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

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NEW BOOKS.

The Elasticity and Resistance of the Materials of Engineering. by Wm. H. Burr. C.E. (New York: John Wiley & Sons, Montreal: Dawson Bro's.)

Prof. Burr's work will be heartily welcomed not only by technical students but also by the purely practical engineer. It is divided into two distinct parts, each complete in itself. In the First Part the author sets forth the general Theory of Elasticity in amorphous solid bodies, and deduces the equations of motion and equilibrium which he applies in the investigation of the thickness of thick hollow cylinders and spheres and also of torsion, concluding with a statement of the general Theory of Flexure. This First Part will probably, as the author anticipates in his preface, be of little interest to the merely practical engineer, and requires a thorough acquaintance with the higher Mathematics, yet it must be borne in mind that a correct knowledge of the strength of materials can only be obtained by a determination of their elastic properties. The practical engineer, however, will find the second and larger part of the work full of valuable information. Numerous Tables are given of the tensile, compressive and shearing strength, the co-efficient of elasticity, the elastic limit, etc., of wrought and cast iron, steel, timber, cement, mortars, etc. Chap. VII. is devoted to an interesting and instructive dissertation on the strength of columns, and the last treats of factors of safety and working stresses as used in practice, and are contained in extracts from a number of specifications of works now completed. It has been the aim of the author, as he says, "to represent truly and completely the great variety of both quantitative and qualitative phenomena exhibited by material under test; to shew not only the variation in products of different mills but the variation in different products of the same mill; to exhibit the variations due to difference in size, shape, relative dimensions and condition of specimens; to shew that specimens apparently identically the same may even give considerable diversity in results, and to prove the difference between the finished member and its component parts, as well as to indicate the direction in which further investigations may most profitably be prosecuted."

Much labour and care must have been expended in the preparation and arrangements of the matter, and the work may be cordially recommended to every engineer.

The Mechanics of Engineering and of Machinery, by Dr. Julius Weisbach, (New York, John Wiley & Sons; Montreal, Dawson Bro's.)

Under the above title Dr. Weisbach has issued a series of valuable engineering manuals, and the reputation of the author is alone a sufficient guarantee of their worth. The volume before us, *viz.*, Vol. III. Part I., Section I. treats especially of the Mechanics of Machinery of Transmission. In Germany the second edition was issued in a revised and greatly enlarged form under the editorship of Prof. Gustav Herrmann. This edition, by permission, has been translated by Prof. Klein, and published by Messrs. Wiley & Son. The work commences with a lucid statement of the principles of Kinematics, *i. e.*, a statement of the principles of motion, without any regard to cause or forces. The remainder of the work is divided into three chapters dealing respectively, with the strength and dimensions of Journals, Shaftings, Couplings and Bearings, in Chap. I, the various kinds of gearing,—circular, bevel, and skew-wheels, trains of wheel-work, pulleys, etc.—in Chap. II. and rods and their guides—including parallel motions, pantographic and other linkages, etc.—in Chap. III.

Kinematics, by Charles William MacCord, (New York, Wiley & Sons; Montreal, Dawson Bro's.)

This work is a "treatise on the modification of motion as affected by the forms and modes of connection of the moving parts of machines." The author introduces his subject by a general statement of the Principles of Motion, the Modes of Transmission, etc., and in Chaps. III., IV. and V. treats of the determination of the velocity-ratio in the case of various elementary combinations, and also in that of rotation by rolling contact with axes both parallel and oblique, specially referring to link, band, and contact motions, toothless, circular and lobed wheels, rolling cones, (pitch-surfaces of circular and elliptical bevel wheels), conical lobed wheels, rolling hyperboloids (pitch-surfaces of skew-bevel wheels), etc., etc. The last seven chapters deal in a very complete manner, with tooth gearing, and with the form, strength and dimensions of teeth. The author, while acknowledging a free reference to Willis' mechanism, and Rankine's Geometry of Machinery, has introduced much new and interesting matter in connection with (*a*). The computation of *Limiting Numbers of Teeth, Spur and Pin Gearing,* (*b*). The Double Contact of Epicycloidal teeth in Inside Gear, (*c*). The Odontoscope, for showing effect of Wear in Bearings upon Velocity-Ratio, (*d*). The Oblique rack and Wheel, with new Theory of Oblique Screw Gearing, etc., etc.

The above works are all in excellent type and form.

THE REMOVAL OF RAIN-WATER FROM TOWNS, CONSIDERED WITH REFERENCE TO THE SEWERING OF BERLIN.

(Abstract from paper by M. Knauff in Gesundheit-Ingenieur.)

The Author quotes from a recent pamphlet by Waring, the engineer who designed the drainage of Memphis, the opinion that the admission of storm-water into the deeply-laid sewers of a town is generally a mistake, and nearly always wholly unnecessary. Waring affirms that rain-water is not in itself either a foul or polluting liquid, and can do no damage to streams; and that only in such cases in which surface-drains are liable to injure the road-ways, to cause the flooding of cellars, or to interfere with the traffic, does it become necessary to provide sewers to carry away the rainfall. He distinguishes between underground drainage adopted as a matter of principle, and employed only as an occasional means of avoiding road-crossings, &c. Waring believes the large modern deep-laid sewers to be wrong in theory, and he sums up his remarks as follows:—" The present method of disposing of the rainfall is a survival of ignorance, and its continuance only shows the preponderance of traditional practices."

The Author traces the advocacy of the separate system to the writings of Chadwick, Philips, and Rawlinson, and instances the drainage of Alnwick, Tottenham, Leicester, and many other towns in England, in accordance with this system, over thirty years ago. The advantage formerly claimed for the practice of admitting the rain-water into the sewers, in order, namely, that it might flush the ill-constructed culverts which at that time existed, no longer stands good under the improved formation of modern sewers. The larger the diameter of the sewers, the greater will be the tendency to the deposition in them of detritus, and the more completely the rain-water can be excluded, the more constant will be the flow in the sewers of the smaller diameter, necessary for the house drainage alone. An argument against the admission of the rainfall into the sewers is the impossibility of accurately ascertaining what volume of water may, under certain circumstances, have to be carried away in a given time. Excessive rainfall, under the mixed system, gives rise to evils of the worst kind, and even in Berlin, in May and September of the present year, the basements of the houses have been flooded by the overflow from the sewers. A consideration follows of the parties upon whom the charges for damages from sewage overflows should fall. The Author observes that the flooding of basements during storms, by the backing-up of the house drains, is a specific evil of the mixed-sewage system, which does not pertain to many other methods of town-drainage.

A Table is given of the heaviest known rainfall, in millimetres, in a number of towns, during specified periods of time, varying from 25 millimetres in 90 minutes (equal to 46 litres per hectare per second, or 4.1 gallons per acre), to 37 millimetres in 10 minutes (equal to 617 litres per hectare per second, or 55 gallons per acre).

The rainfall, assumed as the basis of calculation for the drainage of Berlin, was 23 millimetres per hour, only one-third of which is supposed to reach the sewers. The Author quotes the experiments of Hawksley, Bidder and Haywood in 1857-8, who came to the conclusion that not less than 50 per cent. of the rainfall must be carried away by the sewers, and this amount *is usually provided for by English engineers. A formula* based on this percentage follows, and the Author shows that the area of the Berlin sewers is insufficient. Their insufficiency can only be remedied by means of numerous storm-overflows, and if the use of such overflows be permitted, there is no reason why the main outfall should not be of perfectly arbitrary size, with hundreds of outlets to guard against the possibility of overfilling. Hobrecht's opinion on the advantages claimed for the separate-system is adduced. The assertion that a twofold system of sewers, in the case of the separate-system, must be more costly than a single one, is examined, and the arguments quoted by Fegebeutel, for and against each plan, are stated in detail. The Author is of the opinion that the facts of Fegebeutel are derived from the writings of Baldwin Latham. The quality of street-washings, which have usually been asserted to be nearly as rich in manurial ingredients as domestic sewage, is examined, and the Author gives a Table of the amount of nitrogen, which would be partially or wholly lost by keeping the rainfall from the sewers. He states that on the road surfaces of a town of one hundred thousand inhabitants, the excrementitious matters of the population would contain, in nitrogen, approximately as follows :—

		Nitrogen. Kilograms.
Dung and urine of 4,000 horses - - -	=	6,859
" " 5,000 dogs and cats - -	=	500
" " birds and poultry - -	=	25
Leather cuttings, etc. - - - - -	=	216
Let it further be assumed that in the third part of the excreta of 9,000 men (a quarter of the adult male population void their excreta improperly on road surfaces, or courtyards) the nitrogen $=9,000\frac{5.48}{3}$	=	16,440
Total - - - - -	=	24,040 kilos
	or	52,998 5 lbs.

or equivalent in round numbers to 66 kilograms (145 46 lbs.) of nitrogen per diem, and in the one hundred and fifty-one rainy days of the year, to say, 10,000 kilograms (22,046.2 lbs.) The excreta of one hundred thousand persons would contain about 133,050 kilograms (426.2 tons) of nitrogen, and the proportion thereof, present in the sewage on the one hundred and fifty-one rainy days would be, deducting the above 16,440 kilograms —162,712 kilograms of nitrogen, or about sixteen times the amount credited to the rainwater from the street-surfaces. The Author assumes, then, that 94 per cent. of the nitrogen of the population would be found in the sewage, as against 6 per cent. in the rainwater from the roads. The contrary opinion of Way, that the washings from the streets are as rich in *manure ingredients as the house drainage, is quoted.* The impossibility of keeping road-detritus out of the drains, and the fallacy of deep gutters or channels for street-drainage, is shown. The views of Hering are examined and quoted at length, and in conclusion the Author remarks, with respect to the drainage of Berlin, that, in the construction of new roads, the crown of the roadway must be considerably lowered; that proper observations must be made of the proportion of the total rainfall which has to be carried away by the sewers; that for the sections of the sewering still to be carried out, a heavier rainfall than 23 millimetres (0.9 inch) per house must be provided for; that, in the portions of the sewers which are executed, numerous additional overflow channels must be made, as the provision of storm-outlets alone does not appear to be sufficient to check inundation. The street-gullies must be fitted with improved gratings; the ventilation of the existing and future sewers must be carried out on a better system than at present. The stoneware pipes, forming the house-connections, must be tested more *carefully, as respects their imperviousness and* durability; the joints of such pipes must be made in cement. Proper back-flow traps must be provided for all the soil-pipes in cellars and the junction between the down-pipes (of iron), and the trap must be made of iron pipes with lead joints.

CRANES AS LABOUR SAVING MACHINES.

A PAPER READ BEFORE THE AM. SOC. OF CIVIL ENGINEER.

A well constructed crane or other similar power machine requiring only one man to drive it would do as much work as could be done by the manual power of ten men, but in one-tenth of the time. It seems singular that railroad and water-side depots and workshops should so rarely be laid out with reference to the employment of such laborsaving machines. The most economical working result is obtained from machines so arranged that when they take hold of the load, it is *not released until final deposit.* The Author considered the following systems for transmitting or applying, power.

1st. The well-known hydraulic system with pressure pumps, accumulator and distributing pipes.

2nd. Compressed air distributed through pipes.
3rd. Steam distributed as above.
4th. High speed rope or "endless cotton cord," which runs at a speed of 5,000 to 6,000 feet per minute.
5th. Low-speed rope running 1,500 to 2,000 ft. per minute.
6th. Square shaft supported on tumbler bearings.
7th. Steam from a boiler delivered on the top of a piston with multiplying chains similar to the hydraulic system.
8th. Boiler and engine fixed on the Crane and driving gear for the several motions required.

The 1st, 2nd and 3rd can only be applied to cranes fixed or moving over very limited areas. The 4th, 5th and 6th will transmit power over large areas, which, however, should be nearly rectangular. The other two can be used generally wherever there is a railway track. The hydraulic system possesses great advantages over compressed air or steam, but experience tends to the conclusion that its common use will be attended with considerable inconvenience where the winters are cold. The use of compressed air has not been applied with great success in many cases.

Steam is largely used, and frequently carried through 1,000 feet of pipe without much inconvenience. The high-speed cotton cord runs at a speed of 5,000 to 6,000 feet per minute. The cord works in grooved pulleys, is carried on rollers or other supports at intervals of ten to twenty-five feet and is kept in tension by a weighted pulley. Low-speed rope transmission is generally effected by a hemp rope running from 1,500 to 2,000 feet per minute. The square shaft has been used for many years, the only special difficulty experienced being that of supporting the long main line of driving shaft. The Author exhibited recent designs whereby this difficulty has been very successfully overcome. The relative advantage of rope or shaft transmission is largely influenced by local circumstances. As a general rule the rope system costs less and is better where the distance for transmitting exceeds 200 feet. Below that distance the shaft is probably the best and cheapest. But the rope possesses advantages when machinery has to be driven at different levels, or at an angle with the point from which the power is transmitted. The steam crane employed under many differing conditions perhaps performs more functions than any other mechanical arrangement for lifting and placing loads. All such cranes should lift and turn around by steam power. One specially illustrated had additional motions for altering the radius of the jib, for hauling materials so as to bring them within the reach of the machine, and also for moving empty or loaded cars. Fixed cranes are often seen so placed that one-third or even one-half of the number erected at a particular point are idle. It would therefore seem that for the same outlay, the best duty will be obtained from movable cranes. Where two or more railroad tracks are parallel with the water front it will often be desirable to make the crane span the two lines of tracks, allowing headroom for the vehicles to pass under it. Cranes fixed on floating vessels were also illustrated up to 60 tons power. Locomotive cranes up to 25 tons were described and also cranes specially adapted to terminal freight stations. One of these has lifted 80 tons per hour a height of 20 to 30 feet and deposited the loads $1\frac{1}{2}$ to 2 tons each 60 feet from the point where taken up. A similar crane commonly delivers 240 barrels of oil per hour the same height of lift and length of deposit.

The cost per day is one driver's wages and the necessary fuel, oil, etc. Five per cent. per annum is ample allowance for depreciation. The cost of this system of working is easily ascertained, but a great gain also arises from the increased speed of passing large quantities of merchandise.

CURVED CROSS-SLEEPERS.

BY — KECKER.

(*Organ für die Fortschritte des Eisenbahnwesens* vol. xx., 1883 p. 31.)

The Author remarks in this Paper that the shortness and curved form of most of the iron cross-sleepers now in use have been regarded as great defects. He determines the most appropriate length, and not only justifies the use of the curved form, but proves its advantages over that of the straight sleeper.

The best length for a cross-sleeper, whether of iron or wood, is found to be 2·57 metres (8·42 feet).

The modulus of elasticity in a beam is found by measuring the versed sine f of the curve of deflection

$$f = \frac{2\text{ P}}{\text{E I}} \cdot \frac{(2\text{ a})^3}{48},$$

where E = modulus of elasticity of prismatic body.
I = moment of inertia with regard to neutral axis of cross section.
2 P = weight over centre of beam.
2 a = distance between supports.

The versed sine of the curve of deflection is thus proportional to the weight 2 P and the cube of the distance between the supports.

It is not necessary to know the absolute weight with which the beam is loaded at its centre, and the amount of its deflection, as long as the proportion to which the deflection increases with the load can be ascertained.

As long as the limit of elasticity is not exceeded, the deflection increases in the same proportion as the load. It would therefore be immaterial whether the beam was originally straight, or shaped according to the curve of deflection. The same applies to an uniformly loaded beam on two supports, as in the case of a cross sleeper, where the ballast forms the load, and the rails the supports, only in this case the deflection would be, of course, less than if the load were concentrated at the centre.

Curved sleepers also possess the following advantages over straight ones. In the former the pressure from the trains acts at right-angles to the sleeper, and is transmitted directly to the ballast, whilst in the latter a horizontal thrust, P cot a (the rails being inclined an angle 90° — a from the perpendicular), has to be borne by the fastenings of the rail and sleeper. Curved sleepers also offer a greater amount of resistance against lateral movement than straight ones.

It might certainly be argued against the curved sleeper that it has a tendency to act as a blunt wedge and force the ballast asunder, but experience proves that this is not the case when tolerably good ballast is used.—*Tr. Ins. C. E.*

THE ZINC MINES OF MINE HILL, N. J.

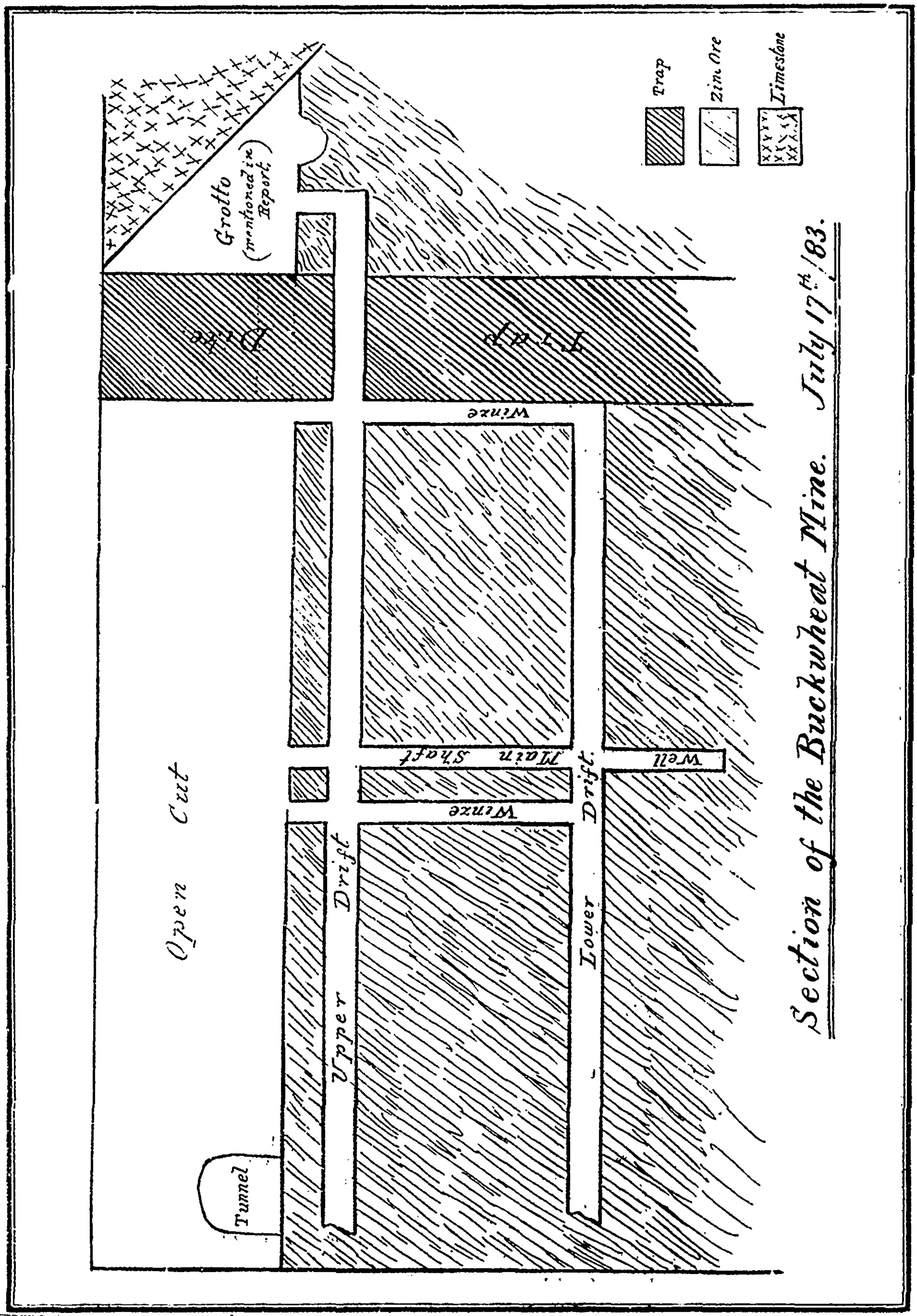
BY W. F. FERRIER.

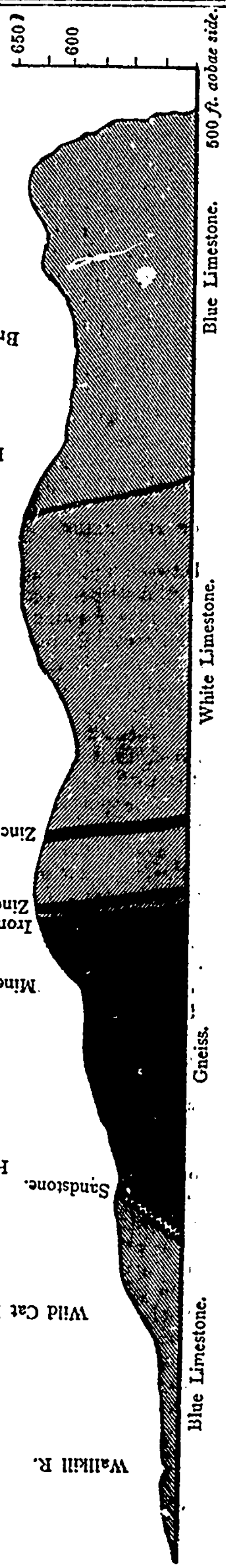
SITUATION, EARLY HISTORY, ETC.

The celebrated Zinc Mines of New Jersey are situated at both Stirling Hill and Mine Hill, but it is with the latter place only that I shall deal in this paper. During the summer of 1883, I accepted the kind invitation of Dr. Cook, the State Geologist of New Jersey, to pay a visit to these mines. He accompanied me to them, and went over the ground with me, explaining all the points of interest. After this I spent some time at Mine Hill, studying the zinc veins and the method of working them, and also collecting the numerous and rare mineral species of the locality.

The vein of zinc ore at Mine Hill is situated in a hill to the N. W. of the Wallkill River, and extends in a S. S. W. direction from the road leading to Hamburgh towards the S. W. end of the hill near the Wallkill. The peculiarities of its formation will be noticed further on. The two names "Mine Hill" and "Franklin" sometimes lead people into the idea that they are two different localities, so that it may be well to mention here, that the full designation of the locality is Mine Hill, Franklin Furnace, Hardiston Township, Sussex Co., N. J. It is situated about 60 miles to the N. W. of the city of New York, on the line of the New York, Susquehanna, and Western Railway. In 1815-16, Dr. Fowler, who was a property-holder of the vicinity, first drew attention to the great variety of minerals to be found in the outcrops of the veins at Mine Hill. He was an enthusiastic mineralogist and although the

NOTE.—Summer Essay, Second Year, Faculty of App. Sc., McGill University.


Section of the Buckwheat Mine. July 17th/83.
Trap
Zinc Ore
Limestone
Grotto
(mentioned in Report)
Dike
Trap
Winze
Main Shaft
Well
Winze
Open Cut
Upper Drift
Lower Drift
Tunnel



SECTION ACROSS THE MINE HILL ZINC MINES.

PLAN OF THE MINE HILL ZINC MINES. Scale—8 in. to mile.

mineral species found attracted him most, yet he also drew attention to the great pu ·y and immense quantity of the zinc ore. Not long after this some capitalists leased from him the privilege of working some of the veins for zinc, and since that time Mine Hill has been a mining centre.

DESCRIPTION OF THE VEINS.

On Mine Hill within 100 feet of each other are veins of magnetite, graphite, and franklinite, 40 feet and more in thickness, which lie on beds of garnet and pyroxene. The principal rock formations which crop out in the vicinity are gneiss, crystalline limestone, and magnesian limestone. The beds of zinc ore occur in the crystalline limestone and conform to the strata. They pitch to the N. E. and dip to the S. E. at an angle of between 55° and 65°. The large amount of manganese which is present gives a very dark appearance to the outcrops of the zinc. The white and pink calcite is also much discoloured from the same cause. The franklinite occurring here differs slightly from that found at Stirling Hill, containing more iron and dissolving with greater readiness in acids. Willemite is the most adundant of the ores. Zincite is is not at all abundant, and although sometimes found lamellar, as at Stirling Hill, is generally in irregular grains. Two distinct layers of ore can be recognised in the N. E. part of the vein, one containing zincite, and the other none of that mineral. These two layers are called "the zinc vein," and "the franklinite vein." The former occupies the outer side of the outcrop, and is now more extensively mined than the latter. Most of the franklinite has been left standing. Two irregular patches of zincite occur in the vein towards the crook. The vein of zinc lies in a direct line N. W. from Stirling Hill with this crook to the N. E. at an angle of about 35° forming the S. end of the vein. (See plan, page 325.) The gangue rock is a carbonate of lime and manganese. Near to the Hamburgh road the zinc vein is 10 feet wide; 300 feet S. W. it is 6 ft. wide with the franklinite vein of the same width.

In the middle of the outcrop the total width is 21 feet, and S. W. from this it reaches 29 feet in width. The deposit of zinc ore at the Southwest opening is 31 feet thick. The dip of the front vein is to the S. E. at about 60° as mentioned above, whilst the east vein is vertical.

DESCRIPTION OF THE MINES AND THE METHOD OF MINING.

The zinc ore has been extensively mined, but the mine which is worked on the largest scale is the Buckwheat Mine on the crook of the vein. The mine is said to have derived its name from the fact that the first opening made was in a field of buckwheat. There is an enormous opening, 310 feet in length, 40 feet wide and 70 feet deep, which is approached by a tunnel from the valley of the Wallkill River. The tunnel is 1,000 feet long. From this large opening, a shaft, 154 feet deep, leads down to the lower levels. Opening in from the N. is a huge grotto where they are now taking out the ore. This part of the vein was cut off from the rest by a huge trap dike which apparently ended the vein. It was at right angles to the vein and about 45 feet thick. On cutting through it the continuation of the vein was found and by the removal of the ore, a large chamber or grotto has been formed.

The ore here is composed of zincite, franklinite, willemite and other less important minerals. The process of mining is exceedingly simple. Compressed air drills are used, the ore is then blasted out with giant powder, and drawn out of the mine in small cars by means of donkeys. At the end of the tunnel there is a small platform where the ore is weighed, and then dumped on to the cars, to be shipped either to Newark, where the works of the Company are situated, or else to Jersey City. The only machinery employed, besides the air-drills, is an engine for hauling up the ore to the donkey-cars, and a small pump. Besides the Buckwheat Mine there are several mines on the main part of the vein. The principal one of these is that owned by C. W. Trotter. The ore from this mine is sent to Bethlehem, Pa.

Some zinc ore from Mine Hill has been sent to Europe, principally to Belgium. A section of the Buckwheat Mine is attached to this report. It was taken by Dr. Cook during my visit on the 17th of July, 1883.

THE PRODUCTION OF ZINC OXIDE.

The ore is first crushed between rollers and then mixed with pea coal (powdered Anthracite coal) and some of the residues from previous roastings. It is then taken to the furnace which resembles an ordinary reverberatory furnace, but which has a floor made of a thick plate of cast iron pierced with conical holes having the smaller opening uppermost.

This plate is placed two or three feet above the ground to allow space for air beneath it. The furnace floor is covered with pea coal and when this is burning well, the charge of ore and coal is put on it, and a powerful blast of air from a fan-blower is driven into the space beneath the plate. Passing through it, it causes the coal to burn violently and reduces the zinc, also supplying sufficient oxygen to re-oxidise the zinc as it rises in vapour. The oxide of zinc thus formed passes through an opening in the roof of the furnace into a tower where it is somewhat cooled by a shower of water. It then passes on in a tube into a room where the tube is connected with a large number of long muslin bags into which the oxide falls as it condenses, while the gases, etc. escape through the muslin. The oxide of zinc thus formed is taken out at regular intervals, pressed into barrels and is ready for use.

The French oxide of zinc used in painting is not made from the ore but by burning metallic zinc. In the manufacture of the white oxide as above described there is a mere trace of manganese carried over with the oxide, just enough to give it a slight buff tinge, so that it is not considered quite so pure as that made directly from the metal. The residuum left after roasting the zinc ores contains a large amount of oxide, of iron and oxide of manganese and is worked over in a blast furnace for the production of spiegeleisen. The small amount of zinc oxide escaping from the residuum is collected in a chamber at the tunnel-head and is worked over for the production of zinc oxide, or else is used in the manufacture of spelter. Some spelter is made at La Salle in Illinois and some in Missouri, but by far the largest amount is made at Newark, N.J., and Bethlehem, Pa. The two latter places are capable of supplying the whole country. I append a tabular statement of the charge of a zinc furnace at Newark, N.J., showing the amount of ZnO it yielded:

	lbs.
Pea Coal	12,800
Ore	35,200
Coal Dust	17,600
Residuum	16,000
From previous workings...	81,600
ZnO produced	11,017

REMARKS ON THE MINERALS FOUND.

The minerals of New Jersey found associated with and including the zinc ores are very interesting both on account of the great variety of species and the curious chemical compounds which many of them represent. But I must endeavor to confine myself mainly to those found at Mine Hill. A number of species which are found at the neighbouring locality of Stirling Hill, do not occur at Mine Hill and vice versa.

Some of the crystals of the various minerals are on a grand scale, Franklinites 4 inches square at the base, Gahnites, twenty inches around the base, and Jeffersonites a foot long and perfect in every angle, having been found. The very large and perfect crystals of these minerals are nearly all in surface pockets, so that as the mining is carried on, these fine specimens become scarcer and scarcer. It is an interesting fact that the first species of American minerals, described by an American mineralogist, come from New Jersey. They were the native magnesia of Hoboken and the zincite of Sussex Co., described by Dr. Bruce in the *American Mineralogical Journal*, of which the first number appeared in 1810. About 50 species of minerals are known to occur at Mine Hill, and it is probable that more will be added to the list. The beautiful colors of the zinc minerals render them peculiarly attractive. Their variety is endless, and often in the same specimen you have two or three distinct colors, as for instance, the brilliant red of the zincite, the black of the franklinite, the rose color of the rhodonite, and the green shades of the willemite. These colours are beautifully set off by the pure white and sometimes light pink of the calcite in which many of the minerals are imbedded.

The granular franklinite is called "shot-ore" by the miners. The old locality for the large garnet crystals was at the base of a huge block of gneiss, but I found a locality equal in every respect to the old one, at the mouth of the mine belonging to Mr. Trotter. A few days after I left, the workmen whilst making an open cut through the outcrop came on some very fine specimens. The very rare mineral sussexite used to be found further along the vein, but now it is hardly possible to obtain specimens. A fine piece is in the cabinet of Mr. Canfield, near Dover, N.J. The large plates of sahlite which occur near Mr. Trotter's mine have a beautiful lustre, some of them resembling a polished green serpentine. By turning over the heaps of rubbish on the dumps very fine specimens are often found.

A LIST OF MINE HILL MINERALS WITH SHORT NOTES.

Molybdenite. — In small scales resembling graphite.

Sphalerite. — A white variety found at this locality is the *Cleiophane* of Nuttal. It also occurs of a yellow and dark resinous color.

Arsenopyrite.

Fluorite.—In very poor specimens near the Furnace.

Zincite.—In foliated masses and granular and rarely in crystals. One of the chief zinc ores.

Spinel.—Crystals of various shades of blue, green, black and red, which are sometimes transparent. A bluish green Ceylonite found here has a lustre like polished steel.

Gahnite. Associated with Franklinite and Willemite, but not so fine as at Stirling Hill. At the latter place a perfect octahedron has been found measuring 20 inches around the base!

Franklinite.—With Zincite and Garnet in granular limestone. Magnificent crystals have lately been found at Stirling Hill. The ore is not much worked at present, the amount taken out being piled up to serve when the other ores fail.

Pyroxene var. *Sahlite.*—Occurs in large cleavable masses near the garnet locality. It is of a deep green color. It is associated with sapphire and ruby spinel.

Pyroxene var. *Jeffersonite.* — This mineral has the angles of the crystals generally rounded, and the faces have a curious corroded appearance. Jeffersonite gives with soda on charcoal, a reaction for Zn and Mn. Some of the specimens are very handsome.

Pyroxene var. *Coccolite* and *Pyroxene* var. *Augite.*

Rhodonite var. *Fowlerite.* — Granular in limestone, also massive and in crystals ½ to 1 inch in diameter. I obtained some measuring a little over 1 inch in diameter. The mineral in its massive form resembles red feldspar. The Keatingine of Shephard is Fowlerite and contains 5·6 per cent. of ZnO.

Amphibole var. *Actinolite.*—In radiated masses.

Amphibole var. *Asbestus.* *Amphibole* var. *Tremolite.*

Amphibole var. *Hornblende.*

Tephroite—In cleavable masses with Zincite, Willemite and Franklinite.

Willemite.—An ore of zinc. Its crystals (*Troostite*) are sometimes 6 inches long and 1 inch thick.

Garnet.—Black, brown, yellow, red and sometimes green dodecahedral crystals. The finest are always found imbedded in calcite which lies on the gneiss rock. I got some very fine specimens near Mr. Trotter's mine.

Epidote.—Massive. *Zircon.*

Idocrase.—In large light brown brilliant crystals. Some very fine specimens have been found but the mineral is extremely rare.

Allanite.—With feldspar and magnetite.

Phlogopite.—Bronze yellow.

Muscovite.—In hexagonal prisms.

Wernerite var. *Algerite*?—In slender square prisms in calcite. 3 or 3½ inches long, yellow to gray. Dull.

Chondrodite.—Honey yellow.

Tourmaline.—Black and brown crystals in limestone, associated with spinel.

Titanite.—Honey yellow. *Chrysocolla.*

Steatite.—Pseudomorphous. *Magnetite.*—Immense quantities occur, and are largely mined.

Quartz.—Pretty amethystine quartz has been found.

Octahedrite. *Aragonite.* *Azurite.* *Beryl.* *Siderite.* *Corundum.* *Cuprite.*

Calcite.—Dog-tooth spar has been found. The zinc ores often occur in pink and white Calcite.

Isopyre (?) *Sussexite.*

Nuttalite. — Very beautiful specimens of this mineral are in the cabinet of the late F. Canfield, at Succasunny, near Dover, N.J.

DIAGRAMS ILLUSTRATING THWAITE'S PAPER ON THE PRESERVATION OF IRON.

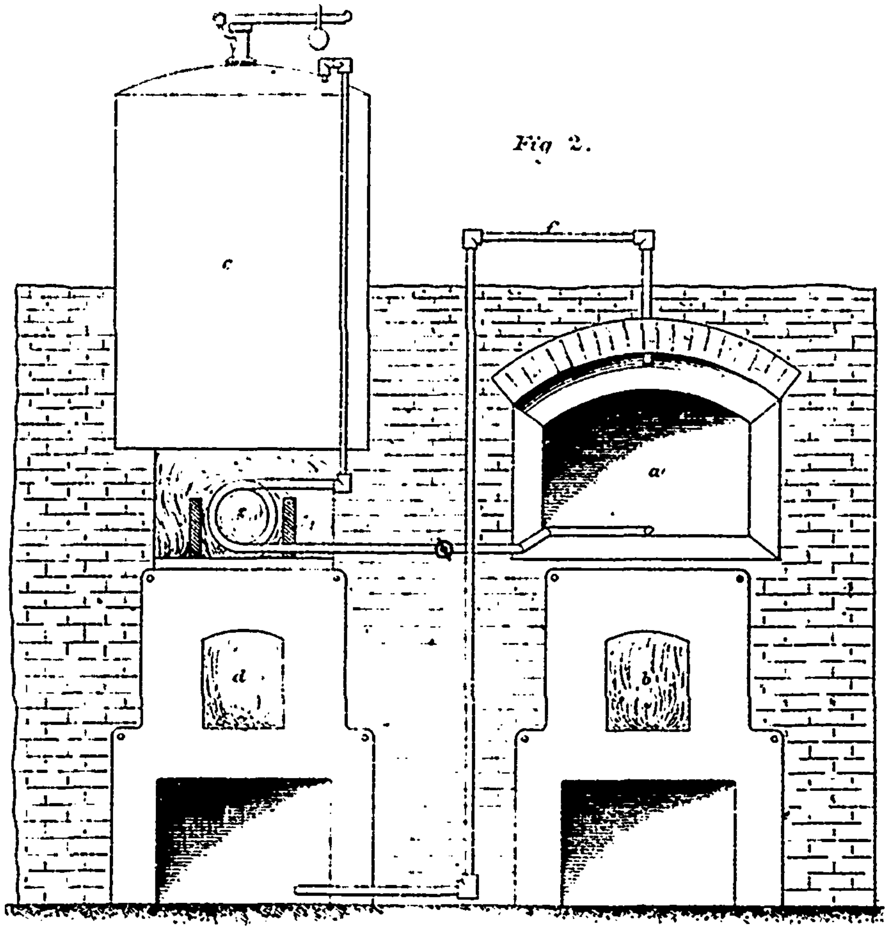


Fig 2.

ON THE PRESERVATION OF IRON BY ONE OF ITS OWN OXIDES.*

BY BENJAMIN HOWARTH THWAITE, ASSOC. M INST. C.E.

(A paper read before the Inst. of Civil Engineers.)

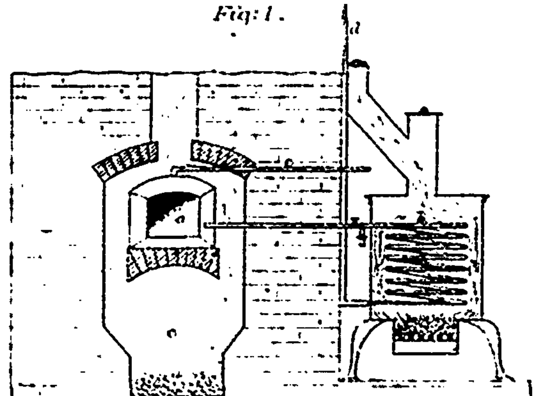
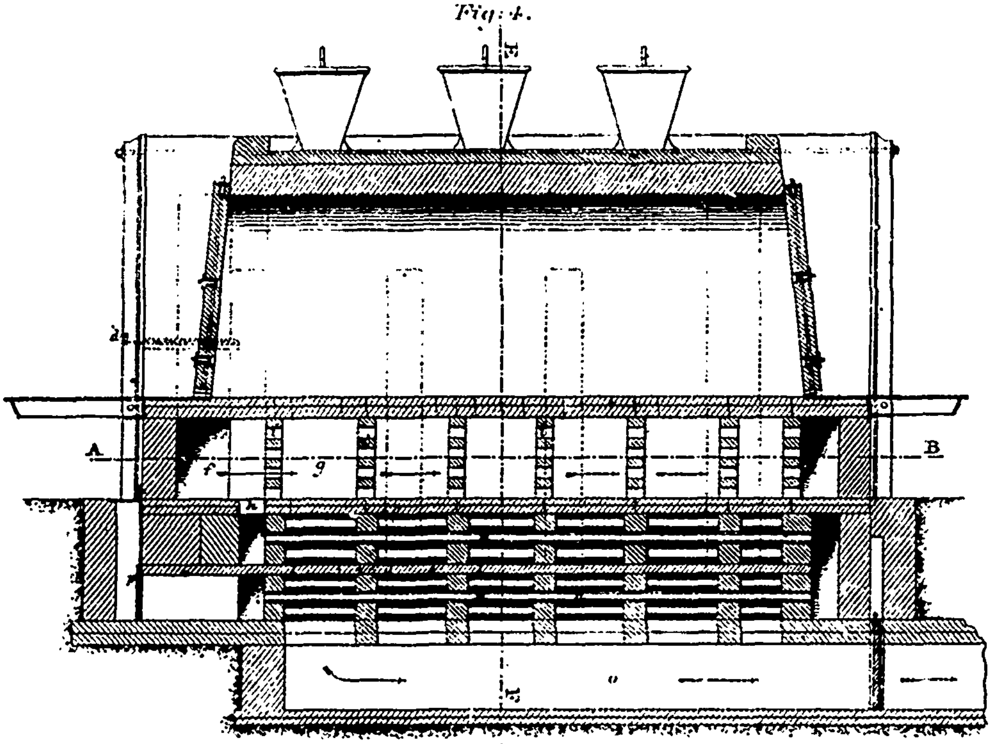


Fig: 1.

When iron is exposed to contact with ordinary moist atmospheric air, it unites with the oxygen of the latter, to form two varieties of oxide of iron; in the first instance, the ferous oxide (Fe O), which becomes rapidly converted into another, or the second variety, the ferric oxide ($Fe_2 O_3$). If a piece of iron is exposed to oxidizable influences sufficiently long its entire substance will become oxidized; for as soon as the superficial filling of oxide on the surface of the iron becomes converted into the second variety, or ferric oxide, part of its oxygen is transmitted to the metallic surface beneath it to form ferrous oxide, and this latter also becomes in its turn converted into ferric oxide, and again transfers its oxygen to the still remaining metallic iron; and this process goes on continuously until the whole of the iron becomes oxidized. Hence, if iron is not protected from this oxidation, corrosion, or action of decay, its strength becomes in time seriously impaired. As will be seen from the formula‡ (arranged by the Author and based on a series of experiments on the action of the oxidation of iron, in order to ascertain the metallic life of iron with a tolerable degree of exactitude), it appears that a bar of wrought iron, 4 inches x 1 inch, subjected to the corrosive atmospheric influences of a manufacturing city, would be entirely corroded away in a little over a single century.

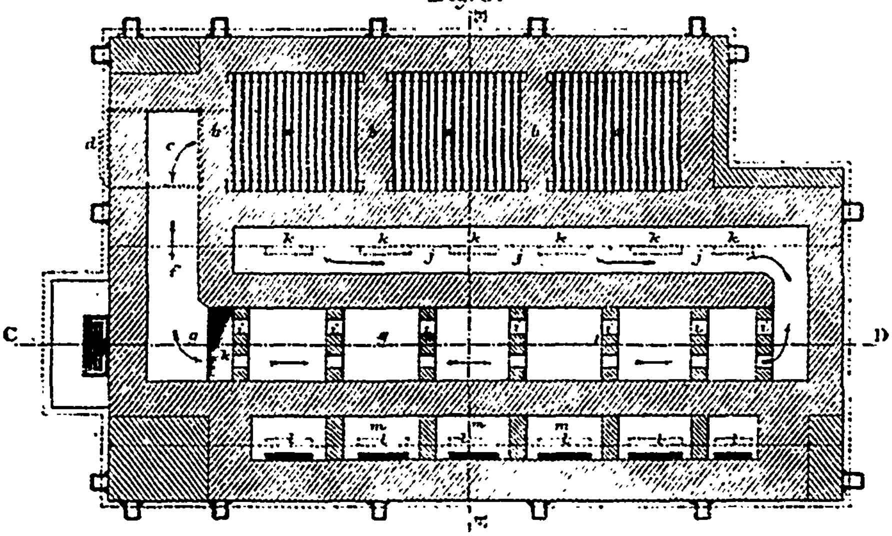
DIAGRAMS ILLUSTRATING THWAITE'S PAPER ON THE PRESERVATION OF IRON.

Fig: 4.



LONGITUDINAL SECTION AT C.D.

Fig: 3.



PLAN AT A.B.

Fortunately, however, besides the two combinations of iron with oxygen already mentioned, there is a third, or the magnetic oxide Fe_3O_4, a most stable oxide, and, as in the examples of the oxides of zinc and copper, once properly formed of a certain thickness, it arrests further oxidation of the iron. It is found in a natural state on the shores of New Zealand, in the form of black titaniferous sand, and although the sea water is constantly washing over it, its stability is apparently unaffected. Lavoisier is credited with the discovery of the artificial formation and staple properties of the magnetic oxide, and the late Mr. Robert Mallet, M. Inst. C.E., discovered it during one of his experiments. Berthier noticed it when iron was subjected to highly-heated air, and, Thirault is said to have produced the magnetic oxide in 1860, in a very peculiar manner. A modification of Thirault's process is now adopted by gunmakers, who, by means of processes, although long and tedious, succeed in obtaining a most beautiful coating of oxide.

The Russian sheet iron is covered with a thin and rather pliable film of this magnetic oxide, but whether this coating of oxide was originally applied by accident or intention it is impossible to say. An interesting paper, by Dr. Percy, F.R.S., Hon. M. Inst. C.E., "On the Protection from Atmospheric Action which is imparted to Metals by a coating of certain of their Iron Oxides respectively," was read at the meeting of the Iron and Steel Institute, in Newcastle-upon-Tyne, in September, 1877‡. In Russia and in the United States common use is made of this sheet iron for covering locomotive-boilers and steam-cylinders, as well as for roofing purposes. Some years ago Professor Barff, F. C. S., whilst engaged in experiments in peat charring, noticed the formation of this peculiar oxide,in a pipe conveying highly-heated steam, and observed its preservative action on the iron. He at once commenced a series of experiments and investigations, which resulted in the elaboration of a process for producing magnetic oxide, for the purpose of preserving the surfaces of iron. Professor Barff's process is a practical adaption of Lavoisier's principle. In his specification Professor Barff describes the process as follows:—"In carrying out my invention, I place the objects composed of iron or steel in a muffle, or chamber, so constructed as that it may be in part wholly closed, and so that the contents of the interior of such muffle or chamber may be raised, by means of external heat, to an elevated temperature, and when the objects or articles have acquired a temperature sufficiently elevated to cause the decomposition of steam or aqueous vapour when brought into contact therewith, I inject the same, and continue the action of the steam, or the aqueous vapour, until the desired protective film or coating of oxide has been produced." Fig. 1, page 328, represents the experimental apparatus used by Professor Barff in his primary investigations—*a*, treating chamber; *b*, coil steam-generator and superheater; *c*, furnace; *d*, water-supply pipe; *e*, hydrogen and escape-pipe. Fig. 2 represents the practical apparatus, subsequently adopted by Professor Barff. It will be seen that the muffle *a* is in this instance a brick chamber (about 6 feet long), beneath which is fixed an ordinary fire-grate, *b*. The heat of this fire passes both under and round the brick chamber, and thence to the chimney. Alongside this chamber is placed the steam-generator *c*, beneath which, and directly over the fire-grate *d*, is placed a coiled superheater *e*, from which the steam, highly superheated, issues direct into the brick chamber or muffle. The hydrogen, the result of the decomposition of the steam, is led by the pipe *f* to the underside of the fire-grate where it is consumed. On hearing of Professor Barff's process, it occurred to Mr. George Bower that highly heated air might possibly be used with success for obtaining a coating of magnetic oxide; Mr. Bower made a series of experiments with air as an agent, and a sample of iron, that was subjected to one of Messrs. Cochrane's hot-blast stoves, was found to have a most decided and adherent coating of magnetic oxide. The first furnace devised for carrying out the air process consisted of an externally-heated chamber, in which the iron articles to be treated were placed. When the iron articles had attained the temperature of oxidation, a few cubic feet of ordinary atmospheric air were blown into the chamber, which was closed, and the iron then entered into combination with the oxygen of the air, a thin film of magnetic oxide being formed on the metal. Fresh air was admitted from time to time, to replenish the oxygen appropriated by the iron, until the requisite thickness of oxide was attained. The difficulty and expense of the application of external heat were so great that it occurred to Mr. Bower's son, who was conducting experiments, that if internal application of heat could be substituted, and the coating of magnetic oxide produced simultaneously with the action of heating, by a series of oxidizing and deoxidizing operations, the process would be much simplified, be more effective, and far less costly. Elaborate experiments were conducted with this aim, and the results far exceeded anticipation. On the basis somewhat of a special furnace, devised and arranged by the Author, Mr. Anthony S. Bower developed a furnace for carrying out this process. Figs. 3, 4, page 329, and Fig. 5, page 332, represent plans and sections of this furnace. The combustible gases are generated in the three producers *a*, *a* and *a* (in the furnaces first designed, an ordinary single Siemens producer, with inclined plates, was used; but owing to the irregular supply and quality of the gas, it was decided to adopt three, of the form shown). By this arrangement a regular plenum of gas can always be obtained; moreover, the producers, are admirably adapted to the form of the furnace. They not only act as buttresses to resist the thrust of the furnace-arch, but they prevent wasteful radiation. Coals are charged through specially devised plug-hoppers. The plugs, in being withdrawn, permit the coals to fall into the producers with a minimum escape of gas. The Siemens balanced coal charging-boxes were tried, but they were abandoned in favour of the form described. The gases, evolved by the distillation of the coal, pass over the partition walls *b* descending by the downcast *c*, in which is fixed a regulating valve *d*. The gas then passes along the horizontal flue *f*, to the mouth of the combustion-chamber *g*, when it meets the current of heated air ascending from the recuperators of the port *h*. Combustion here ensues, perfect mixing and oxidation of the gases being attained by the series of intercepting chequer walls *i*; the products of combustion then pass into the side flue *j*, where they ascend into the furnace or muffle, by means of or through the ports *k*. The products of combustion descend from the muffle by the ports *l*. into the side flue *m*, passing from thence into the recurperator, where, by going round the air-tubes *n*, of fire-clay, they transmit their heat to the air flowing to support combustion. The products of combustion then escape into the chimney flue *o*. The air passes into the recurperators by means of the regulating valve *p*, and after flowing through the whole length of the tubes in the recuperator chamber twice, it ascends into the port *h*, where it meets the combustible gases coming from the producers.

The cast iron articles to be treated are placed in the chamber or muffle, and gradually heated by combustion of producer-gas within the chamber, up to the temperature of oxidation, say 1,600° Fahrenheit. The oxidizing process is then commenced, first by submitting the iron to an oxidizing flame, that is to say, by allowing highly-heated air in excess of that necessary for combustion to enter the furnace. The oxygen of this air in excess enters into a double combination with the iron. On the immediate surface of the iron a film or coating of the magnetic oxide (Fe_3O_4) is formed, and over this a film of sesquioxide (Fe_2O_3). The oxidizing operation generally occupies about twenty minutes. The air-valve is then entirely closed, and the combustible gases from the producers (carbonmonoxide, &c.) are allowed to enter unconsumed into the muffle. By this operation, a deoxidizing one, the sesquioxide is converted into the magnetic oxide; this deoxidizing operation generally occupies from fifteen to twenty-five minutes, the duration entirely depending upon the quality of the coal gas. The richer it is in carbon the less the time required to effect the deoxidizing operation. The air valve is now opened, and another double combination of oxygen and iron effected, which, by another deoxidizing operation, is reduced to one combination of Fe_3O_4, the magnetic oxide. It will be understood that by repeating the alternate operations of oxidation and deoxidation sufficiently often the entire metal could be oxidized.

The duration of the process depends upon the size, number, and intended use of the articles. For instance, only six double-oxidizing and deoxidizing periods are necessary for articles intended for internal or indoor use. For articles intended to be subjected to external atmospheric influences, from ten to twelve double periods of oxidation and deoxidation are necessary. Owing to the great sensitiveness of wrought malleable iron and steel to oxidisable influences, the Bower process produces the coating of oxide in these varieties too rapidly, and it is not sufficiently uniform or adherent; and the Barff process has been found by experience to be more satisfactory for producing the magnetic oxide coating on the surface of malleable wrought iron and steel.

However the two inventors combined their respective processes, and a furnace, having the economic features of the Bower furnace, was designed to effect the Barff process. This furnace is shown on pages 332 and 333, Figs. 6, 7, 8, 9, and 10; *a a a* are three gas-producers; the gas generated therein passes over the partition or division walls, descending by the downcast *b*, where its flow can be regulated by the damper *c*. The air to support combustion enters by the regulating air-inlet valve *d* and combustion takes place at the point *e*. The flow of the products of combustion can be directed either over the muffle *f*, by the side flue *g*, and then be turned into the chimney flue, or by withdrawing the damper *h* directly on to the steam-superheater *i*, or by closing the damper *h* and withdrawing the damper *j*, the products of combustion can be directed immediately on to the steam-superheater, without having to pass over the muffle.

In the preliminary experiments great difficulty was found in obtaining a satisfactory and durable form of steam-superheater. Circular coils of lap-welded steam-pipes, as shown in Fig 2, were first tried, but although effective as superheaters, their cost and liability to stoppage, the necessity of frequent renewal, and the rapid oxidation of the wrought iron, were grave objections, and cast iron was used in the form of a rectangular casing of the whole length of the furnace, and filled with small cast-iron balls. In order to prevent the oxidation of the casing its outer sides were grooved, to retain a refractory lining of a mixture of silicate of soda and fire-clay; but this lining soon commenced to crack and flake off on continuous exposure to the flame. Further, the oxidation and expansion of the cast-iron balls produced fracture in the outer casing; in other respects this form of superheater gave highly satisfactory results. The form of superheater now adopted is shown on Pages 332 and 333, Figs 6, 7, 8, 9, and 10. It consists of a cast-iron casing, rectangular in section, having a longitudinal division dividing the casing into two parts. The steam entering the lower division is compelled to traverse the whole length of the superheater twice before it can escape; to increase the heating surface the cast-iron casing is filled up with broken pieces of fire-clay of irregular size; the sides of the cast-iron casing are protected from actual contact with the flame by means of fire-clay tiles. The superheater can be renewed without disturbing any part of the structure or cooling down the furnace, a great desideratum, as the latter operation is very detrimental to the condition of the furnace. The superheater is connected to the muffle by means of an expansion coil (*k* Fig 6), which permits the superheater to expand and contract. It further serves as a pyrometer as by the relative visible temperature of the coil, which can be visually examined by removing a portion of the loose coal ashes which cover it, the temperature of the steam entering the muffle can be ascertained.

A great difficulty was at first experienced in arranging a satisfactory rolling-carriage, for carrying into and out of the muffle the articles to be oxidized; but the difficulty has been solved by the arrangement shown in Figs. 11 and 12, consisting of a cast or wrought-iron table having equally distributed perforations over its entire surface, and having horizontal cast or wrought-iron webs or ribs on its underside, which keep the differential rolling arrangements in position. This latter consists of a series of double rollers, their peripheries running in the channels formed on the underside of the table, and upon the false cast-iron base-plate forming the muffle floors. The rollers are held together by wrought-iron bars. By this arrangement, although there is no part of the rolling apparatus actually bolted, the carriage runs as freely and firmly at a temperature of bright red heat, as when cold, and each part can easily be removed, and renewed.

A point of importance to ensure success of the process, is the arrangement of the articles on the table before treatment. If placed indiscriminately and carelessly upon each other, they may become distorted during the process. All articles of any great length should be laid perfectly level, and be evenly supported, with sufficient space to allow for expansion. This is easily accomplished by the form of cradle or frame used. This consists (Figs. 11 and 12) of a framework of wrought-iron bars. Loose T-irons, bent at the ends, so as to hang over the horizontal bars of the frame, are fixed in any position suitable for supporting uniformly and level, the articles to be treated; the treating-table is drawn in and out of the muffle by means of a crab-winch.

When ornamental, or other castings of great delicacy of form are treated, a sheet-iron cooling cover (*m*, Fig. 6) is lowered to receive the table as it is withdrawn from the muffle. This allows the castings, &c., to be very slowly cooled; but generally this cooling cover is not required, as the accumulated heat of the carriage and frame rarefies the air and prevents the castings from becoming cooled too rapidly. After the articles to be treated are properly arranged on the table, the chain from the winch is attached to a portable handle, which is dropped into holes in the table; the muffle doors are then lifted, and the table is slowly and carefully drawn into the muffle. The doors are next lowered, and with a trowel the attendant lutes their edges with a mixture of loam and sand. Just before the articles are drawn into the muffle the steam is gradually turned through the superheater into the muffle. A pressure varying between one atmosphere and two atmospheres is all that is necessary, as great pressure only forces the steam too rapidly through the superheater. What is necessary, before the articles are placed in the muffle, is that a plenum of steam should be established, in order to prevent the influx of air into the muffle, the heat of combustion is then turned fully over it, by withdrawing the damper *o* (Figs. 8 and 9), is afterwards directed on to the superheater, where it is compelled to pass under and over the latter by baffler walls. These also support the floor of the muffle, and act as accumulators of heat. After passing around the superheater the products of combustion may be directed into a steam-generator. In the works of the Bower-Barff Rustless Iron Company at Southwark, it is intended that the waste heat shall, on its way to the chimney, be directed through the tubes of one of Cochrane's patent vertical multitubular boilers—a form of steam-generator very suitable for this purpose. After the temperature of oxidation is attained in the muffle, the flow of combustion is almost entirely directed immediately on to the superheater, by withdrawing the damper *h* (Figs 8 and 9), only as much heat being allowed to pass round the muffle as will maintain the temperature of oxidation; the temperature of the muffle can be ascertained either by using a pyrometer, or visually, by withdrawing one of the movable movable sight-plugs provided in the doors. If the articles are covered with rust before they are treated, the rust must be reduced, immediately the temperature of oxidation is attained, by first shutting off the steam from the muffle, and turning into it instead carbonmonoxide gas from the producers, by means of the valve *p* (Fig 9) and its connections. During this process a good pressure of C.O gas must be maintained, otherwise there is a danger of the ingress of air into the muffle. After the process of deoxidation, which varies in time according to the extent of the rustiness of the article, the steam must be turned on carefully.

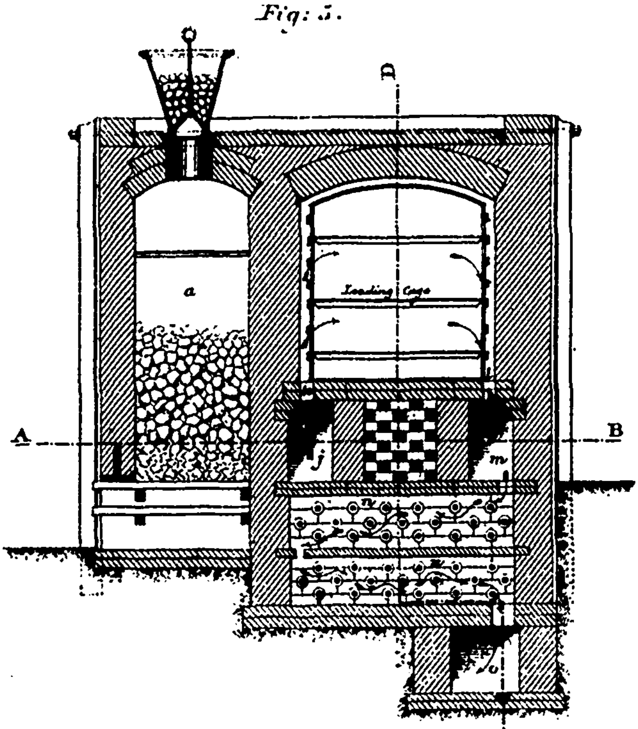
Another deoxidizing process is occasionally used, with very good results. The method is as follows. Oil is poured into a funnel, having a siphon bend, from which it passes into the muffle by a ½-inch gas-pipe. In its passage through the latter the oil becomes decomposed and volatilized, and the hydrocarbon vapours, being prevented from escaping by the liquid seal of the oil siphon bend, are driven into the muffle, where they effectually convert the red rust Fe_2O^3 into the magnetic oxide Fe^3O_4.

It is important, in order to prevent the possibility of the influx of air into the muffle, that a continuous and uniform pressure of steam should be maintained. The least admission of air will produce an imperfect and unstable coating of magnetic oxide. Generally when air obtains ingress into the muffle, the articles are found to be covered with a film of oxide of a brilliant red colour and having a lustrous appearance. When this occurs the furnace should be at once examined, as it is a clear proof that air gets into the muffle somewhere. Occasionally there may be a leakage, and air may enter in such small quantities as not to exhibit the phenomenon described, and such has been the case with one of the furnaces at St. Neots. The magnetic oxide coating, although apparently perfect, was, after a few times of exposure to oxidizing influences, found to exhibit incipient signs of red oxidation. On examination the muffle was found to have a fractured plate. In an externally heated muffle, like that of the Barff furnace, it is possible to regulate the temperature to a nicety, a feature of great importance, when intricate and delicate articles of steel or wrought iron require oxidizing; but for heavy cast-iron articles external heating is very disadvantageous, both from the question of economy in the use of fuel and in the time required to heat the articles up to the temperature of oxidation. Hence the advantage for cast iron of the internal and direct heating features possessed by the Bower process. Another great advantage of the latter process is that the progress of oxidation can be readily and almost closely examined during one of the oxidizing operations. Through one of the sight-plugs in the muffler-door a lighted gas-rod is inserted, and by looking through one of the other adjacent sight-plugs, the exact character and progress of the oxidation can be clearly seen, hence the process is exactly reliable, and there need be no sense of uncertainty as to results. By the Bower process a most effective coating of magnetic oxide can be obtained in from three to eight hours, according to the thickness, character, and size of the articles to be operated upon.

(*To be continued.*)

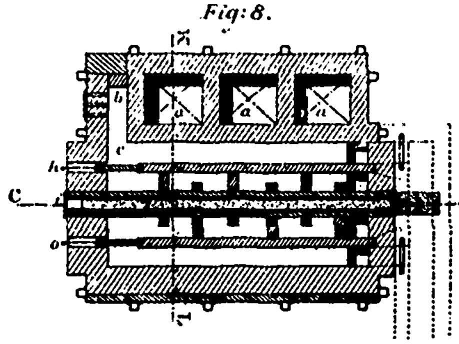
DIAGRAMS ILLUSTRATING THWAITE'S PAPER ON THE PRESERVATION OF IRON.

Fig: 5.



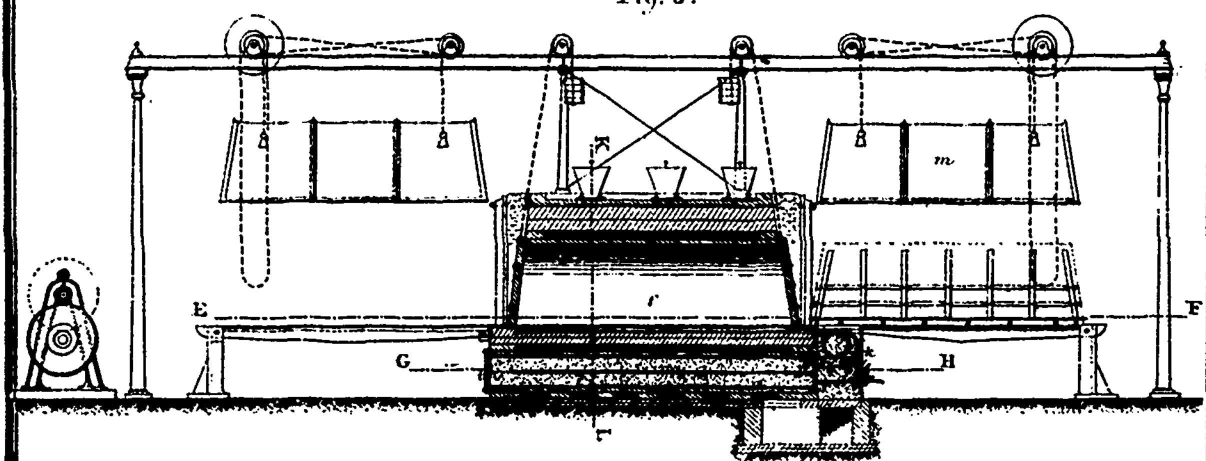
CROSS SECTION AT E.F.

Fig: 8.



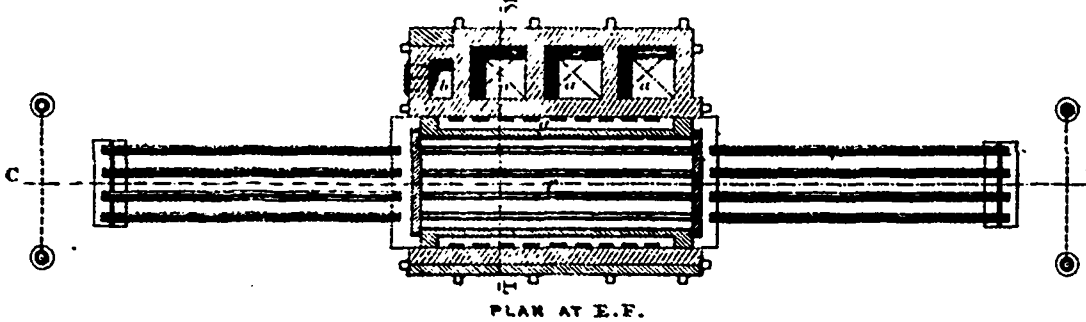
PLAN AT G.H.

Fig: 6.



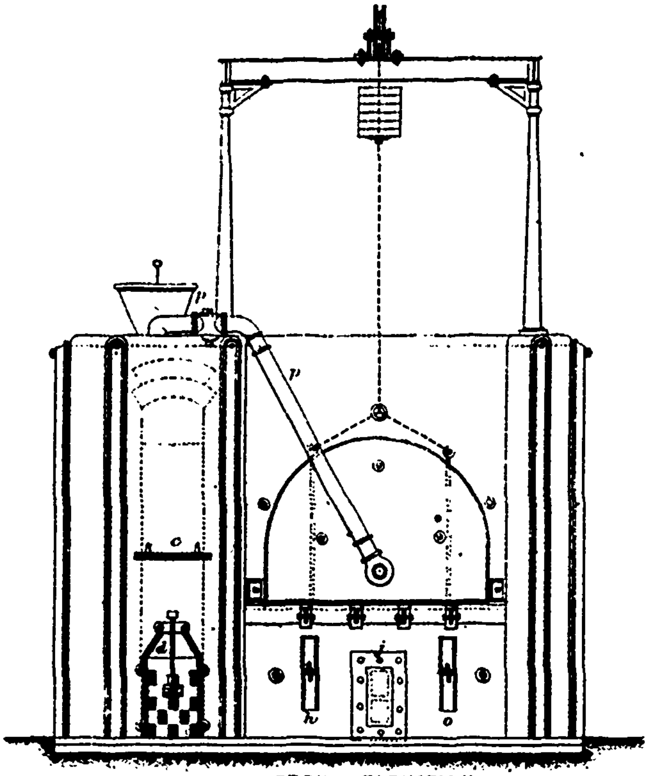
LONGITUDINAL SECTION ON LINE C.D.

Fig: 7.



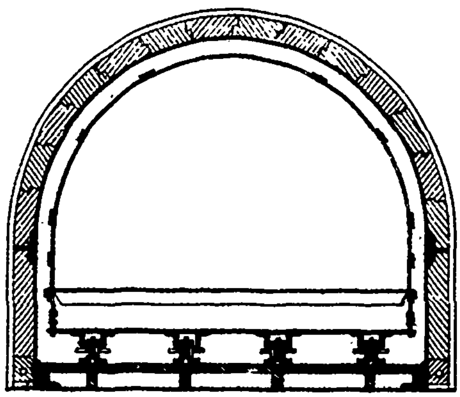
PLAN AT E.F.

DIAGRAMS ILLUSTRATING THWAITE'S PAPER ON THE PRESERVATION OF IRON.



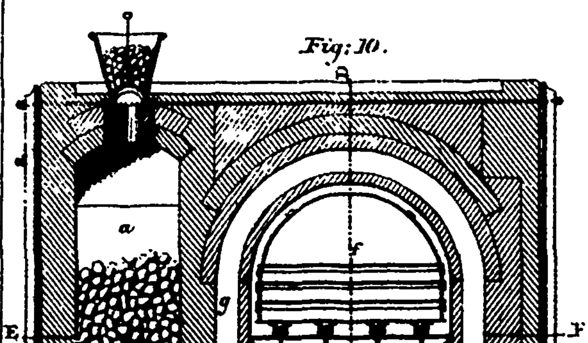
FRONT ELEVATION.

Fig: 11.



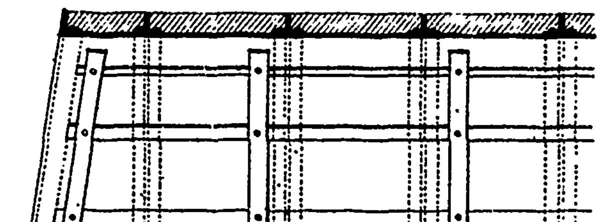
CROSS SECTION.

Fig: 10.



CROSS SECTION AT E.F.

Fig: 12.



HALF LONGITUDINAL SECTION.

ASBESTOS AND ITS USES.

Asbestos must be considered, in mineralogy, rather as a term implying a peculiar form sometimes assumed by several minerals than as a name denoting a particular species. It is, in fact, applied to varieties of amphibolic minerals, such as actinolite, tremolite, etc., when, as frequently occurs, they are found in the form of long capillary crystals, lying side by side in parallel position, and thus composing a fibrous mass Those varieties, the fibres of which are very delicate and regularly arranged, are called "amianthus"—a word of Greek derivation having reference to the ease with which when soiled the substance may be cleansed and restored to its original purity by being heated to redness in a fire Charlemagne is said to have had a tablecloth woven of this beautiful material, which, after dinner, for his amusement and the astonishment of his guests, he would gather up and throw into the fire, taking it out afterwards not only unconsumed, but freed of previous stains and soils. Asbestos of this delicate quality is found in deposits, usually several inches thick, in the crystalline rocks in Piedmont, Savoy, Salzburg, the Tyrol, Dauphine, Hungary, Silesia, and so abundantly in Corsica as to have been made use of by Dolomieu for packing minerals Of the finest kind of asbestos the individuals crystals are readily separated from each other, and are very flexible and elastic, and have a white or greenish colour, with a fine silk lustre Though a single fibre is readily fused into a white enamel, in mass it possesses the well-known property of resisting the ordinary flame, so that when woven it produces a fire-proof cloth. The common asbestos, however, is a variety in which the crystals are coarser, with scarcely any flexibility. This is usually of a dull greenish, and sometimes pearly lustre, and readily fuses below the blow-pipe flame. In the serpentine formation at Lizard Point, in Cornwall, it is common, as also in the micaceous slate in Inverness. In upper Saxony, Silesia, and Switzerland it is also found in conjunction with serpentine, and in Bohemia it occurs in metalliferous beds, accompanying magnetic ironstone In short, it belongs to no country or zone, being, in various degrees of quality, distributed over almost the whole world having been found and used in Greenland and Australia, in America and Russia, in Canada, Germany, Austria, and Spain There are, beside those already mentioned, other qualities of mineral comprehended under the general title of asbestos, such, for example, as what is sometimes called mountain leather or mountain paper—which is not found in parallel fibres, but with the fibres interwoven ; mountain cork—so called because it floats on water —which has, like the preceding, an interlaced fibrous texture, varies in colour, being white, grey, yellow, or brown, and in appearance and feel is not unlike common cork ; and mountain wood, which is usually massive and of brown colour, having much the appearance of wood.

Asbestos is almost Protean in the number and variety of the forms in which it is capable of serving the requirements of industry, and contributing to the comfort and security of life. As a packing for engine cylinders, a binding for joints, a covering for pipes to prevent the radiation and to secure the transmission of heat, it lends itself with results that no other material can excel. As a flooring-felt it renders any building in which it is employed, comparatively fire-proof, and with a curtain of the woven fibre the proscenium of a theatre may, in case of fire, be completely isolated from the auditorium. As a material for clothing, it enables firemen and others to move in the midst of fire unscathed. Asbestos paint and putty resists fire and acids, and asbestos blocks make an ordinary fireplace into a stove, adding all the convenience of gas to the cheerful aspect of a coal fire.

The discovery of asbestos and its application to useful purposes are not to be numbered among the achievements of modern times. The incombustibility of the mineral was well known to the ancients who made a kind of asbestos cloth, in which they used to wrap the bodies of the illustrious dead on the funeral pile, that their ashes might not mingle with the ashes of the wood One of these shrouds, containing ashes and burnt bones, was discovered in the year 1702 in the Vatican, at Rome Napkins were also made of a similar cloth, and wicks of asbestos were used in the ancient temples, as they still are used by the Greenlanders How or at what time asbestos was introduced into this country is not known, but during the last fifteen years great progress has been made here, both in the development of its manufacture and in its application to the various purposes for which its peculiar properties render it especially suitable.

The fibres of asbestos differ from all ordinary fibres in having a perfectly smooth surface, and in being less elastic than those of either vegetable or animal origin, and these peculiarities practically defeated until very lately all attempts to weave and spin the material. Flax and other vegetable fibres were mixed with asbestos, but these formed most objectionable adulterations. Lately, however, the difficulty of weaving has been overcome, and now yarns capable of great tensile stresses are being produced by special machinery. One of the most important applications of this yarn is for the manufacture of steam packings, of which a great variety are made, each description being designed to meet some special demand. In making packing it was at first not sufficiently recognized that the fibres of asbestos were apt to be largely charged with minute particles of pyrites, and until the fact was appreciated it was often found that the piston-rods were scored, the damage being attributed to the action of the asbestos itself, instead of to the impurities it contained. To obviate this defect it therefore became necessary, not only to carefully select the most suitable kind of asbestos for the purpose, but to thoroughly cleanse it from all stone and grit before spinning, for which duty machinery had to be adapted. The yarn now produced is quite pure, and is capable of being woven into almost any kind of fabric. This manufacture was introduced by Mr. Bell in 1879, and its worth was at once testified to in the most conclusive and gratifying manner by its adoption in the British and German navies, where it still continues in use. Special cases, however, were soon met with in which it was discovered that a special treatment of the material was required, in the case especially of steam-engines with extremely high-piston speeds, such as are now being adopted in the merchant service. To meet this requirement the yarn was first woven into a cloth, which being slightly waterproofed with vulcanised india-rubber, was rolled up into a rope. This packing was found to answer the purpose admirably, and it is being largely used in cases where the rapid destruction of ordinary packings gave rise to most serious inconvenience. In addition to the two varieties here mentioned, other forms are made asbestos with soapstone being found to be excellent for locomotive work, while a more elastic packing, in which a core or internal band of india-rubber is introduced, gives great satisfaction in the large glands of marine engines and other similar cases. This latter form has been designed to overcome the difficulties met with in working with steam of very high pressure, the economical advantages of which cannot be realised without a much more durable packing than most of those generally used. The enduring powers of the asbestos block-packing are remarkable In one case, after being taken out after twelve months, working with steam of 70 lb. pressure, it was found to be perfectly good, and was accordingly replaced, while as an instance of its efficiency, we have before us particulars of a case in which, after trying almost every kind of packing in a troublesome stuffing-box of a large pumping engine without avail, the asbestos packing was used, with results that were at once completely satisfactory, and have since led to the maintaining in the cylinder of a vacuum nearly two pounds better on the average.

The production of a pure asbestos yarn has made possible the weaving of a pure asbestos cloth ; and this manufacture has already considerably enlarged the sphere of the useful application of asbestos. Very long ago Chevalier Aldini, of Milan, constructed an incombustible dress for firemen, and to test it conducted some interesting and fairly successful experiments. The parts of the dress which protected the body, arms and legs were formed of strong cloth steeped in a solution of alum, while those for the head, hands, and feet were made of cloth of asbestos. Very great improvements, however, have been lately introduced in the production of a light, yielding, and perfectly protective fabric, which obviously renders asbestos applicable to many new uses. We have already referred to the manufacture of fire-curtains for theatres, and for such purposes asbestos cloth is now being largely adopted. It is also found to be admirably adapted for all kinds of filtering. It is woven into funnel form for chemists, and according to each special requirement is adapted for waterworks, breweries, baths, mills, and manufacturing purposes, as well as for domestic use. For the joints of pipes exposed to the action of moisture, and for man and mud-hole doors requiring frequent removal, asbestos woven cloth is also found to be well adapted. A combination known as asbestos and india-rubber woven sheeting effectually resists heat and damp. It is made to any thickness, and supplied in sheets to cut to the required shape, or in tape 1 in. to 2 in. wide which can be cut to length and bent to circle or oval without puckering. In the case of man and mudhole doors and feed-water pipes the joint can be broken twenty times without requiring renewal of the strip. The yarn is further adapted to the manufacture of rope and cord. Having great tensile strength, and being unaffected by heat and damp, this material is being introduced for sash-lines and for ropes of fire-escapes. It is also adapted for covering rollers in print works, especially when aniline dyes are used, and in cases where it is exposed to great heat and to the action of hydrochloric acid. Asbestos cord has also been found to be the most effectual material for making the joints of the hot-air pipes for blast furnaces, which are exposed to an exceedingly high temperature.

Another form into which the mineral is made up, and in which it has become an important article of commerce, is asbestos millboard. In this case, the rock is broken down and reduced to fluff, then pulped and formed by pressure into sheets of varying thickness. In such a form it is very suitable for making joints not exposed to the action of moisture, such as for dry steam, air, and gas. The board is easily cut to the desired size, and as no time is required for drying and setting, steam can be turned on directly the bolts are screwed up. It is safe to say that of no material can dry steam and air joints be made with more ease and certainty than with asbestos millboard. A much commoner and cheaper millboard, though it still possesses most of the essential qualities, is manufactured for fireproofing floors and ceilings. It is made in sheets about 1-24th in. thick, and is applied in the simplest possible way either above or below the joists. It is also used for lining the walls of wooden buildings, where, from its non conducting and fireproof qualities it affords an immense protection in case of the outbreak of fire. For surrounding flues or covering the parts of a building exposed to the action of heat, or in the neighbourhood of a fire, it is also a reliable safeguard.

THE BRITISH INSTITUTION OF MECHANICAL ENGINES.—This society held its summer meeting in Belgium. It was received by the Association of engineers of Liége university, and visited the principal engineering establishments of the country. President Westmacott, in his opening address, called attention to the progress recently made in the rapid production of good articles of manufacture, and to the fact that speed and excellence of work are not incompatible where machinery is used. The materials must be of the best quality, however, the machines well proportioned, and all working parts well balanced and well fitted. He referred to Thorneycroft's experience with torpedo-boats, and called attention to the fact, that, at high speeds, the difficulties of lubrication and the jar observed at lower speeds disappear. In the speed of railway-trains, no advance has been lately made, and the maximum speeds remain at the figures of earlier years. Some economy has been obtained by the use of the crude products of the distillation of petroleum in the fireboxes of locomotives, this economy sometimes amounting to fifty per cent. Cotton-machinery has been speeded up, until the spindles which formerly made 5,000 revolutions are now making from 8,500 to 10,000 on fine American cotton. The increase in speed of wollen-machinery has not been great. In gunnery, the weight of gun and projectile have increased, in twenty five years, from 5 tons and 66 pounds to 100 tons and 2,000 pounds. The shot has an initial energy of nearly 50,000 foot-tons. High speed is the direction of change in all departments of engineering.

NEW METHOD OF LAYING RAIL.—John Reid, of Alleghany City, has patented a design for laying steel or iron railroad rails which he claims will forever bar accidents caused by ditching of trains through the expansion or contraction of rails by heat or cold. The object of the invention is to produce a better railway, more reliable and safer than heretofore and without lateral or vertical motion. Instead of wasting so much timber in the ties, Mr. Reid proposes to have only 900 ties per mile of single track, and these need not be more than seven feet long by five inches square. He then lays timber cushions or beams under both rails, lengthwise, twelve inches deep by six inches thick, the beams having a lengthwise groove to receive the diaphragm of the rails, completing both ties and cushions with not more than 6,300 feet of preserved wood. The crown or upper part of the rail, which is subjected to friction, is made much heavier than usual, the base is made broader, with a diaphragm below to resist lateral pressure. A safety-stay coupling made of cast steel, is fitted and inserted in the abutting ends of the rails. These are held down by heavy screws in the wood cushion beneath. In addition to the safety guarantee in this invention, it is claimed that it is cheaper and can be kept in repair for much less cost than any other method in operation. It will be noticed that Mr. Reid's device is much the same as that of Thomas Johnson, Vice-President of the Indianapolis Street Railway. The track laid about one year ago, on North Illinois street, is similar to that which Mr. Reid has secured his patent on.

GASEOUS FUEL IN IRON MANUFACTURE.—Mr. W. S. Sutherland read a paper before the British iron and steel Institute, on the production and utilization of gaseous fuel in iron manufacture, in which he claims that the seams of boilers can be welded instead of riveted, if the heat can be applied uniformly, and of sufficiently high temperature, without excess of air or admission of dirt. This kind of heat he has obtained only by the use of coal-gas, Siemens-producer gas, or water-gas, the preference being given to the latter. To secure the requisite air in constant proportion, the gas being in excess, gas and air are mixed before combustion; probably the first instance of such a utilization of the principles of a Bunsen burner on a larger scale. Explosions are prevented by having an outlet lightly covered by india-rubber, at some corner of the main; and when the wave, or disk of flame, which does not readily turn a corner, reaches this cover, it breaks the rubber just as a blow would. The method has been worked some ten years without accident. From all his experience, Mr. Sutherland concludes, that to produce a good, true, wrought iron, Siemens gas with varying proportion of air. instead of air alone, should be blown into the iron in the Bessemer converter.

THE WESTINGHOUSE AUTOMATIC BRAKE.

For Illustrations see Pages 336, 337 and 340.

The first view is a section of the air pump carried on the locomotive. This is so well understood as hardly to need any description. The steam enters the valve chest by the inlet 34 at the left of the figure, between the two pistons of the main valve 14, and tends to raise them, as the upper one is of greater diameter than the lower. It also gains access through the small passage *f* to the upper side of the piston 20, when the slide valve 13 is in the position to permit of it, and under these conditions the main valve is forced to the bottom of its stroke, as in the figure, and steam admitted to the lower side of the main piston. When the latter approaches the end of its stroke, the plate 10 catches the shoulder of the rod 12, and moves the valves 13 into the other position, breaking the communication of steam to the upper side of the piston 20, and opening one with the exhaust outlet 35. The main valve then rises and the pump makes a stroke in the opposite direction, until it is reversed by the plate 10 catching the hemispherical head on the rod 12. The difference between the present pump and that illustrated in engineering in 1875, is that all the air valves are arranged one above another, so that they are all accessible from one side of the pump. The rod 12, which formerly came through a stuffing-box at the top, is now entirely enclosed. We may mention that the pumps are manufactured by the Westinghouse Automatic Brake Company, King's Cross, in various sizes, and for general purposes.

Fig. 2, on page 339, is a section of a 3 in. triple valve, whose office is to admit air to the brake cylinder and exhaust it in response to the variations of pressure in the train pipe. The construction and operation of this valve are as follow: Enclosed in a case 1 is a piston 5 carrying with it a slide valve 6 which covers the port *a* to the brake cylinder, and in the position shown establishes a communication between *a* and the atmosphere by the exhaust cavity *b* and passage *c*. Compressed air from the train pipe enters the lower part of the case at E, and forcing up the piston 5 feeds past it into the reservoir through the groove *d*. When the pressure in the train pipe is reduced suddenly the piston falls, and in so doing shuts off both the reservoir from the main pipe E, and the cylinder from the exhaust port D: at the same time the passage from the reservoir to the cylinder is open and the brakes are applied. For the purpose of graduating the brake force a small valve 7 is introduced into the slide valve 6. Its action is as follows: Upon a slight reduction of pressure in the brake pipe, the piston 5—having a limited movement without affecting the slide valve 6—will descend, thereby closing the feed groove *d*, and at the same time unseating the valve 7, which thus opens the passage *e*. The slide valve 6 then moves until the passage *e* opens into the port *a* leading to the brake cylinder, the communication from which to the exhaust is at the same time cut off. The further downward movement of the slide valve 6 is arrested by the decrease of pressure above the piston caused by air flowing into the brake cylinder. So soon as the pressure in the reservoir is thus reduced a little below that in the brake pipe the piston 5 moves up of its own accord, and closes the valve 7, while the slide valve 6 retains its position. By repeating this movement the driver can obtain any desired pressure, up to the maximum, in the brake cylinder.

On reference to the engraving of the triple valve in Engineering of July 18, 1879, it will be seen that the valve 7 is now much more firmly mounted than it was then, but in other respects the appliance, as far as the above description goes does not show much change. A addition has, however, been made to the valve 6 to prevent the application of the brakes by leakage to the train pipe. A small hole runs from the face of the slide valve to the passage *e*, and as the valve creeps down, this hole allows the air to escape into the atmosphere instead of into the brake cylinder. The reduction of pressure thus caused above the piston, as already explained, prevents the slide valve from moving far enough to close communication between the port *a* and the exhaust cavity *b*.

Fig. 3 is a section of the driver's brake valve placed between the main reservoir on the engine and the brake pipe. As the parts are shown the air from the reservoir passes through the openings *a* in the main valve 6 into the brake pipe on the right of the figure. This is the first position, and corresponds with the act of charging the train pipe and releasing the brakes. When the train is running the valve is turned until the holes *a* and *e* do not face one another, and the air passes by the valve 7 and a passage, not shown, to the brake pipe. This valve requires a pressure of 10 lb. to the square inch to lift it, and consequently the pressure in the brake pipe is 10lb. less than in the main reservoir. A little past the second position all communication between the main reservoir and the brake pipe is cut off, and the further turning of the handle towards the right lessens the pressure on the spring 4, and permits air to escape from the train pipe into this atmosphere through the opening M until an equilibrium is established between the spring and the air pressure.

Fig. 4 shows two couplings (one of them in section) united to form the connection of the main brake pipe between two vehicles. The two couplings are exactly alike, and an air-tight joint is formed by means of the rubber packing ring 3 in each; these rings press against each other when the couplings are united. To effect the connection the couplings are placed face to face at right angles, the stop pins being on the underside, and then they are turned until the projection *g* on each takes firmly into the groove provided for it on the other. No damage is done if the couplings be drawn apart forcibly by the separation of the train, as the rubber rings are forced into their respective couplings far enough to permit the projections to disengage themselves from the grooves. It will be noticed that there is no provision for opening and closing the ends of the loose pipe when the coupling is made and unmade as in the design illustrated in *Engineering* on July 18, 1879.

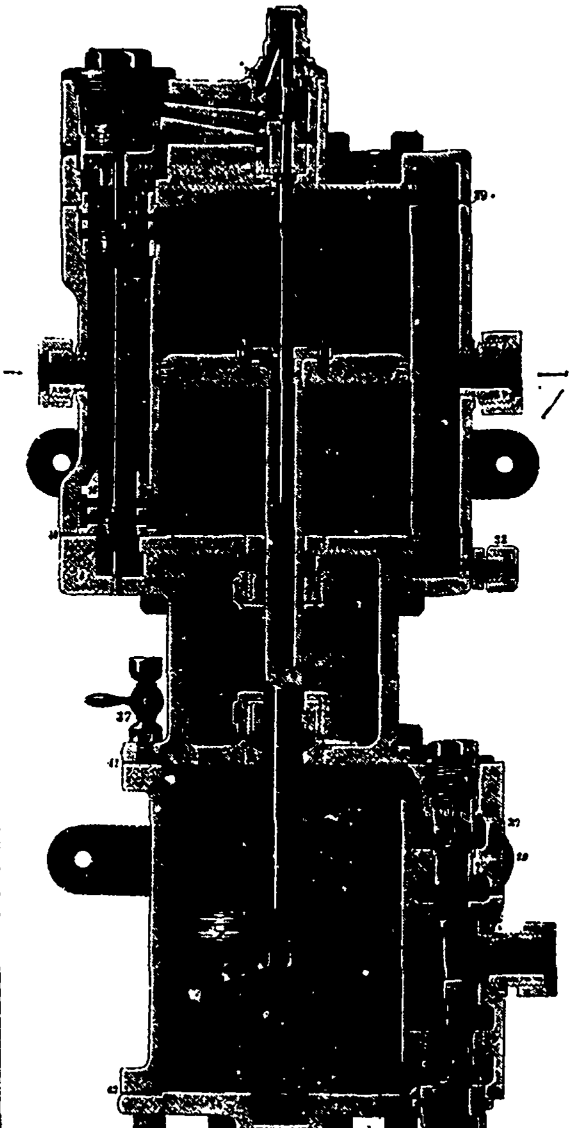
Fig. 5 is a half sectional elevation of an 8 in. double piston brake cylinder, the size used for ordinary carriages of from 6 to 12 tons weight. Air is admitted between the two pistons which are thrust outwards with equal force, compressing the spiral springs. Upon the air being allowed to exhaust the springs push back the pistons and release the brakes. No glands or stuffing boxes are required. A leakage groove is cut in the cylinder from one side of the piston to the other to prevent the brakes being applied by leakage; when the compressed air is admitted rapidly the pistons move past the groove and the air is retained.

Fig. 6 is an 8 in. single piston cylinder of the same general design as the above. In some cases it is necessary to attach the automatic brake to vehicles already fitted with hand or other brake gear. To save the expense of alterations, single piston cylinders are then employed.

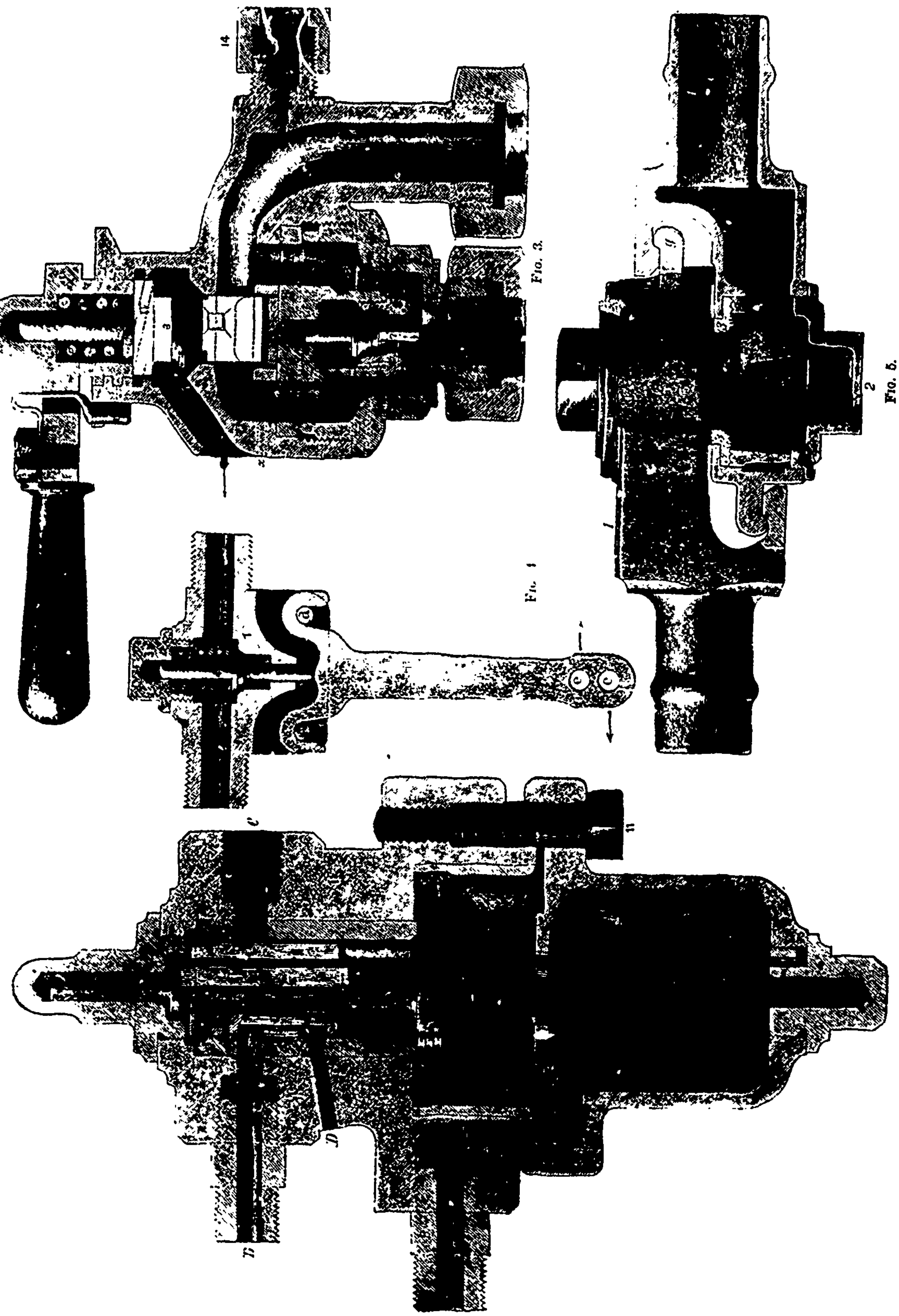
Fig. 7 is a 6 in. driving wheel brake cylinder. Air is admitted above the piston, and the brakes are released by the spring. There is no gland or stuffing box.

Fig. 8 is a 13 in. vertical cylinder of the kind used for tenders and driving wheel brakes when operated by a rocking shaft. It admits of being easily connected to the hand brakes, and the trunk piston permits the use of very short connecting rods. The air enters at the upper left hand corner.

THE WESTINGHOUSE AIR PUMP.



DETAILS OF THE WESTINGHOUSE AUTOMATIC BRAKE.



Scientific.

PLEASANT HOURS WITH THE MICROSCOPE.

(*For illustrations see page* 348.)

BY HENRY S. SLACK, F.R.S., F.R.M.S.

Goethe anticipated the mode of studying nature now generally admitted to be right, when he said to Eckermann, "The utility teachers say that oxen have horns to defend themselves, but I ask, why is the sheep without any? If, on the other hand, I say the ox defends himself with his horns because he has them, it is quite a different matter." Some shallow thinkers have regarded this mode of reasoning as opposed to a recognition of design in nature, but it is not so. Sciences of observation and experiment have to do only with how and what. The *why* remains for philosophical consideration, and as the old design argument fades away on account of its narrowness and insufficiency a much grander one arises, showing that the adaptation of organisms to their surroundings arises out of general laws, and cannot be rightly viewed as so much disconnected exhibitions of creative skill. Let us examine two insects belonging to the great Order Hymenoptera, and notice how importantly their mouth organs help to determine their way of living. If the head of a wasp is looked at with a hand magnifier, immediately below it upper lip two remarkably powerful mandibles are seen. They work—as insects' jaws generally do—horizontally, and are furnished with strong, pointed teeth. Look in the same way at a honey bee. Its mandibles are much smaller, its face looks more innocent; quite mild as compared with the tiger-like countenance of the wasp. Its jaws inform us at once by their aspect that the creature will not be engaged, as the wasp will, in hard biting work. Extending a little beyond the mandibles, the pocket lens will show, in the wasp, a short, squarish, three-cleft organ of gauzy texture, the centre portion being the biggest, with a yellow spot at each tip, and similar spots, one each at the tips of the side divisions. This is a lapping tongue. The bee's tongue is also a lapping one, but constitutes a much larger and more powerful-feeding machine. It lies between two labial palpi and two maxillæ, which all join to form a tubular sort of sheath for it.

A good way to know something of this remarkable apparatus is to catch a bee in a bottle, and see it feed. For this purpose a wide-mouthed bottle, of thin glass and about one inch in diameter, will do, or, still better, a wide-mouthed test-tube, which can be bought for one penny, and which should be fitted with a cork not tight enough to exclude fresh air. The bee is easily caged while busied with a flower. Let it have a little time to recover from its astonishment and alarm, and then, while it is in the bottom of the tube, withdraw the cork, and put a little syrup of sugar and water upon it before replacing it. Previous to commencing dinner, the bee's tongue and adjacent mouth-organs look like a brown flattened tube of gutta-percha, curved—if one may so speak—under its chin, and towards its breast. As soon as it finds the syrup, the jaws open, the tongue is thrust forward between them, and an unexpected piece is shot out beyond the maxillæ. The pocket lens will indicate that this portion is very hairy, especially towards its tip. It may, in fact, be likened to a long-haired flexible broom, and the insect uses it accordingly. The long hairs all point downwards, so that, when the creature bends the end of the tongue backwards, lays it along the cork, and then draws it forward, it acts exactly as we should do if we were using a flexible brush to wipe up a slop. Every now and then the creature draws the tongue between its hairy forelegs, as if to clean it, but the action may also bring the fluid down to an orifice through which, I think, it is sucked up. Another curious motion may also be seen, that of thrusting the tip of the tongue backwards towards it body. Is this only another cleaning process? or does the bee propose to carry off some of the syrup sticking to its hairs? Let the reader catch some bees, feed them well, and pay attention to their ways.

In a former number will be found figures of the mouth organs of the biting breeze flies. Their maxillæ are carving-knives, very unpleasant when used upon ourselves. The bee's maxillæ serve quite another purpose; they are not cutting implements at all, but combine with the next inner organs, the hairy labial palpi, to cover the tongue, and stroke down the fluid it laps up, when the insect rapidly withdraws the extended part up into the tube-like sheath which they form. This is the interpretation of their use which watching the feeding process suggests.

It is evident that the wasp's very different tongue could not do such effective lapping, and its shortness would prevent its gathering the nectar of many tubular flowers.—*Knowledge.*

THE CHOLERA BACILLUS.—(*Nature.*)

The report in which Dr. Koch, chief of the German Scientific Expedition, embodies the results hitherto obtained by him and his assistants with regard to the cholera in Egypt, deals in a very guarded manner with the question of the discovery of a definite cholera bacillus. As the result of experiments carried out both on living and dead cholera subjects, it appears that, whereas no distinct organism could be traced in the blood and in the organs which are so frequently the seat of micro-parasites, yet bacteria having distinct characteristics and resembling somewhat in size and form the bacilli found in glanders were discovered in the intestines and their mucous linings; and this under circumstances which seemed to identify them with the disease from which the patients were suffering. Thus, their existence in the intestinal membranes was obvious so soon after death that they could not have been brought about by any *post-mortem* changes; they were present in the case of all patients who were actually suffering from the disease, and in the bodies of all those who had died of it, whereas they were absent in the case of one patient who had had time to recover from cholera but who had died of some secondary complication; and they were not discoverable in the case of patients who, during the cholera epidemic, succumbed to other diseases. And further, the same bacillus had been met with by Dr. Koch, a year previously, in the case of four patients who had died of cholera in India, and portions of whose intestines had been forwarded to him for examination.

From these circumstances, Dr. Koch feels justified in provisionally holding the belief that these bacilli are in some way related to cholera, but as yet he is not prepared to say whether they are the cause or the effect of that disease. The number of cases which the Scientific Expedition were able to utilise for the purposes of their inquiry was very limited, and it is also suggested as possible that some of the experiments were vitiated owing to the circumstance that the disease was already subsiding in intensity when the investigations were commenced. Especially does Dr. Koch suggest that this may account for the invariable failure to produce cholera in any of the lower animals into whose bodies the intestinal secretions were inoculated; but as to this it must be remembered that human diseases are rarely communicable to other animals, and that, as regards enteric fever, a disease which etiolgically and otherwise has many points of resemblance with cholera, every effort to communicate it to other mammalia has hitherto invariably failed. But the failure of infective power which may possibly be associated with the declining stage of an epidemic would be very likely to interfere with experiments having for their object the isolation and cultivation of the bacillus, and hence we are glad to learn that Dr. Koch is to continue his investigations in India, where the varying stages of the disease can easily be met with. In the meantime, however, it will be well to remember that Drs. Lewis and Cuningham have, notwithstanding laborious microscopic and other researches in India, hitherto failed to identify any of the organisms they have met with as specifically related to cholera.

One point is set at rest by Dr. Koch's Report, and that relates to the actual nature of the disease which has been epidemic in Egypt. Both pathologically and otherwise he declares it to be identical with Asiatic cholera.

EVIDENCE OF MODERN GEOLOGICAL CHANGES IN ALASKA.—Mr. T. Meehan, at a meeting of the Philaetropic Association of Science, exhibited a piece of wood taken from a prostrate tree which had been covered with glacial drift on a peninsula of Hood's Bay, Alaska, formed by the junction of Glacier Bay and Lynn Channel. The trunk, which lay under a block of granite estimated to measure 2,214 cubic feet, was quite sound, and exhibited no evidence of great age since it became covered. The shores are strown with rocks and stones of various kinds, as usual in cases of glacial deposits. All the surroundings indicated that there had been a sudden subsidence of the land, accompanied by a flow of water with icebergs and huge boulders, which crushed and tore up the trees. The whole surface was afterwards covered to a great depth with drift. Since that time, there must have been an elevation of the land bringing the remains of trees to their original surface, but with a deep deposit above them. A study of the existing vegetation might afford an approximation to the time when these events occurred. The living forests indicated clearly that it could not have been, at the farthest, more than a few hundred years since the elevation occurred. The trees in the immediate vicinity, indeed, were not more than fifty years old; but unless the original parent trees, which furnished the seed for the uplifted land, were near by, it might take some years for the seed to scatter from bearing trees, grow to maturity, again seed, and, in this way, be spread to where we now find them. But, as original forests were evidently not far distant, two or three hundred years ought to cover all the time required. The Indians of the region have a tradition of a terrible flood about seven or eight generations ago, from which only a few of the natives had escaped in a large canoe. The probable identity of the sunken trees with the present species, and the freshness of the wood, indicate no very great date backwards at which the original subsidence occurred.

In connection with the subject of the comparatively recent occurrence of great geological changes, as indicated by botanical evidence, Mr. Meehan referred to an exposure of the remains of a large forest near the Muir glacier,—one of five huge ice-fields which form the head of Glacier Bay between Lat. 59 ° and 60 °. This glacier is at least two miles wide at the mouth, and has an average depth of ice, at this spot, of perhaps five hundred feet. At the present time there is not a vestige of arboreal vegetation to be seen in the neighbourhood. The river which flows under the glacier rushes out in a mighty torrent a few miles above the mouth, and has cut its way through mountains of drift, the gorge being many hundred feet in width, and the sides from two hundred to five hundred feet high. The torrent, though the bed is now comparatively level, carries with it an immense quantity of heavy stones, some of which must have contained six or eight cubic feet. Along the sides of this gorge were the exposed trunks referred to, all standing perfectly erect, and cut off at about the same level. Some were but a few feet high, and others as much as fifteen, the difference arising from the slope of the ground on which the trees grew. The trunks were of mature trees in the main, and were evidently Abies Sitkensis, with a few of either Thuja gigantea or Juniperus, perhaps J. Occidentalis. These trees must have been filled in tightly by drift to a height of fifteen feet before being cut off, otherwise the trunks now standing would have been split down on the side opposite to that which received the blow. The facts seemed to indicate that the many feet of drift which had buried part of the trees in the first instance were the work of a single season, and that the subsequent total destruction of every vestige of these great forests was the work of another one, soon following. As in the case of the facts noted in Hood's Bay, the conclusion was justified, that the total destruction of the forests, the covering of their site by hundreds of feet of drift, and the subsequent exposal of their remains, were all the work of a few hundred years.—*Meeting of Phil. Acad. of Nat. Sc.*

THE MAGNETOPHONE.

(*For illustrations see page* 341.)

In the *Electrical Review* for September 8th 1883, was published a short note on the subject of this apparatus. Mr. H. S. Carhart, of Evanstown, Ill., the deviser of the instrument, describes and illustrates his experiments more fully in *Science* of September 21st. The author says:—"The experiments of Bell, Preece, Mercadier, and others on the radiophone, suggested to me the possibility of interrupting, or at least periodically modifying the lines of force proceeding from the poles of a magnet, by means of a disc of sheet iron, perforated with a series of equidistant holes, and rotated so that the holes should pass directly in front of the magnetic pole. It is well known that an armature, placed on the poles of a permanent magnet, diminishes the strength of the external field of force by furnishing superior facilities for the formation of polarized chains of particles from pole to pole. This is the case even when the armature does not touch the poles, but is in close proximity to them.

If a piece of sheet iron be placed over the poles of a magnet without touching, and the magnetic curves be developed on paper above the iron, they will be found to exhibit less intense and less sharply defined magnetic action than when the sheet iron is removed. If, however, a small hole be drilled directly over each magnetic pole, the screening action of the sheet iron is modified in much the same way as when a hole is made in a screen opaque to light; for the developed curves show distinctly the outline of the holes. If, therefore, the sheet iron in the form of a circular plate, pierced with a number of holes, be rapidly rotated between the pole of a magnet and a small induction bobbin, the action of the magnet on the core of the bobbin will be periodically modified because of the passing holes; and hence induced currents will flow through a circuit including the bobbin. A disc of sheet iron was pierced with two circles of quarter-inch holes concentric with the disc, the number of holes in the two circles being thirty-two and sixty-four respectively. On one side of the disc was placed a horse-shoe magnet with its poles very near the rows of holes, on the other side were arranged two corresponding induction bobbins. The circuit was completed through a telephone and either bobbin at pleasure. Upon rotating the disc rapidly, a clear musical sound was produed in the telephone, the pitch rising with the rapidity of rotation. Moreover, the bobbin opposite the circle of sixty-four holes gave the octave above the other, and each gave a note of the same pitch as was produced by blowing a stream of air through the corresponding holes. Hence, as a beam of light, focussed upon a circle of equidistant holes in an opaque disc, is rendered periodically intermittent by the rotation of the disc, and produces a musical tone when falling upon the proper receiving apparatus, so the lines of force proceeding from a magnet may be rendered periodically intermittent in their action on an induction bobbin by a similar metallic disc, set in rapid rotation; and the induced currents arising from the periodic change of magnetism in the core of the bobbin, produced a musical tone in a telephone, the pitch depending in both cases only upon the number of holes passing in unit time.

The experiment was modified by so placing the poles of the magnet that the same circle of holes passed them in succession. By the proper connections, the currents from the two bobbins were made to pass either in the same or in opposite directions through the telephone. In the latter case, an almost perfect neutralization of currents took place, so that the sound was scarcely audible.

Non-magnetic metallic discs produce similar musical notes by the periodic modification of the magnetic field by means of the distortion or bending of the lines of force. The solid parts of the conducting disc deflect the lines of force in the direction of the rotation, but upon the passage of a hole they fall back towards their normal position. A periodic movement of the lines of force will, therefore, take place when the disc rotates. Discs of zinc and copper produce a clear musical sound, somewhat less intense than that given by iron under the same conditions. Any discontinuity in the rotating disc recurring periodically will roduce corresponding induction currents in the bobbins. Thus V-shaped notches round the circumference of the disc are quite as efficient as the holes in effecting the requisite modification of the magnetic field. Moreover, it is not necessary that the holes extend entirely through the disc. Two discs of zinc, of the same diameter and thickness, were placed together on the same rotating spindle, one pierced with a circle of holes, and the other not. The combination proved as efficient in producing the sound as the single perforated disc. A sheet of tinfoil, with a circle of small holes, was pasted on the continuous zinc disc. The perforations, extending only the thickness of the tinfoil into the compound disc, constituted a sufficient discontinuity to produce a clear, though somewhat faint, musical sound. About the same result was given by a disc consisting of the same sheet of tinfoil pasted on card-board.

Any periodic variation from uniformity in the disc appears to produce corresponding variations in the magnetic field when the disc is rotated. Depressions made with a punch, at regular intervals, in a zinc disc, rendered it a sound-generator when rotated in this apparatus.

Since the pitch of the note obtained depends only on the number of holes passing the pole of the magnet in a second, it is easy to construct a piece of apparatus to illustrate musical intervals. A cylinder of galvanized iron, with four rows of holes in the ratio of 4 : 5 : 6 : 8, was mounted on a whirling table, and provided with two U-magnets and two electro-magnets for induction. The latter were placed inside the cylinder, and the former outside. By means of four keys, any one of the bobbins, or all of them, can be put in circuit with the telephone. By depressing the keys, the four notes of the common or major chord are brought out with great distinctness and clearness. In fact, the intensity of the sounds obtained by the magnetophone is sometimes as great as to be painful to the ear when the telephone is held closely against it.

THE WESTINGHOUSE AUTOMATIC BRAKE.

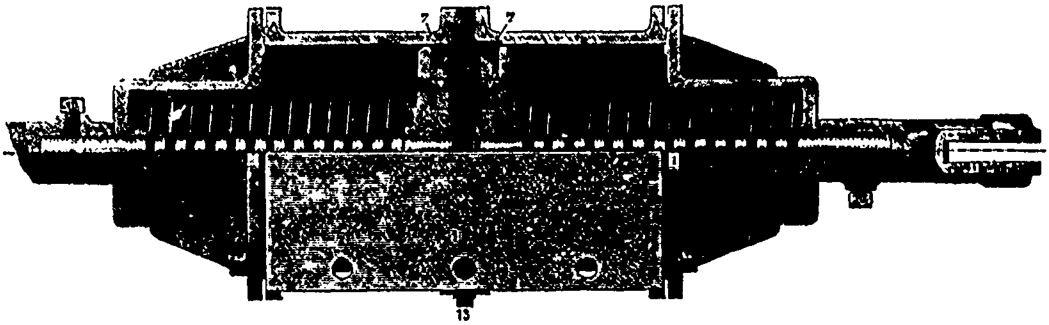


FIG. 6.

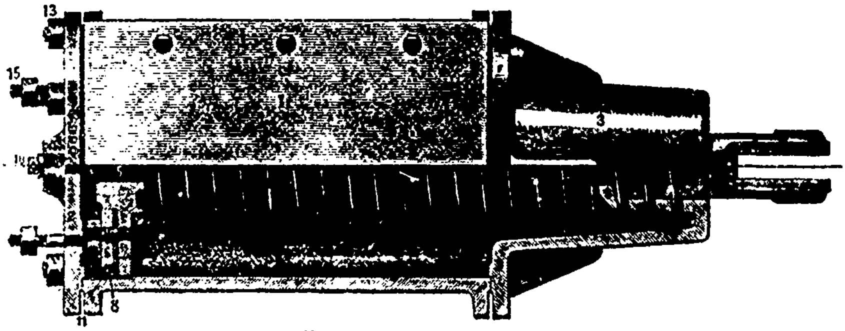


FIG. 7.

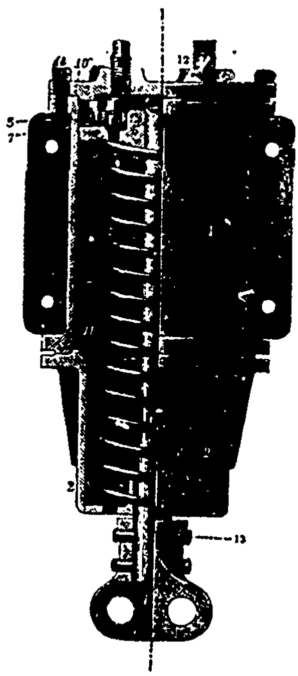


FIG. 8.

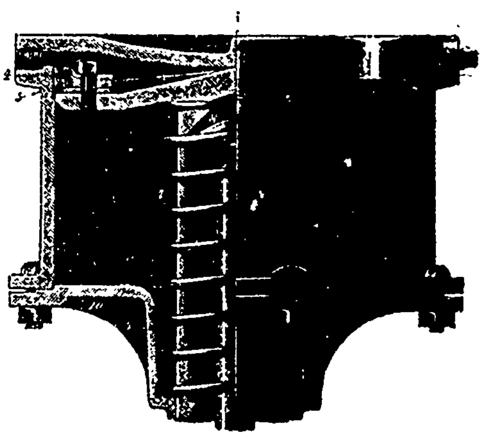
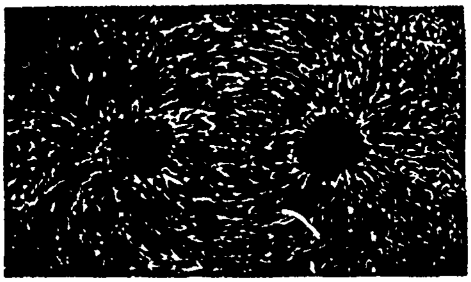
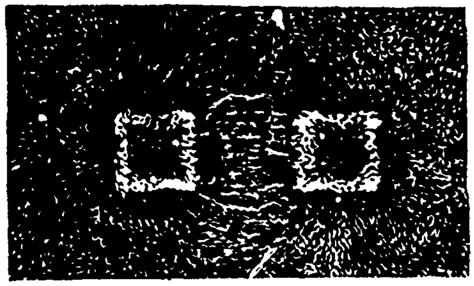


FIG. 9.

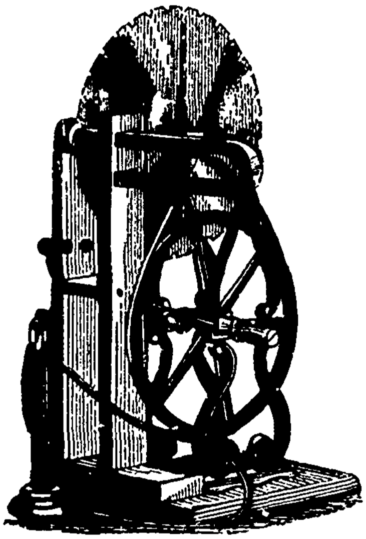
THE MAGNETOPHONE.

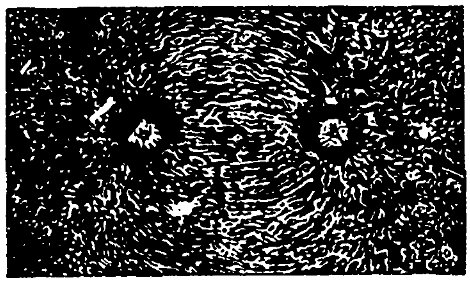


EFFECT OF SCREEN OF SHEET IRON.

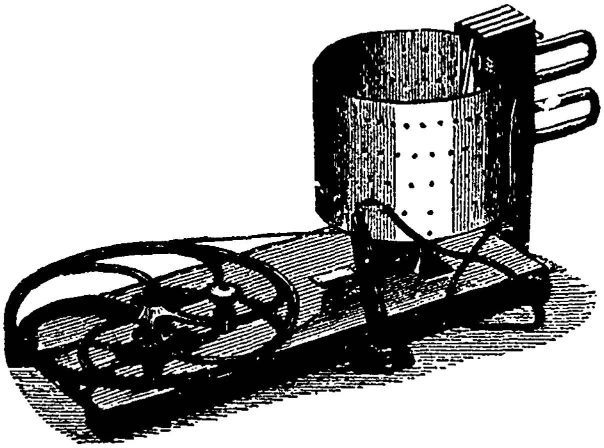


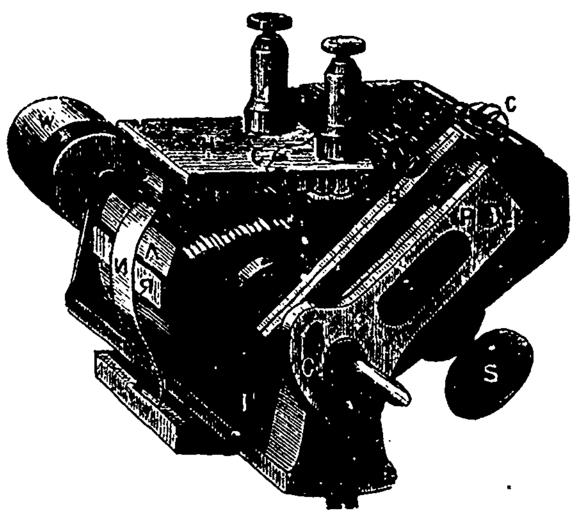
MAGNETIC CURVES OVER HORSE-SHOE MAGNET.





EFFECT OF HOLES THROUGH THE IRON SCREEN.





COMPARATIVE COST OF ELECTRICITY AND GAS.

MR. FRANK GERALDY has published some interesting statistics comparing the cost of the electric light with gas, both as to its actual cost and its cost per candle power:—

Installation.	Electric light system.	No. of lamps.	Candle pow of lamps.	Motor.	Tot. cost p. hour gas.	Tot. cost p. hour electric light.	Cost per candle power gas.	Cost per candle power electric light.
Salle des Télégraphistes at Brussels (Nord)	Jaspar	3	235		1·86	3·42	0·0265	0·0054
Halle aux marchandises, Lyons Station (Paris)	Lontin	18	64	Steam	6·825	6·625	0·0273	0·0054
Spinnery at Riverside (United States)	Brush	71	75	"	36·80	11·18	0·0353	0·0022
Ducommun Establishment at Mulhouse	Serrin	4	110	"	—	6·64	0·044	0·015
Passage in the Friedrich-strasse (Berlin)	Siemens	10	50	Gas	9·14	6·45	0·040	0·013
Thames Embankment	Jablochkoff	20	23	Steam	—	0·487	0·0150	0·018
Spinnery of E. Manchon (Rouen)	Sautter-Lemonnier.	6	150	"	9·550	7·0597	0·0597	0·0082

This is only an extract from a longer list, but conclusively shows that in large instalments electric lighting is cheaper than gas on the total cost, whilst considered per candle power it is far away cheaper. An exception to the rule seems to occur in the first on the list, this is due to the smallness of the installation. In the case of the Thames Embankment the *light is reduced by the use of ground glass globes.* If we bear in mind the fact that the economy consists in having large installations, we shall be brought face to face with the fact that whereas gas is now made in as large quantities as is practicable, electricity has still to be brought to that state of economy. Thus we may still expect a greater economical advantage than is shown by the above figures.

DR. HOPKINSON'S ELECTRICITY METER.

(*For illustrations see page 349.*)

It is not a little curious that so important a subject as that of electricity meters should have received—comparatively speaking—but scant attention, whilst many of the other details of electric lighting have been overdone. Perhaps the demand for such apparatus is at present so limited that inventors have preferred to turn their thoughts in more profitable directions; but the few who have in the meantime brought their inventive skill to bear upon the instruments will, doubtless, secure the leading positions, when the time has arrived, which shall make electricity meters a necessity. At various times, the meters of Edison, C. Vernon-Boys, Cauderay, etc., have been illustrated, and we now present to the notice of our readers the instrument invented by Dr. Hopkinson. This gentleman's eminent position in the scientific world is a sufficient guarantee that the subject has received due and careful consideration at his hands, and that the apparatus has not been constructed without a thorough knowledge of requirements. Fig. 1 is a general view of the meter, and figs. 2 and 4, for which we are indebted to Messrs. Chamberlain & Hookham, the licensees and manufacturers, show the details of its *construction.*

The method of working is as follows:—One of the main leads, say, the positive, enters at one of the binding screws, is wound around the core of the electro-magnet, forming the solenoid, *f*, and leaves at the other binding screw. One binding screw is in contact with the frame of the machine; the other is insulated from it. The shunt circuit, the current which drives the small dynamo, is taken from the negative lead, enters the machine by a small insulated binding screw (not shown), is carried in series round the magnets and armature of the small dynamo, and is attached to the insulated bar, *h*. So long as *h* remains insulated it is clear that no current passes through the dynamo; but if *h* is put in connection with the frame of the machine a current passes, since the positive lead is also connected to the frame. Now, as soon a current passes round the solenoid, *d* is drawn down by the magnetic action, *g* falls with it, and touching *h*, puts it into *connection with the frame. A current now passes through the* dynamo; the governor balls rotate with increasing speed till their centrifugal force is sufficient to overcome the magnetic attraction of the solenoid, *g* then rises again, the current ceases through the dynamo, the speed of the governor falls till *d* is again drawn down by the magnetic attraction, and the operation described is repeated. Now, it is clear that when a small current is passing along the main leads, *e g*, when but few lamps are in in use, the attractive power of the solenoid and its iron will also be small; consequently, a comparatively low speed of the governor balls will suffice to overcome it. If, however, many lamps are in circuit, the current will be greater, the attraction stronger, and a higher speed of the governor necessary to break contact. Thus it is plain that there is a relation between the current strength passing along the main circuit and the speed of the governor. It may be seen, further, that they are directly proportional, the one to the other, for *the attraction of an electro-magnet varies as the square of the* current round it, and centrifugal force as the square of the velocity of rotation. Hence, in the present case the current in the main leads is proportional to the average speed of the governor balls. This speed is indicated, in the usual way, with dials, and, in practice, the machine is standardised so as to register ampère hours.

The range of this meter is only limited by the speed of rotation which it is possible or advisable to impart to the revolving shaft. The inventor has designed a modification of the present instrument of which the range would be practically unlimited, but it is very doubtful whether this will be called for as its price would be higher, and it is unlucky that in practice any accuracy greater than that of gas-meters will be found worth paying for. In the meantime, owing to improvements in mechanical detail, each succeeding set of instrument shows an increased range. At first this was from 1 to 20. At *present they are producing meters which have a range of at least* 1 to 30.

In practice, and from the consumers point of view, the instrument has the following special advantages.—

(1.) It is read as a gas meter is read. No electrical or other scientific knowledge is necessary in order to understand its registrations.

(2.) It is not merely easily understood, but a consumer can tell at any moment of the night or day whether his house wires are in order, either by noticing whether there is any movement of the hand when no lamps are in circuit, or by observing whether, with a given number of lamps, a proper current is being registered. Even with an illuminant, to which the public is well accustomed, as gas, the consumer is often suspicious when the quarterly bill is presented. This would be still more the case with the early use of electricity, and anything which will enable the consumer to judge from time to *time what is the amount of his supply will greatly tend to the* smooth working of the undertaking.

(3.) The meter is, practically, independent of friction, no clockwork is used in it, and it requires no attention beyond such as the inspector, at his quarterly visit, would be able to give it.

Before closing this notice, another important use of the electricity meter should be referred to. Just as electro-deposition affords a measure of the electric current flowing in a circuit, so that the current passing through a circuit of which depositing cells form a part is an exact measure of the metal deposited. This current meter will be found of value to electro-platers in their business. Placed between the battery (or dynamo) and the depositing vat, or vats, it will indicate (1) whether the proper amount of current is passing, and, therefore, wher the battery or dynamo, and the solutions are in good working condition (2.) By means of a printed table, giving the proper multiplier for each metal, the electro-plater is able to translate the readings of the meter into the weights of the various metals deposited. At present the methods are cumbersome, and at the best uncertain, and in the case of the more expensive metals, the loss is occasionally great. With the electricity meter the measurement is at once easy and accurate.

FISH AND PHOSPHORUS.

BY W. MATTIEU WILLAMS.

A curious notion concerning fish diet is widely prevalent. It is supposed to supply special brain food. If this were true the Dogger Bank fishermen, who feed on cod-fish, should be intellectual giants. I sailed for two months in a schooner, the skipper, the mate, and half of the crew of which had for many years eaten cod-fish at every meal. They were by no means remakable for cerebral activity, nor are the rest of their class.

The popular fallacy seems based on a series of other fallacies. First, that there is something very spiritual in phosphorus; second, that phosphorus is a special and exclusive constituent of the brain; and third, that fish contains more phosphorus than other food materials.

The first is mere imaginative nonsense. The second is a half-truth. Phosphorus is a constituent of cerebral and other nervous matter, but it is also a constituent of bone, which contains about eleven per cent. of phosphorus, while brain matter contains less than one per cent.

The third fallacy seems to have originated in that very common source of error--viz., dependence on mere words. Fishes are remarkably phosphorescent — *ergo*, says the word-slave, they must abound in phosphorus.

The fact is that the chemical element named phosphorus has nothing whatever to do with the phosphorescence of fishes, nor with that of the multitude of other phosphorescent animals. The glow-worms (of which there are many species in England alone) and the numerous insects included under the general name of fire-flies are brilliantly phosphorescent without the aid of phosphorus. The minute jelly-like creatures that at certain times render the crest of every breaking wave a blaze of light, and mark the course of porpoises and bonettas with pale rocket-like trails, are animals in whose composition phosphorus is especially lacking.

The true connection that exists between the luminosity of phosphorus and that of organic phosphorescence is that both are dependent on slow or languid chemical combination, while vivid combustion is a manifestation of intense or vigorous chemical combination. Ordinary combustion is a vigorous combination of something with oxygen, the phosphorescence of phosphorus is due to a slow oxidation of this element, and it is probable that the other cases of phosphorescence are due to the slow oxidation of something else.

B. Radziszewski are recently investigated this subject, and concludes that the phosphorescence of organic bodies is produced by the action of active oxygen in alkaline solution. (Ozone is another name for active oxygen.) He describes two kinds of organic phosphorescent matter, the first of which contains hydrocarbons, and the second aldehydes, or yields aldehydes when treated with alkalies.

According to this, all phosphorescence is a result of slow combustion, like that which produces animal heat, or the heating of a damp haystack or other heap of vegetable matter and water.

As heat and light are both due to internal activities of matter, differing only in a manner analogous to the difference of notions of the air produced by the difference of the vocalisation of Santly and Patti, the mystery of Willo'-the-Wisp, of oceanic phosphorescence, glow-worm light, &c., is no greater than that of the warmth of our own bodies.

The anomaly of phosphorescent light is that it is accompanied with no sensible elevation of temperature, while ordinary combustion, when it rises to the pitch of effecting luminosity, is accompanied with intense heat.

There must be an essential difference between the waves of white light emitted by incondescent platinum or whitehot carbon, and those from the glow-worm.—*Gentleman's Mag.*

NOTES ON SASSAFRAS-LEAVES.—(*Science.*)

(*For Illustrations see page* 352.)

There are three distinct forms of sassafras leaves. The simplest is ovate, varying to oval and obovate. A second form is three lobed, the incisions running from near the middle of the upper half of the leaf's edge to the centre of the blade. The third form is midway between the entire and three-lobed sorts, and has but one side-lobe, the opposite half of the leaf being entire. It is as if one-half of a three-lobed leaf were joined by the midrib to the opposite half of an entire one of the same size. This form may be very appropriately called the " mitten."

In the study of these three forms, branches of sassafras have been gathered from a large number of places through the surrounding country. Some have been obtained from the woods, and others from the open field. Branches were cut from the largest trees and from the smallest, from vigorous trees and those of slow growth. Ten hundred and fifty leaves were examined. and of these, five hundred and thirteen were entire; four hundred and fifty-eight, three-lobed, and seventy-nine, " mitten form."

The first leaves of spring were invariably entire, and a lobed leaf was rarely found until the fourth leaf was passed in counting from the base of the branch toward the tip. No regular order was discovered. In one case the arrangement was as follows. three entire, four three-lobed, one " mitten," one three lobed, one " mitten," one three-lobed, one " mitten," one three-lobed; on another branch, four entire, one "mitten," five three-lobed, one "mitten," three three-lobed, three "mittens." The leaves on short spurs of old trees were nearly all small and entire, when the branches were somewhat longer, and the leaves larger, there were one or more three-lobed or "mitten" leaves in the middle of the stem. A number of branches taken from slow-growing trees gave the following aggregate; entire leaves, seventy; " mittens," six; three-lobed leaves, three. A vigorous young sprout gave twenty-seven three-lobed leaves, one " mitten " near the middle of the stem, and no entire leaves. Another had two entire blades at the base, and twelve three-lobed leaves above. A number of these rapidly-growing young trees together gave twenty-seven entire leaves, fourteen " mittens," and eighty-one three-lobed leaves.

The entire and smaller leaves are in the majority on slow-growing trees, while, on the young sprouts, larger three-lobed leaves predominate. The " mitten " form is mostly found with the entire leaves. This form of leaf is probably about equally divided between the " right-handed " and "left-handed," though, of the number found (seventy-nine), those with the " thumb " to the left, when held with under side upward, exceeded the other sort by half. About every thirteenth leaf is a " mitten,"—a form not found mentioned in the botanical description of the sassafras.

There seems to be no order in the arrangement of the three forms upon the branch. Leaves from the buds were examined, and all of the three forms were found. Each kind is distinct, from a very early state, and there is no indication that one ever passes in the other. No intermediate forms have been found. The venation of the three forms is very much the same. There is a midrib running lengthwise through the leaf, and a strong lateral vein on each side, which runs from near the base to beyond the middle of the leaf. Smaller veins form the framework of the middle and upper parts of the leaf. The portion of parenchyma absent in a lobed leaf is midway between the strong lateral veins. This is very clearly shown in a " mitten," where one side is lobed, and the other entire. It would seem as if the lobing is a failure to fill up the framework, and apparently due to a too vigorous growth of the veins, and a lack of a sufficient amount of the soft, filling tissue. In the formation of leaves the sassafras is certainly " at loose ends," but in this it is not alone.

Fig. 1 page 000 shows an entire sassafras-leaf; fig. 2, a three-lobed leaf; and fig. 3, a " mitten." Fig. 4 shows the young leaf of the three forms. All the illustrations are drawn from nature. BYRON D. HALSTED.

THE MOVEMENTS OF THE EARTH[1]

I.—*Measurement of Space*

IN proceeding to deal with the application of the various branches of physical science to the investigation of those phenomena which lie beyond the earth, there is a very large field from which to make choice of a subject which will show, now the application of one branch of science, and now the application of another, and bring us, in this way, somewhat nearer to the truths and the beauties which lie in the most distant realms of space for all who will take the trouble to look for them. But perhaps it may be more desirable to select that part of the subject which, so to speak, lies nearer home, and endeavour to point out how, by means of the application of principles, and methods, and instruments which are generally familiar, and which at all events are of daily use, the various movements with which our planet is endowed may be studied, not only with reference to the phenomena themselves, but with reference also to the causes which lie at the bottom of them.

The various branches of knowledge which will have to be drawn upon in furnishing the materials necessary for this inquiry were really started long before it was imagined that the earth had any movements at all; but still, on the whole, the growth of the knowledge of its movements has been so beautifully continuous, that we cannot do better now than consider historically the way in which those sciences have grown up, which enable us to make certain measurements, and to get out correctly certain quantities, which must necessarily lie at the bottom of any sound knowledge.

What particular things do we want to measure? It has been already said that when the sciences to which attention will have to be called later on were founded, very few people on this planet knew that it moved at all, but it is now generally known that the earth does move. It will be obvious however that, whether the earth moves or not (and that may be considered still a moot question), if we wish to form a basis for our judgment in any direction, we must be able to measure time and space. It has been well said that "time and space are the moulds in which phenomena are cast;" for when it is desired to gain any useful knowledge concerning any fact, the relation which it bears to the things around it, and the time of its occurrence must be known, and that is the only thing an astronomer tries to do when he is investigating that portion of his subject to which we must first turn our attention. We will begin then by considering those measurements of space which are of the first importance to the astronomer. I do not here refer to the ordinary familiar measurement of inches, yards, and miles, but to the measurement of angles, and it will be well to get a good notion of this angular measurement as soon as possible.

There is no special necessity for dividing the circle into 360 parts, but the greatest number of people have made that division, and it is still continued to be done. When the Chinese began to make circles they divided them, not into 360 parts, but into 365¼. Now there was a great advantage, and a great disadvantage about that. The advantage was that this number of divisions in the Chinese circle was the same as the number of days in the year; the disadvantage was that they were not dealing with whole numbers, and their 365¼ was not such a convenient number to halve and quarter, and so on, as is 360. In quite recent times it has been suggested that 400 parts should be taken instead of 360, but that is a suggestion which up to the present time has not been acted upon.

We have then an angle defined as the inclination of two straight lines starting from a centre; if we get one of these lines traversing an entire circumference, the other remaining at rest, the travelling line will have traversed 360°; we have what is called a right angle when one of the lines has been separated from the other through a quarter of a circumference—that is, 90°. This is the fundamental idea of angular measurement, the only measurement of space with which we shall have to deal at present.

For instance, if a little ivory rule be opened, its two parts become inclined to each other, and inclose what is known as an angle. That angle may be made large or small by opening and closing the two parts, A and B (see Fig. 1) of the rule. Suppose the rule to be shut, the point on which it turns being in the centre of the circle, C D E F, and that, whilst A remains at rest, B is made to travel successively through B and B¹ to B². It will then have travelled half the circumference of the circle C D E F but civilised people, in order to get perfectly clear notions about this measurement, and to be able to tell each other what particular measurement they have made in this way, instead of talking of a circumference merely,

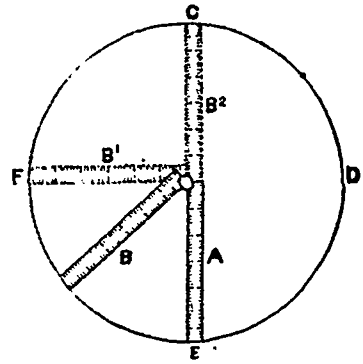


Fig. 1.—Use of a two-foot rule to explain angular measurement. With the part A at rest, the movement of the other to B, B¹ and B² gives us 45°, 90°, and 180°.

and of certain rough divisions of it, have divided all circles into 360 parts called degrees, and say that the travelling part, B, of the rule has travelled through not a quarter, or a half circumference, but through 90 and 180 degrees respectively.

Why are these measurements of space required? For the reason that when we are dealing with the heavenly bodies and seeking to define the position of any object, two facts at least are required to be known before its exact position can be determined. An observer going out at night upon an extended plain would see some celestial bodies near where the earth meets the sky all round, which is called the circle of the horizon, and he might happen to see another body exactly overhead, in what is called the zenith. In passing from this zenith to the horizon it will be obvious that a quarter of a circumference is traversed (see Fig. 2). That distance may therefore be divided into 90°.

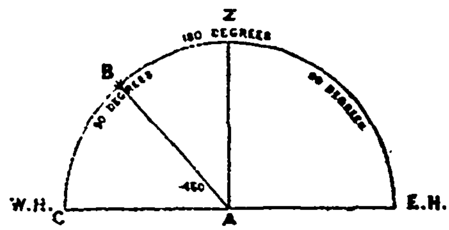


Fig. 2.—Measurement of altitudes.

Similarly in passing from the eastern horizon to the western horizon half a circumference is travelled over. This distance therefore is divided into 180° of angular measurement in the same way that the half of the circumference traversed by the travelling rule was divided into 180°.

Now if it can be ascertained of any body that it is exactly in the zenith, the position of that one body has been definitely stated for the particular time at which the observation is made. But consider the case of another body not in the zenith. Suppose that the lines, the one A B (see Fig. 2), passing from the observer to the object, and the other, A C, passing from the observer to the horizon, inclose an angle of 45°. This angle is called the star's altitude. But to say simply that the altitude of a star is 45° does not sufficiently define its position. Let the reader imagine himself to be standing in the Albert Hall. He knows that he may look up and see rows of panes of glass and ornamented work running around the hall at different heights above the floor. He may also notice, let us say, various series of ornamentation arranged vertically from floor to roof. Now suppose it were desired to define the position of any one pane of glass or piece of ornamentation in any one of these horizontal or vertical rows. It is obvious that to say of any pane of glass at one level that it is at a certain height above the floor will not suffice, for all the panes of glass in that row are at the same

[1] Report of Lectures to Working Men given at the Royal School of Mines by J. Norman Lockyer, F.R.S.

elevation. In like manner in defining the position of any one piece of ornamentation in the vertical series it will not be sufficient to say that it is at a certain angular distance from any one point, say a door, because all the pieces in the same row are at this angular distance from the door. But if these two methods of stating position be combined, if the height above the ground as well as the angular distance from the door be given, then a definite statement may be made both of the position of the pane of glass and the piece of ornamentation. Similarly with the stars. Imagine a horizontal circle passing from north to south, and thence to north again. A line from the zenith through any body will cut this circle at some one point, and the number of degrees included between that point and the north point will give the angular distance from the north point, or, as it is called, the azimuth. The whole of an imaginary line of bodies extending from the zenith to the horizon will have the same azimuth (see Fig. 3). In the same way we may imagine a whole ring of bodies

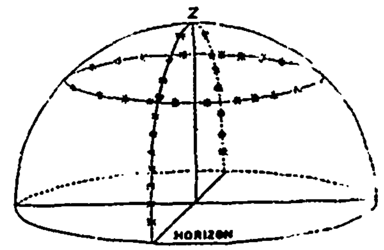


FIG. 3.—Stars with equal altitudes and stars with equal azimuths.

at the same height above the horizon, having the same altitude (see Fig. 3), but a particular altitude and a particular azimuth can be true of only one of those bodies. It is in this way, then, by a statement of the altitude and azimuth, that the position of a star or other celestial body can be indicated with reference to any one particular place of observation and any one particular instant of time.

It is by thus dealing with this angular measurement that the exact positions of the heavenly bodies have been determined.

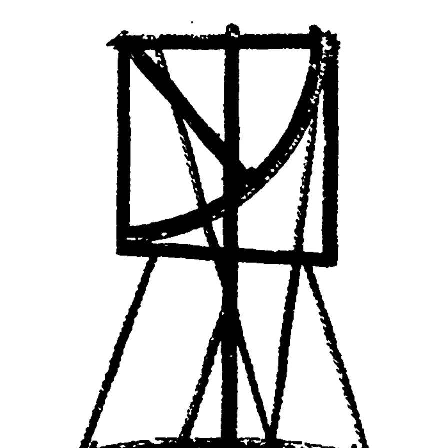


FIG. 4.—Tycho Brahe's altitude and azimuth instrument.

This point has been discussed at some length, because in making an historical survey it will be found that the growth of that particular knowledge of which we shall come to speak, has been the growth of man's capability of getting finer and finer in this angular measurement. To go back to the time of the old Greeks, Hipparchus, one of the most eminent of ancient observers, even in his day could define the position of a heavenly body to within one-third of a degree. Since these 360 degrees into which circles are divided are each subdivided, first into 60 minutes, and each of these again into 60 seconds, the one-third of a degree to which Hipparchus attained may be called 20 minutes of arc.

Passing from his time to the middle ages, a most interesting instrument then in use claims attention. Fig. 4 is a copy of a photograph of the instrument.

The model, from which the photograph has been taken, is an exact copy of an instrument made by one of the most industrious astronomers that ever lived, Tycho Brahe, and shows how, even in the very beginning of this observational science, men got at a very admirable way of making their observations, considering the means they had at their disposal. First there was in this instrument a quadrant of a circle (see Fig. 4), which served their purpose just as well as a whole circle. Combined with this was an arrangement somewhat resembling the "sights" on a modern rifle. Remember this was before the days of telescopes. So they started with these sights and a little pinhole, that they might take a shot, as it were, at a heavenly body, putting the eye near the pinhole, and seeing the heavenly body in a line with the front sight. Then the instrument was provided with a plumbline to show the vertical. This plumbline was so arranged that when the sight lay along it, a body in the zenith would be observed, and an angle of 90° altitude recorded. With the instrument thus set, any smaller altitude could be read along the quadrant, according to the position of the line of sight passing through the eye, the centre of the quadrant, and the place of the heavenly body.

To get azimuth they used a horizontal circle, shown at the base, also divided into degrees and provided with a pointer. By sweeping the instrument round until the azimuth was such that the body was seen through the pinhole, and the altitude was such that it was seen in a line with the front sight, they fixed its position, as well as that instrument enabled it to be done. Supposing that their circles were properly divided, it was quite easy to determine a division as small as the quarter of a degree. This would put Tycho Brahe in only a little better position than Hipparchus. That is to say, from the time of the Greeks until about the middle of the fifteenth century, the only advance made with this angular measurement, was that a reading of one-third was improved into a reading of one-fourth of a degree.

Another notable improvement and advance towards a finer and more accurate measurement was made by Digges. He introduced the diagonal scale, the principle of which is shown in Fig. 5. The arrangement consists of a number of concentric

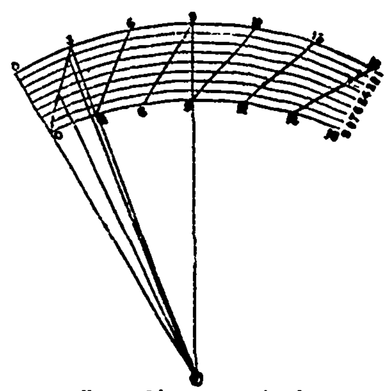


FIG. 5.—Digges' diagonal scale.

circles, in this case nine. The distance between the divisions of the inner circle is 3°. From each of these divisions diagonal lines are drawn to the outer circle in such a manner that the diagonal cutting the first circle at 0° cuts the ninth circle at 3°. That cutting the first circle at 3° cuts the outer circle at 6°. So with the other diagonal lines. Consider the diagonal passing from 0° on the inner circle to 3° on the outer. If the pointer cuts the scale at the former point, an observation of 0° will have been made; if it cuts at the latter point, an observation of 3° will have been made. But it may cut the scale at some intermediate point. Suppose it falls on the eighth of the nine concentric circles, then the value of the observation will be 7/8ths of 3°. Should the pointer fall half way between 0° and 3°, the reading will be 4·8ths of 3°. So with the other intermediate points. In this way, then, Digges enabled a much greater accuracy to be attained in this circle reading.

The next great improvement after that of Digges was one made by M. Vernier, a Frenchman, who, in about the year 1631, invented the instrument which bears his name. The following is the arrangement. Let the scale on which the measurements are made be divided into a number of parts. Take a second scale called the vernier, shorter than the first by the length of one of its divisions, and make the number of divisions in this vernier equal to the number of divisions in the scale. Then each of the divisions of the vernier, will be less than each of the parts of the scale, by a fraction having one for its numerator, and the number of divisions in the scale or vernier respectively for its denominator. Thus, if the number of divisions be ten (see Fig. 6, page 348,) and the vernier equal in length to nine of such parts has also ten divisions, each of these divisions will be shorter by 1-10th than each of the parts of the scale. If the number of divisions be seventeen (see Fig. 8) the different parts of the vernier will be less by 1-17th than each of the divisions of the scale. So when the number of divisions is thirty (see Fig. 9), the parts of the vernier will be less by 1-30th than the divisions of the scale. The arrangement, however, is not limited to straight scales. It may also be used for the determination of small fractions of degress on a circle. Fig. 10 represents a vernier giving tenths of degrees on a circle. It need hardly be said that the vernier may be constructed to give readings upon the inner as well as the outer edge of the graduation.

In using the vernier the observer looks along it until he meets a coincidence, that is for a point where one of the divisions on the scale coincides with a division on the vernier. If this occurs at the eighth division, then the observation is some whole number, and 8-10ths, 8-17th, or 8-30ths, according as the scale used is divided into ten, seventeen, or thirty parts. In Fig. 7 the coincidence occurs at the third division; the reading in that case would be some whole number and 3-10ths.

To the instrument of Tycho Brahe, then, the vernier, which can be adapted to it, has now been added. Of course by taking division enough the measurements may be made as fine as possible. A vernier of 100 divisions may replace the vernier of 10, or 17, or of 30 divisions. Seventeen have been chosen to show that the principle is not limited to tenths. Any number of divisions may be taken. A very fine degree of accuracy can be attained then in angular measurement, owing to the introduction of the vernier, and that is why there is what is practically a vernier upon almost every measuring instrument in every workshop and laboratory. The question next arises whether with the introduction of the vernier the limit of accuracy has been reached, or whether it be possible to go beyond this. A negative reply may be made to this question. The limit of accuracy has not here been reached. In order to get more accuracy in this angular measurement, it is only necessary to add some branch of physical science to those geometrical considerations by means of which circles have been so finely divided. The astronomer calls certain portions out of the science of optics, and uses them for his purpose. It is perfectly clear that the reason a limit is reached, with an arrangement of the nature of the vernier is, that at least the divisions get so small that the eye cannot distinguish them, so that optical principles have to be appealed to to increase the power of the eye.

Before discussing this question of whether it be possible to select some principal of optics, by the application of which the power of the eye may be increased, it will be well to consider in what it is that that power consists. Fig. 11 will give a rough notion of those parts which specially relate to this matter. First comes the curved surface *Cn*, the cornea, and next *Aq*, the small anterior chamber which contains the aqueous humour. Behind this comes, *Ir*, the iris, which limits the amount of light entering the eye, this being immediately succeeded by *Cry*, the crystalline lens. Then comes the large posterior chamber of the eye which contains the vitreous humour. Behind this the optic nerve enters the eyeball, expanding itself into the delicate layer of nervous elements, *Rt*, which lines the inner surface of the vitreous cavity.

When any object is seen by the eye, the rays of light emanating from that body, impinging first upon the curved corneal surface, have to pass successively through *Aq*, *Cry*, and *Vt*, before they can effect the nervous retinal elements and cause the sensation of light. In passing through these portions of the eye, the rays of light are dealt with in a peculiar manner, especially perhaps by the crystalline lens, and are brought together to form what is called an image on the retina. This image influences the nervous elements of which the retina is composed in such a way, that a sort of telegram is sent to the brain through the optic nerve, and the brain becomes conscious of having seen something, the particular object seen being included in the message.

ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

Newton's third law of motion is as follows:—

LAW. III. *Action and reaction are equal and opposite.*

In the first interpretation Newton gives of this law he points out that whenever one body presses or pulls, attracts or repels, another, it is pressed or pulled, attracted or repelled by the second body with a force exactly equal to that which itself exerts, so that forces always come into existence in pairs, each pair consisting of two equal and opposite forces, or an action and an equal and contrary reaction. Action and reaction together constitute a *stress*, and the forces themselves may be regarded simply as aspects of the stress. It is, however, often convenient to abstract one of the forces, together with the part of the system on which it acts, and to omit the consideration of the other force or opposite aspect of the stress. Thus, we may consider the effect of the sun's attraction on the earth's motion without taking into account the equal and opposite attraction exerted by the earth upon the sun, and the consequent disturbance of that body.

In Newton's second interpretation of the third law of motion he states the principle of the conservation of energy, so far as it could be stated before the fate of the work done against friction and other similar forces was known.

DEF. The energy of a system is its capacity for doing work, and is measured by the number of units of work it is capable of performing in passing from its existing state into some standard condition.

A mechanical system may possess energy in virtue of (1) its configuration, or the relative positions of its parts, or (2) of the relative motions of its parts.

The energy possessed by a system in virtue of the relative positions of its parts is called its *potential energy*. The energy which it possesses in virtue of the relative motions of its parts is called its *kinetic energy*.

The work done by a falling weight or a bent spring is due to the potential energy of the earth and weight or of the elastic spring, while the work done by a cannon shot on its target is due to the kinetic energy of the system consisting of the earth and target and the cannon shot moving relatively to them.

The principle of the conservation of energy was stated by Maxwell as follows:—

The total energy of a system is a quantity which can neither be increased nor diminished by any actions between the parts of the system, though it may transformed into any of the forms of which energy is susceptible.

When work is done against forces which, like gravity, are independent of the motion of the moving body on equivalent amount of *potential energy* is produced.

When work is done against forces which, like friction, are reversed in direction as soon as the direction of motion of the moving body is reversed, an amount of *heat* is generally produced which Joule proved to be always equivalent to the work so done.

When work is done in producing motion in a body an equivalent amount of *kinetic energy* is produced.

Thus, in the most general case, if an agent do work upon a mechanical system, some of the work done has its equivalent in potential energy, some in heat, and some in kinetic energy developed in the system.

Heat is in reality a form of kinetic energy, but it is due to the motions of molecules, and not of tangible bodies.

DEF. The unit of heat is the amount of heat required to raise the unit mass of water from 0 °C to 1 °C.

Joule showed that the amount of work which, if entirely converted into heat, would raise 1 lb. of water from 0 °C to 1 °C was 1,390 foot pounds.

Hence the amount of work which, if entirely converted into heat, would raise one gramme of water from 0 °C to 1 °C is about 42,000,000 ergs. This is called the mechanical equivalent of heat.

If a glass rod be rubbed with silk and then brought near to a pith ball suspended by a silk (insulating) cord, the ball will be attracted, and cling to the rod, but after remaining in contact with the glass rod for some time it will be repelled by it.

If a stick of sealing wax be rubbed with flannel and brought near to a second similarly suspended pith ball the same phenomena will be observed.

If the excited sealing wax be brought near the ball which has been in contact with the glass, it will attract the ball, and the glass rod will attract the ball which has been in contact with and is repelled by the sealing wax. Also the two balls will attract one another.

From these experiments we infer that there are two kinds of electrification, and that bodies similarly electrified repel, while bodies dissimilarly electrified attract one another. The electrification produced upon the glass rod is called vitreous or positive electrification; that upon the sealing wax is called resinous or negative electrification.

The law according to which the repulsion or attraction between two electrified bodies varies with the distance between them was investigated by Coulomb and by Cavendish. The apparatus employed by Coulomb is known as the torsion balance. In it the repulsion between two electrified balls is balanced by the torsion of a wire from which one of the balls is suspended at the end of a shellac rod. The amount of twist which must be given to the wire in order to retain the suspended ball at a given distance from the fixed ball is observed for different given distances, and since the torsional couple is proportional to the angle through which the wire has been twisted the forces between the balls at different distances can be compared. From these experiments it appears that the force varies *inversely as the square of the distance* between the electrified bodies, provided that the bodies are small in comparison with the distance between them.

Cavendish verified the same law by shewing that there is no electrification on any conductor in contact with the interior of a closed hollow conducting sphere, however strongly the sphere itself may be electrified. The accuracy of this result admits of being tested with very great delicacy, as modern instruments are capable of detecting the millionth part of the charge which may conveniently be communicated to the apparatus, and it can be demonstrated that if the law of electrical action differed very slightly from that of the *inverse square* the interior of the conductor would be electrified in the same manner as outside or in the opposite way. Hence the fact that a body which is made to touch the interior of a closed hollow conductor becomes entirely discharged, however strongly the conductor itself may be electrified, may be regarded as the highest evidence in favour of the foundamental law of electrical action. This law may be thus stated:—

Bodies similarly electrified repel, and bodies dissimilarly electrified attract one another, with forces which are directly proportional to the products of the charges, and inversely proportional to the square of the distances between them.

The attraction or repulsion existing between electrified bodies furnish a method of comparing, and therefore of measuring, quantities of electricity.

DEF. *The unit of electricity is that quantity of positive electricity which, acting* THROUGH AIR *upon an equal quantity at unit distance repels it with the unit of force.*

Hence the unit of electricity is that quantity of electricity which acting through air upon an equal quantity at the distance of a centimetre repels it with a force of one *dyne*.

If two balls, each of one gramme, be suspended from the same point by silk fibres, each 490.5 centimetres in length, the force required to pull each ball through .5 cm. is one dyne, so that the repulsion which must exist between the balls in order to cause their centres to separate to a distance of one centimetre apart is equal to one *dyne*. Hence if the balls be charged with equal quantities of electricity, and the charge of each be varied until the centres of the balls are separated by one centimetre, then the charge upon each ball will be the electrostatic unit of electricity.

If an insulated conductor be brought near to a sphere charged positively the end of the conductor which is near to the charged body will be found to be negatively electrified, while the other end will have required a charge similar to that on the sphere, a certain line upon the conductor (not far from the centre, but nearer to the sphere) remaining uncharg·d. This line, which separates the positive from the negative portion of the conductor, is called the *neutral line*, and the whole phenomenon is an example of *electric induction*.

If the conductor be touched, or in any other way placed in communication with the earth while it is still under the influence of the positively electrified spheres, the conductor will be found to be negatively electrified all over its surface, the electrification, however, being very much stronger near the sphere than at the other end, but the distribution of electricity on the conductor being precisely the same whether it be touched at one end or the other. The conductor is now said to be electrified by induction, and if it be again insulated, and removed from the neighbourhood of the sphere, it will be found to possess a free negative charge.

If a plate of metal be placed on an insulating support, and a sheet of warm and dry brown paper be laid upon it and then struck with a cat's skin, or piece of flannel, while the metal plate is touched with the finger, and if the finger be then removed, and after-

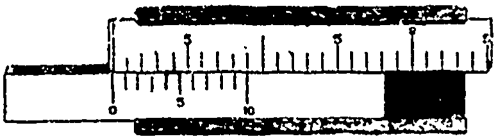


FIG. 6.—Vernier reading to tenths of divisions.

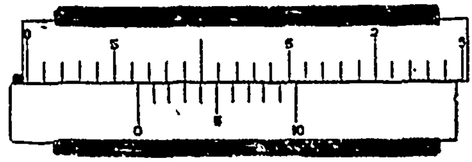


FIG. 7.—Vernier shown in Fig. 6 reading to three-tenths.

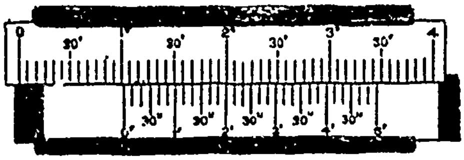


FIG. 9.—Application of vernier to circle reading to one-tenth of a degree.

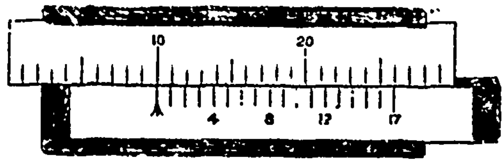


FIG. 8.—Vernier reading to seventeenths.

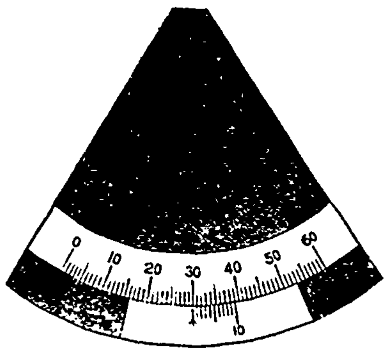


FIG. 10.—Application of vernier to circle reading to ten seconds of arc.

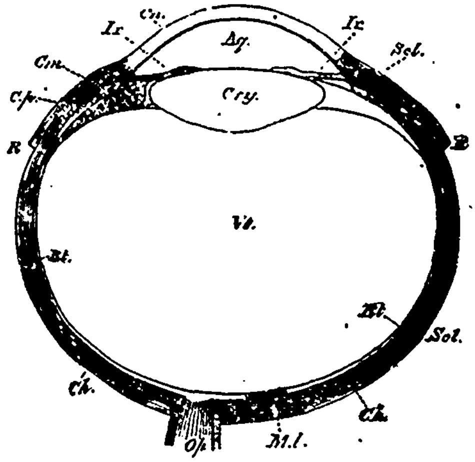
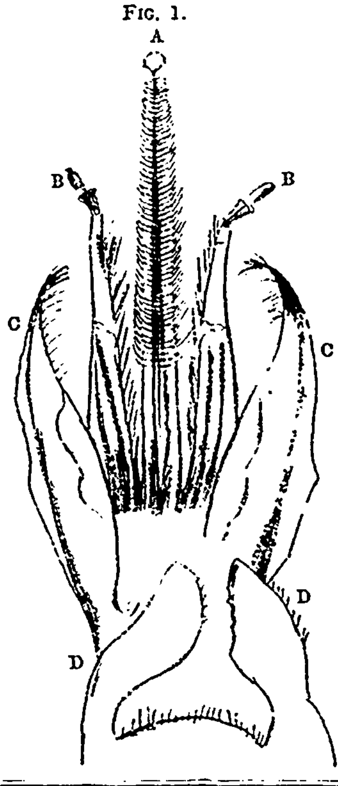


FIG. 11.—Horizontal section of the human eye.

FIG. 1.



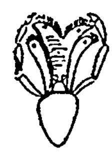


Fig. 2.—Wasp's tongue and labial palpi. (Copied from Westwood.) × 10.

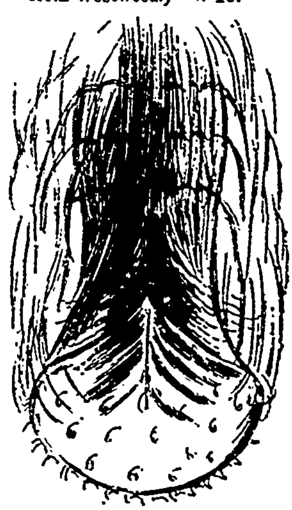


Fig. 3.—Tip of Bee's tongue, underside uppermost. (Drawn from preparation in Canada balsam by Mrs. Slack.) × 600.

HOPKINSON'S METER.

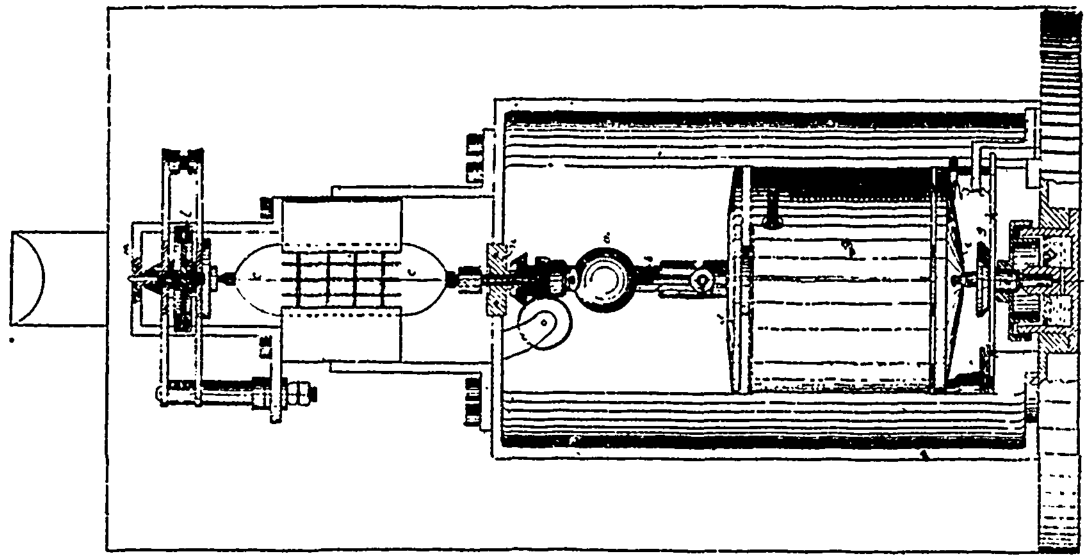


Fig. 3.

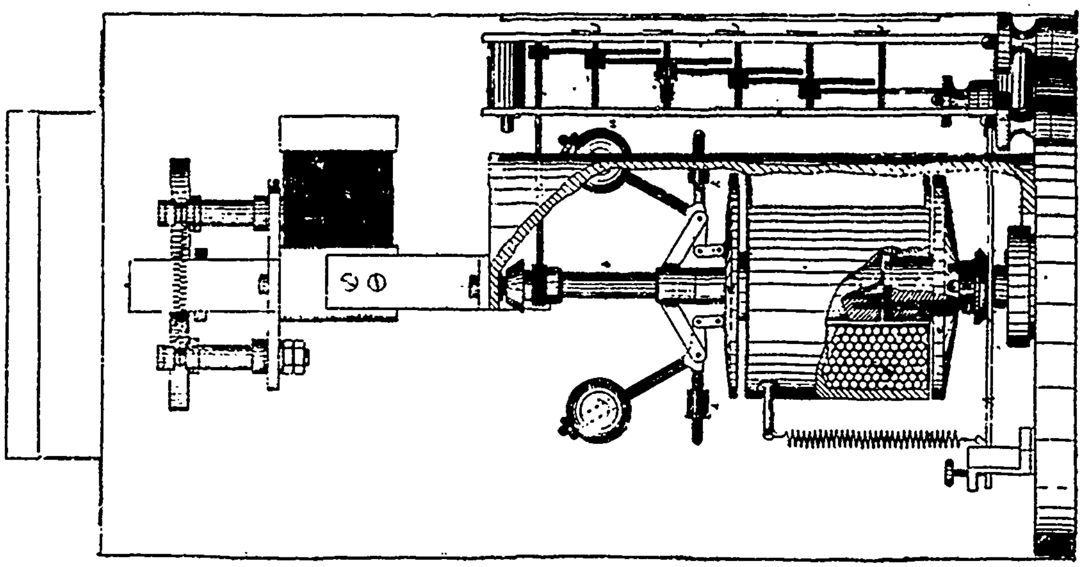


Fig. 2.

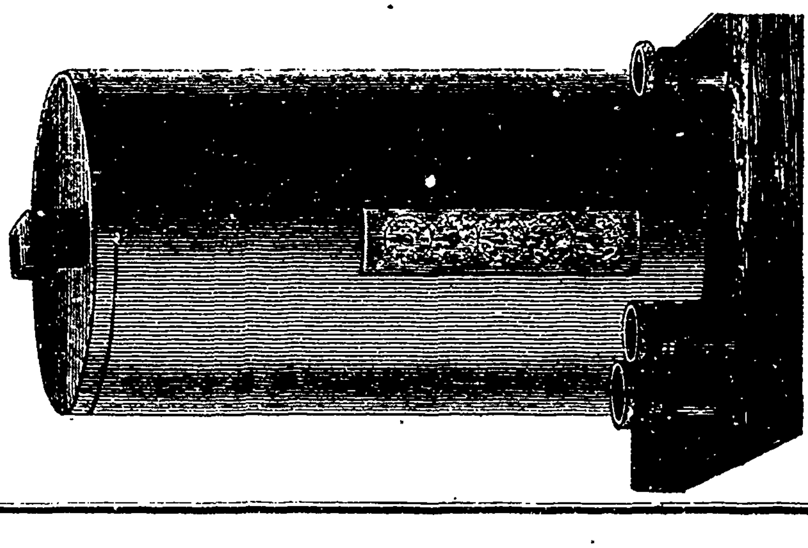


Fig. 1.

wards the brown paper, the metal plate will be found to be strongly electrified, its charge being positive. When the brown paper is struck it becomes negatively electrified, and attracts positive electricity from the earth, through the finger into the metal plate. On removing the finger and then raising the brown paper the plate is left charged with positive electricity, and there is no negative electrification in the neighbourhood to interfere with the freedom of the charge. This apparatus may be regarded as a simple form of electrophorus.

The electrophorus consists essentially of a plate of ebonite, or of some resinous material, which is placed upon a metal "*sole*." A brass carrier plate, furnished with an insulating handle, can be placed on the disk of ebonite, when it nearly covers it. The ebonite is first electrified (negatively) by rubbing it with a cat's skin or fox's brush, the sole being in communication with the earth during the operation. The carrier plate is then placed on the ebonite. Although the brass plate rests on the ebonite disc it only *touches* at a few points, and the ebonite being an excellent insulator, the electricity is unable to pass from the ebonite to the carrier plate. Hence the carrier plate becomes electrified positively on its lower surface, and acquires a free negative charge on its upper surface. A connection is now made between the carrier plate and the earth, or between the carrier plate and the metal sole, when the free negative electrification leaves the carrier plate, which then possesses only the "bound" positive charge on its lower surface. The carrier plate is then removed from the ebonite, when its positive charge becomes free, and may be employed for charging Leyden jars, or for other purposes. The *energy* of the charge is derived from the work done in removing the carrier plate from the ebonite, during which operation the attraction of the positively electrified plate and the negatively electrified ebonite has to be overcome, in addition to the weight of the carrier plate. In Phillips' electrophorous the connection between the carrier plate and the sole is made automatically by a small brass pin, which passes through the ebonite to its upper surface, and is connected with the sole.

An ordinary electrophorus can be made to furnish negative electricity to a conductor by bringing the conductor into communication with the carrier plate immediately after placing it upon the ebonite. Phillips' electrophorus cannot, of course, be used in this way.

The chief use of the sole is to diminish the tendency of the negative electrification of the ebonite to escape into the air. The sole when in contact with the earth becomes positively electrified by induction, and the negative electrification on the ebonite prevents the latter from escaping into the air to the same extent as it otherwise would. When the carrier plate is placed on the ebonite and touched most of the positive electricity leaves the sole and comes into the carrier plate, because the latter is so much nearer to the upper surface of the ebonite than the sole is. On raising the carrier plate with its charge positive electricity returns into the sole from the earth. During the lifting of the carrier plate the sole must be in connection with the earth, otherwise the sole becomes inefficient. The action of the electrophorus will be best understood after mastering the conception of electric potential.

The phenomenon of induction above described explains why electrified bodies should attract small insulated conductors which are unelectrified. If a positively electrified body be brought near to an insulated pith ball the ball becomes electrified negatively on the side near the conductor, and positively on the opposite side. The negative electrification is attracted and the positive repelled by the charged body, but as the negative portion of the ball is nearer to the charged body than the negative portion the attraction *exceeds the repulsion*. If the light body is not insulated then the positive electrification escapes to the earth, and there is, therefore, no repulsion.

Inventions and Miscellaneous Notes.

Old Yew Trees. — Apropos of the age of yew trees, it is stated in "Chamber's Information" that "yews are believed to be the most ancient planted trees in Great Britain, and no doubt can exist that there are individuals of the species in England as old as the introduction of Christianity, and there is every reason to believe very much older. It is the opinion of Decandolle that, of all European trees, the yew is that which attains the greatest age. The following are some of the more remarkable British specimens to which the attention of the curious has been directed. Those of the ancient Abbey of Fountains, near Ripon, in Yorkshire, which yews were well known as early as 1155. Pennant says, that in 1770 there were 1,214 lines in diameter, and consequently, according to Decandolle's method of computation, were more than twelve centuries old. Those of the churchyard of Crowhurst, in Surrey, on Evelyn's authority, were 1,287 lines in diameter. There are two remarkable yews still in the same cemetery, and if they be the same that Evelyn refers to, they must be fourteen centuries and a half old. The yew tree in Fortingal, in Perthshire, mentioned by Pennant in 1770, had a diameter of 2,588 lines, and consequently we must reckon it at from twenty six to twenty seven centuries old. The yew of Brabourn churchyard, in Kent, is said to have attained the age of 3,000 years. That at Hedsor, in Bucks, however, surpasses all others in magnitude and antiquity, measuring above 27 ft. in diameter; thus indicating the enormous age of 3,240 years.

A New Kind of Gunpowder.—Himly, in his efforts to discover a new kind of gunpowder that should possess more power than the ordinary powder, without the dangerous properties of the nitro-compounds like dynamite and that class, found that the best results were obtained with a mixture of salt-peter, chlorate of potash, and a solid hydrocarbon.

The new powder is made by mixing finely pulverized salt-peter, chlorate of potash, and coal tar pitch with enough benzol (from coal tar) to make a plastic paste or dough. This is formed into flat cakes by pressing it into moulds, and the benzol allowed to evaporate. The cakes are then granulated like any other gunpowder. Like ordinary powder, the grains are irregular and can be made of any desired size. Its specific gravity is 0.9, or a little more, agreeing with common gunpowder.

It is quite hard, and does not smut off even when damp. It will bear a heat greater than that of melting tin without change. It will not ignite by a single spark of short duration. If ignited in an open vessel, it burns rapidly with a white light. In a closed space it burns violently, and leaves behind a slight residue, producing but little smoke. A gun is not injured in the least by the products of its combustion.

The advantages of this powder over hose previously in use are essentially the following:

1. Ease and rapidity of manufacture.
2. There is no danger in making it.
3. Its freedom from any hygroscopic qualities, 100 grammes of it exposed to damp weather for four days in an open window showed no gain of weight with a delicate balance.
4. It is two and a half times more powerful than common powder.
5. The slight residue, leaving scarcely anything.
6. The fact that it gives off so little smoke as to be scarcely noticed, and what is formed is totally innocuous as contrasted with that from nitro-explosives.

A NEW FLUX.—A French metallugist, M. Brunow, claims to have discovered a reducing substance which so promotes liquefaction that by its aid he has melted pig iron in fourteen minutes.

CONSTRUCTION OF PORTABLE RIVETTING MACHINES.—The object of this invention of R. A. Binns, Halifax, Eng. is to construct and arrange a portable rivetting machine, one that will be inexpensive, simple in construction, and operated without the aid of either steam, air, or water. The apparatus the inventor proposes to employ consists of two levers, hinged about the centre, and connected together by a cross bearer. At one end of these levers are dies for rounding or heading the rivets, whilst at the other end of the levers are knuckle joints, consisting of two short links or arms connected together by a suitable pin or bolt. At the part where these links are hinged together a stud or boss is formed for receiving one end of a screw, the outer end thereof entering a nut projecting from the cross bearer. By means of a handle the screw can be operated in such a manner as to cause the knuckle joints or links to assume an inclined position whereby the jaws of the two levers are opened, and when the screw is operated n an opposite direction, the links are straightened, and the aws close up on the rivet.

ELECTRIC TRAMCARS.—An electric tramcar trial was recently successfully accomplished in Paris by the French Electrical Power Storage Company. At three o'clock p.m. the vehicle, an ordinary three-horse tramcar, left the Place de la Nation in the far east, and, after traversing the capital through several important thoroughfares, reached the starting point soon after six o'clock. A distance of thirty English miles was thus made in about three hours. There was not the slightest accident. The ease with which the car was turned off one set of tram lines and got on to another across several yards of unmetaled ground is stated to have been admirable. The locomotion is affected by means of Faure accumulators, weighing some fifty hundredweight, which are fixed under the tramcar seats and connected with a Siemens' machine placed under the floor. The machine, which makes twelve hundred revolutions a minute, sets in movement, by means of a pulley, an axle to which are connected the chains which give impulse to the wheels. These wheels revolve sixty times to twelve thousand revolutions of the machine. The speed of the electric tramcar is nine and a third miles an hour on level ground, and five and half miles on an ascent. The present tram lines are not well adapted for the new locomotion. On the newer lines the movement was sufficiently smooth, but on those that have been laid for some time there was a marked difference, and the actual working force was considerably lower than the indicated horse-power. The estimated cost is one-half that of horse trams.

THE MISSOURI RIVER CHANGING ITS CHANNEL.—A letter appears in the *Kansas City Times*, calling attention to the danger of Kansas City being cut off, if some improvements are not made in the channel. The current of the river across the bottom below the mouth of Lime Creek has been more rapid than in the natural channel. It has cut an artificial channel several feet in width and depth, notwithstanding that the unfinished labors of our scientific engineer (Mr. S. Yonge) has revetted the banks for 1,000 feet. That gentleman informs us that if left in its present condition, another overflow similar to that of 1881 will most certainly cut through above Harlem in spite of the work now done. The effect of this cut off is the loss of the Kansas City bridge, the removal of the levee a half a mile north, forming an immense sandbar in front of the flouring mills. This huge sandbar will be overflowing for years, shifting and changing the city frontage, and the whole surface of the accrued lands will be unfit for buildings and improvements of any character. The Kaw River must have a place for outlet, either along the present channel or follow its onward course northeast until it intersects or empties into the river in its newly formed bed. The sewerage for the cities would prove a source of trouble and disasters that no engineer, however scientific, can now estimate. Millions of dollars will not cover the expense of repairs, damage and extension. To-day, notwithstanding that the city, by its naturally inclined surface, is the best adapted to perfect waterways of almost any other, yet it is almost, if not altogether, impossible for the engineers to adopt a system of drainage adequate to its necessities without occasionally sustaining heavy losses.

AT the British Association meeting a paper by Prof. J. A. Ewing was read, on the magnetic susceptibility and retentiveness of iron and steel. This paper was a preliminary notice of some results of an extended investigation which the author had been conducting for three years in Japan. Experiments with annealed rods and rings of soft iron wire showed that that material possesses the property of retentiveness in a very high degree. As much as 90 and even 93 per cent. of the induced magnetism survived the removal of the magnetising force. The extraordinary spectacle was presented of pieces of soft iron entirely free from magnetic influence nevertheless holding an amount of magnetism (per unit of volume) greatly exceeding what is ever held by permanent magnets of the best tempered steel. The magnetic character of the iron in this condition was, however, highly unstable. The application of a reverse magnetising force quickly caused demagnetisation, and the slightest mechanical disturbance had a similar effect. Gentle tapping removed the residual magnetism completely. Variations of temperature reduced it greatly, and so did any application of stress. On the other hand, the magnetism disappeared only very slowly, if at all, with the mere lapse of time. The residual magnetism in hardened iron and steel was much less than in soft annealed iron. The maximum ratio of intensity of magnetism to magnetising force during the magnetisation of soft iron was generally 200 or 300, and could be raised to the enormous figure of 1590 by taping the iron while the magnetising force was being gradually applied. A number of absolute measurements were made of the energy expended in carrying iron and steel through cyclic changes of magnetisation; and the effects of stress on magnetic susceptibility and on existing meguetism were examined at great length. The whole subject was much complicated by the presence of the action which, in previous papers, the writer had named *Hysteresis*, the study of which, in reference both to magnetism and to thermoelectric quality, had formed a large part of his work.

THE CONSUMPTION OF FUEL IN LOCOMOTIVES.

(*Revue Générale des Chemins de fer*, 1883, *p.* 403.)

In 1881, Mr. Marié published results of experiments he had made on the consumption of fuel in locomotives on the line from Paris to Montereau, where he had found that in the course of regular service, the consumption frequently fell to 3·31 lbs. per H P. delivered at the rail. Like experiments were made in July 1882, by Mr. Hirsch and Mr. Marié on the Saint-Jean line between Maurienne and Modane, a length of 17 miles, on a continuous incline of from 1 in 100 to 1 in 33 3, averaging 1 in 54. The trains rise to a height of 568 yards.

The work done was calculated by means of a formula constructed in terms of the weight of the train, the length of the line, the frictional resistance, and the total rise of the line.

On the 18th July, 1882, an express train was run from Saint-Jean-de-Maurienne to Modane in 1 hour 4 minutes, stopping once at Saint-Michel, for 4 minutes, and making the run in 1 hour. The speed was 17 miles per hour, and the resistance was taken at 9.63 lbs. per ton gross weight, reckoned at the rails, after deducting the resistance of the machinery. Of the fuel briquettes, 1,113 lbs. were consumed for the trip, being at the rate of 65½ lbs. per mile; and 3·26 lbs. per H P. at the rails. The fuel, on analysis, was proved to contain 6.90 per cent. of ash, and 1 per cent of moisture. Water was evaporated at the rate of 8·83 lbs. per pound of fuel; or allowing 9 per cent for priming, 8·03 lbs. per pound of fuel; and at the rate of 26·19 lbs. of dry steam per H P. at the rails. The steam was cut off at 19 per cent. of the stroke of the pistons.

On the 17th and 19th July, 1882, the experiment was repeated, with the same train, on the same course, with the same driver, and at the same hour of the day. The fuel was briquettes made with dry coal. The quantity of dry steam consumed was 29 4 lbs. per H P. at the rails.

The Author concludes that, for locomotives in which the speed of piston is not too low, the consumption of fuel of good quality is 3.35 lbs per H P. developed at the rails per hour; and that, including the machinery-friction of the engine, the consumption is at the rate of from 2·24 lbs. to 3 lbs. per indicator H P. The great economy, he says, is due to the high state of maintenance, and the great speed of pistons. Stationary engines usually cause a consumption of from 4½lbs, to 6¾ lbs. per H P. per hour; and in general, it is better to employ small engines running fast than large ones going slowly. For further economy of fuel, the Author looks to the heating of the feed-water by the exhaust steam; and the elevation of the working pressure to from 10 to 20 atmospheres, with compounding of the cylinders.

SASSAFRAS-LEAVES.