-hard and could not be marked by a file, whilst the wire S5 with 0.75 carbon could be easily cut by the same file. Again we notice that in Table IV. the wires T, of soft Swedish Iron, contain precisely the same amount of carbon (0·15 per cent.) as those Y1 of Bessemer soft steel in Table V.: but that, whilst Y1 is comparatively hard when tempered, it does become greatly softened by annealing. This is due probably to its greater proportion of some other ingredient. Similarly the wire S is much softer than H in Table IV., both having the same percentage (0·10) of carbon. The hardness of H when annealed is probably due to its greater proportion of phosphorus or some other substance.

It may be too soon to try to correlate with the corresponding chemical analyses the physical changes occurring in tempering : but the author believes he has shown reason to hope that we may eventually obtain by uniting chemical with physical analysis, a more clear insight into the mysteries of iron and steel.

PROPOSED DIVIDING LINE BETWEEN IRON AND SLEEL.

Mechanical tests, as well as chemical analyses, have failed to find any distinct line of separation between the numerous varieties of iron and steel. The physical method which the author has employed shows clearly that there is no dividing line between iron and steel. If we glance at Fig. 6, page 164, we see that we have a continuous series from the softest iron to the hardest steel, and between these extremes we have every variety of intermediate quality. In point of fact the sixty brands which have been tested fill up all the gaps : and by their means we could choose irons gradually hardening into steel, or steels gradually softening into iron. Thus ordinary iron is physically a soft steel, and steel a hard iron. All are hardened by temper ; all are hardened by mechanical treatment, as hammering and rolling ; all are hardened by strains and stresses of any nature whatever : the differenence, though large, is only in degree. At the extreme end towards iron, mechanical hardening has a greater effect than tempering. At the steel end, tempering has a greater effect than mechanical hardening. We might here suppose we could find a physical dividing line ; but the author has found some mild steels to stand just on that dividing line which had previously appeared the most satisfactory. We are thus forced to adopt an arbitrary line. Nither mechanical or physical methods will suffice to overcome the difficulty. Mechanically a certain tensile strength has been proposed—the oblection to which is that unless we take note of the physical conditions (such as whether soft, tempered, &c.) we shall have very different magnetic readings for what would stand as the same material. The addition of the ultimate elongation might to some extent weaken this objection, but would not remove it. The physical method would allow us to fix upon a certain molecular rigidity, or difference in the readings of the same metal annealed and tempered, as the boundary ; it would however have all the objection of being a pure arbitrary line. Chemical analyses also fail to show a dividing line, since the same proportion of carbon is accompanied by very different physical results, if sulphur, phosphorus, &c., be present. In the authour's researches he has adopted the plan of simply reading an unknown piece of iron or steel in its annealed state ; if the figure stands above 400 ° it is classed as iron ; if below, as mild or hard steel according to its magnetic capacity. This classification happens to agree with that in general use at present, and suffices as a general division.

RELATIONS OF PHYSICAL FORCES IN IRON AND STEEL.

Iron is by far the richest of all metals in its physical nature. It stands almost alone in its magnetic qualities, as well as in its tempering properties ; and, while there is an evident relation between capacity for temper and loss of magnetism when tempered, so these experiments show an intimate if not absolute relation between electric conductivity of iron and its magnetic capacity. In Table IV., in the column of electric resistances as given by Messrs. Smith & Co., we find a progressive decrease of magnetic capacity. And there is an exact correspondence between the two variations : as is shown graphically in Fig. 7, Page 164, where both sets of figures are marked off on horizontal scales, and then lines are projected upwards for magnetic capacities, and downwards for electric resistances, to meet on a common diagonal line drawn at 45 °. It will be observed how nearly the two vertical lines coincide for each of the respective samples. The molecular rigidity, observed by the author as the cause of hardness, gives at once dncreased magnetic capacity and increased electric resistance ; so that from the magnetic capacity we might deduce its electric resistance, and *vice versa.* A very remarkable phenomenon is that this only holds true in the limited sphere of elastic rotation, which the author has already described.

This demonstration the author believes to be of great theoretical value ; and in a future paper, upon the theory of magnetism, its importance will be shown. In the present paper the author has tried as far as possible not to bring theoretical considerations forward ; in the results presented we are dealing with proved facts.

Another extrordinary relation of physical to mechanical tests may be mentioned. In Table IV. the tensile strength bears no relation either to the magnetic or to the electric qualities. On increasing the electromotive force in the magnetic balance, all the readings became confused ; there was no longer any fixed relation as to hardness, or as to any other quality. But on again forcing the magnetism to a very high point, the figures for magnetic capacity was found to bear exactly the same relation to one another as those for tensile strength. This however may have been only an accident, as it seems true at present in relation to the wires in Table IV. ; but it gives hope that by a new method we may some day be enabled to deduce from magnetic capacity not only electric conductivity but also tensile strength. Already in Table IV. we notice a close relation between molecular rigidity, as indicated by the figures for the annealed wires, and tensile strength. This is shown graphically in Fig. 8, page 165, where the reciprocals of the figures for the annealed wires are used to form a scale of hardness, and it is seen that the figures for hardness rise with the figures for tensile strength. The only exception is the wire H, but the cause of this is clearly the small difference between its magnetic capacity as annealed and as tempered.

Leaving aside all theoretical considerations and hoped-for improvements in the methods of observation, the author believes he has demonstrated clearly that, by the aid of the instrument and methods described, we can at once determine the physical state of iron, as influenced by tempering and by mechanical hardening, from the ultimate degree of softness to that of hardness: and that we can at once determine the best iron for the electro-magnets, and the best methods of softening it, as well as the best steel for permanent magnets, and the best temper to be given to it. He therefore ventures to hope that the Magnetic Balance will prove an aid of no small value in all researches into the physical state of iron and steel.

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The Panama Canal.—It is affirmed that of 90,000,000 cubic mètres of earth which have to be excavated from the Panama Canal, only 2,500,000 cubic mètres had been removed up to October, 1883. In that month more than 10,000 men were employed on the work. It is now proposed to increase the working force to 15,000 men, and it is expected that with better weather the extraction will be materially increased. It is still hoped that the canal will be inaugurated in 1889.

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HEAT-ACTION OF EXPLOSIVES.*

BY CAPT. ANDREW NOBLE, C.B., F.R.S., M. INST. C.E.

The lecturer commenced by pointing out that the salient peculiarities of some of the best known explosives might roughly be defined to be the instantaneous, or at least the extremely rapid, conversion of a solid or fluid into a gaseous mass occupying a volume many times greater than that of the original body, the phenomenon being generally accompanied by a considerable development of measurable heat, which heat played a most important part not only in the pressure attained, if the reaction took place in a confined space, but in the energy which the explosive was capable of generating. Fulminates of silver and mercury, picrate of potassa, gun-cotton, nitro-glycerine and gunpowder, were cited as explosives of this class. The lecturer asserted that substances such as those just named were not the only true explosives. In these solid and liquid explosives, which consisted generally of a substance capable of being burnt, and a substance capable of supporting combustion, in, for example, gun-cotton or gunpowder, the carbon was associated with the oxygen in an extremely condensed form. But the oxidisable and oxidising substances might themselves, prior to the reaction, be in the gaseous form; as, for instance, in the case of mixtures of air or oxygen with carbonic oxide, of marsh gas with oxygen, or of hydrogen and oxygen. He added that these bodies did not complete the list, and that, under certain circumstances, many substances ordinarily considered harmless, must be included under the head of explosives, making a reference to finely divided substances capable of oxidation, or certain vapours which when suspended in, or diluted with atmospheric air, formed mixtures which had been the cause of many serious explosions.

These instances served to show that an explosive might be either solid, liquid or gaseous, or any combination of these three states of matter. In the first place, a brief account was given of the substances of which some explosives were composed, illustrated by the composition of one or two well-known types. In the second place, the lecturer showed the changes which had occurred when explosives were fired, and gave the substances formed, the heat developed, the temperature at which the reaction took place, and the pressure realized, if the products were absolutely confined in a strong enough vessel; relating the experiments which had been made, and the apparatus which had been used, either to ascertain or to verify the facts required by theory. He further supposed all the explosives to be placed in the bore of a gun, and traced their behaviour in the bore, their action on the projectile, and on the gun itself. He also described the means and apparatus that had been employed, to ascertain the pressure acting on the projectile and on the walls of the gun, and to follow the motion of the projectile in its passage through the bore.

He mentioned that the potential energy stored up in a mixture of hydrogen and oxygen forming water was, if taken with reference to its weight, higher than that of any other known mixture, and explained why such an explosive, whose components were so readily obtainable, was not employed as a propelling or disruptive agent, the main objection being that if a kilogram of gunpowder, forming a portion of a charge for a gun, was assumed to occupy a litre or a decimetre cubed, a kilogram of hydrogen, with the oxpgen necessary for its combustion, would at zero and at atmospheric pressure occupy a volume sixteen thousand times at great.

The lecturer next passed to gun-cotton, described its composition and the various forms in which it was manufactured, referring especially to the forms which were so largely due to Sir Frederick Abel. The various forms of gun-cotton were exploded, and the lecturer remarked on the small quantity of smoke formed, as an indication of the small amount of solid matter in the production of combustion. Also, that instead of the explosions which took place when gaseous mixtures were fired, gun-cotton appeared rather to burn violently than explode. This was due to the ease with which the nascent products escaped into the atmosphere, so that no very high pressure was set up; but it was pointed out that by a small charge of fulminate of mercury, or other means, a high initial pressure was produced, and the harmless ignition shown would be converted into an explosion of the most violent and destructive character. This transformation differed materially from those which he had hitherto considered. In both of these the elements were, prior to ignition, in the gaseous state, and the energy liberated by the explosion was expressed directly in the form of heat. In the present instance a very large but unknown quantity of heat disappeared in performing the work of bringing the products of explosion to the gaseous state.

Captain Noble then showed that gunpowder, the last and most important example selected, was also by far the most difficult to experiment with, as well as the most complicated and varied in the decomposition which it underwent. One great advantage for the artillerist which gunpowder possessed, in being a mixture not a definite chemical combination, was that when fired it did not explode in the strict sense of the word. It could not, for example, be detonated as could gun-cotton or nitro-glycerine, but it deflagrated with great rapidity, that rapidity varying with the pressure under which the explosion was taking place. As a striking illustration of the effect of pressure in increasing or retarding combustion, he showed an experiment devised by Sir Frederick Abel. It consisted in endeavouring to burn powder *in vacuo*, and he demonstrared that it would not burn until sufficient pressure was reached. He exhibited the various forms under which gunpowder was manufactured, and ignited some samples of powder, pointing out the essential difference between their combustion and that of gun-cotton, namely, the large quantity of what was commonly called smoke slowly diffusing itself in the air. He also exhibited a portion of the so-called smoke of a charge of 15 lbs. of powder collected in a closed vessel.

Captain Noble next described at some length the experiments made with gun-cotton and gunpowder by Sir Frederick Abel and himself. With reference to the latter he reiterated their opinion that, except for instructional purposes, but little accurate value can be attached to any attempt to give a general chemical expression to the metamorphosis of a gunpowder of normal composition.

He further pointed out that heat played the whole *rôle* in the phenomena. He explained that a portion of this heat, to use the old nomenclature, was latent; it could not be measured by a calorimeter; that was, it had disappeared or been consumed in performing the work of placing a portion of the solid gunpowder in the gaseous condition. A large portion remained in the form of heat, and performed an important part in the action of the gunpowder on a projectile.

After describing the apparatus used by Sir Frederick Abel and himself, Captain Noble illustrated the progress that had been made in Artillery by mentioning that thirty years ago the largest charge used in any gun was 16 lbs. of powder. The 32-pounder gun, which was the principal gun with which the Navy was armed, fired only 10 lbs.; but he had fired and absolutely retained in one of these vessels, no less a charge than 23 lbs. of powder and 5 lbs. of gun-cotton.

The lecturer next referred to erosion and its effects, and added that he was not one of those who advocated or recommended the use of gunpowder giving very high initial tensions. If such a course were followed, much would be lost and little gained. The bores of guns would be destroyed in a very few rounds. There was no difficulty in making guns to

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* A paper read before the Institution of Civil Engineers.

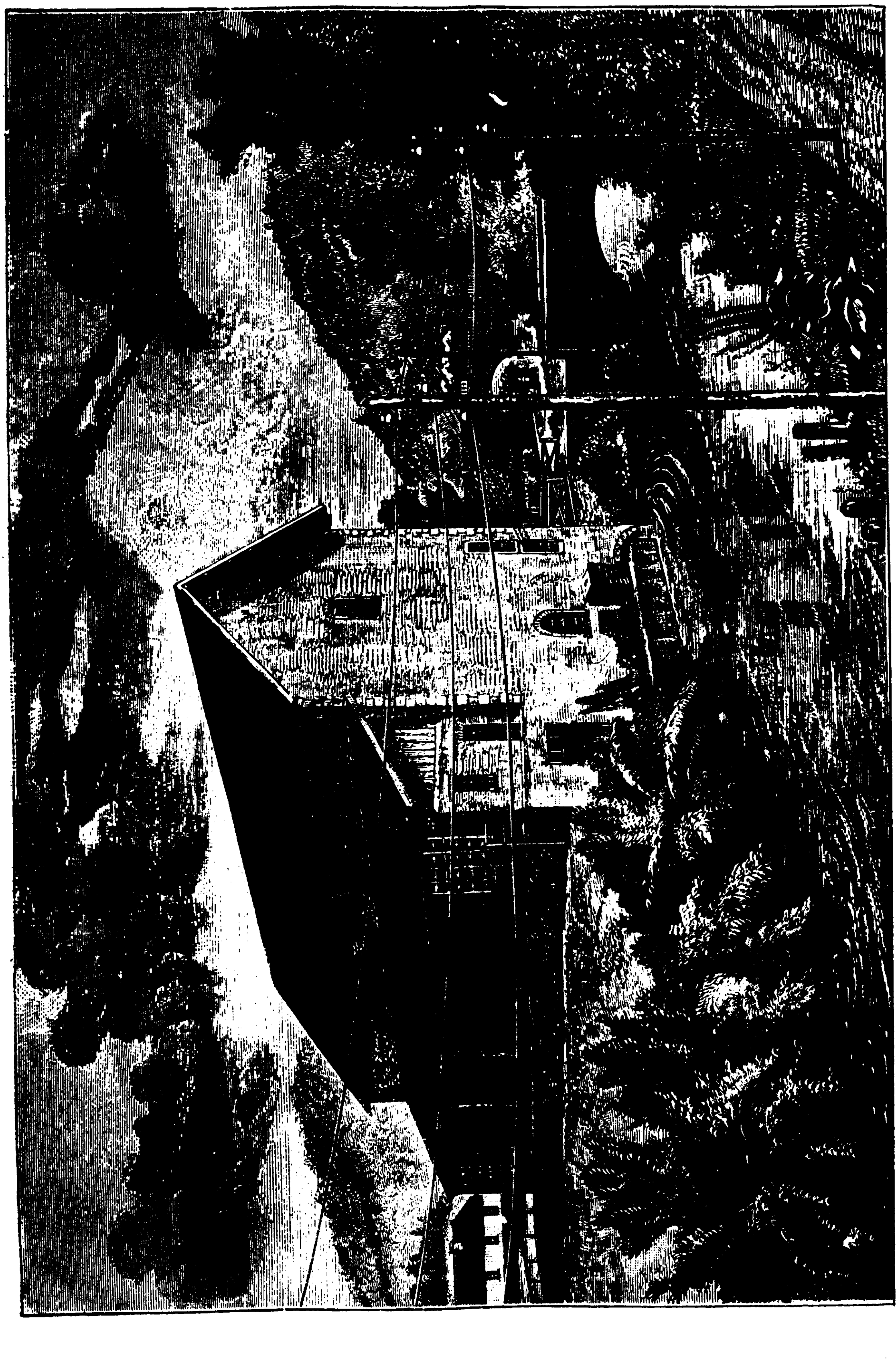
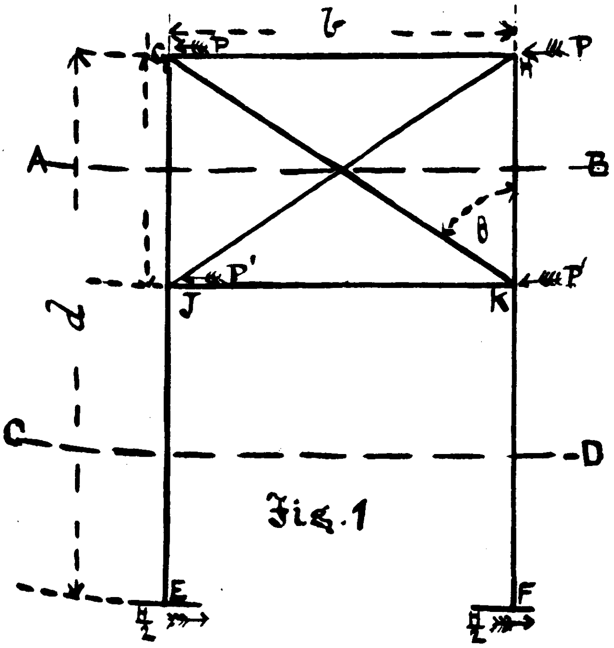
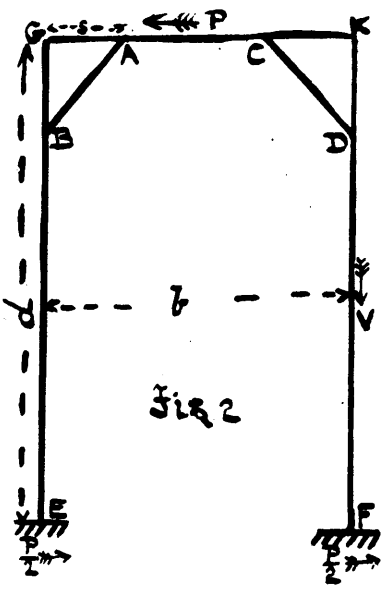


Fig. 13.—Exterior View of the Vizille Installation.

LATERAL SYSTEMS FOR IRON PRATT TRUSS HIGHWAY BRIDGES.





ELECTRIC TRANSFER OF ENERGY.

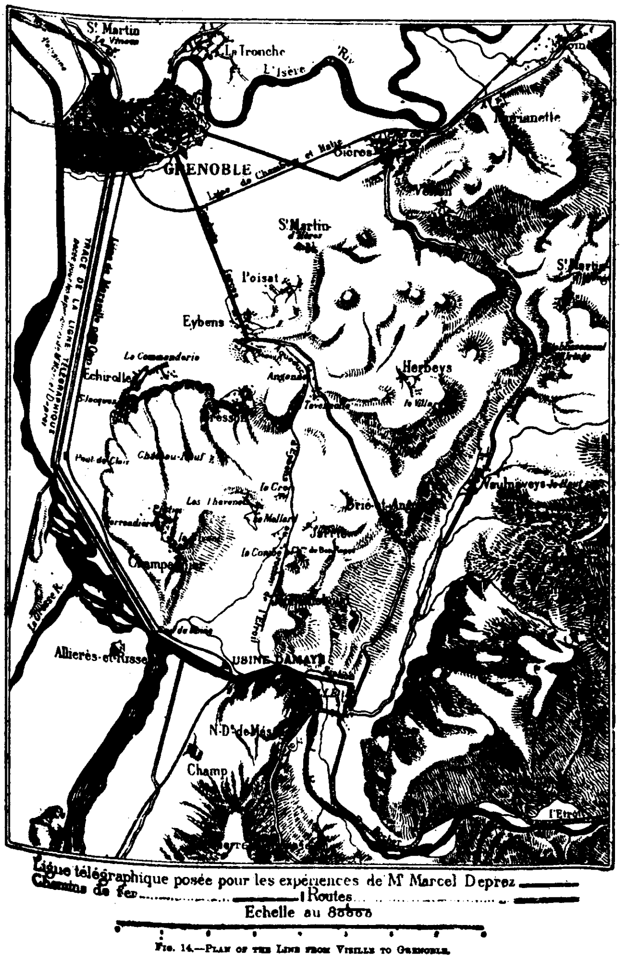


Fig. 14.—Plan of the Line from Vizille to Grenoble.

FIG. 12.

stand pressures much higher than those to which they were normally subjected, but then they must be in a serviceable condition. Nine-tenths of the failures of guns with which he was acquainted had arisen, not from inherent weakness of the guns when in a perfect state, but from their having, from one cause or another, been placed in a condition in which they were deprived of a large portion of their initial strength. He added that, with a given weight of gun, a higher effect could be obtained if the maximum pressure was kept within moderate limits.

He stated that the actual pressure reached by the explosion of gun-cottons experimented with by Sir Frederick Abel and himself, assuming the gravimetric density of the charge to be unity, would be between 18,000 and 19,000 atmospheres, or say 120 tons on the square inch. While at the same density, in a closed vessel with ordinary powder, the pressure reached about 6,500 atmospheres, or about 43 tons on the square inch, he had found it possible to measure the pressures due to the explosion of charges at considerably higher density, and had observed pressures of nearly 60 tons with a density of about 1·2.

The lecturer then considered the case of a charge of gunpowder placed in the chamber of a gun; he supposed the gravi-metric density of the charge to be unity, that it was fired, and that it was completely exploded before the shot was allowed to move. He exhibited on a diagram a curve indicating the relation between the tension and the density of the products of combustion when employed in the production of work; and observed that in this diagram the tension was represented by the ordinates, the expansions by the abscisses, and the energy developed by any given expansion was denoted by the area between the corresponding ordinates, the curve, and the axis of abscisses. He said that if this theoretic curve was compared with the curve deduced from experiments in the bores of guns, after the charge might be supposed to be completely consumed, the agreement was most remarkable, and afforded ample evidence of the approximate correctness of the theory. He had stated that he could not agree with those who were in favour of the strongest—meaning by the term the most explosive—powder manufactured. To show the advance that had been made by moving in exactly the opposite direction, he exhibited diagrams of two guns of precisely the same weight, but differing in date by an interval of ten years. One of these guns was designed to fire the old-fashioned R. L. G., the other, modern powders. The maximum pressure in the older gun was nearly double that in the modern gun, while the velocity developed by the latter was twice, and the energy not far from three times, that of the former; and if the foot-tons per inch shots' circumference were taken to represent approximately the respective penetrating powers of the projectiles, the superiority of the modern gun would be still more apparent. He directed attention, however, to one point. The new gun was as a thermo-dynamic machine much less efficient than the old. This arose chiefly from the fact that although the new gun was absolutely much longer than its rival, it was, taken in relation to the charge, much shorter; that was the gases were discharged at the muzzle at a much higher tension.

It remained to consider the total amount of energy stored up in explosives. In the case of the most important, gunpowder, he stated that the total energy stored up was about 340,000 kilogrammetres per kilogram of powder, or in English measure, a little under 500 foot-tons per lb of powder. He said that if the potential energy of 1 lb of gunpowder was compared with that stored up in 1 lb of coal, his audience being accustomed to the enormous pressures developed by gunpowder, might be somewhat astonished at the results of the comparison. The potential energy of 1 lb of gunpowder was as nearly as possible 1-10 of that of 1 lb. of coal, and 1·40 of that of 1 lb. of hydrogen. It was not even equal to the energy stored up in the carbon which formed one of its own constituents. As an economic source of power coal had the advantage by at least two thousand to one.

He had stated that the total theoretic work of gunpowder was a little under 500 foot-tons per lb. of powder, but it might be desirable to mention what proportion of this theoretic work was realized in modern artillery. He concluded by arguing that were it necessary to urge the claims of the modern science of thermo-dynamics, he might take, as perhaps the most striking instance, the progress of artillery during the last quarter of a century. Twenty-five years ago our most powerful piece of artillery was a 68-pounder, throwing its projectile with a velocity of 1,600 feet per second. Since then the weight of our guns had been increased from 5 tons to 100 tons, the projectile from 68 lbs. to 2,000 lbs., the velocities from 1,600 feet to 2,000 feet per second, the energies from 1,100 foot-tons to over 52,000 foot-tons. Large as these figures were, and astonishing as were the energies which in a small fraction of a second could be impressed on a projectile of nearly a ton weight, they sank into the most absolute insignificance when our projectiles were compared with other projectiles, velocities, and energies existing in nature. Helmholtz had given an estimate of the heat that would be developed if the earth were suddenly brought to rest, but if, looking at the earth in an artillery point of view, and following the principles he had laid down, the earth was considered as an enormous projectile, and if, it was supposed further, that the whole energy stored up in gunpowder could be utilized, there would yet be required a charge 150 times greater than its own weight, or 900 times greater than its volume, to communicate to the earth her orbital motion.

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LATERAL SYSTEMS FOR IRON PRATT TRUSS HIGHWAY BRIDGES.

BY PROF. J. A. L. WADDELL Ma. E.

The bridges treated of in this paper are those of most economic depth and panel length, which dimensions have been already presented to the Club in a paper upon "Economy in Highway Bridges." The portal struts are assumed to belong to the first panel, the first intermediate upper lateral strut with its sway bracing to the second panel, etc., so that when the bridge has an odd number of panels there is no lateral strut or vertical sway bracing given for the middle panel. The 40', 50' and 60' spans being pony trusses, have only lower lateral rods.

Spans above 150' in length have vertical sway bracing.

The wind pressure assumed is 40 pounds per square foot for spans of 100 feet and under, 35 pounds for spans between 100 and 150 feet including the latter, and 30 pounds for all greater spans. It is true that actual wind pressures do occasionally exceed these amounts, but in view of the fact that the chances of any one bridge ever being subjected to such pressure throughout its whole length are extremely small, and that it could receive once in a while a far greater pressure without suffering material injury, if the bridge be properly designed, it seems legitimate to adopt the pressures assumed. Moreover, when a highway bridge is blown down, the actual loss is seldom greater than the value of the bridge. Travellers can cross the stream at the nearest bridge above or below until the structure is replaced; and the fall of the bridge need involve no loss of life, for in the first place no human being would be likely to be upon it in such a storm, and in the second, if there were, he could not escape being dashed to pieces or blown off, even if the bridge were sufficiently rigid to withstand the pressure.

With railroad bridges, of course, it is a very different matter. The delay caused by the loss of a bridge may be much more expensive than the replacing of the structure, besides railroad bridges are subjected to the greatest wind pressure when covered by a train, so that the fall usually involves the loss of human life.

If the lateral systems of highway bridges were to be made as strong as those of railroad bridges, eye bars could be very seldom employed for the bottom chords, because the compression there due to the wind pressure would be far in excess of the tension due to the dead load. Even with the pressures assumed it is necessary to rely upon the stiffness of the joists to prevent the buckling of the bottom chords of at least two-thirds of the iron and combined highway bridges in the United States. Upon this point the writer would refer to an editorial in the *American Engineer* of July 20th, '83 upon "A Neglected Consideration in Highway Bridge Designing," where the effect of wind pressure upon bottom chords is mathematically discussed.

In calculating the area exposed to the wind, the area of the vertical projection of one truss, hand-rail with its posts, hub-plank, guard-rail, and the rectangles described about the ends of the floor-beams was doubled, and to this was added the area of the vertical projection of the floor and joists. As the windward hand-rail and hub-plank would probably fail, the total area thus found is somewhat too great; but such a failure should not be depended upon, when the wind is considered to strike the bridge suddenly.

The areas thus found vary between 6.8 and 7.6 square feet per lineal foot for the portion of the structure below the middle horizontal plane. For spans of 200 or 230 feet and under, the sizes of the upper lateral rods were not determined by the effect of the wind, as this method would make them smaller than experience would indicate to be necessary to give sufficient rigidity to the bridge.

The wind stresses on the lateral rods were calculated for a moving load, instead of one upon the whole bridge, because this method causes the rod towards the centre of the span to be somewhat increased in diameter, besides, it is possible for a portion only of a structure to be subjected to wind pressure, the rest being protected by a hill, a building, or some other neighbouring object. The method of calculating the stresses in the vertical sway bracing is as follows: it is essentially that of Prof. Burr, as given in his treatise on "Stress in Bridge and Roof Trusses." The reason why the demonstration is given here is because of a few changes introduced by the writer.

In Fig. 1 page 173 let *P* be the pressure supposed to be concentrated at the upper panel point on one side of the bridge. It is that which comes upon a panel length of top chord, one-half the area of the diagonals meeting at the panel point and the portion of the post above the plane AB. Let *P'* be the pressure concentrated at one end of the intermediate strut. It is that which comes upon the portion of the post between the planes A B and C D, the latter passing half-way between the intermediate strut and the bottom chords. If the intermediate strut should be at the middle of the post and the main diagonals and counters be coupled on a pin at this point, it would be necessary to divide the pressure upon the main diagonals and counters between the upper, middle and lower points of the posts, the middle point taking one-half, and the others a quarter each.

Let d = depth of truss.
f = vertical distance between upper lateral and intermediate struts.
b = distance between centre of trusses.
And o = angle made by vibration rod with the vertical.

The pressures concentrated at the lowest points of the posts do not affect the sway bracing, so are not considered.

The total pressure $2\,(P + P') = H$ is assumed to be equally resisted by the feet of the posts. It is possible that this assumption is incorrect, for one foot may resist more than the other, but when it is considered that perhaps the whole of the force 2 P passes through the upper lateral system to the pedestal as the feet of the batter braces it will be conceded that the assumption is not upon the side of danger.

If the whole of $2\,(P + P')$ were to be resisted by the feet of the posts, the functions of the upper lateral system would be rather limited, nearly the whole of the wind pressure upon the structure being then carried by the lower lateral system. If such were the case, the lower lateral systems given in the table would all be too weak, which is not likely to be so; for they are much stronger than those usually found in highway bridges. But whether the wind pressure upon the upper part of the trusses is resisted by the upper or by the lower lateral bracing, it is better as far as the sway bracing is concerned, to proportion it, under the supposition that the pressures at the upper panel points are carried thereby to the feet of the posts.

Taking the centre of moments at E, the moment of the wind pressure is—

$$\underline{2\,Pd + 2\,P'\,(d - f),}$$

which can be resisted only by the moment of a released weight *V* upon the foot at F, thus—

$$\underline{2\,Pd + 2\,P'\,(d - f)} = Vb$$

and

$$V = \frac{2d\,(P + F') - 2\,P'f}{b}$$

This release of weight *V* must pass up the vibration rod KG, causing a tension therein equal to

$$V \sec O = \frac{\{\,2l\,(P + P') - 2\,P'f\,\}\ \text{see}\ O.}{b}$$

To find the stress on the strut J K pass a plane through the sway bracing cutting GH, GK and JK, take the centre of moments at G, and consider the forces acting on the left side of the truss, then the moment of the stress in JK will balance the moments of P' and ½ H, thus—

$$(JK) = \frac{\tfrac{1}{2}\,H\,d - P'f}{f} = \frac{d}{f}(P + P') - P',$$

to which must be added the horizontal component of the initial tension in JH.

The stress in the upper lateral strut G H is that due to the wind pressure. considering it as a portion of the upper lateral system, plus the sum of the horizontal components of the initial tensions in the three rods meeting at one of its ends.

These formulæ may be used for the portal bracing by putting for *d* the length of the batter brace, for *f* the distance between centre lines of upper and lower portal struts, for *P'* the pressure on one-half of the batter brace and for *P* one-half the reaction of the upper lateral system, including the pressures concentrated at the hips.

The division of *P* between the two sides does not affect the stresses in the lower strut and vibration rods; it affects only that in the upper strut, which is equal to the transverse component of the stress in the end lateral rod, plus the pressure concentrated at one hip, plus the components in the direction of its length of the initial tensions in all the rods meeting at one end. For any span where the size of the end lateral rod was assumed, the stress in the rod is to be calculated by multiplying the area of its section in square inches by the intensity of working stress, which is seven and a half tons, and omitting its initial tension.

In the discussion the effect of initial tension in the lateral rods is neglected; so the actual compression on the windward bottom chord is even greater than there calculated.

If any bridge is designed with the object of relying upon the joists to prevent chord buckling, it will be necessary to stiffen the chord from end to end. An easy method of accomplishing this would be to truss the two inner chord bars. The compression members thus formed would be neither very elegant nor very strong, but they would be effective enough to resist the surplus compression. Instead of designing highway bridges to resist the greatest recorded wind pressures, is it not better to run the risk of occasionally losing a structure than to make all the bridges so much more expensive.

Exceptions should, of course, be made for highway bridges in unusually exposed situations.

The writer wishes it to be distinctly understood that in advocating the adoption of low wind pressures he does not countenance the building of such miserable apologies for lateral

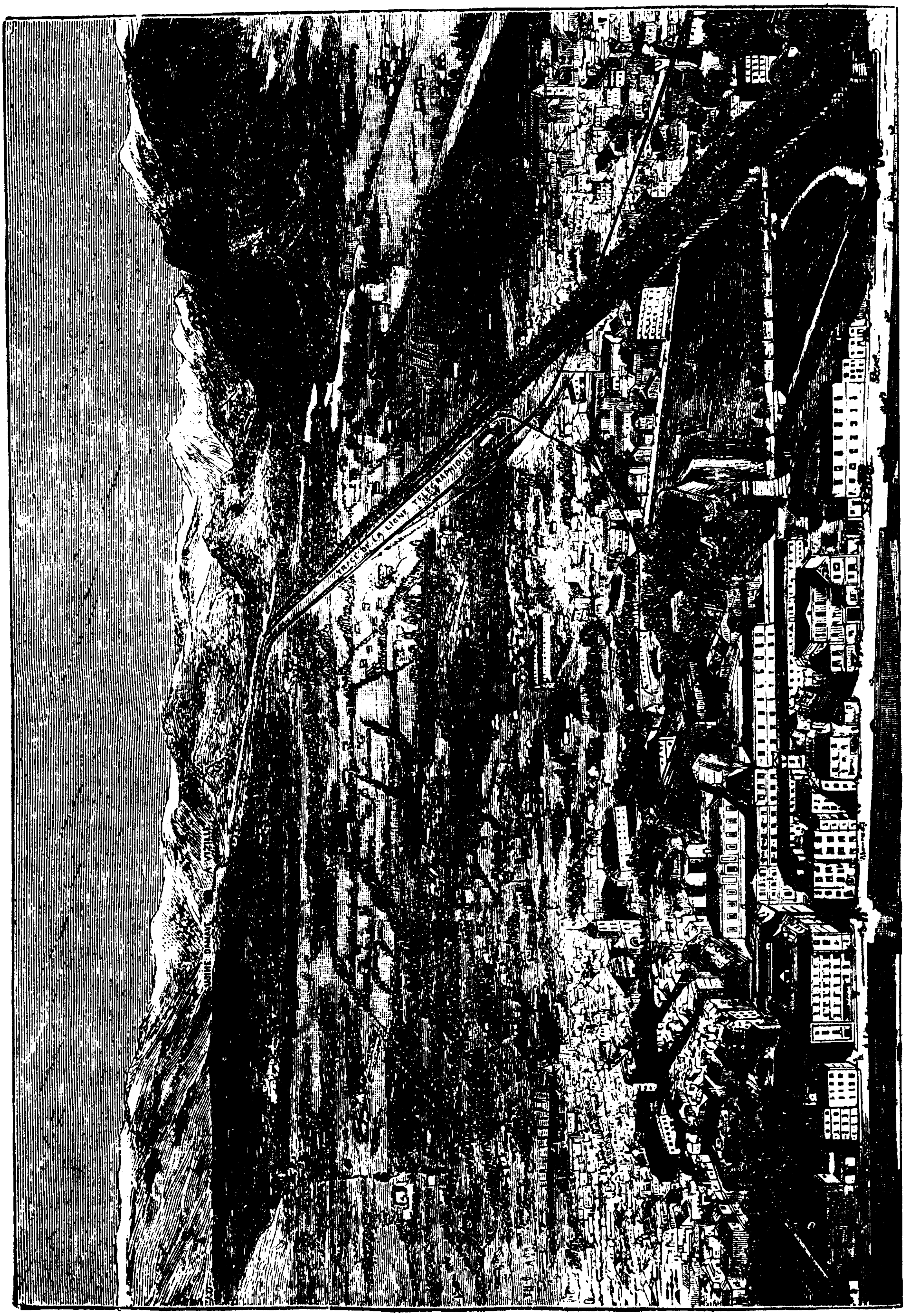

Fig. 15.—Bird's-eye View of the Track of the Line from Vizille to Grenoble.

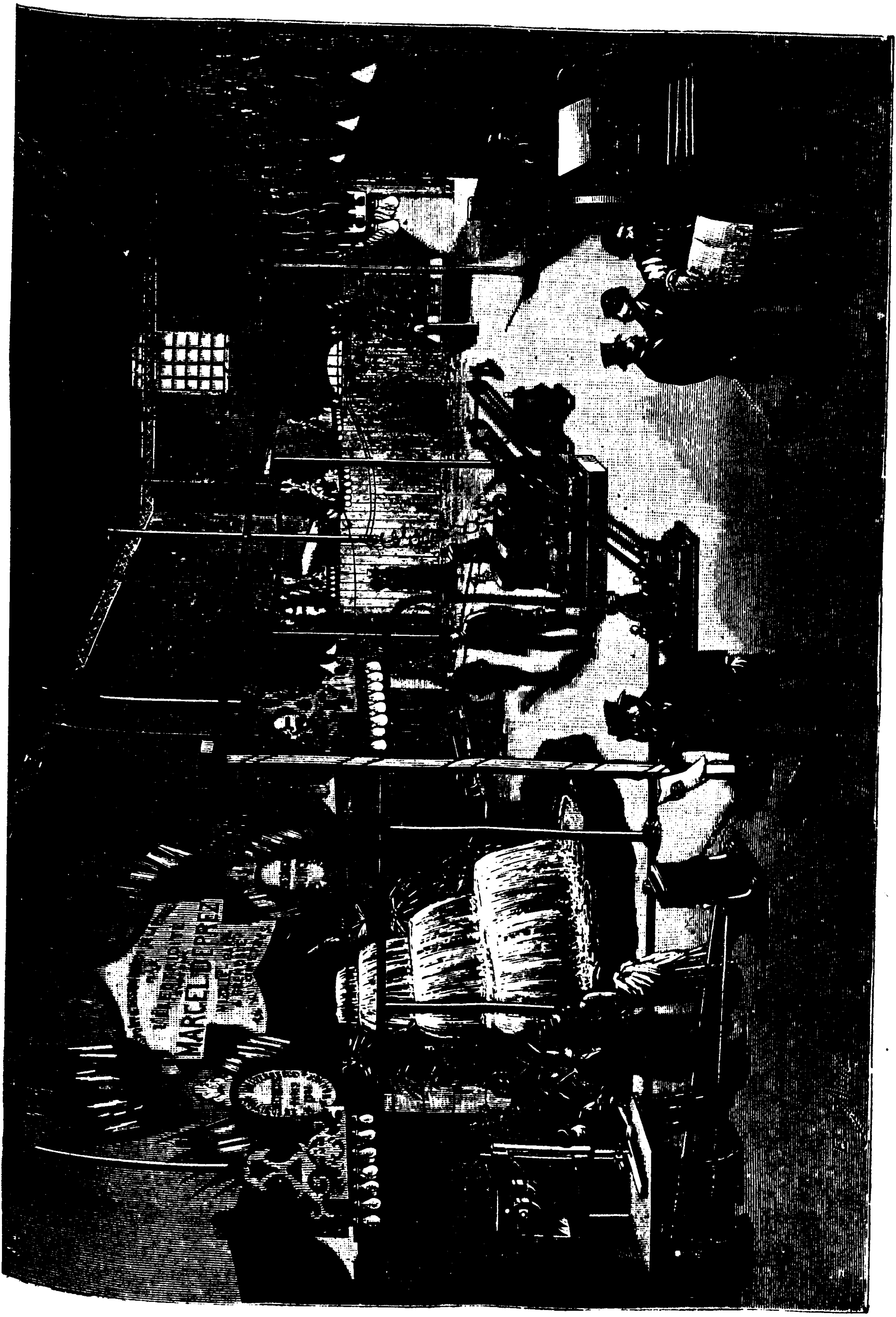

FIG. 16.—INSTALLATION AT GRENOBLE.

systems as one finds in the majority of highway bridges. I beams are not fit for upper lateral struts, especially when they have jaws their ends, nor should ⅝″ rods be employed anywhere in a bridge.

Some of the most flourishing highway bridge companies never figure at all upon the effect of wind pressure, but content themselves with using rods from ⅝″ to 1″ in diameter for all spans under 150′ in length and I beams or even pieces of gas pipe for lateral struts. It is not necessary to add any area to the section of the bottom chord to resist the tension due to wind pressure, unless this tension exceed that due to the live load, for, as before stated, there is no likelihood of travel during heavy winds, nor are any loads ever supposed to remain upon a bridge for any length of time.

For this same reason the bending effect of the wind upon posts and batter braces is neglected, unless it produce a greater stress than that due to the live load.

But the bending effect upon portal and lateral struts where no vertical sway bracing is used, is much greater than the effect of the direct pull of the lateral rods. It is only lately that the writer has fully appreciated the magnitude of the bending stresses in these members.

The area of bridge per lineal foot was calculated from a number of diagrams of stresses and sections, and was divided between the upper and lower lateral system by supposing a horizontal plane to pass through the middle of the posts and assuming that all the pressure above this plane is carried by the upper lateral system and all below by the lower lateral system.

This may be a correct assumption and may not, but it is as likely to be correct as any other. Where vertical sway bracing is used, the division of wind pressure becomes still more ambiguous, but as before the same assumption is as likely to be correct as any other.

As the stress thus found for the upper portal strut is only a little in access of that found for the lower, the size of the latter has been made equal to that of the former in the table. When there is no vertical sway bracing, stiffness is obtained by the use of knee braces or brackets A B, C D, Fig. 2, making angles of about forty-five degrees with the vertical. Let the notation be as shown in the figure, *V* being as before the relief of weight at F. *P* is the sum of the pressures at K and G.

Taking the centre of moments at E gives $Vb = Pd$ and $V = \frac{Pd}{b}$

Again taking centre of moments at A gives the value of the bending moment *M* on the strut at that point, thus

$$C = M = \frac{Pd}{2b}(b-2s)$$

Let *h* = the distance between the centres of gravity of the two channels of which the upper lateral strut is composed, then the bending stress

$$C = M = \frac{Pd}{2bh}(b-2s)$$

The intensity of working bending stress for this case was taken equal to six tons, so that

$$\frac{C}{6} = \frac{Pd}{12bh}(b-2s)$$

the number of square inches of area to be added to each channel in order to resist bending.

The intensity of direct working stress was taken from the well-known formula,

$$P\left(4 \div \frac{H}{30}\right) = \frac{f}{1\cdot + \left(\frac{H}{c}\right)^2}$$

which is a little too strong for lateral systems; but this will be a grand fault, as it will add a little stiffness to the bridge. The total area of each channel is equal to sum of the areas required to resist bending and that to resist direct compression.

The stress in the knee-brace A B is calulated by taking the centre of moments at G and making the moment of its stress equal to the algebraic sum of the moments of *V* and ½*P*. As before to make these formulæ applicable to a portal make *d* equal to the length of the batter brace and *P* one-half of the sum of the pressures concentrated at the upper panel points. All lateral and vibration rods were proportioned by using the following table, which gives the allowable stresses—in tons of 2,000 pounds upon the rods after the initial tensions have been deducted, also the initial tensions.

Dia. in.	Working Stresses.		Initial Tensions.		Dia. in.	Working Stresses.		Initial Tensions.	
	....	....	....	....		....	....	....	....
¾	2.815	3.574	0.500	0.635	1.11-16	14.399	18.342	2.375	3.016
13-16	3.261	4.157	0.625	0.794	1¾	15.540	19.794	2.500	3.175
⅞	3.760	4.789	0.050	0.953	1.13-16	16.726	21.305	2.625	3.334
15-16	4.303	5.481	0.875	1.111	1⅞	17.959	22.874	2.740	3.493
1	4.890	6.230	1.000	1.270	1.15-16	19.237	24.503	2.875	3.651
1.1-16	5.525	7.038	1.125	1.429	2	20.562	26.190	3.000	3.810
1⅛	6.205	7.904	1.250	1.588	2.1-16	21.933	27.935	3.125	3.969
1.3-16	6.931	8.830	1.375	1.746	2⅛	23.349	29.739	3.250	4.128
1¼	7.704	9.814	1.500	1.905	2.3-16	24.812	31.603	3.375	4.286
1.5-16	8.523	10.856	1.625	2.064	2¼	26.321	33.524	3.500	4.445
1⅜	9.387	11.956	1.750	2 223	2.5-16	28.875	35.504	3.625	4.604
1.7-16	10.298	13.117	1.875	2.381	2⅜	29.476	37.541	3.750	4.763
1½	11.253	14.335	2.000	2.540	2.7-16	31.123	39.640	3.875	4.921
1.9-16	12.256	15.611	2.125	2.699	2½	32.815	41.795	4.000	5.080
1⅝	13.304	16.947	2.250	2.858	2.9-16	34.554	44.009	4.125	5.239

The distance G A = *s*, Fig, 2, was assumed equal to 4 feet for narrow roadways, and 6 feet for wide ones, values for intermediate roadways being interpolated. Curved brackets are used in bridge-designing, but if anyone will calculate the stress in a bracket, he will no longer think of curving it for the sake of appearance.

Brackets are also used below intermediate struts both for appearance and to aid the I beam strut to resist bending in its weakest direction, so that in proportioning it the length may be taken as the distance between the points of attachment of the brackets.

The details used for the lateral systems are shown on the accompanying plate. As can be seen there, the upper lateral strut is composed of two channel bars, either laced or latticed, the upper resting on the chord plate and rivetted thereto, and the lower attached to the lower flange of the inner chord channel by a connecting plate in the form of the letter T.

The upper lateral rods are connected by bent eyes to the pins and pull against short short pieces of channel which are rivetted to the channels of the lateral struts.

The intermediate struts are I beams having their webs horizontal and connected to the webs of the inner post channels by bent plates. The vibration rods are connected to the upper lateral and intermediate struts by bolts. The portal struts are connected to the webs of the inner batter brace channels by bent plates. Where vibration rods are used at the portals the webs of the portal strut channels are made parallel to the length of the batter brace, and the rods, of which there are four at each portal, are attached to pins passing through the ends of the struts. Where there are no vibration rods at the portals, the flanges of the portal strut channels are made parallel to the direction of the batter-braces, and the distance between the channels is increased so as to give a greater leverage to resist the bending moment on the strut. The lower lateral struts are of wood usually 8 x 8 in. upon which rest the joists, so that the lateral rods pass beneath and attach by bent eyes to the chord pins, or, if more than 1¾ inches in diameter, to vertical pins dropped through the jaws, by which the lateral struts are connected to the chord pins. The lateral struts are also firmly bolted to the upper flanges of the floor beams, upon which they rest.—(*Eng. Club of Phil.*)

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

RESEARCHES OF M. MARCEL DEPREZ.

Summary of Experiments.

(Continued from page 139.)

(*For illustrations see pages* 172, 173, 176, 177, 180 *and* 182.)

It was forgotten in this comparison that the latter were machines with alternating currents, but the others continuous current machines. The difference of the physiological effects is very great, an alternating current having a tension of 600 volts is almost certainly fatal, whilst a continuous current of 1,900 volts, if not free from danger, does not kill*

The report drawn up by the Commission of the Academy of the Academy of Sciences concludes as follows: "In fine, the results obtained by M. Marcel Deprez, conformable in every respect to the theoretical principles which ought to guide engineers, surpass by far all that had heretofore been accomplished, by the magnitude of the work transmitted, in comparison with the resistance of the transmission conductor, and are, moreover, remarkable for the mechanical yield obtained.

"The Commission is not prepared to judge the economical value and the industrial future of the results obtained; but, from the thorough examination which they have made of the apparatus and the principles brought into play, they do not hesitate to proclaim the importance of the facts which they have been enabled to verify.

"In consequence, they propose to the Academy of Sciences to congratulate M. Marcel Deprez on the important progress which he has effected in the solution of the interesting problem of the electric transmission of energy, and encourage him to pursue his lobors, continuing, as hitherto, to place the resources of an ingenious mind at the service of the best established principles of electrical science."

Number of the Experiment.	NUMBER OF REVOLUTIONS per minute.		MECHANICAL WORK.		NET YIELD.
	Generator.	Recipient.	Supplied at the Generator.	Collected at the Recipient.	Transmission deducted.
1	378	104	3·838	0·578	0·176
2	370	88	3·854	0·489	0·147
5	850	602	9·771	3·344	0·435
6	923	709	10·556	3·939	0·477
7	850	643	9·514	3·572	0·482
8	1,024	799	12·267	4·439	0·456

The advance made, as compared with the Munich experiments, was certainly considerable; the force transmitted was increased from one-fourth to four and a-half horse-power, the yield had risen from 30 to 48 per cent.; the distance, though less, was still, in effect, considerable, and the two stations were, in fact, in the same electrical relations* as if at the distance of 8·5 kilometres from each other.

In reality, as we know, they were not separated; the Commission had made special electric measurements, showing that the influence of this arrangement was nil, and that the machines acted quite as if they had been at a distance; nevertheless, this gave scope for criticism. It must be added that, in consequence of the circumstances already mentioned, the experiments had to be made rapidly; the high velocities could only be maintained during the time necessary for taking account. Scientifically the results were obtained; industrially speaking they might require confirmation.

M. Marcel Deprez, however, had no intention of resuming these trials with the machines which he had used. Such as they were, the experiments made on the North of France Railway, joined to the numerous laboratory experiments, were sufficient for determining the proper construction of machines for transmitting great powers to long distances; he went to work, therefore, to prepare practical models.

Fig. 13 shows that there were three wires; the two upper served for the power, and the lower for communications. There were at first two telegraphic stations, but even before the commencement of the public experiments there were placed there two telephonic stations on Adee' system, which furnished an extremely conveuient means of correspondence, and greatly facilitated the experiments.

We may add that in the public experiment which were made, the use of this telephone was a great attraction. Many persons requested permission to hear it, and at the end of each experiment the public took particular pleasure in seeing the results of the day exchanged, and orders for the morrow given by means of the telephone.

Fig. 15 gives, on the plan of the neighbourhood of Grenoble, the track followed by the line. Fig. 14 is a bird's-eye view of the country traversed. The line runs in the splendid valley of Gresivaudan, along a promenade named the Boulevard Saint-André, which extends nearly 10 kilometres, almost to the Bridge de Champs. It leaves the the torrent of the Drac at its junction with the Romanche, and still following the road, ascends the valley of this latter torrent as far as the cement works. The resistance of this circuit was found to be 150 ohms.

The receiver was in the centre of Grenoble, in an ancient building called the old market-hall, and which was once a Church. The site was very large and high, but nnfortunately badly covered, as was discovered too late. The upper storey was perforated with large openings, the frames of which hed disappeared long ago. In fine weather this was charming, and a delicious coolness pervaded the hall. But in bad weather the cold wind from the mountains, and the rain, raged fiercely. One day it was necessary to break off the public experiments because there fell in the hall nearly as much rain as in the neighbouring square. The engineers' warned by experience, feared lest the machines might get wet. This circumstance is mentioned here in proof that the weather was not uniformly favourable. On the oontrary, the work was carried on in rough weather, and even in the midst of a heavy storm. Cold or hot, foul or fine, dry or wet, the machines did not seem affected, and went on always equally well.

Before requiring any work from the machines they were of course tried. To this effect the receiver was fitted with a Prony brake, and instructions were given to the station at Vizille to start at a velocity of about 500 revolutions, increasing slowly up to 1,200 or 1,300, which speed was to be kept up, and to work for an hour, unless a signal to stop was sent from Grenoble.

The trial gave full satisfaction. We saw with pleasure the work received rising from 3 to 4, and then to 5 horse-power, thus exceeding former results, and then still increasing to about 5 horse-power, at which it remained during the whole time of the experiment.

It was then certain that the machines were in very good condition, that they were doing excellent service, and that they could be depended on.

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*[M. Geraldy is evidently misinformed on this point.—Eds. Elec. Rev.]

* [Our readers will doubtless remember our criticisms on the method adopted of joining up these machines, a method manifestly unfair and misleading.—Eds. Elec. Rev.]

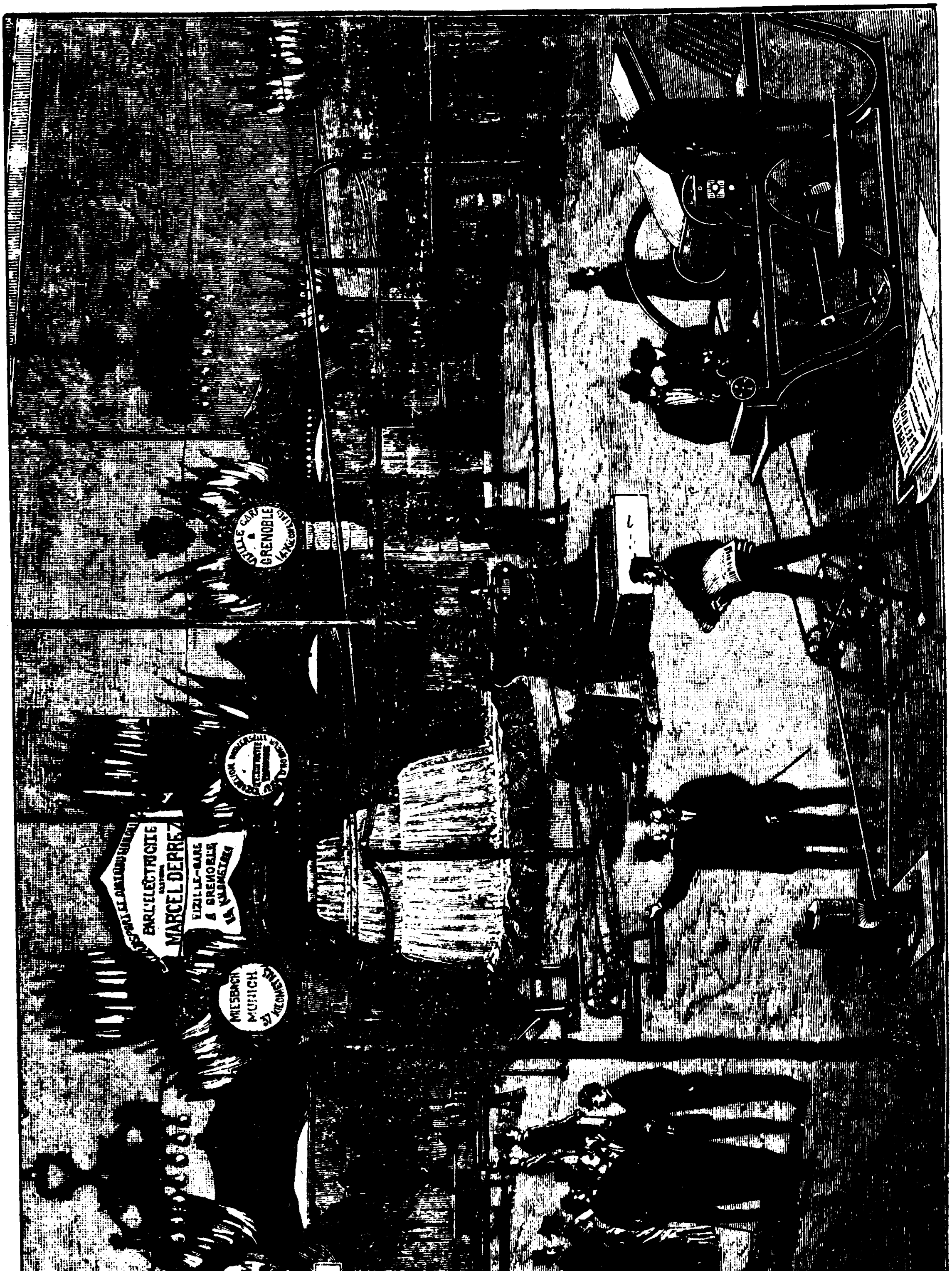

FIG. 18.—INSTALLATION OF THE DISTRIBUTION OF POWER AT GRENOBLE.

Fig. 17.

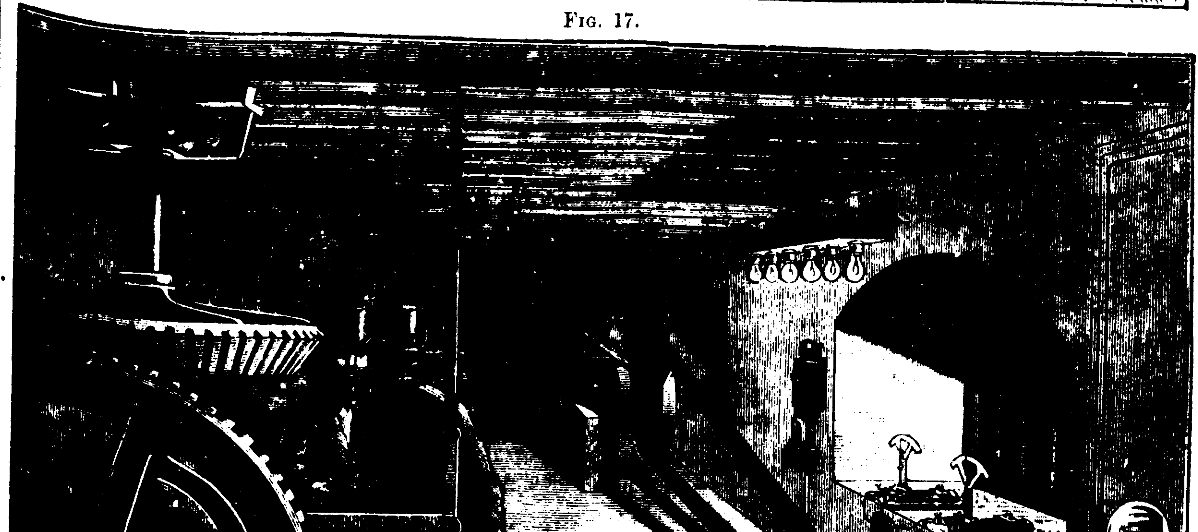

Fig. 20.

To begin with, the receiver was merely set to work a rotatory pump, feeding a cascade. Under these conditions it was far from exerting its entire force. They worked at a low speed at Vizille, and about 2 horse-power were received at Grenoble. This was a pretty experiment, fit to interest the public. We proceeded thus daily for about a fortnight, from 2 to 4 p.m., during which time the Municipal Commission was organized.

A commission has been nominated to waten the experiments. The Mayor of Grenobse, desirous of complete information, had chosen a number of engineers, and having assembled them under the presidency of Captain Boulanger. had commissioned them to furnish a report.

A practical study was especially wanted. Exact information was required on the forces transmitted and expended ; on the regularity of working on the industrial possibilities ; the electric data were regarded as interesting, but secondary ; the means were not so much the object of inquiry as the results.

Above all, dynamometric measurements were to be taken. At the arrival station this involved no difficulty ; the Prony brake which had been used on the North or France Railway, having been refitted, was used again. At the departure station the difficulty was greater ; we had there no transmission-dynamometer. These instruments are very rare. Further it must be said the ona which had been used on the North of France Railway, and which could at need have been procured, was not thought fully trustworthy. It had been constructed for moderate volocities, and when set in action at the speeds which the electric machines require, it only admitted of registrations of a very short duration, at most 30 seconds. The Grenoble Commission purposed making less rapid studies. There might be an advantage in a change of method, and recourse was therefore had to a process of substitution. The commission has given in its report a detailed account of this means. It is in principal as follows:—On the transmission-shaft, moved by the turbine, there was placed a Prony brake. Its position is shown in Fig. 10, and its appearance is repre-presented in Fig. 17. This apparatus, which is very strong, was in constant action, moistened by a stream of water mixed with oil and soap. Its friction was thus rendered very constant, and it worked with great regularity. Its sensitiveness was ascertained by dint of very precise experiments.

The turbine was then set in movement ; its work was completely absorbed by bringing it to a given speed, the electric machine being disconnected up to this moment. The *régime* being once established, the generator was connected, and by taking away weights from the scale of the brake, the velocity was brought back to the same pitch. The total work did not vary, as the turbine remained in the same condition. Consecquently- the weights removed from the brake represented exactly the portion of the total work absorbed by this machine.

There were three series of operations on three different days ; each of them occupied an entire day. The speed of the machine being varied within very wide limits. About three operations were made hourly, each of them lasting about twenty minutes. It was no longer a question of computations taken rapidly, as in the experiment on the North of France, but of series and prolonged examinations. We give below the table of the last experiments, which were naturally the most precise,

Number of Experiment.	Revolutions of Generator.	Motive Work transmitted to the Generator.	Rsvolu- of Recipient.	Available Work collected at the Recipient.	Yield.
H 1......	780	6·97	484	3·30	47·3
2......	730	8·20	446	3·75	43·2
3......	732	8·96	406	3·69	31·1
K 1......	865	8·39	614	4·19	50·3
2......	865	9·82	586	4·66	47·4
3......	875	11·05	558	5·08	45.9
L 1......	946	8·40	712	4·86	57·7
2......	954	10·10	686	5·46	54·0
3......	570	11·46	662	6·92	52·5
M 1......	1,040	9·69	830	5·66	58·3
2......	1,040	11·08	778	6·19	50·8
3......	1,050	12·33	734	6·68	54·1
N...1......	1,227	11·18	865	6·97	62.3

It will be seen how superior are the results to those obtained on the North of France Railway.

The resistance of the circuit was about the same, but it was represented by a longer line, exposed, consequently, to more chances of loss.

As this question of losses on the line had been a great subject of discussion on which precise information was wanting, a direct experiment was made to show what was the value of the losses. For this purpose there were employed voltameters with plate of silver and nitrate of silver—a very accurate method. It was found in two successive experiments that the mean proportion of these losses was, in round numbers, 5 per cent. which is a very reassuring result, and when in the experiments on the North of France these losses were considered as admitted of being overlooked, it is certain that a proportion of this kind was understood. It is in fact a loss which may be considered as without practical influence upon the working of the apparatus.

As for the theoretical deductions which may be drawn, it must be remembered that the line used at Grenoble was in the most ordinary or rather inferior, condition, and that in an installation where the losses threatened to be inconvenient, it would be easy to diminish them greatly by taking extra precautions.

The experiments relating to the transmission were quite sufficient from a dynamo-electric point of view, there is added a summary of the electric elements so as to give a complete notion of this transmission.'

This was the whole result which it was proposed to obtain. The Commission, however, wished to go further, and requested the engineers in charge to add to transmission that of distribution. This did not enter into the programme. It was quite impossible to effect a distribution at a distance, as nothing had been arranged for that purpose. It is known, in fact, that in order to affect this distribution of electricity, M. Marcel Deprez used machines having two coils, the one of which received a current proceeding from a special exciter, or from a derived current taken from the working circuit. The generator at Vizille had not two coils, and there was no suitable exciter. There was no receivers which could work with currents at a high tension. In short, nothing could possibly be done in the way of a distribution effected from Vizille, which, we repeat, had not been in question. All that we had of this kind was the old material which had been used in the Exhibition of 1881, which might serve to effect a distribution on the spot. It was sent for, which was all that could be done to satisfy the Commission. It was necessary to arrange the distribution at Grenoble, with a special motor. The idea was then taken up of using as a motor the receiver of the transmission. It was remarked at once that this arrangement was incomplete, and could not be adapted to measurements. In fact, to effect distribution requires that the generating machines should always be working at the same speed, whatever the work required. This pre-supposes a motor fitted with a regulator, and always retaining its velocity.

This was not the case with the receiver, which, according to the duty imposed upon it, slackened or accelerated its speed. Still this distribution, effected by a double electric transformation, was a brilliant experiment. well calculated to strike the public, and it was fitted up accordingly. Fig. 18 gives an idea of the work-room thus organised. The receiver in the middle of the hall worked on the one hand the pump feeding the cascade, and on the other the two generating machines for the distribution. The current produced by the latter went round the hall, giving off at different points derived currents, supplying small Siemens machines, which worked a lathe, a saw, a printing-press, and a glow-lamp. All these implements acted effectively and independently, On the press was struck off a single number of a journal describing the experiments, Fig. 19. The whole was then thrown open to the public, and acted daily with great regularity, from 2 to 4 p.m. The work collected was about 6 horse-power.

On coming to the experiments of distribution, as a motor of a regular speed was required, a locomotive was substituted for the receiver. It was thus proved that the distribution was effected with very satisfactory regularity.

To complete the demonstration of the applicability of transmitted electric energy to all uses an illumination was got up. The hall was lighted with 108 Edison lamps, forming nine groups of 12 lights each. On the other hand, at Vizille, a group of 12 lamps illuminated the machine, and served as evidence. Fig. 20 gives an idea of the station of departure, and 31 shows, very imperfectly, the fine effect of the hall lighted up and filled with an admiring crowd.

The machines were then taken down and sent off in a perfect state of preservation, ready for resuming work.

In addition to the striking numerical results found and reported there was obtained by these researches a great sense of security. All who had been present at this experiment, so prolonged that it might be regarded almost as an industrial application, went away with the conviction that the practical period had opened, and that success was ensured.

Some time after the end of the trial M. Marcel Deprez received the following document from Grenoble :—

"*Extract from the Register of the Municipal Council of Grenoble.*

"The Mayor made the following communication to the Council :—

"Gentlemen,—I have the honour of depositing at the office the Council a copy of the report of the commission appointed to examine the experiments which took place at Grenoble in September last on the transmission and distribution of power by electricity by M. Marcel Deprez.

"By occasion of this report, which has been distributed to you, permit me to remind you that the experiments in question have fixed the attention of the learned and of the industrial world, and that they have been the subject of an official communication at the Academy of Sciences. The eminent perpetual secretary concluded his note with the following words, which I have pleasure in reproducing :—

"'These new experiments have been completely successful, and the town of Grenoble may claim the honour of having taken the first step in a path repeatedly marked by the encouragements and the good wishes of the Academy of Sciences.'

"In order to consecrate the memory of these experiments, I have the honour of proposing, gentlemen, that you express your gratitude to the illustrious savant who has chosen your town to give there a public proof of the results of his precious discoveries.

"The proposition of the Mayor was put to the vote and carried unanimously.

"Edouard Rey,
"Mayor of Grenoble."

Notes.

The Local Heliostat.—At a recent meeting of the Royal Society of Dublin, Dr. Johnstone Stoney, F. R. S., exhibited one of his heliostats on Gambey's principle, but designed for use within a limited area such as Great Britain, and hence called a "local" heliostats. The limited range enables the instrument to be simplified ; a form of sun-dial enables it to be placed in the meridian ; and a polar axis driven by a common clock at the rate of one revolution in twenty-four hours carries an arm whicd trammels the mirror as in Gambey's holiostat, so that the reflected ray continues in the direction of a bar which can be placed in any azimuth. The sunbeam is thereby reflectep to the same distant point, whatever the position of the sun.

A New Phenomenon of Electrolysis.—Dr. G. Gore, F. R. S., recently announced to the Royal Society that he had made the following observation of what appears to be a new pheeomenon of electrolysis. Dr. Gore found that on passing an undivided electric current through a series of portions of the same metallic solution, that cathodes composed of different metals of equal amounts of immersed surface, required currents of different degrees of density to cause deposits of the same metal upon them, and that the differences in some cases were considerable. Another singular circumstance was also observed, viz., that the cathode which most readily received a deposit was frequently the one composed of the same kind of metal as that which was being deposited.

Concrete water pipes of small diameter, according to a foreign contemporary, are used in parts of France, notably for water mains for the towns of Coulommiers and and Aix-en-Provence. The pipes were formed of concrete in the trench itself. The mold into which the concrete was stamped was sheet-iron about two yards in length. The several pipes were not specially joined to each other, the joints being set with mortar. The concrete consisted of three parts of slow-setting cement and three parts of river sand, mixed with five parts of limestone debris. The inner diameter of the pipes was nine inches ; their thickness three inches. The average fall is given at one in five hundred ; the lowest speed of the current at one foot nine inches per second. To facilitate the cleaning of the pipes, man-holes are constructed every one hundred yards or so, the sides of which are also made of concrete. The trenches are about five feet deep. The work was done by four men, who laid down nearly two hundred feet of pipe in a working day ; the cost was about ninety-three cents per running yard. It is claimed as an advantage for the new method that the pipes adhere closely to the inequalities of the trench, and thus lie firmly on the ground. When submitted to great pressure, however, they have not proved effective, and the method, consequently, is only suitable for pipes in which there is no pressure, or only a very trifling one.

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THE STRENGTH AND ELASTICITY OF STRUCTURAL STEEL.

BY JAMES CHRISTIE, M.A.S.C.E.

He said that the various grades of steel possess such a range of physical properties that it is impossible to consider the metal as one might treat of iron. It is customary to denominate the grades of steel by the percentage of carbon they contain. The higher the carbon the higher the tenacity of the steel and the lower its ductility. Steel whose carbon is below fifteen hundredths per cent. is conventionally known as mild or soft steel. The steels subjected to the tests described in this paper were of two distinct grades—mild and hard ; both being products of the Bessemer converter. the hard steel having thirtry six hundredths per cent. of carbon, and the mild steel twelve hundredths per cent. The tensile tests were made on strips about 24 inches long, to which were clamped plates exactly 12 inches apart. The compression tests were made on specimens 12 inches long, inserted in a tube and the space between the specimens and the tube filled with fine sand. The tests on transverse resistance were made on bars of 3 or 4 inches diameter and on solid flanged beams from 3 to 12 inches deep, all being supported at the ends and loaded in the middle.

Extended tables were then presented of these various tests, and it was stated that the results showed that the elasticity of steel and iron is practically uniform ; the steel may stretch less than the iron in tension, but the steel shortens most under compression.

Transversely, if there is any practical difference, the advantage in stiffness probably belongs to steel, but the elasticity of both metals is so close and uncertain that further experiments may modify the average results here found. The specimens show that the elastic limits for tensile and compressive stress for the different grades of steel are practically equal per unit of section, and the transverse resistance is approximately proportionate to the longitudinal resistance, and that the strength of the material indicated in tensile stress will serve as a comparative measure of the absolute strength of iron, or of either grade of steel ; but as the transverse elasticity is practically alike, beams of iron or of either grade of steel of the same length and section, will deflect alike under equal loads below the elastic limit of iron.

Tables were presented of experiments on flat ended struts of both mild and hard steel. It was stated that the experiments on direct tension and compression prove that the elastic limits of steel of any particular grade are practically equal per unit of section for either direction of stress. A similar equality is known to obtain with iron. Therefore, for the short struts in which failure results from the effects of direct compression, the tensile resistance of the material will serve as a comparative measure of strut resistance. As struts increase in length, the lateral stiffness becomes a factor of increasing importance.

The transverse elasticity of steel and iron does not vary much. The tendency will be for struts of steel and iron to approach equality of resistance as the lengths are increased. Mild steel will fall to equality with iron when the ratio of length to least radius of gyration is about 200 to 1. Hard steel would fall to practical equality at the point beyond the bounds of practice.

This paper, and the paper previously presented by Mr. Christie, giving experiments on the strength of wrought iron struts were then discussed.

Mr. A. P. Boller expressed the opinion that the variations in the compressive resistance of iron shown by these very careful experiments were so great that it was impracticable from them or from any other experiments so far as had yet been made to prepare a formula which would ever give satisfactory results, and that dependence must be placed upon experimental charts which will express extreme values for all sections progressively determined.

Mr. Onward Bates considered that the experiments developed the great importance of placing the centre line of pressure coincident with the centre of the struts. If this could be done perfectly, a round-ended strut would be as good as a flat-ended one. In actual practice in the construction of bridges, the methods of securing the ends of such struts are so various, that it is impracticable to make from such experiments a table of safe loads. The only safe practice is that of low unit strains corresponding to the lowest results of recorded tests.

Prof. E. A. Fuertes considered that the areas of cross-sections should be obtained by direct measurement instead of deriving them from the weight and length of the bars, particularly when the specifix gravity of the material is not determined. The reason why an accurately centered straight bar behaved as a flat-ended strut when hinged, is due to the friction developed by pressure on the bearing of the hinge, and the early failure of flat-ended struts was probably due to the want of parallelism between the planes at the extremities, or the one or both of these planes being warped surfaces. Since a bar very long in proportion to its radius of gyration fails with a comparatively light load without permanent injury, it would seem proper that such load should be given a name other than ullimate load, the latter being restricted to its bearing on the elastic limit.

Mr. Theodore Cooper considered the experiments of Mr. Christie most valuable, particularly in carrying out a complete series with different end connections upon the same class of materials. The paper shows that slight changes in the direction of the lines of applied forces produce great changes in the results. By interchanging different sizes of ball and socket-joints it shows the influence of the size upon compressive resistance of the struts. It gives a more complete knowledge of the action of struts of high ratios of length to transverse dimensions than before existed. The method of using the least radius of gyration instead of the least dimension, gives a fair comparison between the various forms. Attention was called to the relation of the ball and sockets to the transverse dimensions of the struts, and diagrams were presented by Mr. Cooper showing the influence of the size of pins relative to the width of the struts. From the great effect of non-centering the line of applied force upon columns and of initial, though minute, bends in the materials, and the increased influence of possible side blows, it is very important not only to keep the working strains within proper limits, but also to specify a limit to the number of diameters to be used in all columns. In recent specifications this limit has been about of 45 diameters, corresponding approximately to about 120 radii of gyration for the usual forms of bridge columns. With this proviso a practical formula may be reduced to very simple forms.—(*Am. Soc. C. E.*)

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DRAINAGE AND GOOD HUSBANDRY.

C. G. ELLIOTT

Plans for Locating drains.

In determining the position of lines for tile drains, give attention to the slope of the surface of the field or farm, for with a few exceptions the water in the soil drains in the same direction as that on the surface. To ascertain the most effective system of drainage, follow the general flow of surface water after a heavy rain. Systematize these surface courses, so as best to economize material and labor.

One general prtnciple is applicable to almost all cases, viz., that drains should extend up and down the slope. Many think that by extending a drain across a slope, water coming through the soil from above will be intercepted by the drain and thus be prevented from passing further toward the foot of the slope. Practice has proven this to be a mistake. Lines for conveying the drainage water may be located at right angles to the slopes if placed so far down in the bottom land that the grade of the drain is greater than the slope of the surface at the side, as a few facts will show. Water oozes through the soil along the line of steepest descent, at all times seeking a lower place where it can remain at rest. If a drain is placed across this course of soil water, the descent of the soil channels being greater than that of the drain, water will flow out of the joints of the drain and continue to ooze through the soil, only a small part being conveyed away by the drain. Place the drains up and down the slope, and all water coming into the drain will be carried away quickly, and little currents induced to flow toward the drain from both sides.

While the above refers particularly to hill-sides requiring draining, it is also applicable to flat land having any slope whatever. There are sags, swales, and ponds into which an outlet tile must be run by the most feasible course; after that our general rule applies.

General Plans.

Drains should be located according to the requirements of the land indicated above, and yet in order both for economy and efficiency, some plan or system must be adopted. No little thought and care are needed to determine the plan, that the work may be complete without being unduly expensive.

Random Drainage.

This is the system first practiced in the West, and in many places the only one still used. It is simply laying the drains in the natural depressions as shown in Fig. 1. This deserves the name of system only because in many kinds of soil drainage is thus made quite complete. The rules to be observed in this kind of drainage are: Locate the drains in the lowest land, making as long curves as possible where curves are necessary; use large tiles, and provide a free outlet. Where the soil can be easily drained sn this way, water passes very quickly to the lower levels, where the drains are located, thus compelling them to carry large streams of water for a short time. For this reason more complaint is made of the incapacity of the drains than where more frequent drainage is necessary.

Gridiron System.

This is the old and generally practiced system where thorough drainage is carried out. Systematic drainage generally implies the location of parallel drains at uniform distances over the entire field. Thorough drainage, however, is so removing water from the entire field as to secure uniform moisture and texture in ordinary conditions of weather. Where the soil is alike in the tenacity with which it holds moisture, the system should be uniform, and every part of the ground brought under the direct influence of drains at regular intervals. But when the soil varies, or the surface is diversified by ponds, sloughs, and draws, thorough drainage means lines with reference to the different conditions. The gridiron system consists of equidistant parallel lines with mains and sub-mains for collecting and conducting the water to the point of exit. It is economy to have the laterals enter the main at right angles, but for completeness and efficiency they should so enter that the currents of the two streams will coalesce and increase rather than retard the flow in the main.

Double Main System.

This is applicable in broad, flat sloughs where it is desirable to use two lines of smaller tile instead of one large main through the centre. It is sometimes necessary to diverge the lines toward the head, making two systems, and running laterals into each from both sides. In draining hillsides and wet slopes it is best to lay lateral drains down the slope, at such intervals as are required, discharging into a collecting drain. In such cases have the collecting drain near the base of the slope, that the laterals need not pass through a flat bottom, which would retard the flow. But locating mains in this way, note that unless the slough slopes but little toward the centre line, one centre main of sufficient capacity gives better results. There are cases where this system may be followed advantrgeously both with respect to cost and efficiency, while in others it would prove expensive and faulty.

The Grouping System (Fig. 4,)

consist in so dividing the field into small drainage sections, that one outlet will serve for each division. It may be employed when the land consists of alternate high portions requiring no drains, and low places to be reclaimed. By this plan, the dry land may be left dry, and the wet land drained by laterals converging toward the lowest part of the section

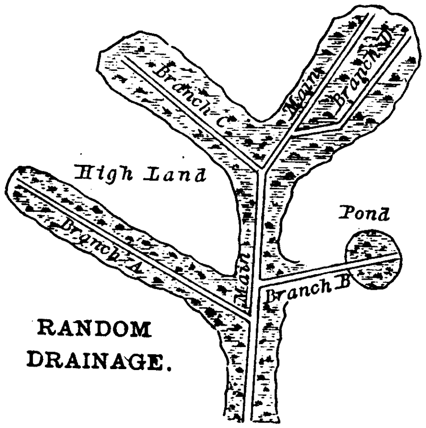

FIG. 1.

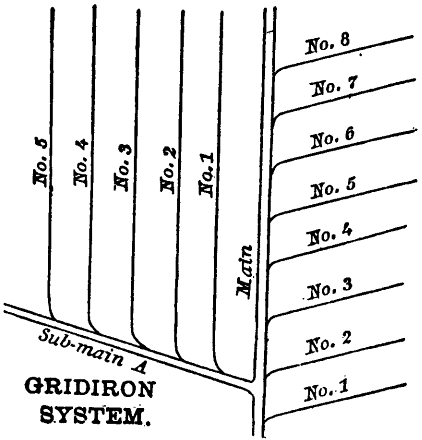

FIG. 2.

through which a main should pass. This system may sometimes be used when it is desired to reduce the number of outlets.

These different systems, or modifications of them, may be used as the land may require. It is safe to say that there is no piece of land requiring drainage to which some of them will not apply. Much may be saved in outlay and gained in efficiency by a careful consideration of a plan which shall meet the case. "Plan well and execute carefully," is a motto worthy the attention of every land drainer.

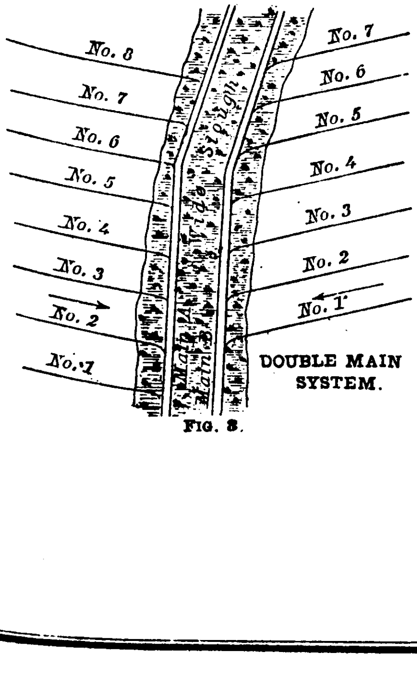

FIG. 3.

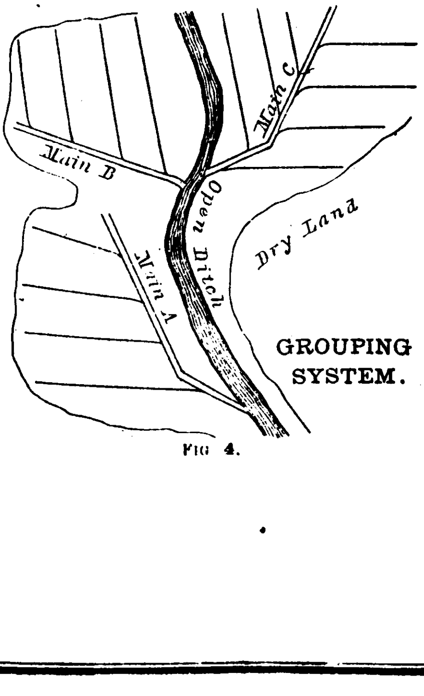

FIG. 4.

"ON THE ANTISEPTIC TREATMENT OF TIMBER."*

BY MR. S. B. BOULTON, ASSOC. INST. C.E.

The author commenced by referring to a paper by his late partner, Mr. H. P. Burt, Assoc. Inst. C.E., on the subject of Timber-Preserving, which had been read at the Institution in 1853. Since that date the use of Antiseptics for the treatment of timber had greatly increased. The process called creosoting, or the employment of the heavy oils of coal-tar had almost entirely displaced the other methods, whilst the manufactures connected with residual products of gas-making, from one of which residuals the creosote-oils were derived, had experienced an enormous development. The author's connection, during thirty-four years, with this group of industries enabled him to offer the results of some personal experience and research, which he presented, together with those arrived at by other instigators.

An historical description of the Antiseptic treatment of timber was preceded by a few notes on the methods pursued by the Ancients for the preservation of wood and other perishable materials. The Ancients were well acquainted with the manufacture and use of many kinds of oils, tars, and bitumens; and frequently used them for the preparation of wood, with respect to which some notable instances were cited. The methods employed by the Egyptians in embalming their dead were dwelt upon at some length, and the author endeavoured to elucidate some discrepancies in the description of these processes, as recorded by Herodotus and Diodorus Siculus. The researches of Pettigrew were alluded to, particularly his interesting experiment upon the heart of a mummy, which, after three thousand years' preservation, began immediately to putrefy, when the Antiseptic substances were removed by maceration. This appeared to prove that no chemical transformation had taken place, but that the long immunity from decay had been the result of the abiding presence of the Antiseptic.

The growth of theories upon the causes of putrefaction was traced down to the commencement of the present century, reference being made to the "Phlogiston," and other exploded theories; also to the opinions of Macbride, Sir Jno. Pringle, Sir Humphry Davy, Thomas Wade, and others, and to their suggestions upon timber-preserving. The progress of timber-preserving during the railway era, and particularly between the years 1838 and 1853, was described with especial reference to the competition between the four most successful of the processes. These four consisted in the employment of Corrosive Sublimate, Sulphate of Copper, Chloride of Zinc, and Heavy Oil of Coal-Tar, which had been patented in England respectively by Mr. J. H. Kyan, Mr. J. J. Lloyd Margary, Sir Wm. Burnett and Mr. John Bethell.

The distinction was pointed out between the red creosote, a product derived from the distillation of wood, but which had never been employed for injecting timber, and the so-called creosote which had been so successfully used for that purpose; the latter being a heavy oil produced from the distillation of gas-tar. The thoory that certain Antiseptics preserved timber by coagulating the albumen. and by forming insoluble combinations with the woody fibre, had been advanced on behalf of all the four processes alluded to. But in spite of some acknowledged success, the Kyanizing, Margaryzing and Burnettizing systems were not found to be so durable in their effects as creosoting. Indeed the salts of metals were gradually washed out of timber exposed to the action of water. On the other hand the success of the creosoting process became completely established.

In order to show the process of manufacture of the creosote-oils, a short description was given of the ordinary methods of tar-distilling. Coal-tar, a black viscous substance, was a residual product of gas-making. It was split up by a preliminary process of distillation into three groups of substances, namely:—

1. Oils lighter than water, containing the napthas, benzoles, toluois and other bodies, from some of which the aniline dyes were manufactured. This series of oils have never been used for timber-preserving.

2. Oils heavier than water; the dead oils or creosote-oils of the timber-yards. These oils contained a great variety of different bodies, the properties of some of which were described, including carbolic acid, cresylic acid, napthalene, anthracene, crysene, pyrene, quinolene, leucoline, acridine, cryptidine, &c.

3. Pitch, the residuum of the distillation.

The creosote-oils varied in their characteristics in different districts, according to the nature of the coal used in the gas-works, and to the varying temperatures at which the coal was carbonized. The type of creosote called "London Oil," made from the tars derived from the coal of the Newcastle District, was contrasted with the co-called "Country Oil," typical of the product from the tar of the Midland and other coals. The former contained less of the carbolic and cresylic acids than the latter, but more of the semi-solid substance, which solidified within the pores of the timber, and more of the Antiseptics which did not volatilize except at exceedingly elevated temperatures. The history of the controversy as to the respective merits of the two types of creosote oils was fully gone into. The carbolic and cresylic acids had been recognized as potent Antiseptics; their presence appeared to arrest the action of all destructive germs, and the lighter and thinner Country Oils, which contained a comparatively large percentage of these tar-acids had therefore been preferred by many. The opinion of Dr. Letheby to that effect was recorded. On the other hand were cited the opinions and practice of the introducers of creosoting and of the earlier operators in thst process, who used in preference the heavier types of creosote; and the early success of that creosote, both in England and in tropical countries, appear to confirm their judgment. A number of experiments were then alluded to, stretching over a long series of years, and conducted by investigators in this and other countries, for the purpose of ascertaining which of the component portions of the creosote-oils were the most durable and efficient agents in preserving timber. The results of these experiments appeared to show that it was not to the tar-acids, but to the heavier and least volatile portions of the creosote, and to those bodies which solidified within the pores of the timber, that the most durable results should be attributed. This apparent anomaly was explained by reference to numerous eminent authorities upon carbolic acid, who, whilst extolling its action as a most useful and powerful Antiseptic for sanitary and surgical purposes, were in general agreement as to its possessing the following characteristics:—That it was exceedingly volatile at ordinary temperatures, that it was readily soluble in water, and that its combinations with other bodies, including albumen, were not stable. It would therefore readily evaporate from timber exposed to the heat of the sun, especially in warm climates, and it would be washed out of timber in contact with water. The author's personal experience and experiments fully bore out the conclusion, that the use of the heavier and least volatile portions of the creosote-oils should be encouraged, and that from them the most durable results might be expected. Moreover, it was pointed that recent investigators had discovered in these heavier oils, bodies, which, if perhaps less potent, were more durable in their Antiseptic effects than carbolic acid. By judicious selection and admixture, both London and Country Oils could be usefully employed. Shale-oil and bone-oil, however, and other oils lighter than water, should be excluded.

The modern germ theory was discussed in its relation to time-preserving, and was believed by the author to be a more practical explanation of the action of Antiseptics upon wood than the older theories, as to the coagulation of albumen and the formation of insoluble compounds. With respect to all bodies which had been extensively used for timber-preserving, their durable results appeared to be in an inverse ratio to their volatility in the atmosphere and their solubility in water. The germ-theory constituted a severe but salutary test in choosing Antiseptics for the treatment of wood. In the author's opinion the substances preferred should be not only germicides but germ-excluders; those being the best which were least soluble in water, least volatile in air, and most capable of becoming solid within the pores of the timber.

A description followed of the various kinds of apparatus which had been in use during the present century for injecting timber with Antiseptic liquids. The paper concluded with some remarks upon the subject of the hygrometic condition of timber at the time of injection, failures having repeatedly arisen owing to the timber being too wet at the time of creosoting. The author dwelt upon the importance of this subject, describing also his experience with various methods of getting rid of superfluous moisture artificially, and of a process which he had recently inaugurated, by which this result could be obtained in the creosoting-cylinder itself, without injury to the timber.

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* A paper read before the Institution of Civil Engineers.

The paper was illustrated by diagrams showing the most important products derived from coal, and the apparatus for coal-tar distillation and timber-preserving; also by tables, giving the properties of coal-tar products and other substances, of timber-preserving specifications, and of more than one hundred references to various authorities upon the topics alluded to in the paper.

Miscellaneous Notes.

Pipes Made of Steel Plates.—Pipes made of steel plates are coming into use in England for the conveyance of water under high pressure. The plates are coated with lead on both sides by immersion or otherwise, then rolled to form, rivetted, soldered the whole length, and covered with pitch. Of this method the first cost, it is said, is not much greater than that of iron, and the steel pipes possess considerable advantages over those of iron.

A Highly Elevated Railroad.—The Pike's Peak Railway, which will be in operation next year, will be the most notable piece of track in the world. It will mount 2,000 feet higher than the Lima & Oroya Railway, in Peru. It is now in operation to a point over 12,000 feet above the sea level. The entire thirty miles of its length will be a succession of complicated curves and grades, with no piece of straight track longer than 300 feet. The maximum grade will be 316 feet to the mile, and the average grade 270 feet. The line will abound in curves from 500 to 1,000 feet long, in which the radius changes every chain.

The Corinth Canal.—The Isthmus of Corinth has been disturbed from its sleep of centuries, and is now the scene of very active engineering operations, a new town, called Isthmia, of at least 200 houses and stores, having risen on the shore of the Gulf of Ægina. The dredging of the approaches of the canal has been commenced on each side at the rate of some 5,000 cubic mètres of sand and soil every 24 hours, while great numbers of workmen are employed on the central portion, the conveyance of the material being provided for by a railway of 15 kilomètres in length, four locomotives, and 150 tip-waggons. Two large dredging machines have also just arrived from Lyons, which will work to the amount of 13,000 cubic mètres per day.

Tamping with Plaster of Paris.—Plaster of Paris makes a very efficient and safe tamping, the peculiar advantage being the abolition of the tamping bar and the consequent danger of explosions resulting from its use. The plaster is mixed to the proper consistency with a little clean, dry sand and poured into the hole. With proper attention the tamping will set in a few minutes, and little more time is required than for tamping in the usual way. It is also found that in many cases the placing of an elastic cushion of some compressible substance just above the cartridge produces goods effects. All danger of cutting the fuse in tamping is also removed entirely by the use of plaster of Paris.

The Refraction of Waves.—At the Birmingham meeting of the Physical Society, on May 10, Professor J. H. Poynting exhibited an experiment designed to illustrate by means of water waves the refraction of waves when they pass from one medium to another in which the velocity is different. The apparatus consisted of a tank 2 ft. 6 in. square with a plate glass bottom. Water is poured into the tank to a depth of, say, 5 or 6 millimetres. The lid of the tank consisted of a calico screen and was slightly tilted uy. A naked lime-light placed under the tank threw on to the screen a picture of the waves in the water. Plate of glass 3 or 4 millimetres thick were placed in the tank, thus reducing the depth of the water. If waves were now sent across the tank they travelled more slowly across the shallower water over the plates and were seen to be refracted. When circular or lenticular plates were employed it was easy to show that the refracted waves converged to a focus.

Sanitation in New York.—An interesting experiment is just now being made in New York with a view to the utilization of the street sweepings and house refuse of that city. A large machine has been erected by a stock company at the East River Wharf of the street cleaning department, which sifts and reduces to its elements all refuse of whatever description, which is brought to it. The average amount of stuff which is brought to this wharf is estimated at 40 loads per diem, but it is claimed that the machine could deal with more than three times that amount in a working day of 10 hours. By an ingenious arrangement all scraps of paper, rag, coal, cinder, glass, iron, &c., become separated, these are afterwards sold, with the exception of coal and cinder, which are used for firing the engine. The projectors estimate that every load of 1,800 pounds of refuse contains about 400 pounds of coal and cinder which is more than sufficient for their own purposes. The residum refuse is cremated and the ashes are discharged into the sea. So far, it is said, the experiment has proved an entire success, and the promoters announce their intention of having machines at every city wharf to utilize all the refuse of the street cleaning department with profit to themselves and the city. Should these anticipations prove well founded a solution will be offered of a problem which has long perplexed New York. The system of the disposal of of refuse which now prevails is most unsatisfactory, the whole of it being carried some way out to sea in scows and then discharged. Year after year the pilots raise warning cries respecting the enormous injury which is being to the harbour's mouth by the accmulation of ashes and street dirt there, and a radical change of method has long been sought.

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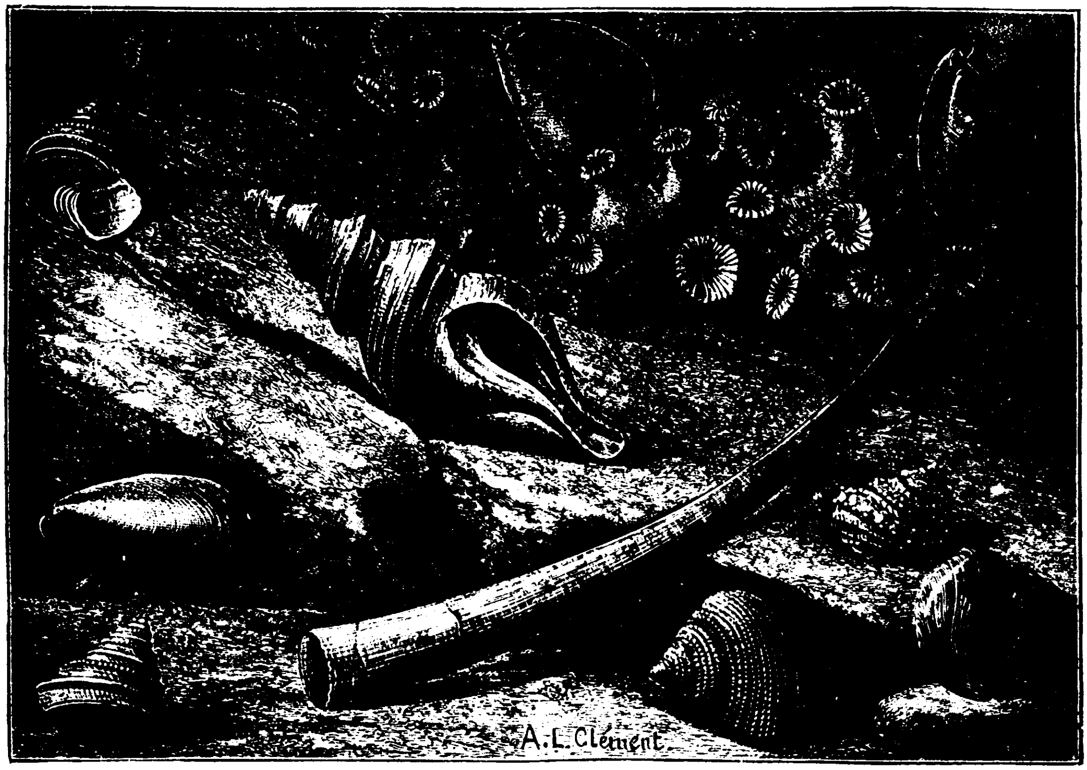
INVERTEBRATES OF THE TALISMAN EXPEDITION.

In a communication to the French Academy, Dr. Paul Fischer observes, that, during the voyage, attention was directed especially to determining whether the deep-sea fauna of the tropical seas is peculiar to the geographical region, or derived by emigration from arctic seas. By dredging in a north and south direction in the eastern Atlantic, and comparing the results from different latitudes with those obtained by others in northern seas, it was hoped to arrive at a satisfactory solution of the problem. The line upon which work was done extended from the mouth of the Charente, over thirty degrees of latitude, to Senegal.

It is known that the superficial and abyssal faunae of the seas of tropical Africa differ greatly. The genera are not the same: their respective assemblages have no parallel relations. If the remains of these two contemporaneous faunae were fossilized, it might be supposed that they belonged to two different epochs, or represented the population of two uncommunicating seas. The abyssal fauna of the coasts of the Sahara, Senegal, and islands of Cape de Verde, contains a number of mollusks common to the arctic seas which have an immensely wide distribution. Such are Troschelia berniciensis, Chrysodomus islandicus, Scaphander puncto-striatus, Lima excavata, Malletia obtusa, Limopsis minuta, Syndosmya longicallis, Neaera arctica, N. cuspidata, Pecten vitreus, and P. septem-radiatus. These range from Iceland and Finmark, or northern European seas, in comparatively shallow water, southward to various points on the line, terminating at Senegal. A blind Fusus was dredged in over twenty-five hundred fathoms. These instonces are sufficient to show the extension of arctic forms into tropical regions, but with these are found a great number of mollusks yet unknown in the North Atlantic. The abyssal fauna of the African coasts is therefore not composed solely of arctic immigrants. Lovén has shown that the arctic species range at greater depths as they advance southward,—a fact confirmed by other naturalists, and by the researches of the Talisman party. It is probable, therefore, that the idea now generally entertained by malacologists is correct, that the range of these animals is determined by temperature rather than by the intensity of light or other factors. The investigations of the Talisman have considerably enlarged the number of Atlantic stations for mollusks reputed peculiar to the Mediterranean. Among these are Cassidaria tyrrhena, Umbrella mediterranea, Xenophora mediterranea, Carinaria mediterranea, Pyramidella minuscula, Pecten pes-felis, Spondylus, Gussoni, and a number of others. Dr. Fischer concludes that the Mediterranean has very few peculiar species, and appears to have been populoted in great part by colonists from the Atlantic, after the geological period in which communication with the Indian Ocean was cut off.

Lastly, the expedition obtained some of the remarkable forms first signalized by the U. S. fish-commission from deep water in the North Atlantic, among which may be muioneedt Pholadomya arata, Mytilimeria flexuosa, etc.—(*Science.*)

W. H. Dall.



DEEP-SEA MOLLUSKS LIVING AT A DEPTH OF FROM 1,500 TO 2,500 METRES. (Taken from *La Nature*.)
Calliostoma, Modiola, Fusus, Dentalium, Turbo, and Terebratula are represented.

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

By E. A. Butler.

Our aquatic insect fauna is both extensive and interesting. The habits are varied and the forms peculiar in consequence of the structural modifications rendered necessary for their adaptation to an aquatic mode of life. They can, moreover, be easily studied, even in the home, by help of suitable aquaria, and, hence, we hope that a few papers devoted to their consideration may be not unacceptable. The insect inhabitants of a pond constitute tolerably well-defined groups, differing according to the area of their distribution. You find one set almost exclusively on the surface, which they rarely leave either for excursions into the depths below or the air above; another in the middle depths, where they disport themselves in all directions, occasionally also visiting both top and bottom, and even escaping upwards into the rarer element; another on the bottom, where they grovel amongst the mud; another, again, round the margin, where, like children at the seaside, they dabble about in the wettest parts, and even let the tiny ripples play on their very feet; and yet another, gracing with their presence the air above the pond, scudding about in search of the two great desiderata of an insect's life, food and mates. We will first turn our attention to

The Surface,

The fauna here is almost exclusively Hemipterous, consisting of bugs belonging to the remarkable section *Hydrodromica*, or Water-measurers. These curious beings will have attracted the attention of even the most unobservant. Blackish spider-like creatures floating on the surface, and jerking themselves rapidly along by vigorous strokes of their long thin legs, leaving little rippling eddies behind them, they will have excited wonder by the apparent impossibility of their submersion, and by the confidence with which, therefore, they trust themselves to what is, to most creatures, the treacherous element. It is not easy to catch them; they are wary and shy, and can calculate with considerable exactitude the area of pond surface that can be covered by the water-net of the expectant biped on the bank, whom they seem to take a delight in tantalisingly watching from just outside the charmed circle. Let him hide behind a bush and wait till they appear on the other side, and then come round with a dash and a swoop of the net—they are equal to the emergency, and before the weapon can reach the surface, a few bold strokes of those long slender legs have carried them in an instant out of harm's way.

Cautious attempts, however, after a time result in the enclosure in the net of some stray individuals less wary than their fellows; but even then their ultimate capture is not a foregone conclusion—those same spindleshanks come to their assistance again, and, unless their would-be captor is vigilant, with a few bold leaps they will be out of the net, and hopping off in all haste through the grass to the water, which, once reached, they will sail gayly away. Suppose, however, we have managed to secure a specimen of the commonest species, *Gerris lacustris* (Figure 1). Let us proceed to examine it. It is a blackish creature, with an orange edge to its narrow body, and a little over $\frac{1}{3}$ inch in length. The head is prolonged into the customary beak, characteristic of the Hemiptera, bent back as usual underneath the body. The wings lie so closely along the back as almost to escape observation, but if we can manage to open them, we find that the upper pair are opaque and tolerably stout, but the under pair thin, membranous, and semi-transparent. They are very neatly packed away, and the upper pair overlap at the tips. Turning the creature over on its back, we notice that underneath it is closely covered with tiny hairs, which in certain lights shine like polished silver, but in others appear of a dull grey. The legs are six in number, but the antennæ, lying close to the front pair, and almost equalling them in size, give the insect the appearance of having eight legs, like a spider; the front pair are short and rest upon the water at their tips, being extended beyond the head, where they are extremely useful in securing prey; the second pair are much the longest and constitute the rowing organs—they are slender, and look like stiff bristles bent twice at an angle; the third pair are similarly constructed, but, being shorter, do not in any way interfere with the powerful strokes of the others, and are used as rudders.

The attachment of the rowing legs to the body, instead of being placed underneath, as is almost universally the case with insects, is thrown well out at the sides, a peculiarity which enables the little rower to use its muscular power to the best advantage. The general appearance of the creature is not particularly attractive; in addition to the dinginess of its colour, the various modifications of its limbs give it, when off the water, an ungainly aspect, which seems to suggest that the owner of such slender appendages must have an anxious time of it to guard them from fracture; but Nature is always prepared to sacrifice elegance and symmetry for the sake of utility. A close inspection, however, reveals many points of beauty besides the silvery hairs, notably some coppery scales, dotted here and there over the upper surface. The eyes are prominent, and no doubt give their possessor a wide range of vision, which it greatly needs, for, living as it does at the junction of two media, it is exposed to the attacks of foes in the air above and in the water beneath.

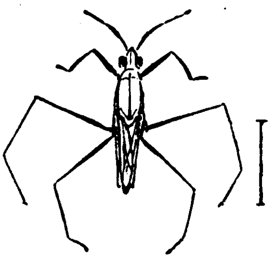


Fig. 1. Gerris lacustris.

The Gerridæ live by sucking the blood of other insects, which they can catch by pursuing and leaping upon them. Even on the water they possess considerable saltatorial power, and when themselves fleeing from their persecutors, if the ordinary rowing does not effect their escape with sufficient rapidity, they will expedite their flight by a few wild leaps.

Ten species of the genus inhabit the fresh waters of the British Isles, two of them occurring only in Scotland. The largest kinds can with fully outstretched rowing legs cover a width of 2¼ in. of water, and are gifted with proportionately rapid powers of locomotion. Like most of the Hydrodromica, all the genus are gregarious, scores of the smaller kinds being often seen dotting the surface of a suitable corner of a pond. Insects somewhat similar are known to exist on the surface of the sea, out in mid-ocean, where, hundreds of miles from land, they spend their whole lives. It is curious how very few insects proper are associated with salt water, though the fresh-water fauna is abundant.

Closely allied to the Gerris group, but differing considerably in appearance and method of locomotion, is the strange insect named *Hydrometra stagnorum* (Fig. 2). This is one of the narrowest of all British insects, and reminds one of the exotic "walking-stick insects" on a small scale: its legs are as fine as hairs, and even its body, with a length of half-an-inch, does not exceed, at its widest part, one-twenty-fourth of an inch in diameter. It does not jerk itself along after the manner of a Gerris, but actually walks or runs upon the surface of the water; it is most frequently found close to the margin of the pond, where it alternates between land and water, equally at home on both. In consequence of their extreme slenderness, they easily escape detection, and half-a-dozen may be walking on the water, just under one's eyes, without being noticed at all.

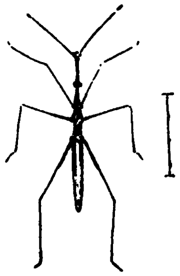


Fig. 2. Hydrometra stagnorum.

This insect exemplifies a remarkable peculiarity often met with amongst the Hemiptera. It will be remembered that the progress of development in bugs is such that no quiescent pupa stage intervenes between the active larval form and the adult insect; the pupa differs from the perfect form principally in the absence of wings, and from the larva in faint indications which form a suggestion or promise of those organs. Occasionally, however, the ultimate form does not acquire wings, but remains "undeveloped," thus greatly resembling a pupa, so much so, indeed, as to have deceived entomologists again and again, until it was discovered that these apparently immature forms were sexually mature, a condition that may usually be accepted as proof that an animal has reached its ultimate state. In all orders of insects there are apterous forms, but the Hemiptera are specially remarkable in two respects, viz., that there are various degrees of imperfect development in different species, ranging from an entire absence of wings to their perfection in all but some minute part, and that these conditions prevail in a large proportion of species. Out of a total of 420 species of British bugs, about 60 occur more or less imperfectly developed. Species thus imperfect when mature, occasionally, from causes at present undetermined, assume in certain individuals the completely winged form, but such instances are, as a rule, rare. The present insect possesses only the merest rudiments of wings.

(*To be continued.*)

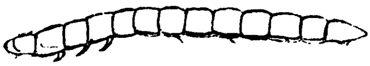


Fig. 1.—Wireworm, magnified.

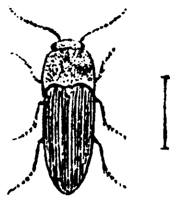


Fig. 2.—Click Beetle. *Agriotes obscurus.*

WIREWORMS AND SKIPJACKS.—(*Knowledge.*)

BY E. A. BUTLER.

In turning up the soil round garden plants, we sometimes find a stiffish, elongated, shiny, yellowish-brown, worm-like thing, about the thickness of a stout pin, and about three-quarters of an inch in length. Under the impression that any living creature found in garden-soil is an intruder that should be summarily disposed of, we may proceed to endeavour to put these ideas into practice, only, however to find that this is not quite so easy a matter as it seemed; the thing is so stiff and tough, that even a good hard squeeze seems to make but little impression on it. This tough, worm-like thing is a wireworm (Fig. 1), and so dire a foe is it to vegetation, that we are perfectly justified in making all efforts to despatch it. On examining it more closely, we find that it is not truly cylindrical, like a piece of wire, but somewhat flattened beneath, and that it is made up of a series of thirteen segments, placed in line, one behind the other. The first of these is the head, and the next three carry six short legs, one on each side of each segment, with which the creature crawls along, trailing the remainder of its body after it. The head is black, and is furnished with a pair of stout, transversely-moving jaws, and a pair of short antennæ.

Wireworms are the larvæ of various kinds of beetles, called "skipjacks" or "click beetles," from a peculiar of springing up into the air, and at the same time, produce a sharp clicking sound. Skipjacks are narrow, elongate insects, with short legs and hard integuments (Fig. 2). The head is small and often much sunk into the thorax, and carries a pair of long, distinctly jointed antennæ; the thorax is of large size, and, roughly speaking, more or less quadrangular in outline, and convex above and beneath. The elytra or wing-cases cover the body, and conceal a pair of ample membranous wings. Each is somewhat triangular in shape, and they form when closed a strongly arched, shield-shaped surface; they are usually marked longitudinally with parallel grooves or furrows and covered more or less densely with short hairs. The under-surface also is strongly convex, and the legs are short, and capable, like the antennæ, of being folded close up to the body. When thus compactly folded up, the insect may easily be mistaken for a piece of stick or earth. When surprised or alarmed, it will thus feign death, relaxing its hold of what it may have been clinging to. and falling to the ground, as often as not, on its back.

Now usually, when a beetle gets into such a position, it frantically waves its legs about till one of them by chance strikes the ground; then, seizing any irregularies of surface with the sharp claws at the end of its feet, and assisting itself with the end of its shanks, it levers itself over sideways. But, owing to the convexity of its back and the shortness of its legs, a skipjack is unable to use this method, unless there happen to be close to it some objects of sufficient height to be reached by its waving legs; failing this, however, it would be were it not for a remarkable contrivance, as helpless as a turtle in a similar position, and would stand a good chance of being doomed to continue its unavailing struggles, at the mercy of any passing foe, till exhaustion ended its woes by death. The contrivance is as follows:—The hinder edge of the thorax is produced in the middle underneath into a long curved blunt spine, which is received into a little pit at the base of the body. The thorax is loosely articulated to the abdomen, and can be freely moved up and down like the lid of a box on its hinge. When on its back, therefore, the skipjack arches its body by bending its thorax backwards, and so balances itself on the two extremities of its body; this movement releases from its hollow the spine above referred to. Having stretched itself to the utmost in this attitude, the insect suddenly and forcibly resumes its former supine position—a movement which has the effect of causing it to rebound from the ground and shoot upwards into the air to the height of several inches, at the same time bringing the spine back into its sheath with a sharp clicking sound. On returning to the ground, the insect generally manages to land itself right side up; if not successful the first time, however, it renews the attempt, and continues skipping till the desired result is obtained.

About 60 species of skipjacks belong to the British Fauna, and three or four of them, brownish insects belonging to the genera *Athous* and *Agriotes* are exceedingly common; the latter genus furnishes the most destructive wireworms. In their larval existence they are subterranean in habits, living for several years a little below the surface and spending their time in devouring the roots and underground stems of plants, and thus, of course, doing much more harm than can be measured by the amount of matter actually devoured. In the winter they retire to a greater depth, descending farther and farther as the frost inceases, and pausing in their depredations only in the coldest weather. They devour all kinds of agricultural produce, destroying both root, grain, and fodder crops. Carrying on the ravages as they do in the complete obscurity of subterranean life, they are rarely detected when at work, and the first evidence that the fatal work has been done is seen in the apparently causeless withering of the plants.

It is fortunate that creatures so destructive have natural enemies. Among the most important of these is the mole, which devours the larvæ with avidity. It is aided in its praiseworthy efforts by several kinds of birds, such as rooks and lapwings. A variety of artificial remedies have been proposed for checking the spread of the mischief, such as the application of liquid manure, which has the twofold effect of strengthening the plants that have not been irreparably injured, and driving away or killing the wireworms; paring off a thin coating of the soil, which will contain most of the insects, and then burning it; imbedding in the soil at short distances apart slices of carrot and turnip to serve as traps, and then examining them and destroying the wireworms every other day. The latter method has been found serviceable in hop-grounds, as many as 150 wireworms having been trapped close to a single hop-hill. It should be remembered in this connection that the abundance of many agricultural pests is due in great measure to man himself. We greatly increase the supply of suitable food for these creatures, and in other ways make the surroundings more and more favourable to their existence, and we need not wonder, therefore, that the inevitable result follows, and that the additional task devolves upon us of devising means to counteract the excessive development we have ourselves unintentionally occasioned.

The group to which these insects belong possesses a few British representatives of considerable brilliance in colouring, but they are far surpassed, both in beauty and in size, by exotic forms, some of which are amongst the most brilliant of all beetles. To this group, also, belong the well-known and remarkable Fire-flies of the West Indies, not to be confounded with the Lantern-flies, which are members of a widely-different order of insects, the Homoptera. The light emitted by fire-flies proceeds from two patches on the thorax and from others concealed beneath the elytra when they are closed, but rendered visible when they are spread for flight. An old writer, Pietro Martire, gives the following quaint account of a method of catching these creatures: "Whoso wanteth cucuij, goeth out of the house in the first twilight of the night, carrying a burning firebrande in his hands, and ascendeth the next hillock that the cucuij may see it, and hee swingeth the firebrande about, calling cucuius aloud, and breaketh the ayre with often calling and crying out 'cucuie, cucuie!' Many simple people suppose that the cucuij, delighted with that noise, come flying and flocking together to the bellowing sound of him that calleth them, for they come with a speedy and headlong course, but I rather think that the cucuij make haste to the brightness of the firebrande, because swarmes of gnattes fly into every light, which the cucuij eat in the very ayre, as the martlets and swallowes doe. Some cucuius sometimes followeth the firebrande, and lighteth on the grounde; then he is easily taken, as travellers may take a beetle, if they have need thereof, walking with his wings shut. In sport or merriment, or to the intent to terrify such are afrayed of every shadow, they say that many wanton, wild fellowes sometimes rubbed their faces by night with the fleshe of a cucuius, being killed, with purpose to meet their neighbours with a flaming countenance, as with us wanton young men, putting a gaping vizard over their face, endeavour to terrify children or women who are easily frighted."

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MONSTER RUSSIAN BRIDGE.—It is reported from Russia that the question is being agitated of connecting Cronstadt and Oranienbaum by a bridge a at cost of 2,400,000, The structure is to rest upon granite pillars fixed by the caisson method, each of them protected from the action of the waves during the prevalence of south-west winds by an angular wall-like guard of stone. The bridge will be about five miles in length, and it is expected to be completed by 1889. When finished—if it ever is finished—it will consist of two parts, a railway and a foot-bridge.

NOTES ON ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

(*Continued from page* 148.)

On sending a current through the bars from antimony to bismuth, the junction will be heated, and the air expand ; on sending the current in the opposite direction, the junction will be cooled, and the air contract. If a very strong current be employed, the Peltier effect will be concealed by the heating of the metals, on account of the resistance they offer to the passage of the current. It may also be shown by means of the Peltier cross, which consists of a bar of bismuth and a bar of antimony made to cross one another, and soldered at their point of contact. One end of the bismuth bar and one end of the antimony bar are connected to a galvanometer, while the other ends are connected with a battery. When the current flows the junction becomes heated or cooled according to the direction of the current, and an electromotive force is set up in the galvanometer circuit, producing a current which continues after the battery has been removed.

If a circuit be formed by soldering together a bar of bismuth and a bar of antimony, and one of the junctions be heated, the current will flow from bismuth to antimony across the hot junction, and from antimony to bismuth across the cold junction. The hot junction will thereby be cooled, and the cold junction heated, but more heat will be abstracted from the hot junction than will be supplied to the cold junction, and the difference will provide the energy which enables the current to flow in opposition to the resistance of the circuit, and will appear as heat diffused through the mass of the metals. The source of the energy of the current is in this case readily recognized in the Peltier effect.

In the case of a pair of metals in which the hot junction is at the *neutral* temperature, no Peltier effect can there occur, so that no heat can be supplied from the hot junction. At the cold junction heat may be developed. Hence the Peltier effect is insufficient to explain the source of the energy of the current. Sir Wm. Thomson pointed out that in this case heat must be absorbed by the current from one or both of the metals. Taking the case of a copper-iron circuit, with the junction at the neutral temperature, and the other below it, Sir Wm. Thomson showed that heat must be absorbed when electricity passes from hot to cold in iron, or else when it flows from cold to hot in copper, or both of these effects may take place. He afterwards showed experimentally that both these effects do take place, and that a current flowing from hot to cold in iron cools the iron, while a current flowing from cold to hot in copper cools the copper. If the direction of the current be reversed, the metals will be heated, the heating and cooling being proportional to the strength of the current. This effect is called the Thomson effect. In lead the Thomson effect is zero. It is the reason why lead is selected as the zero of thermo-electric power.

A thermo-electric pile is generally constructed by soldering together a number of bars of antimony and bismuth, in such a manner that the alternate junctions occur at opposite faces of the pile. When the faces are exposed to different temperatures, the electromotive forces of the several couples are added together.

The Claymond thermo-electric battery consists of alternate strips of tin plate (charcoal iron tinned) and lozenge shaped masses of an alloy of antimony and zinc. These are united so that the alternate junctions appear on the inside and outside of a ring and several rings so formed are built into a cylinder. The interior junctions are heated by a gas flame or charcoal fire, while the alternate (exterior) junctions are exposed to the cooling action of the air.

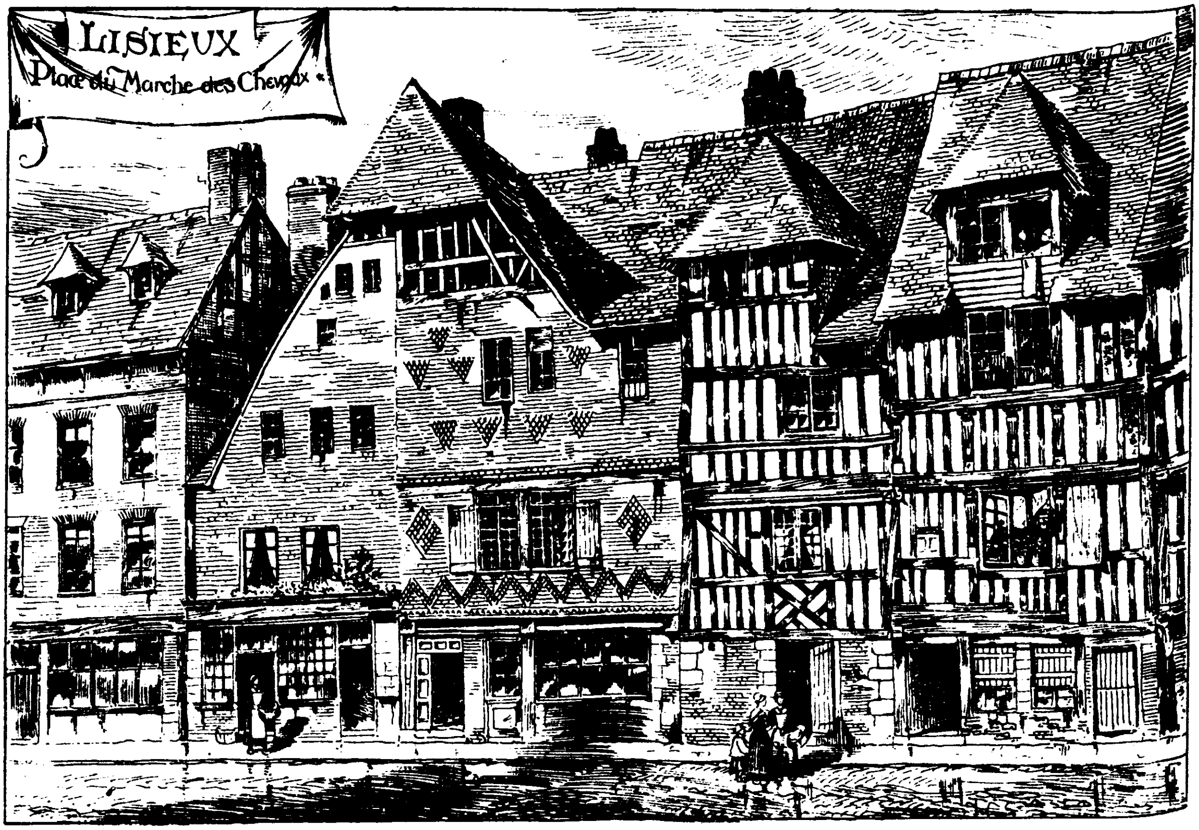
Galvani's discovery in 1790 of the effect of the contact of dissimilar metals in producing contractions of a frog's leg was followed in 1800 by the construction by Volta of the Voltaic pile.

The Voltaic pile consisted of a series of disks of copper, zinc, and flannel, which were placed on above the other so as to form a pile. The flannel disks were moistened with a zinc disk at the bottom the order in which the plates were arranged was zinc, flannel, copper, zinc, flannel, &c., the same order being maintained throughout. and the pile terminating with a copper plate. To prevent the liquid running between the copper and zinc plates they were soldered together where they were in contact. On connecting the zinc and copper terminals of the pile a current flawed from the copper to the zinc terminal through the were.

The " crown of cups " of Volta and the early batteries of Wollaston and others consisted of plates of two dissimilar metal, (generally copper and zinc) placed in vessels, or cells, containing dilute acid or solution of salt, and connected alternately so that the copper of one cell was connected with the zinc of the next, and ao on. On connecting the final copper and zinc plates by a wire a current flowed round the circuit as in the Voltaic pile. In Wallaston's battery the copper and zinc plates were immersed in cells containing dilute sulphuric acid.

In 1830 Sturgeon introduced the improvement of amalgamating the zinc plates, thus preventing " local action " and preserving the zinc from the action of the acid, except when the current is flowing in the circuit. This improvement obviated the necessity of lifting the plates out of the acid when the battery is not in use.

The followers of Volta maintained that the electric current in the Voltaic cell was due entirely to differences of potential produced at the three places of contact of the metals with the acid, and with each other. They held that although in the case of three metals in contact at the same temperature the difference of potential between the metuls at the three points of contact balance one another so that there is no resultant electro motive force round the circuit, yet this is not the case when one of the metals is replaced by a liquid which can act chemically upon one or both of the remaining metals. Thus, supposing the potentials of zinc and of copper to be both lower than that of sulphuric acid when the metals are in contact with the acid, and in electrical equilibrium, and the potential of zinc to be higher than that of copper when the metals are in equilibrium, the supporters of the Voltaic or contact theory maintained that the difference of potential between the sulphuric acid and the zinc necessary for equilibrium was greatet than the sum of the differences of potential between the acid and the copper, and between the copper and the zinc, the difference being the resultant electro-motive force which urges electricity from the zinc through the acid to the copper and back to the zinc through the metallic junction, when the three subtances are connected as in the Voltaic cell.—(*To be continued.*)



BUILDING AND ENGINEERING TIMES.

BOARD SCHOOL FOR INFANTS, WALTON-ON-THAMES.