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ARTICLES.

REVIEW OF THEORIES OF ELECTRICAL ACTION.*

BY PROFESSOR H. S. CARHART.

The physics section of this association congratulates itself because it deals with topics of the most lively and general interest, not only from a practical point of view, but still more from a theoretical one. Even popular interest in electricity is now well nigh universal. Its applications increase with such prodigious rapidity that only experts can keep pace with them. At the same time the developments in pure electrical theory are such as to astound the intelligent layman and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the illustrious name of Faraday; a million messages daily over land and under sea serve to emphasize the value of Joseph Henry's contribution to modern civilization. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilization of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort, and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science, however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to inquire into their causes, to frame a satisfactory theory of their correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvelous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make, even in a period of two hundred years. For more than twenty centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical attraction deserves commendation, for it evinces a mental inaptitude to account for physical actions "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion, and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies or with an invisible, imponderable medium, suspected by no sense of man, but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of certain bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain. "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism by calling them particular species of attraction peculiar to certain bodies." *

The discovery by Stephen Grey that "the electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist, or Cuneus, had the effect of annihilating many mushroom theories constructed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest in both Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time. His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad, and secured

* Address by Professor Carhart, Vice-President Sec. B. American Association for the Advancement of Science, delivered at the annual meeting, Toronto, August 28th, 1889.

* Priestley's Hist. of Elec., vol. ii., p. 18.

for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating, a discovery gravely communicated to the Royal Society by William Watson, is not so well-known, and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says: "Nor is it of much importance for us to know the manner in which Nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which Nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science; and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole, of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalizations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present, physicists have been in pursuit of the connection between light and electricity. As early as Newton's time, the ether was conceived by some to be a subtle medium confined to very small distances from the surfaces of bodies, and to be the chief agent in all electrical phenomena. "But," says Priestley,* "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid, *sui generis*, principally concerned in the business of electricity. They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of especial service in the study of electricity is the doctrine of light and colors. The invention of the voltaic battery, and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated inquiry in this same direction. Mrs. Somerville, Morrichini, and others, sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success. Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical considerations" of a direct relation between light and electricity that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarization of light by means of magnetism. "Thus is established," he says,† "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together, and have one common origin."

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter, Maxwell, to construct a most marvelous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery in electrolysis; that even right and left-handed circularly polarized light cannot be considered the analogue of the two poles of a magnet, for the two polarized rays when combined do not neutralize each other but produce plane polarized light.

It may be said, however, that if a right-handed circularly polarized ray produces magnetism in one direction, and a left-handed ray in the opposite, then the combination of the two rays may neutralize their magnetic effect, inasmuch as plane polarized light may have no magnetic influence. Professor J. J. Thomson has lately shown mathematically that a circularly polarized ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has secured by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space had magnetic properties, and that the space or medium around a magnet is as essential as the magnet itself, being a part of the complete magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I cannot tell," he says,‡ "perhaps the ether." No doubt existed in Faraday's mind that these lines represent a state of tension; but whether that tension is a *static* state in the ether, or whether it is *dynamic*, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts have been of the utmost productiveness. They have revolutionized the science of electricity, and have been the most potent factors in the genesis of a theory, including all radiant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equaled by his philosophic insight, his

* Hist. of Elec., vol. ii., p. 22.

† Exp. Researches, 2,221.

‡ Exp. Researches. 3,277.

poetic feeling and imagination, his profound sincerity and his great sympathy with nature. Here him sing at Aberdeen :—

" Alone on a hillside of heather,
I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
I was deaf, I was dumb, I was blind,
I knew not the glories around me,
I counted the world as it seems,
Till a spirit of melody found me,
And taught me in visions and dreams."

" For the sound of a chorus of voices
Came gathering up from below,
And I heard how all Nature rejoices,
And moves with a musical flow.
O strange ! we are lost in delusion,
Our ways and our doings are wrong,
We are drowning in wilful confusion
The notes of that wonderful song."

To appreciate Maxwell's relation to theories of electrical action, it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600, and it lasted for about 225 years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical investigations, founded upon the law of inverse squares, naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance ; Faraday saw a medium where they saw nothing but distance ; Faraday sought the seat of the phenomena in real actions going on the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids." * Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence ; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease, due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalization of the conservation of energy was looming up all along the horizon of science, as the towers and spires of a great city appear to rise out of the sea to a traveler approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army, but one constantly augmenting in numbers by deserters from the enemy. At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes only to translate Faraday's ideas into mathematical language ; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electro-magnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained ; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electro-magnetic phenomenon, though it may now seem to be a short one, must nevertheless, upon careful consideration, always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing, and a comparatively easy one ; but to make original explorations into unknown regions of nature, and to tread where no human being has ever before set foot is quite another thing. The electro-magnetic theory of light must be regarded as a great generalization, inferior only to that greatest one of all time—the conservation of energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated :—

1. An electro-magnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electro-magnetic to the electrostatic unit of quantity. If light is an electro-magnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity, K, of any transparent dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favorable case is that K is the most important term in the expression for the refractive index, while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should be perpendicular to the plane of polarization of plane polarized light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise both to electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators, and all good conductors are opaque. The degree of opacity is, however, far from being proportional to the conductivity.

5. But perhaps the most important criterion of all is the one

* Maxwell's Elec. and Mag., p. x.

relating to the very existence itself of a medium. Such a test lies in the *time* element involved in transmission from point to point. Since energy is transmitted from a luminous body, as the source, to another body which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts.

Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites, when the earth is moving away from Jupiter, is, therefore, a confirmation of the undulatory theory of light and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electrical action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electro-magnetic theory of light. The noteworthy experiments of Professor Hertz, of Carlsruhe, are known to all. Rightly conceiving that the reality of electro-magnetic waves would be best established by the same experiments which would also establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness he produced electrical oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished by attaching to the secondary terminals of an induction coil two rectangular sheets of metal each supplied with a short, stout wire, ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir William Thomson, published in 1853.*

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire, interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electrical oscillations in it, synchronizing with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbances. The astounding fact was thus brought out that these electro magnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the *time element* was experimentally detected in the propagation of electrostatic and electro-dynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted, and as interference phenomena show them to be in light. Hertz has also found an electro-dynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave metallic reflectors, and has shown that electric waves suffer polarization and refraction in a manner exactly analogous to light. Professor Fitzgerald, of Dublin, has added another confirmation of Maxwell's doctrine, demonstrating that the *electric* disturbance is perpendicular to the plane of polarization as Maxwell's equations require. Finally, the velocity of propagation of these electro-dynamic waves is found to be the same as the velocity of light. Thus not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added. Electro-magnetic waves are therefore not merely like light, but they are light. Or perhaps, to speak more exactly, all radiant energy is transmitted as electro-magnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Professor Lodge says, "has become a truly imperial realm." The difference of wave-length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million-fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light Even the long heat waves would be absent, and only those producing the sensations of light and color would remain.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry, in 1832, by means of the magnetic effects produced in small steel needles. It was not until 21 years later that Sir William Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has lately shown that they rotate the plane of polarization of light in one direction and then in the other as they surge back and forth. He has also reduced the number of oscillations from several millions per second to a few hundred by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant 30 feet from one which served to discharge a Leyden jar is now seen to have been a case of resonance; that is, the absorption of electric waves by a conductor, producing currents therein. And it is an evidence of the great genius of Henry, that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension, that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery

* Math. and Phys. Papers, vol. i., p. 540.

of electro-magnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared, and its discovery was impossible.

Waves similar to those from a Leyden jar discharge, but of longer period, are sent out from a wire conveying alternating currents. We must conceive of such a wire not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether, great waves of electro-magnetic disturbance. For 300 complete alternations per second, these waves are a million meters, or over 600 miles in length. They present a marked contrast with the waves corresponding to the D lines of the spectrum which are only about one five-millionth of a millimeter long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity, precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may indeed be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent role in what may be called its dynamic relation to electric displacements. In its capacity as a reservoir of static or potential energy its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet, with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects, may be we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellant laterally. When a current is sent through a conductor the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current, which maintains this state of tension, ceases to flow, the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential energy at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electro-magnetic disturbance in the surrounding medium; and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action it will be quite evident that henceforth the language applied to electrical phenomena must always include the luminiferous ether as a prominent term. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations, the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has, at least, been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

"The discord is vanishing slowly,
And melts in the dominant tone.
And they that have heard it can never
Return to confusion again,
Their voices are music forever,
And join in the mystical strain."

ASSAY OF COAL.

Those who are prospecting for coal often have difficulty in determining to what class their finds belong. The principal varieties of coal are as follows:—

Anthracite, or Hard Coal—Hardness, 2·2·5; specific gravity =1·32–1·70. Contains volatile matter after drying 3 to 6 per cent. Contains carbon 80 to 95 per cent. It has a high lustre and burns without flame, as it contains little or no bitumen. It is totally devoid of impressions of plants, and is, geologically speaking, the oldest of all kinds of fossil charcoal, and is regarded as the last stage of carbonization. It yields from 1 to 7 per cent of ash, but 3 per cent may be called the average.

Brown Coal, or Lignite, much of which is found in California, contains from 57 to 70 per cent of carbon, and represents the first stage of carbonization, being a coal of comparatively recent formation. It is composed of fossil plants more or less mineralized, and when burnt evolves much smoke and affords a dull flame, generally yielding a large quantity of ash. It contains from 2 to 19 per cent ash.

Caking Coal is a bituminous coal which softens and becomes pasty in the fire, and after the heat has become continued for a time, the volatile ingredients are driven off and a grayish-black fretted mass is left. The coke obtained from this coal varies from 50 to 85 per cent.

Non-caking Coal resembles the above in its external character, but burns freely without softening or showing any appearance of incipient fusion.

Cannel Coal is a bituminous coal which generally cakes. It is compact with little or no lustre, and has a dull black or grayish-black color. On distillation it affords, after drying, 40 to 66 per cent of volatile matter. When held in the flame of a candle, it easily ignites, burning with a steady, bright flame. It is used extensively for making illuminating gas, of which it affords a better quality than any other species of coal.

It is well to know that no very extensive apparatus is required to determine many points about coal. It can be examined and its commercial properties determined by the blowpipe with great accuracy. Mr. George Attwood (eldest son of Melville Attwood, of this city), in his work on "Practical Blowpipe Assaying," gives the following methods of determining the character and properties of coal, by means of the blowpipe :—

The assay is divided into five heads :

1st. The moisture determination.

Select from the mass of coal to be examined a few lumps representing as nearly as possible the average quality. Crush them up in the agate mortar into small pieces about the size of a mustard seed.

Weigh out five grains, place in a small porcelain dish, and dry at a gentle heat over the spirit-lamp. Hard coals sometimes fly when heated, so it is best to cover the dish with a watch glass while heating. After about five minutes, remove the assay and weigh; then repeat the heating and again weigh. As soon as the weights agree the assay is ready to be converted into coke. Plattner states that the percentage of moisture is lowest in anthracite; in bituminous coals it is usually three to four per cent, seldom six to seven, and reaches its maximum in lignite and brown coals, which contain 20 per cent and sometimes more.

2nd. Determination of the coke production.

Take the dried coal and remove to a clay or platinum crucible, and cover with a small roasting clay dish or platinum cup. Place the crucible on a triangle of platinum wire on the blowpipe stand under the flame, using alcohol, and cover it with a small sheet-iron funnel (the same that is used in roasting copper ores). The heat is continued until all the volatile gas has escaped, when the assay generally will appear to possess a fused porous appearance, and to have a metallic lustre.

The coke so made is now removed and weighed. It should be weighed quickly, as coke absorbs moisture from the air rapidly. The coking takes about 10 minutes, and the crucible should not be allowed to get beyond a red heat.

3rd. The estimation of the amount of ash.

After the percentage of the coke has been determined, remove the assay to a small clay or platinum capsule, and, without using a cover, again heat over the lamp—this time to a bright red color—until all the carbon has been consumed. The operation is much facilitated by occasional stirring the assay with a piece of platinum wire, also by applying the blowpipe flame to the bottom of the cup when the assay is nearly finished.

If alcohol cannot be obtained, the assay for coke and ash can be conducted in the charcoal furnace by using the blowpipe flame, as in the copper assay, and if the ash amounts to more than five per cent, the value of the coal is much diminished. If the ash presents a brown, red, or gray color, sesquioxide of iron has been formed by the oxidation of the pyrites in the coal.

4th. Determination of the absolute heating power by Berthier's process.

Take an average sample of the coal and crush it up to the finest powder. Weigh out 0·3 grain of the coal dust and mix it with 12 grains of oxychloride of lead, and after placing the mixture in the crucible, cover it with an additional 12 grains of oxychloride of lead.

Oxychloride of lead fuses more readily than litharge; therefore, owing to the large quantity of material which must be brought into a state of fusion in this determination, it is employed instead of litharge.

The assay is next covered with a little powdered glass, also with a few spoonfuls of borax glass. A clay cup is placed over the crucible, and the assay is then fused in the charcoal furnace in a similar manner to the silver assay when litharge is used.

About seven or eight minutes suffices to melt the assay, and the lead button produced by the carbon in the coal acting on the lead oxychloride will be found lying upon the bottom of the crucible when the assay is cool and the crucible is broken.

The weight of the button, when cleaned from the slag, divided by 20, gives the quantity of lead that one part of the fuel under examination can reduce; and since one part of carbon reduces 34 parts of lead, the heating-power of the fuel may be easily ascertained. The amount of lead reduced by one part of coal varies with the diferent pit coals between 21 and 32 parts, with the lignites between 16 and 25 parts. In making this assay the heat must be applied at first very gradually, and afterwards increased to a bright redness.

Dr. Ure's experiments, published in the "Supplement to the Dictionary of Arts, Mines, and Manufactures," have appeared to be unsatisfactory in regard to the accuracy of Berthier's method. Mitchell, however, has found the method correct, and the author has found it equally so. The lead oxychloride should always be pure.

5th. Estimation of sulphur in a sample of coal.

Sulphur generally exists in coal as a sulphide of iron, and as the presence of more than two per cent of sulphur depreciates the market value of coal, owing to its destroying the iron boilers and grates under and over which the coal is consumed, it is always an important part of the examination of coal to ascertain the quantity present.

Mitchell, in his "Manual of Practical Assaying," recommends the following process :—

Take one part of the finely pulverized coal and mix with seven to eight parts of nitre, and 16 parts of common salt, and four parts of carbonate of potash, all of which must be perfectly pure. The mixture is then placed in a platinum crucible and gently heated at a certain temperature; the whole ignites and burns quietly. The heat is then increased until the mass is fused; the operation is finished when the mass is white. It must, when cold, be dissolved in water, the solution slightly acidulated by means of hydrochloric acid, and chloride of barium added to it as long as a white precipitate forms. This precipitate is sulphate of baryta, which must be collected on a filter, washed, dried, ignited, the filter burnt away, and the remaining sulphate of baryta weighed; every 116 parts of it indicate 16 of sulphur.

The above described methods of examining coal are all that are required for commercial purposes. The assay may be carried on still further by estimating the iron oxide contained in the ash. The ash can also be examined qualitatively for silica, lime, soda and potash.—*Mining and Scientific Press.*

An impervious enamel for paper, wood, etc., is a solution of shellac in methylated spirit. A coating of this is applied, and then another coating laid at a high temperature and under great pressure.

PREVENTIVE OF FOAMING IN BOILERS.—A writer in the *American Machinist* recommends the use of castor oil in boilers where alkaline water is used. He says that from two ounces to a pint of oil will prevent foaming all day. The oil is put in after the engine has started if foaming begins.

PORTELECTRIC SYSTEM OF RAPID TRANSMISSION.

The possibility of adapting an electric method to the practical solution of the problem of rapid transportation, has universally been admitted by electricians for years past, but until the present it has been assumed by experts that the difficulties to be overcome were too serious to warrant much hope of a successful issue. Several schemes have, indeed, been proposed, which, though they served to confirm the belief in the possibility of ultimate success, yet left its actual realization apparently as far off as ever. The Telpher system proposed some years since by the late Professor Fleeming Jenkin, and by him put into actual practice, comes, perhaps, the nearest towards a practical solution of the adaptation of the electric method to the prompt transmission of comparatively light weights, than any that have yet been put into service; but the Telpher method, though ingenious, in no adequate measure realizes the idea of *rapid transmission*—no more, in fact, than the several methods that have been devised and practiced in connection with the passenger service in cities. Six or ten miles per hour is apparently the practical limit of the speed of these methods.

To pass from these modest achievements to the consideration of a system by which, it is claimed, a speed of two miles a minute can easily be secured and maintained, imposes a severe strain upon the credulity; but such, we are assured, is the fact, and a consideration of the means by which this astonishing result may be accomplished, leaves one equally astonished at their simplicity. We may premise, in advance of any description, that the method, the "Portelectric" system as it is called by its inventor, John T. Williams, has been developed, in the first instance, to serve the highly desirable purpose of expediting the transmission of mail matter, and of comparatively light parcels, for which, if but a portion of the claims of its advocates shall be substantiated, it must unquestionably bring about a complete revolution in existing methods. What it may accomplish in the future in connection with the problem of transporting passengers and goods, at high speed and over long distances, we shall not dwell upon. It will be an enormous stride ahead, if it shall be found practicable, by this system, to transmit mail parcels (as it is claimed can be done) between New York and Boston in two hours.

A meeting of a number of persons interested in the Williams system was lately held in Boston, at which its capabilities were exhibited with the aid of a working model, and the principle of its operation was thereupon explained by the inventor, and by Prof. A. E. Dolbear, a distinguished electrician, whose endorsement of the value of the new method cannot fail to demand for its claims the respectful attention of men of science.

The principle involved in the operation of the Williams system is an extremely simple one, that is familiar to every tyro in electric science. It is, in fact, none other than the well-known sucking action that a helix or a coil, in which an electric current is flowing, will exert upon a rod of iron, when this is brought within range of its inductive influence. Thus, if a bar of iron or steel be placed with one end near the centre of the helix, on passing a current through the latter, the bar will be drawn in and maintained in a central position as long as the current continues. If, now, the current be broken, the bar will again be free to move; and if we imagine a second helix placed in a position similar to that which it first occupied with relation to the bar, then, on the passage of the current through this second coil, the bar will be drawn toward that one, and out of the first, so that with a number of helices arranged side by side, and with an arrangement for making and breaking the current at the proper time, it is evident that a bar of iron could be moved continuously in any desired direction. In the practical application of this simple electrical experiment to a system of rapid transportation, this is precisely what Mr. Williams does.

The practical details of the system will readily be appreciated from the following description, with the aid of the accompanying illustrations:—Of these, Fig. 1 exhibits a view of the structure, in perspective, which the inventor has designed to carry a small carriage for the rapid dispatch of mail and of small parcels. An elevated structure, in the form of a continuous girder of iron borne on the top of a series of iron columns, carries upon it two beams of wood, placed one above the other, with hollow rectangular blocks placed at intervals, the whole forming a continuous passageway, and having on the inner faces of the beams a single-rail track for the guidance of the carriage. In this figure, each of the seven blocks shown contains a coil, placed between the upper and lower beams. The position and appearance of the carriage are likewise exhibited. This is a box of steel of rectangular form, in the compartments of which the parcels, letters, etc., may be placed, and having an upper and lower guiding wheel at both ends. The details of the helices, and their mode of action, will be understood from Fig. 2, which exhibits one of the boxes, with the covering removed. The circuit is connected through each helix at the contact point C, with the main line conductor L L, through the pivoted magnet N S, whose function is to make and break the circuit of the helix at the proper time. The steel carriage containing the mail is magnetized. The front of the car being the S pole, as it enters the helix it repels the S pole of the pivoted magnet N S, forcing it upward, which brings the N pole down to the contact point C. This closes the circuit through the helix, which thereupon draws the car in with a sucking action. This contact with C is maintained up to the time that the centre of the carriage arrives at a short distance from the centre of the helix, when the influence of the carriage on the magnet N S becomes neutralized, and the contact is broken. This making and breaking of the circuit is thus repeated as the car enters and passes through each succeeding coil. It is evident that if the circuit is still to be maintained after the carriage had passed the centre of the helix, the action would be to retard the motion of the carriage, and, indeed, to stop it entirely, for, as is well-known, the suction power of the coil is equally strong at either entrance. The object of breaking the contact a short distance before the centre of the carriage reaches the centre of the helix, is to avoid the retarding effect upon the carriage which would be experienced on account of the extra current in breaking in the coil. This extra current, being in the same direction as the main current, would tend to drive the carriage forward as long as it was behind the centre of the helix; but it will readily be seen that, if the carriage had passed the centre, the extra current would tend to retard it in the same way that the main current would.

It will thus be noted that each helix comes into action successively, and only one is in action at any one time, so that the current is utilized to the best advantage. It will readily be understood that when once the carriage is in motion and its inertia has been overcome, comparatively little force will be necessary to maintain it at speed; and this is shown to be the case in the present system. As a consequence, the strength of the coils may be considerably diminished after a short distance from the terminal station, as the power required is

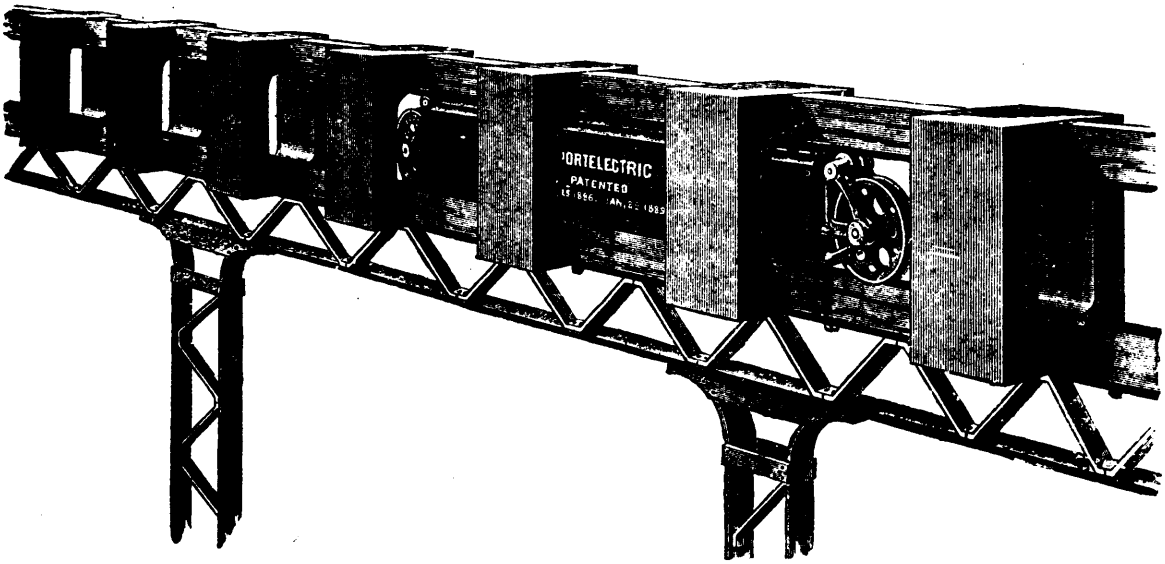


Fig. 1.

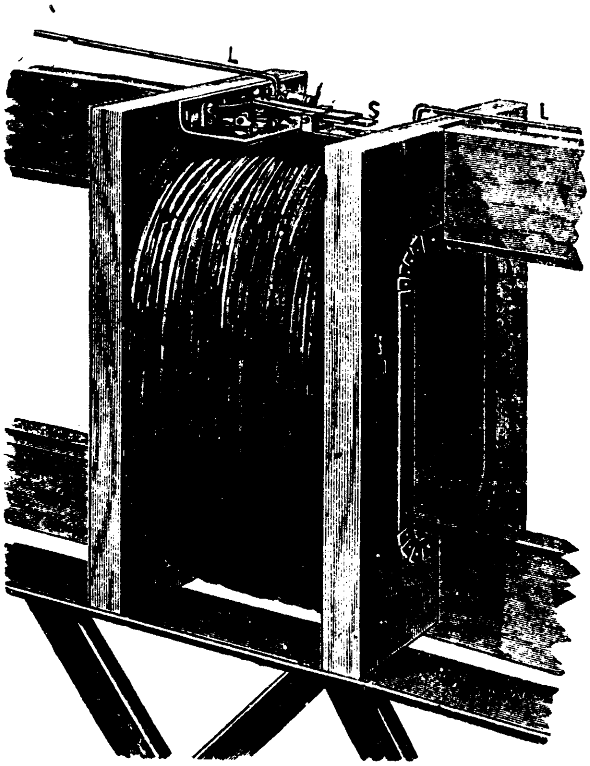


Fig. 2.

PORTELECTRIC SYSTEM OF RAPID TRANSMISSION.

diminished accordingly when the carriage has attained its proper speed. Another interesting fact in connection with the system which we must take occasion to observe, and which must necessarily follow from its construction, is that the current in the helices is considerably cut down by the counter E. M. F. generated by the passage of the carriage through them, so that, in a certain sense, the system is self-regulating to maintain the carriage at its proper speed. A system of this kind must necessarily be provided with means for stopping the car gradually, and without jar, at a terminal station, and this has been worked out very ingeniously by Mr. Williams. The brake consists of a helix similar to those shown, which is provided with a contact that, unlike the others, remains closed after the carriage has passed the centre of the helix. The effect of this is that the car is retarded, or pulled back, and rapidly brought to a standstill.

The practicability of the system here described, is said to have been demonstrated very fully with the aid of the model above referred to, which was designed more especially to exhibit the adaptability of the system to the wants of the postal service. With a suitably constructed line, it is confidently affirmed by the inventor, that a speed of not less than two miles per minute could easily be maintained, and the advantages in point of speedy delivery of mail between important centres which could thus be realized, are obvious. The inventor affirms that the journey between Boston and New York would take about two hours, more or, perhaps, even less. Even a small shuttle-like carriage of the dimensions of the model carriage on exhibition, weighing only 56½ pounds, and some 4 feet long, could carry 1,000 letters. With 1,000 letters dispatched every five minutes, the present daily work of the Boston post office between Boston and New York could be accomplished. But in the construction of these cars there is a perfect practicability in their bei g twice or three times the length of the model, with accompanying added capabilities of transportation. But it is apparent, if these claims can be substantiated, that the system will not be confined to the postal service. It is rather a revolution in the realm of rapid transportation.

As to power, that of the present proposed system is an Edison incandescent circuit of 110 volts. The resistance of the first coil amounts to 25 ohms. There is four-seventh horse-power propelling the carriage at the start. The coils in the model are placed two feet apart. This nearness of the coils may be necessary at the start, and upon any up grades which might occur in a long-distance system; but on any main line it would be perfectly practicable for them to be eight, ten, or even twenty feet apart. In such a distance as that from Boston to New York, sufficient power could be furnished by five or six stations placed at equal intermediate distances. The cost of constructing such a system is confined relatively to the cost of the plant, for the cost of maintaining the power is slight. The structure itself, simple as it is in design, would also need no very extended outlay of capital: the cars and the helices form the remaining details of expenses in the first plant. The speed attainable by a car in this system is declared to be almost incalculable. As is well known in mechanics, a constant propelling force is productive of almost infinite velocity, obstructed only by the resistance of friction. In this system the only friction comes from the air and the contact of the car with the rails, which is very slight.

We shall await further developments in connection with this promising invention with great interest.—*The Manufacturer and Builder.*

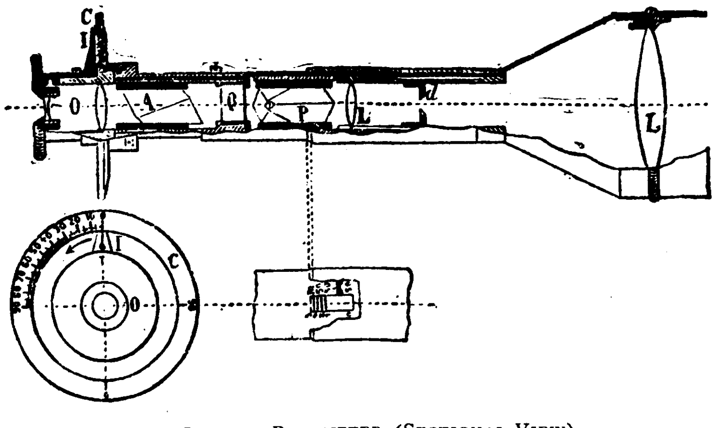


FIG. 1.—OPTICAL PYROMETER (SECTIONAL VIEW).

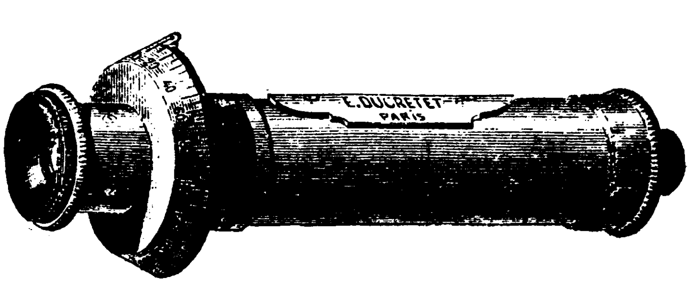


FIG. 2.—OPTICAL PYROMETER (PERSPECTIVE VIEW).

THE OPTICAL PYROMETER.

The exact determination of the temperature of incandescent bodies is a problem which offers considerable practical importance in a great number of industries, founded upon the application of high temperatures. Such is the case in metallurgical operations, for example, in steel-melting furnaces, in re-heating furnaces, in blast furnaces, and in the manufacture of glass and porcelain.

The chemical reactions developed in these furnaces vary with the temperature, and the attendent physical phenomena vary in the same manner. A piece of porcelain, baked under proper conditions, cannot withstand, without some risk of cracking the enamel, an excessively high heat, and if the temperature be not sufficiently high, the important reactions will not take place—the enamel will be insufficiently fused.

In the same manner, in the furnaces for the manufacture of steel, the degree of temperature attained modifies, in an important degree, the oxidizing or reducing reactions, and determines in all cases a considerable modification of the proportion of combined carbon in the finished product. From these facts, it is evidently a matter of the highest importance, to insure success in metallurgical operations of this nature, that the operator shall be able to determine temperatures in a precise manner, independent of all causes of error, in order that he may reproduce with certainty, under similar circumstances, the reactions which he has in view.

As a result of the observation of the color of incandescent objects, it is well known that as the temperature rises the color passes from dark red to light red, then successively through the shades of yellow-red, orange, pale yellow, and at last to white. We have here a gamut of colors, well known to all observers, for which Pouillet has given in his scale the thermometric degrees corresponding thereto. These colors furnish a most characteristic indication of the variations of temperature ; but it is impossible to determine these delicate tones of color with accuracy by direct observation, since the personal error cannot be completely eliminated. But the eye is not able to appreciate the shades of color with sufficient definiteness, and is able to judge only by comparison ; dark red appears as a light red in an obscure medium, and light red will appear dark in a very clear medium ; and this shows the necessity of an instrument which will register correctly without being influenced by the surrounding medium.

Such has been the starting point of many instruments made to register high temperatures, by the well-known phenomenon of color ; but, unfortunately, the larger number have not given satisfactory results. The photometers of Crova, Trausine, and Violle, are more suitable for the laboratory than for rough usage in the workshop.

The optical pyrometer, however, of which we give an illustration, furnishes a solution of the problem, by permitting an exact appreciation of the color of the incandescent body. The apparatus is portable, not to be easily broken, simple, and, thanks to the mode of construction, preeise in its indications, no matter what the surrounding conditions may be. It is the invention of Messrs. Mesure and Nouel, engineers of the Saint Jacques workshops at Montluçon, belonging to the Compagnie des Forges de Chatillon-Commentry, which has become well known to the metallurgical world by the scientific interest of its productions.

The eye-glass is shown in Figs. 1 and 2. The apparatus, based upon the application of the phenomenon known as rotary polarization, comprehends essentially two Nicol prisms, the one a polarizer P, the other an analyzer A, of which the principal sections describe an angle of 90°. Between these two prisms there is a plate of quartz Q. It is known that as it passes through the first prism P, the ordinary ray is polarized in a plane defined by the axis of the polarizer, and is completely extinguished in traversing the second prism A, the axis of which is perpendicular to the first. The plate of interposed quartz, cleaved perpendicularly to the axis, has the object, on the other hand, of deflecting the plane of polarization, which becomes oblique to the principal section of the analyzer, and is able then to traverse it without being completely extinguished.

By the law discovered by Biot, the angle of deviation is proportional to the thickness of the plate of quartz, and, in consequence, inversely proportional to the square of the length of the wave. As the length of the wave varies with the color, which itself depends upon the respective proportions of the simple rays of light transmitted in the ordinary ray ; and, if we have the means of measuring this deviation, it is obvious that we are able to decide immediately the temperature from the color of the incandescent body. To effect this, the analyzer is movable in the interior of the tube, in order to bring the principal section to make a certain angle with the polarizer. An index I shows upon the graduated scale C the angle of deviation, of which zero corresponds to complete extinction.

If, when looking at the incandescent body, the analyzer is slowly turned, the observer will perceive the light under a determined tint, variable with the temperature, and this tint disappears by an angle of corresponding rotation ; it is, then, this angle which serves to define the observed temperature.

Generally there is selected for observation a determined tint, that may be easily distinguished. One may readily observe that, by a very slight rotation of the analyzer, the tint perceived passes rapidly from green to red, and, between these two complementary colors, one may easily observe another shade, called the tint of "passage," of an impure citron shade. The angle at which this sensible tint becomes appreciable, is noted.

Fig. 1 shows in section the optical system employed in the construction ; L is the objective, which receives the rays from the incandescent body, and directs them upon the polarizer P; O is the eye-piece, which receives the rays upon leaving the analyzer A, and which is movable with the analyzer in its setting. Fig. 2 shows an exterior view of the portable model, a little simpler in construction than that above described.

These glasses for heat measuring, constructed with care by E. Ducretet, according to the instructions of the inventors, have been regularly used for more than a year in the forging department of the Saint Jacques works. The foremen have become quite familiar with the use of the apparatus, and as it insures that all the operations shall be conducted under absolutely uniform conditions, its introduction readily accounts for the remarkable quality of the products of these works.—*The Manufacturer and Builder*.

MANAGING FIRES.

In order that a boiler may furnish steam uniformly, says the *Safety Valve*, regularity in firing is necessary, and the water should be kept at a uniform height also, by feeding constantly. But previous to cleaning a fire, the water may be allowed to rise a little above its ordinary level in the boiler, and the feed may be partly, or wholly, shut off during the operation, and until the fire has "come up," as it is called.

It is also productive of great economy in fuel, as well as increased evaporative efficiency, to heat the feed water to a high degree before it is allowed to enter the boiler; this also adds to the life of a boiler, by preventing unequal contraction of the sheets by cooling, which often costs crystallization, grooving and ruptures.

When using bituminous coal, with a rapid rate of combustion, the fire should be from 8 to 10 inches in thickness; but if the combustion is slow, a thickness of 5 or 6 inches is sufficient, care being taken to prevent the fuel from burning into holes.

The furnaces should be regularly fired at intervals of from ten to fifteen minutes, to avoid making a great change of temperature, which always occurs when a large mass of coal is thrown in at one time, due to heat becoming absorbed in the evolution of the gases. And for the same reason it is best to fire only on one side of a wide furnace at a time. The several furnaces of a battery, or of a range of boilers, should be worked in rotation, and the coaling and working of the fires should be done as quickly as possible, in order to allow the influx of no more cold air than can be avoided.

With anthracite coal the fires should be kept as thin as possible, from 4 to 7 inches being the usual limit, dependent on the size of the lumps, which should be as nearly uniform as possible, and also open the strength of the draught.

In the use of some bituminous coals it is found that they agglutinate and form a cake over the whole surface of the furnace, and to maintain the steam at a constant pressure, it is then necessary to introduce a slice-bar into the furnace and break up this solid cake into fragments. This operation liberates the gases and fills the furnaces with flame, generating an intense heat. By watching the needle of the steam gauge, and breaking up only so many fires at a time as may be found necessary to keep up the pressure, the fireman will find it easy to carry steam uniformly and with economy of fuel.

When a fire reaches a certain point of intensity, after the gases have been driven off, it is necessary to put on more coal, for if it is suffered to go beyond that point before the addition of more fuel, the chilling effect produced is so great that the temperature is reduced to so low a point that it is with difficulty that the fresh mass can be sufficiently heated to ignite, causing a waste of the gases and a diminution in the evaporative efficiency of the boiler for the time being, and a consequent drop in the steam pressure. The condition of the fire, suitable for cooling, can be learned only from practice, and a knowledge of this very point is what constitutes the principal difference between a good and a poor fireman. When a uniform, bright light is thrown over the ashpit from the fuel on the bars, the fires are clean and burning well; but when the ashpits are partially or wholly dark, there must be ashes or clinker on the grates, which should be removed. Ashes and clinker are very apt to accumulate at the front and corners of furnaces, against the sides, and also at the back and against the bridge wall. These places must be kept as free as possible from this refuse, and the coal heaped a little above the general level on the bars.

The fires should be cleaned at least as often as once in twelve hours, sometimes at shorter intervals, dependent upon the amount of refuse in the coal and the rate of combustion.

In cleaning a fire the fireman sometimes pushes with a hoe the live coals from the front half of the fire into the back of the furnace, and then hauls out the ashes and clinker, and then pokes all the fire to the front, and pulls the ashes and clinker of the back end of the furnace over the top of the live coal and out at the furnace door. He then closes the door for a moment, wets down the ashes and clinker, throws it one side, opens the furnace door again, spreads the fire evenly over the grate, and throws on a light charge of coal as quickly as possible. That is the old method of cleaning a fire, and it is still practised to a great extent both on land and at sea.

A much better plan, and one which is coming into vogue, is to move all the live coals from one side of the furnace along its length to the other, then haul out the clinker and ashes, then move all the live coals to the side already cleaned, and remove the remaining refuse from the other side of the furnace, afterwards spreading the live coals evenly over the grates and charging the furnace with fresh fuel.

Where the furnaces have considerable width, it is better to clean only one side of the furnace at a time, cooling it of course, but leaving the other side to be cleaned in an hour's time or so. This method will promote economy of fuel and render it much easier to maintain a uniform supply of steam.

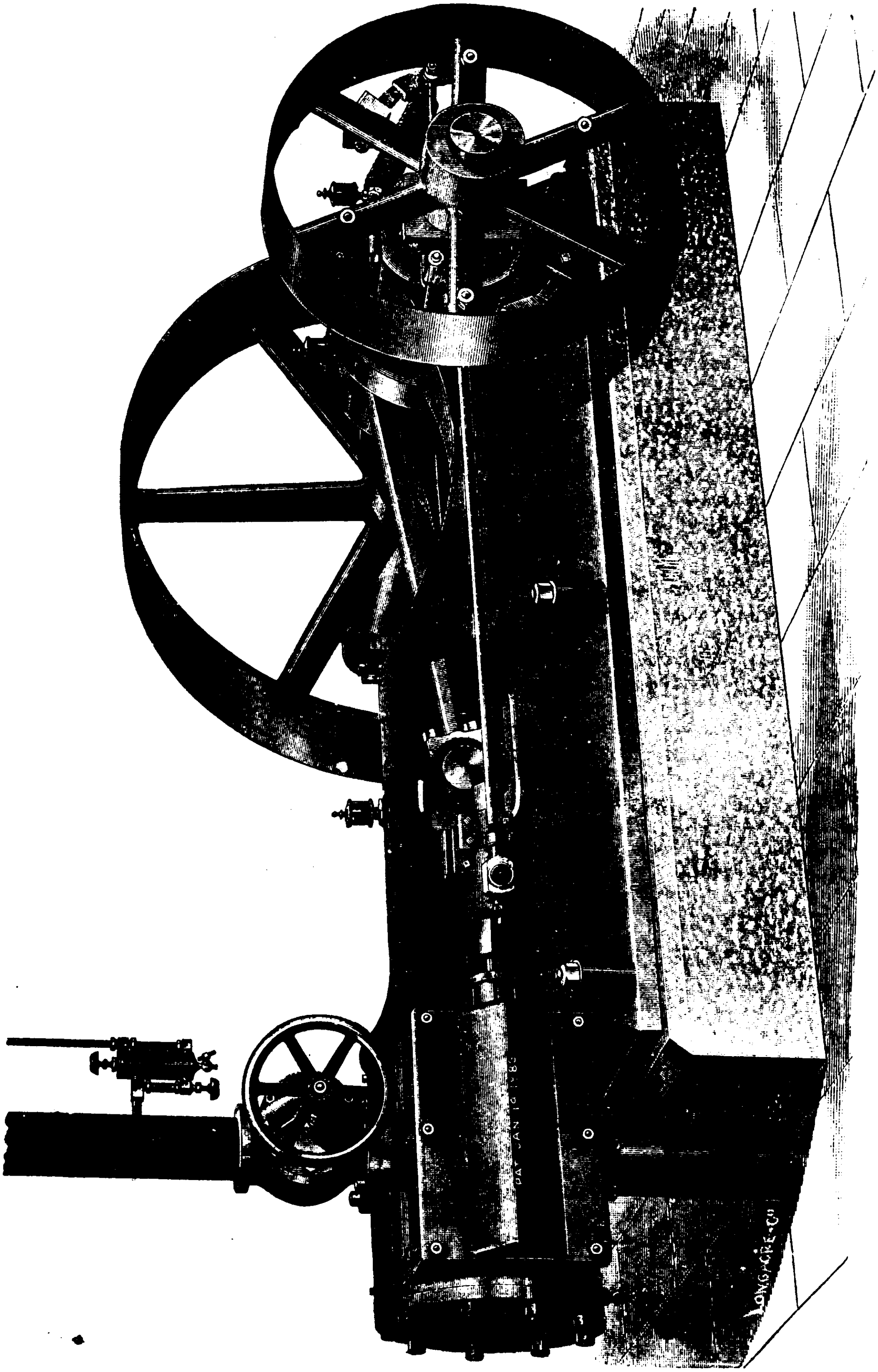
Different kinds of coal require different modes of treatment in a furnace, and the best method of handling each is determined by experience only.

AUTOMATIC ENGINE.

The style of engine represented in the accompanying engraving (which is an elevation of the valve side in perspective) was designed to meet the requirements of limited space when it is desired to drive from one wheel to line shaft. The engraving shows the style of two sizes, namely: 12 × 14 and 14 × 16, centre crank engine.

The two features that claim special attention are the slide-valve and governor. These are represented by Figs. 2 and 3. Reference being made to Fig. 2 and the side elevation it will be seen that the shape of the valve is square and is set in the valve seat with cover pointing to centre, or, in other words, it is placed diagonally. Over the valve is placed a cover. Between this cover and the seat are placed two strips of copper 1-1,000 of an inch in thickness. They are for the purpose of removal and taking up the wear as the valve requires it. The objection of wear still existing in the piston valve, is entirely obviated by this construction. Live steam is admitted inside the cover around the valve, and exhaust steam is let out at the end. This construction enables the engine to be run under full boiler pressure with the exhaust chest cover removed, and a thorough inspection of the valve for leakage made under steam pressure. The exhaust, starting as it does at once into the exhaust pipe, obviates the objection of exhaust jacketed valves and cylinders. By the particular shape of this valve the ports can be made large, and, with its ample travel, admits, as the indicator cards show, of a most perfect diagram under high rotary and piston speed, giving a most perfect steam and exhaust-line and a high initial pressure, resulting in a low terminal compared to average pressure.

Reference being made to Fig. 3, it will be seen that the governor of this engine belongs to that class in which the operation is to move the eccentric across the shaft, altering its throw and varying the length of travel of the valve. In the manner it changes the point of cut-off to suit the varying conditions of load and steam pressure. The range of the governor is the earliest point of cut-off or that which will restrain



VALLEY AUTOMATIC ENGINE.

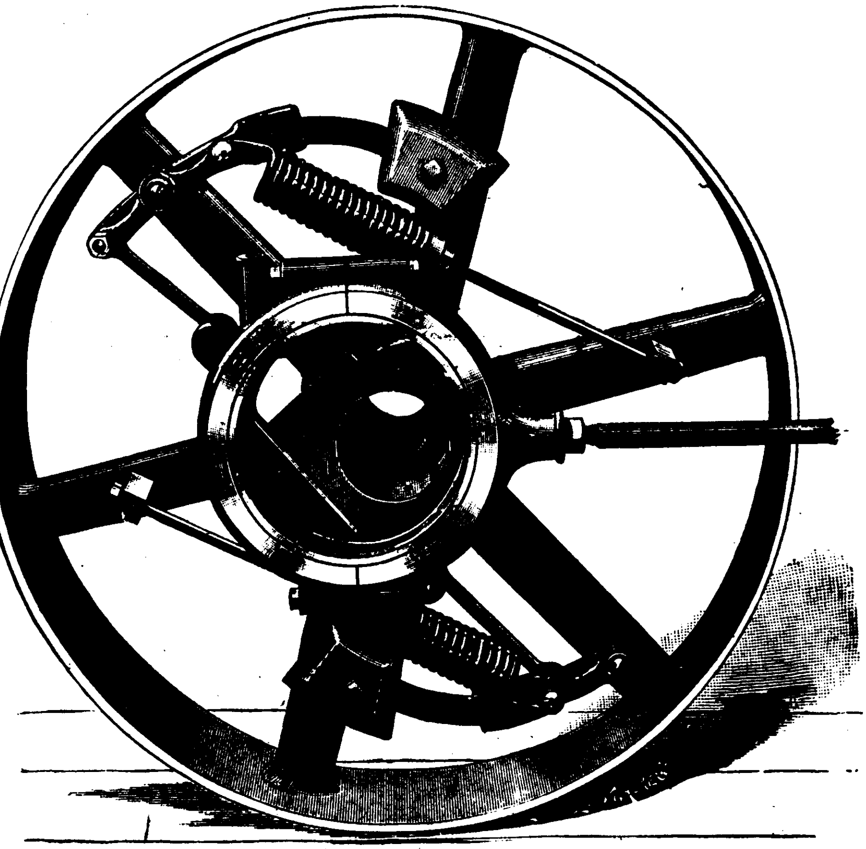


FIG. 3.—GOVERNOR.

the engine under its lightest load and highest boiler pressure—while the latest point of cut-off allows full boiler pressure to follow for 7-10 of the stroke. This whole range of adjustment is under complete control of the governor within less than ·02 variation of speed. By the train of mechanism employed the governor preserves a constant lead, which is of the greatest importance to insure good results. Owing to the perfect balance of the valve it has not been found necessary to design a governor that is locked in all positions, but, on the contrary, lighter springs and weights are used by this governor than any other of its class in he market, the valve movement not requiring that great amount of power in the governor that is given by heavy springs and weights. Dash pots and friction brakes are not required to insure steadiness.

There are two sets of levers pivoted near the rim. The outward movement of these levers is produced by the centrifugal force of the weights and resisted by the centripetal force of the springs, the tension of which is controlled by the screws shown. The movement of the eccentric is in a straight line across the shaft, and is slotted in a stationary sleeve next to the wheel. This movement of the eccentric is taken from the levers through the links shown. By this arrangement such an adjustment of centrifugal force of the weights and centripetal force of the springs can be employed that will admit of the best attainable results in regulation. The tension of the springs should be as much as the governor will admit of, and as near the theoretic tension as possible. Too much tension will be indicated by violent oscillation of the governor. Two-thirds of the distance from the centre of the lever stud, or where the lever is pivoted to the centre of spring stud or where the spring is hooked, is about the proper tension. Change of speed is obtained by shifting the weights in and out of the lever, or by increasing or diminishing them. An examination will show they are made with pockets to increase or diminish, and one weight is heavier than the other. This is done to balance the heavy side of the eccentric, and the heaviest weight should always be placed opposite the throw

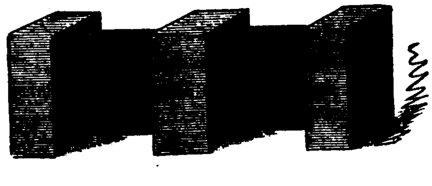


FIG. 2.—VALVE.

of the eccentric, or on the shortest lever. The governor is entirely fitted with automatic lubrication, thus permitting of continuous running.

Among other features in the details of this engine we notice the following :—

The piston is of the solid locomotive type, with rings entirely of spring packing. Its length is ample to insure large bearing surface, preventing wear and tendency to lower the rod. The rings being of spring packing also insure the cylinder, being one diameter all through. The cross-head is of cast-iron with a steel pin cast in. By the method of casting employed it is burnt to the iron, and the first one to come loose has yet to present itself. The pin is flattened top and bottom and boxes milled to suit, preventing the connection from irregular wear. The shoes or sides are of cast-iron, babbitted, and circular in shape, allowing of adjustment to the unequal wear of bearings and keeping the connection rod always in line. The cranks are large and heavily balanced. The pin is one-fourth the diameter of the cylinder, and the pin and shafts are ground to a perfect circle in special grinding lathes. The connecting rod is of forged wrought-iron with solid end (marine style). The boxes are made of brass filled with babbitt and the babbitt is spun to size against the brass with the boxes revolving under a high speed, and the babbitt is forced out with small rollers under a heavy pressure.—*American Engineer.*

STAINS AND SPOTS.

GENERAL PROTECTION FROM STAINS.

D. M. Lamb, of New York, is reported to have inventeda method of treatment which will protect fabrics of all kinds from stains, caused by rain, wine, hard usage, and other things. It consists in the application of some preparation of rubber dissolved in naphtha. It is said that fabrics so prepared will neither shrink, mildew, decay, nor be attacked by moths.

GENERAL DIRECTIONS.

Pure water, cold or hot, not mixed with acids, serves for rinsing goods in order to remove foreign and neutral bodies which cover the color.

Steam softens fatty matters, and thus facilitates their removal by reagents.

Sulphuric acid may be used in certain cases, particularly for brightening and raising greens, reds, yellows, etc., but it must be diluted with at least one hundred times its weight of water, and more in case of delicate shades.

Muriatic acid is useful for removing ink stains and iron mold from a number of colors which it does not attack.

Sulphurous acid is only employed for whitening undyed goods, straw hats, etc., and for removing the stains of certain fruits on silks and woolens.

Sulphurous gas is also used for this purpose, but the liquid acid is safer.

Oxalic acid is used for removing ink and rust stains and remnants of mud stains which do not yield to other detergents. It may also be used for destroying the stains of fruits and astringent juices and old stains of urine. However, its use is limited to white goods, as it attacks fugitive colors, and even light shades of those reputed to be fast. The best method of applying it is to dissolve it in cold or lukewarm water, to let it remain a moment upon the spot, and then to rub it with the fingers.

Citric acid serves to revive and brighten certain colors, especially greens and yellows. It restores scarlets which have been turned to a crimson by the action of alkalies, acetic acid (or tartaric) may be used instead.

Liquid ammonia is the most powerful and useful agent for cleaning silk stuffs and hats, and for neutralizing the effects of acids. In this latter case it is often enough to expose the spots to the vapor of ammonia, which causes them to disappear entirely. It gives a more violet tone to all colors obtained with cochineal, lac, Brazil wood, and logwood, or topped with cochineal. It does not injure silks, but it sensibly attacks woolen tissues at high temperatures. It is also used for restoring black silks which have been damaged by damp.

Carbonate of soda (crystals) may be used in many cases where ammonia is employed. It is good for silk hats which have been injured by sweat.

Soda and potash (caustic) only serve for white linen, hemp, and cotton goods; for they attack colors and injure the tenacity and flexibility of wool and silk. For the same reason white soap is only used for cleaning white woolen goods.

Mottled soaps suit for cleaning thick tissues of woolen and cotton, such as quilts, which are not submitted to friction. For such tissues, when they do not require much suppleness or softness, the action of the soap may be enhanced by a slight addition of potash.

Soft soap may be usefully employed in solution along with gum or other mucilaginous materials, for cleansing dry-goods, and especially self-colored silks. It removes spots more easily than white and mottled soaps do, and injures the colors less. A soap-bath serves for thoroughly cleansing whites and fast colors. It may be employed in washing-machines like the solution of soda crystals, and often after a passage through the latter liquid. It is prepared by dissolving thin slices of soap in boiling water, and should be kept in stoneware pans or wooden troughs.

Soap powder is used chiefly in cleansing kid gloves.

Ox gall has the property of dissolving most fatty bodies without injuring the tissues or the colors. It may be used in preference to soap for cleansing woolens; but it cannot be used for very light colors, for it sometimes gives them a pale greenish-yellow shade. It is occasionally mixed with oil of turpentine, alcohol, honey, yolk of egg, clay, etc., and in this state it is used for cleansing silks. (Unmixed gall may also be used with perfect success for dark silks). To produce a satisfactory effect the gall should be *very fresh.* A simple method to preserve it consists in tying a strong cord round the neck of the membrane containing the gall, and immersing it in boiling water for some time. When this is done take it out and dry it in the shade.

Yolk of egg has about the same properties as gall, but it is too costly for general use. It must also be employed as fresh as possible as it loses its efficacy on growing old. Sometimes it is mixed with an equal volume of turpentine and employed lukewarm.

SPECIAL DIRECTIONS.

Sugar, Gelatin, Blood and *Albumen* may be removed from all kinds of fabrics by simply washing with water.—*The Manufacturer and Builder.*

CONCERNING MINERAL WOOL.

The name "mineral wool," as many of our readers are aware, is applied to an artificial product made from blast-furnace slag, or similar vitreous or scoriaceous substances, by the action of a jet of steam, by which the liquid material is transformed into a fine fibrous or filamentous condition. In this state, the finely-spun vitreous material, occupying an enormous volume as compared with the substance from which it is made, closely resembles in appearance ordinary cotton wool, so that the names—"mineral wool," "slag wool," "silicate cotton"—by which it is variously known, are not inaptly chosen.

In the process of conversion, it is found that a cubic foot of slag (equivalent to 192 pounds in weight) will be transformed into 13 cubic feet of mineral wool. The resulting fibrous mass must, therefore, carry entangled among its fibres 12 cubic feet of air. About 8 per cent only of this finely-spun product is composed of the solid substance from which it originated, the remaining 92 per cent consisting of entangled air. In some of the specially prepared grades of the product, indeed, the percentage of entangled air rises, we are informed, to 97 per cent. To this imprisoned air the product owes principally the admirable qualities which have gained for it a wide application in the arts for the insulation of heat; while in addition, certain other peculiarities which it possesses, fit it remarkably well for the deadening of sound, the prevention of the spread of fire, and the protection of buildings from the incursion of rats and vermin. The material of the fibre being of an incombustible nature, and itself a poor conductor of heat, like all vitreous substances, it is reasonable to infer, from what we know of the high heat-insulating qualities of confined air, that a mineral substance of this nature, carrying more than 90 per cent of air imprisoned in its interstices, should prove to be a heat non-conductor of high efficiency. This fact has been fully proved in practice, and the material, of which several grades are manufactured, has come into use extensively for this special form of service. At the same time, the physical condition of the material appears to adapt it equally well as a sound-deadener. The sharp, needle-like spiculæ of the mineral wool, furthermore, appear to be a source of irritation to rats, mice and vermin, which refuse to harbor in its vicinity. In the following we give some account, with illustrations, of its several applications.

House Lining.—Figs. 1, 2 and 3 represent the mode of applying mineral wool as a lining for hollow walls of frame houses, empty floor spaces, partitions, and beneath the roof, for the several purposes above-named. The advantages claimed for it are substantially as follows: A filling of mineral wool in the ground floor, say 2 inches thick, protects against the dampness of the cellar; in the outside walls, from foundation to peak, between the studding, it will prevent the extraction of the warmth of the interior, and will destroy the force of winds, which otherwise will penetrate and cause draughts; in the roof, say 2 inches thick, it will retain the heat which rises through stair wells, bringing about regularity of temperature in cold weather; the upper rooms will not receive the heat of the summer sun and store it up for the occupants during the night, but remain as cool as those on the floor below; the water fixtures in bath-rooms, closets and pantries will not be exposed to extremes of heat and cold.

The space generally afforded by floor beams in dwelling-houses is deeper than is required for the introduction of mineral wool, if used solely to prevent the passage of noise. The thickness may be made 2 inches, or less, by putting in a false floor; the partition walls should be filled to the full width of the joist.

As sound is communicated by the actual contact of beams, and also by the vibration of the air between them, it can well be understood how a porous-like material like mineral wool will have a muffling influence on the solid parts of a building, and so occupy the space, that wave motion will not be possible. Such a thing is especially desirable about bath-rooms, to deaden the noise of the valves and flowing water.

The analysis of mineral wool shows it to be a silicate of magnesia, lime, alumina, potash and soda. The slag wool contains, also, some sulphur compounds. It is plain there is nothing organic in the material to decay or to furnish food and comfort to insects and vermin; on the other hand, the fine fibres of glass are irritating to anything which attempts to burrow in them.

Fig. 2 shows the wool applied behind wire lathing for rendering partitions and walls fire-resisting, and another method for deadening floors.

The application in the manner described of mineral wool, an incombustible material, in the hollow spaces of floors, partitions, walls, etc., may not unreasonably be claimed to reduce materially the danger of the spread of fire, should an accident of this kind occur. The application of the material must interpose a decided hindrance to the spread of the flames, thus rendering the structure slow burning, and affording greater opportunity for the extinguishment of the fire, the saving of imperiled property, and of lives, where these might otherwise be endangered.

As to the manner of applying the material to buildings, the following instructions are given: Mineral wool must be held in position by retaining walls, which should be sealed tight to keep the finer particles from sifting out. The house should be closed in, so that the material may not become wet, and the walls filled from the inside. The job should be done at the same time that the laths are being put on. It should be applied by the handful, and only pressed into place so that it fills the space completely—not jammed or pushed roughly with sticks. Being applied dry, the other work is not delayed at all, and there is no possibility of dampness. Once in place, it remains intact until the retaining walls are removed. The presence of mineral wool behind the lath does not prevent the plaster "keying." It is pliable, and gives way readily to pressure. A lining in the roof of a city dwelling is shown in Fig. 3. It is not only valuable in this case for keeping the house cool in summer, but to prevent the sparks of adjacent chimneys or fires from burning through quickly. Figs. 4 to 6 exhibit one of the most useful applications of the material—namely, to the lining of railway cars. In the case of cars, heat is lost both by radiation and contact of cold air, but the cooling by the first process is inconsiderable in comparison with the last. The motion of the car is an important factor, for, by reason of it, the second process is going on much more actively than in the case of a stationary structure. With great differences of temperature, it has been shown that the loss of heat increases in a much higher ratio than that difference—in other words, the colder the weather, or the greater the difference between the external and internal air, the more rapid the extraction of the heat; and, furthermore, as the speed of the car increases, the loss of heat increases, because of the contact of a greater amount of cold air in a given time. The proper ventilation of cars becomes a difficult matter only when they are in motion, because then the penetrating force of the exterior air is increased, and it is not possible to confine the in-flow to the openings intended for it; but, on the contrary, the cold air is rushing through the cracks on all sides, in quantity increasing with the speed.

If traveling is to be made entirely comfortable, we must provide against all discomforts, such as exposure to draughts, and rapidly changing temperature in the winter season; to the intolerable heat of the sun in summer, and to noise all the year round. It is claimed that a lining of mineral wool will accomplish these objects, because it is a poor conductor of both heat and sound. It is a most excellent deadening substance and makes the cars noiseless. Its moderate weight adjusts the centre of gravity of the car, and gives stability to the whole structure. A stove in one end, or steam pipe, will furnish sufficient heat, and the warm air will be found to follow along the floor, because it remains a warm surface, while the upper part of the interior presents a cold surface, and repels the heated air. The sides and ends of a passenger car need the protection quite as much as the floor, so that they are usually filled in to the base of the windows. The material may be applied without altering the construction of the car at all. The simplest method is to fill the floor-space to full depth of beam, using half-inch matched stuff beneath for sealing boards.

For the retention of low temperature in ice-houses, brewery vaults, cold-storage rooms, refrigerators, etc., the material has been found equally advantageous. For equal thickness, this material is claimed to be the best that can be found for the purpose. Being non-decaying, and always remaining in vertical walls just as it is applied, it makes a durable application, and renders the structure fire-proof and vermin-proof.

As a heat insulating application for steam pipes and boilers, the material has acquired a high reputation. In proof of this, it need only be mentioned that the 5½ miles of street mains and service pipes of the New York Steam Company are covered with mineral wool, and immense quantities of the material are in use throughout the country among steam users. The manner of employing it is by the application of a box or casing of wood surrounding the pipe or boiler, as shown in Fig. 7.—*Manufacturer and Builder*.

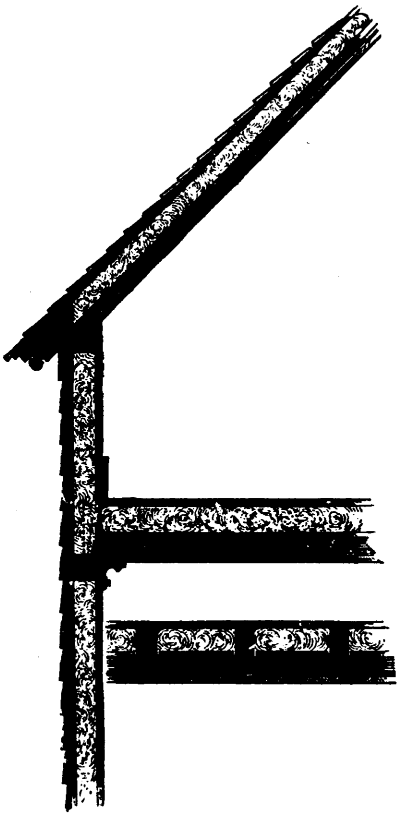


FIG. 1.

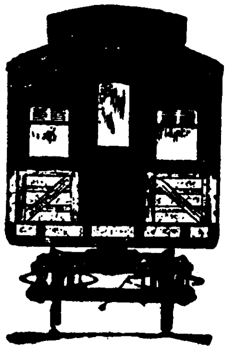


FIG. 5.

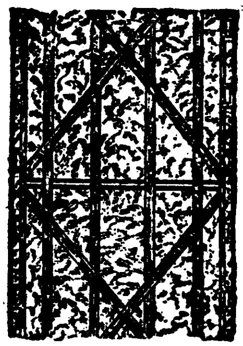
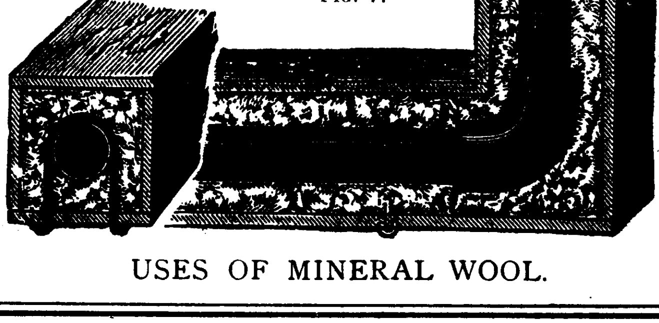


FIG. 6.

FIG. 7.



USES OF MINERAL WOOL.

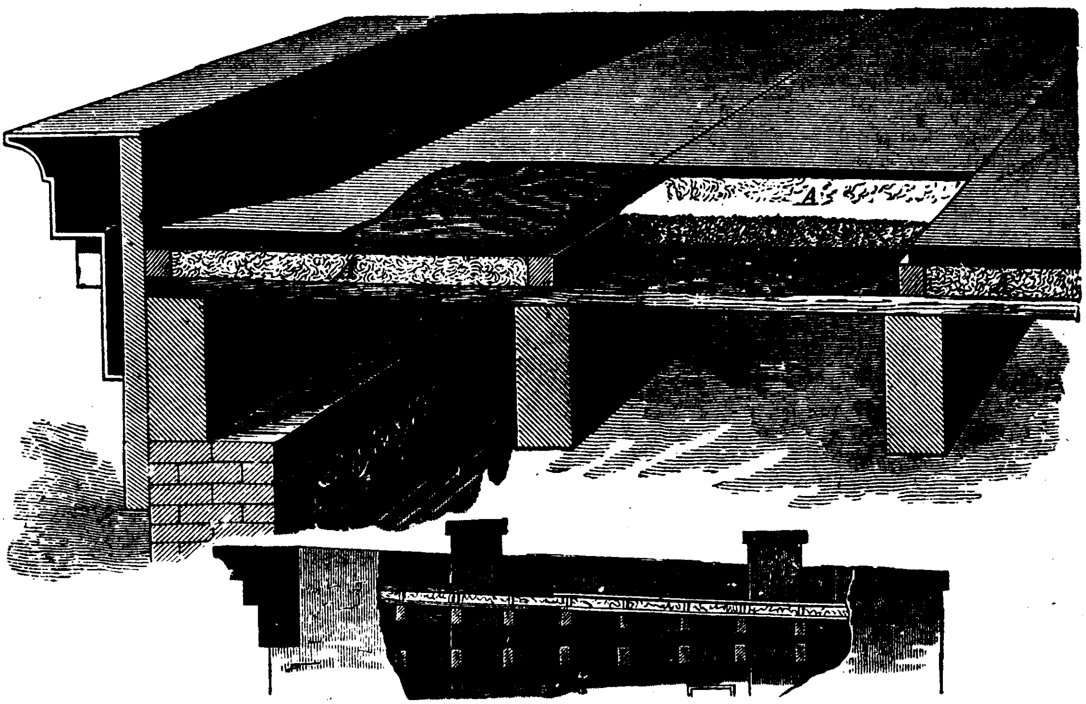


FIG 3.

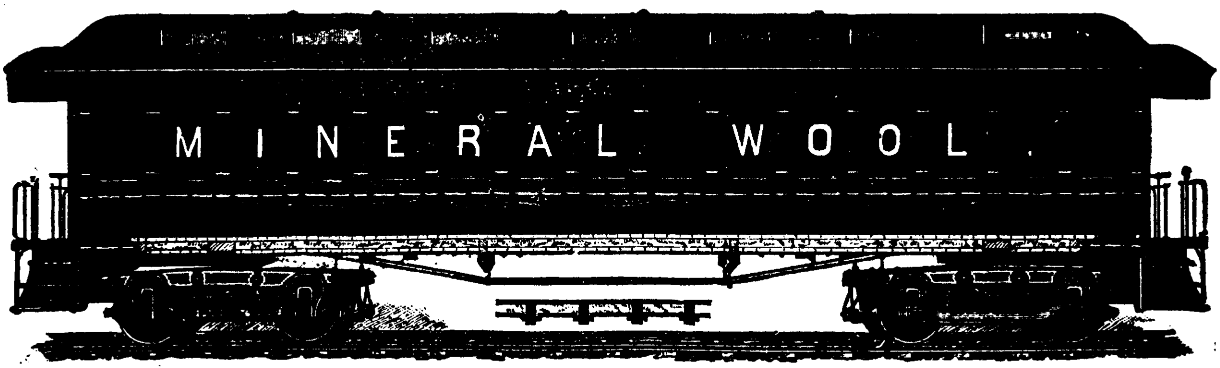


FIG. 4.

USES OF MINERAL WOOL.

CRYSTALLIZED GRASSES.

The grasses must be thoroughly dry, formed in the desired shape and fastened securely before being put in the bath. The long feathery grasses are best for this purpose. Dissolve one pound of the best alum, pounded quite fine, in a quart of clear water, over a slow fire, but do not let it boil. Suspend the bouquet by a string from a stick laid across the jar into which the solution is to be poured. When the solution is milk warm pour it over the grasses, cover it up and set it away for twenty-four hours. Then take them out carefully and let them hang several hours in the sun till all the water is drained away. Then set them away and do not move them for two or three days when they will be entirely dry. The solution may be heated over and used as before.

For blue crystals use a saturated solution of sulphate of copper. For yellow, use the yellow prussiate of potash. For ruby, use the red prussiate of potash. These bouquets should be kept under glass.—*Exchange.*

HARDWOODS.

A writer on cabinet woods says:—

"A handler of veneers thinks black birch is not appreciated at its real merit. For veneers he considers birch nearly, and can almost say quite, as good as cherry. Birch is becoming more highly appreciated than it was, and we may not be surprised to see a boom in it before long. When birch becomes fashionable everybody will want it."

In the foreign wood trade prima vera, the fashionable light mahogany, is very scarce all over the country. The principal foreign wood house in Chicago has a stock of only 3,000 feet on hand, and out of this New York orders are being supplied with the prospect that shortly not a plank will be left in the sheds. It is a curious fact that mahogany is being shipped from the depository in Chicago to New York right along, when the same stock was brought from the same seaboard city. A carload of mahogany was lately shipped from that city to Germany.

TELEGRAPHY REGARDED FROM A FINANCIAL POINT OF VIEW. (HIGH SPEED AND LOW SPEED.)

It is now notoriously admitted by everyone that telegraphy, along with its undeniable political and moral aspect, has also a financial side not less evident.

As a public service its mission is to furnish a trustworthy instrument for the prompt exchange of ideas and to render its means of communication available for the mass of the public. It is important that the country should be able to make use of the telegraph to the utmost limit of possibility, the increase of the number of telegrams contributing incontestably in no small degree to the development of national prosperity.

As an industry, the fundamental point to be reached is to bring in the greatest profit. But in a great number of countries the telegraph, far from yielding a profit, does not cover expenses. What means can be employed to remedy this situation? Shall the price of telegrams be increased?

To demonstrate the slight efficacy of a rise of charges, I will confine myself to a single instance, but which, I hope, will be considered decisive.

Conjointly with the adoption of the scheme of charging per word, the cost of internal telegrams in Switzerland has been raised to such a point that the mean returns per dispatch which, prior to October 1st, 1877, were 55 centimes during the three first months of the innovation rose to 71 centimes, or an increase of 16 centimes. But as we learn from the Report of the Administration of the Swiss Telegraphs on its working in 1877 it was expected that the average number of words, which was still 16·24, would gradually sink to 14, whence there would result only the modest increase of 10 centimes per telegram.

The following table indicates the financial results of working according to official data published up to this day :—

Years.	Number of telegrams.	Difference from 1876.	Returns.	Difference from 1876.
1876	2,118,373	....	1,164,513	....
1877	1,950,546	— 167,827	1,138,366	— 26,147
1878	1,590,108	— 528,265	1,100,404	— 64,109
1879	1,679,831	— 438,542	1,158,684	— 5,829
1880	1,751,018	— 367,355	1,202,447	+ 37,934
1881	1,837,385	— 280,988	1,221,061	+ 56,548
1882	1,790,311	— 328,062	1,191,556	+ 27,043
1883	1,750,045	— 368,328	1,137,050	— 27,463
1884	1,724,989	— 393,384	1,116,667	— 47,846
1885	1,759,054	— 359,319	1,138,507	— 26,006
1886	1,793,938	— 324,435	1,159,083	— 5,430
1887	1,816,524	— 301,849	1,177,107	+ 12,594
Total since 1878.....	17,493,203	— 3,690,527	11,602,566	— 42,564

If we suppose that with the maintenance of the old scale of charges the internal tariff of the Swiss offices, the number of which has increased by more than 300 from 1876 to 1887, had merely reached each year the figure shown in 1876, we should have had in the decennial period 1878—1887, 21,188,-730 telegrams, yielding 11,645,130 francs, or 3,690,000 telegrams and a return of 82,500 francs in excess of what has taken place.

In 1876, the number of telegrams exchanged with foreign countries, the international correspondence at the end of the ten years period would be 5,876,700 telegrams. But there have been in reality 8,214,211; that is to say, 2,337,000 in excess. Thus, whilst on the one hand the home correspondence, as compared with 1876, shows a decrease of 14 per cent., the foreign correspondence, on the other hand, has increased by 71 per cent.

II.—The increase of charges not giving the result expected, let us see if by a reduction of the price of telegrams we might prepare budgets which should show a favourable balance.

The partisans of this measure ask why, if we wish to extend the use of the telegraph and make of it an excellent source of revenue for the Treasury, we do not do with it as we have done with the post, since the decrease of postage to a uniform and very trifling sum has yielded such happy results.

To this observation, which was made at the Telegraphic Conference which sat at Berlin in 1885, the Italian delegate, Sen. D'Amico, replied: The post can double its traffic with a slight increase of outlay, whilst in the telegraph a small increase of dispatches would suffice to require new wires, new apparatus, and new officials.

Such is the fact. The post both in point of time and of material transmits a thousand, ten thousand, fifty thousand letters as easily as a hundred. The whole goes off in the same train. But the telegraph can, generally speaking, only forward one dispatch at a time and must be equipped on a vast scale to be in a position to preserve a reasonable mean speed for correspondence. Hence, an increase of traffic may sometimes involve an increase in the facilities for working in a very rapid proportion. Under these circumstances we must use circumspection in estimating the increase of profit which would result from an influx of telegrams.

Still we cannot deny that the telegraphic systems in general have still on their lines a very fair margin. If we examine tables showing the occupation of the lines, we discover everywhere blank intervals in their working in the main lines as in those of an inferior order. Thus it is evident that all the wires are capable of a greater sum total of work. But the increase of work should not be produced at hours of the day when the lines are already sufficiently engaged.

Save this reservation, there is still more than one stage to be traversed before the transmitting power of the net is carried to the maximum, which is the basis upon which rests all the economy of the telegraphic service.

This leads us in the third place to the examination of the means indicated as leading to the desired solution.

III.—The means which, in my opinion, whilst developing the traffic would increase the returns, and the application of which would direct the institution towards its double object, consists in the classification of the dispatches under three heads :—

1. Telegrams for accelerated transmission (urgent telegrams) to be sent in preference to dispatches of the following class.
2. Telegrams for normal transmission.
3. Telegrams at low speed (with a reduction of price) to be sent after the dispatches of the second class have been finished.

We may first note that with the exception of the four following States, Great Britain, Bulgaria, Norway, and Switzer-and "urgent telegrams" are already admitted in European relations, and let us observe that these full speed correspondences, the utility of which is duly recognised, do not come in in such numbers that their treatment can sensibly affect the rapidity of transmission of ordinary telegrams. Further, if the number of the former increased so as to become an obstacle to the free disposal of the general correspondence, the extra fees which would be charged would largely contribute to the expenses of laying down and operating new wires, and apparatus for multiple transmission where the want was felt.

The telegram of the third class (low speed) which would be the complement of the urgency telegrams (high speed) has not yet made its appearance in Europe.

I have shown elsewhere what might be expected from a reduction of charges for correspondence which might undergo a delay in transmission without running the risk of failing in their object. These telegrams would be numerous, seeing that there are thousands of circumstances in life in which the telegraph would be utilised, to get rid of small epistolary jobs which generally cost more time than we care to devote to them. And as the transmission of slow telegrams might be effected at moments when at present the wires are unoccupied without increasing the outlay the profits would accrue to the Treasury.

On the lines which are now idle for the greatest part of the day, the creation of a class of cheap telegrams between the offices on such lines would be equivalent to a general reduction of charges, and the results which might be involved would not necessitate any increase in the means of transmission.

Here are a few figures which show what gaps still exist in the working of the lines. Among 387 Dutch offices there were in 1887, 134 which, on the average, sent out only five telegrams daily; in 1886 in Switzerland among the 1,222 offices, there were 1,062 which sent out less than 10 telegrams daily, and 159 with less than one telegram daily. And it will be something similar everywhere.

It is evident that where there exists a wire, an apparatus and an official, the tariff which lets all these elements of production stand idle instead of keeping them employed has something wanting, for work alone yields receipts, and the expenses go on always whether the line works or stands idle.

Hence it follows that in searching for measures which would lead to a maximum employment of the wires it is proper to follow the advice of economical science, which, if applied to telegraphy, declares that *within the limits of the organisation of the lines* it is more profitable to transmit dispatches cheaply than not to transmit them at all. We may differ as to the method of applying this principle, but it is nevertheless the only one which remains applicable, industrially speaking.

From the moment when we recognise that telegraphy contains the commercial element, we have only to follow the track which the nature of the case has distinctly proved, and introduce measures which free trade would not for a moment hesitate to apply.

After having contended that if the end proposed is to render telegraphy available to more persons, and to make of it, if possible, at the same time a source of revenue, M. E. Cuper asserts that we must look for inspiration to commerce, to the great industries, to companies. In developing this idea, he adds :—

"On railways are not there transports of goods by swift and slow trains? Are there not express trains, direct, semi-direct, and 'omnibus trains,' which everyone is free to use, according as he is more or less pressed for time! By the express and direct trains only the great centres are placed in communication, and for some hours the other towns situate along the line are as if non-existent. Why are not 'omnibus trains' the only ones in existence, seeing that they are the only ones which can, for financial reasons, be utilised by everyone? In one and the same train are there not often first, second, and third class carriages? Certainly the first class does not arrive sooner than the third, and this division merely gives the traveller the option of seating himself more or less comfortably, and of spending only what he wishes, or what he can. Can he not even, if needful, have a special train?

"All these distinctions, based upon advantage and free choice, are a means of connection more certain than would be absolute uniformity.

"The post itself, has it not registered letters, the carriage of which is certainly not more rapid, but the delivery is more certain? In a word, take all the great undertakings which affect the public, and you find various grades of price uniformly varied."

IV.—After having explained the different grades of urgency for telegrams, it remains merely to show the advantages of the system proposed. These advantages would appear :—

1. In an increased transmission power of the system of wires, by leaving to the last place the transmission of telegrams which will bear delay, we should enlarge the means of action for business hours, which would enable us, without additional expense in wages, to increase the total number of transmissions effected on the totality of the lines in a given time.

2. By a development of the traffic in consequence of the reduction of charge for slow telegrams.

Thus regarding the situation which would be created, we may consider the innovation useful, since it would postpone the time when additional means of transmission would be needed. It would lead to the full utilisation of the resources of the wires.

P. G. H. LINCKENS,
Commissioner in the General Direction of Dutch Posts and Telegraphs.

Journal des Economistes, July, 1889.

THE EXECUTION OF CRIMINALS BY ELECTRICITY.

The passage by the Legislature of New York, last year, of a law providing for the execution of the death penalty upon criminals by means of electricity, in place of hanging by the neck—which law has become operative since the beginning of the present year—has awakened much interest and discussion as to the proper and most effective method that could be employed for the purpose. Until quite lately, the relative deadliness of the continuous and alternating currents of equal pressure had not been determined by actual experiment upon living creatures; and the carrying on of a series of experiments having in view the accurate determination, by comparison, of this fact, has accomplished two things—first, it has shown that the alternating current is deadly at far lower electrical pressures than the continuous current; and, second, it has set the advocates of these two rival systems by the ears. With the last we have nothing to do. Respecting the first, a brief account of the experiments, and their results, will, we are sure, be of interest.

The experiments here referred to, were made in the laboratory of Mr. Edison, and elsewhere, under the direction of Harold P. Brown (an electrical engineer of excellent repute), A. E. Kennelly (Mr. Edison's principal electrical assistant), and Dr. Frederick Peterson (chairman of the Committee of the Medico-Legal Society on the best method of executing criminals by electricity), in the presence of a number of pro-

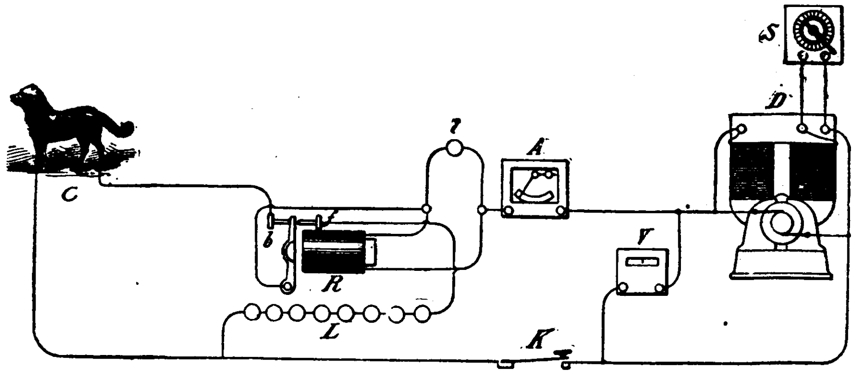


FIG. 1.—DIAGRAM OF CONNECTIONS IN FIFTH TO EIGHTH EXPERIMENTS.

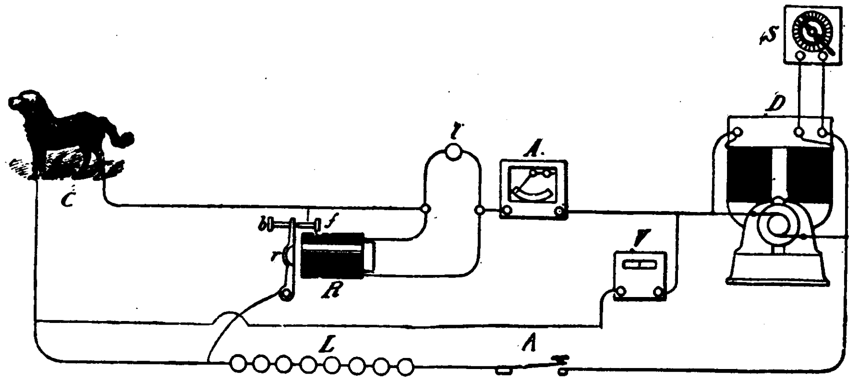


FIG. 2.—DIAGRAM OF CONNECTIONS IN TENTH TO SIXTEENTH EXPERIMENTS.

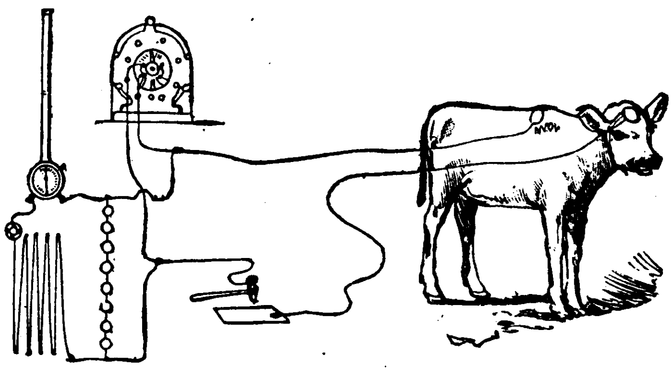


FIG. 3.—METHOD OF CONNECTING DYNAMO AND SUBJECT.

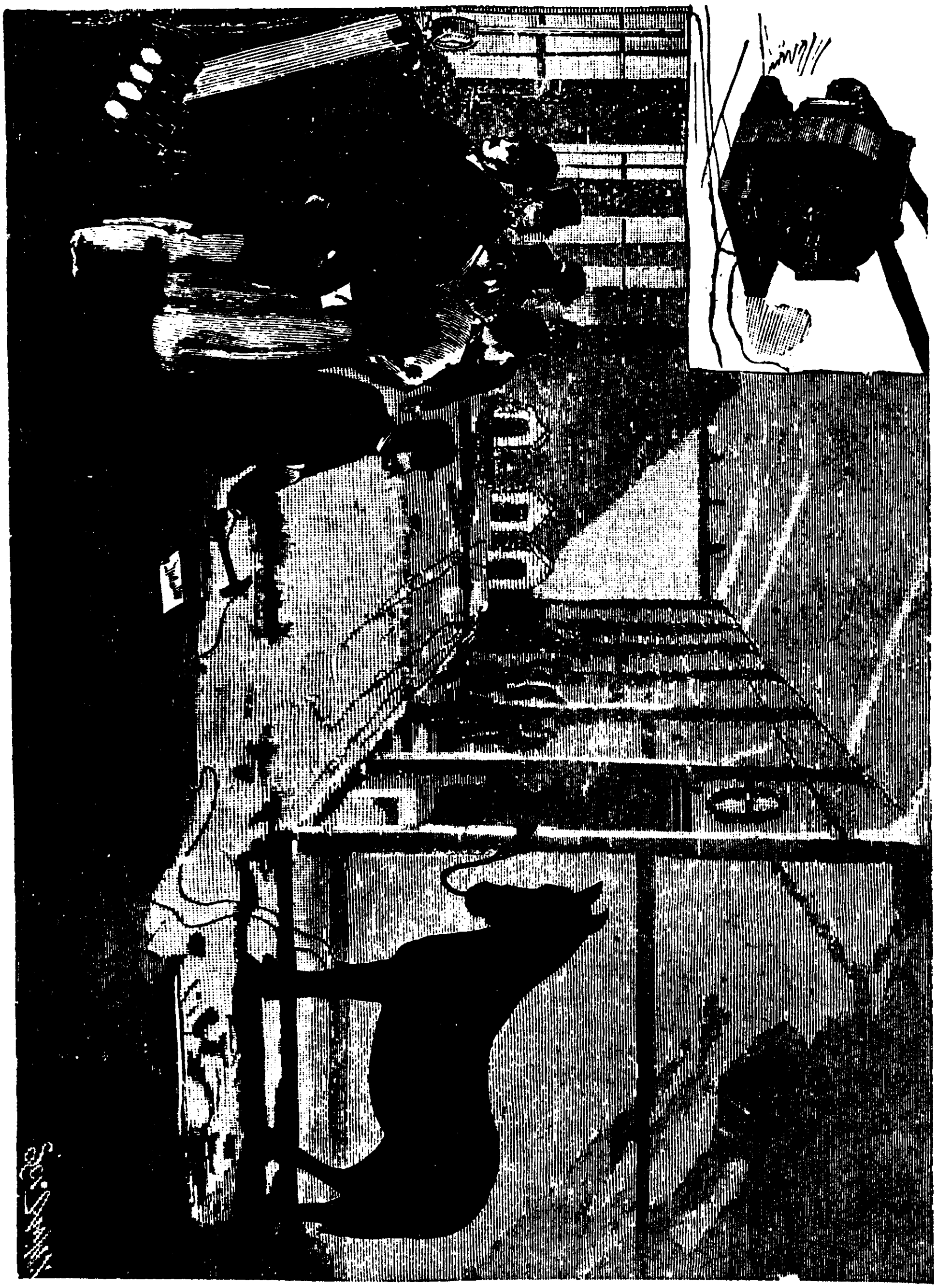


FIG. 4.—EXPERIMENTS IN KILLING ANIMALS BY THE ALTERNATING CURRENT, AS CONDUCTED IN THE EDISON LABORATORY AT ORANGE, N. J.

fessional gentlemen interested in the scientific aspect of the work. The animals subjected to the experiments were for the most part dogs ; but objection having been made to the drawing of any conclusions from the trials, because of the small weight of the animals, several calves and a horse were afterward experimented upon by Mr. Brown before the Committee of the Medico-Legal Society, and with confirmatory results.

In their report, this committee, referring to the experiments, find that, with the alternating current, a pressure as low as 160 volts was sufficient to kill a dog : and that with a continuous current, a much higher voltage was necessary for the production of a fatal effect. They recommend that the death current be administered as follows : A stout table, covered with rubber cloth, and having holes along its borders for binding, or a strong chair, should be procured. The prisoner, lying on his back, or sitting, should be firmly bound upon this table, or in the chair. One electrode should be so inserted into the table, or into the back of the chair, that it will impinge upon the spine between the shoulders. The head should be secured by means of a sort of helmet fastened to the table or the back of the chair, and to this helmet the other pole should be so joined as to press firmly with its end upon the top of the head. The rheophores can be led off to a dynamo through the floor, or to another room, and the instrument for closing the circuit can be attached to the wall.

The electrodes should be of metal, between one and four inches in diameter, covered with a thick layer of sponge or chamois skin. The poles, and the skin and hair at the points of contact, should be thoroughly wet with a warm aqueous solution of common salt. The hair should be cut short. Provision should be made for preventing any moisture reaching from one electrode to another.

A dynamo capable of generating an electro-motive force of at least 3,000 volts should be employed, and a current used with a potential between 1,000 and 1,500 volts, according to the (electrical) resistance of the criminal. The alternating current should be used, with alternations not fewer than 300 per second. Such a current, allowed to pass from 15 to 30 seconds, will insure death.

Appended to this report were the records of the experimental tests establishing the greater deadliness of the alternating currents over the continuous currents, which we need not reproduce. It may suffice to say that they exhibit the fact that in one instance—the case of a dog weighing 56 pounds—an alternating current of 160 volts, continued for 5 seconds, caused death, and that alternating currents of from 160 to 800 volts caused death uniformly with these animals ; while, in at least one case—that of a dog weighing 50 pounds—a continuous current of 1,000, 1,100, 1,200, 1,300, 1,400, and 1,420 volts left the animal unhurt. In the case of the horse (weight 1,230 pounds), and two calves (weight 125 pounds each), an alternating current of 700, 770, and 750 volts, respectively, continued for 25 seconds in the case of the horse, and 8 and 5 seconds, respectively, in the case of the calves, caused death. Our pictures show the manner in which the experiments were conducted.

Figs. 1 and 2 show the apparatus designed by Mr. Brown, the adoption of which, on arc-light circuits, would render it almost impossible for fatal accidents to occur. The relay R is arranged so as to short-circuit the dynamo field magnets the instant a ground connection is made, thus stopping the production of current until the dangerous contact is removed. The current necessary to operate this apparatus could pass through a man's body without any ill effect.

Since the foregoing was written, the results obtained and therein described have been verified by a series of final experiments, made by the New York State authorities at the Edison laboratory, on March 12th, to satisfy themselves as to the best means of executing condemned criminals by electricity. They had previously determined that the alternating current was the most swift and certain means of terminating life, and that the best dynamo for the purpose, with the proper pressure, was that used for electric lighting by the "converter," or "transformer," system. This was conclusively demonstrated last fall by the experiments of Harold P. Brown, above referred to, and approved by the Medico-Legal Society ; but the committee wished to determine the best points of application for the current and the most practical means of attaching the deadly wires.

For this purpose, a Siemens alternating-current dynamo was used, the field having an adjustable resistance in circuit with a continuous-current dynamo, so that the electro-motive force could be varied at will from 100 to 1,000 volts. A Cardew voltmeter was used to measure the pressure of the alternating current, with a series of 100-volt incandescent lamps in parallel with the same, to check the reading.

With this arrangement of apparatus, a number of animals were submitted to the influence of the alternating current of the machine at pressures varying with the different subjects, from 500 volts in the case of a small dog weighing 35 pounds, to 1,000 volts in that of a horse weighing 880 pounds. The duration of contact varied from 10 to 25 seconds. In every case (nine in all) death was seemingly instantaneous, without sound or struggle. In each experiment the electrode was kept saturated with the zinc sulphate solution. The alternating current was used in each case, with reversals at the rate of 288 to 300 per second.

The tests were under the charge of Dr. Carlos F. MacDonald, of the Auburn State Asylum, assisted by A. E. Kennelly, Edison's chief electrician, and Harold P. Brown, the electrical engineer. Several other State officials took part, as did Dr. A. D. Rockwell and Dr. Edward Tatum, of the Pennsylvania University. After submitting a careful report to Gen. Austin Lathrop, who has charge of the matter, it was decided to purchase, for the purpose of electrical executions, three of the alternating-current dynamos which are built for electric lighting on the converter system, to use 1,000 volts pressure for 15 to 30 seconds, and to apply the current from the head electrode to the feet. The criminal will be fastened by straps in a heavy wooden chair, the electrodes quickly adjusted, and life instantly extinguished during the first few seconds in which the current flows.—*The Manufacturer and Builder.*

EIKONOGEN—A NEW UNIVERSAL DEVELOPER FOR PHOTOGRAPHIC DRY PLATES AND BROMIDE PAPER.

Advances in photography are now so rapid that it is somewhat confusing to the professional or amateur photographer as to when and where the improvements will stop, if they ever do. Simply the subject of developers for dry plates would compose a volume if all the formulas, with their variations, were published, including as it would the experience and whims of hundreds of photographers. Scientists in chemistry have been experimenting upon the remarkable reducing power on the silver salts observed in the derivatives of aniline, and have endeavored to make them of practical use in photography.

Such a derivative was discovered early in this year by Dr. Andresen, of Berlin, Germany, and is named "eikonogen." It is manufactured there by very extensive aniline dye works, and promises to supplant all other developing agents yet proposed.

It is a substitute for pyrogallol, hydroquinone, oxalate of potash, and sulphate of iron, and, in fact, of all chemicals that reduce the silver salts. As it can be so easily made, it becomes at once the cheapest reducing chemical now on the market, and we have no doubt, as the demand increases, the price will be still lower. It is packed in small tin cans similar to those holding aniline dyes, having a hinged spout at one corner.

It will keep indefinitely in a dry powder in any climate, provided it is not injured by the fumes of ammonia, with which it must not come in contact. It is in the form of a greenish-white powder, which, when dissolved in water, turns to a dark green color, but is perfectly clear.

The advantages claimed for it, and which we have found to be substantially true by experiment, are that it produces a bluish-black colored image, depositing in the film a very delicate precipitate, which, in consequence, brings out the finest details to a degree that is surprising. The structure of the picture film is, therefore, much more compact and finer grained than it is possible to obtain with the pyro or ferrous oxalate developer. The developer operates regardless of the temperature. Hence it is adapted for use in hot or cold climates. It is non-poisonous, perfectly harmless, does not stain the fingers, does not discolor or deteriorate when exposed to the air in a tray or graduate, always keeps clear, will keep mixed in a well-stoppered bottle ready for use for over a month, and acts so quickly and powerfully that the ordinary exposures given for pyro development may, it is said, be reduced one-half. But its pre-eminent quality, in addition to its great reducing power, is that it does not stain the film in the least, even after repeated use, and hence a given quantity of solution may be used over and over again, until its developing power ceases.

The stainless nature of the developer adapts it admirably for the production of line work negatives on dry plates, for the development of lantern slides, and for positive prints on gelatino-bromide paper or porcelain. So satisfactory is its working on paper that we have substituted it for the ferrous oxalate developer. Its particular merit is that every copy on paper is beautifully clear in the high lights, which is a point of great importance in making bromide enlargements.

For shortly exposed plates and bromide paper the following formula for a one-solution developer works well :—

Sulphite sodium C. P	2 oz.
Carbonate of potash	1 "
Distilled, melted ice, or rain water	30 "
Eikonogen	1 "

Dissolve in the order named. Eikonogen is perhaps ten times less soluble than pyro. We tried to dissolve the ounce in 10 and 20 ounces of distilled water, but without success. In using this developer it is advised that from six to eight drops of the following accelerating solution be added :—

Hyposulphite of soda	60 gr.
Bromide of sodium	360 "
Water	8 oz.

We simply added three or four grains of bromide of potassium to five ounces of the developer and obtained good results.

It is not necessary to mix the carbonate of potash to form one solution. It may be kept separate and dissolved in concentrated form in the proportion of 160 grains to the ounce of water. Taking five ounces of the sulphite and eikonogen solution and adding thereto from ¼ to ½ a drachm of the potash solution, as a developer will bring out an ordinarily well-exposed plate as rapidly as if a strong pyro and potash solution were employed. After the image is well out and there are some details in the shadows that do not appear, it is only necessary to add a drachm of the potash solution to the developer to easily bring them out. There is no fogging of the film whatever by the developer. Hence though the image may appear suddenly and be well developed within a minute after the developer is applied, one need not fear to leave it on long enough to acquire sufficient density. If the developer operates too fast, it may be improved by diluting with water and adding a few grains of bromide of potassium. Or the developer may be poured off and a weak bromide of potassium solution be poured on. A developer for lantern slides need not be as strong in eikonogen as for negatives. We recommend the following proportions :—

Sulphite sodium C. P	10 gr.
Carbonate of potash	2 "
Eikonogen	5 "
Water (distilled or rain water)	1 oz.

The above may be used as one solution, and will develop a number of lantern slides. As soon as it begins to work slow, 2 or 3 grains of carbonate of potash added will accelerate it. The high lights will be absolutely clear, while the black portions will not be too dense for the lantern. The tone is bluish black.

Eikonogen and Soda Developer.

A.

Sodium sulphite (crystals C. P.)	4 oz.
Distilled water	60 "
Eikonogen	2 "

B.

Sodium carbonate (crystals)	3 oz.
Distilled water	20 "

Dissolve in order named. A developer is made by adding to 3 oz. of A, 1 oz. of B.

Single solution, Eikonogen and Soda Developer.

Sodium sulphite (crystals C. P.)	4 oz.
Sodium carbonate	3 "
Distilled water	80 "
Eikonogen	1 "

Dissolve in the order named. Add a few drops of the hypo solution during development. All of the formulas are based on 437½ grains to the ounce.

The usual alum and fixing baths may be employed.

We notice that the developer permeates the film more evenly and rapidly than with pyro, and acts with an energy which is astonishing. For under-exposed or instantaneously exposed plates it is especially adapted, and will make the production of such pictures a pleasure.

We have developed in seven ounces of solution twelve 10 by 12 plates in succession, without replenishing it. After four plates have been developed, the solution should be filtered to eliminate the floating particles of gelatine that become detached during development. The color becomes yellow when it is exhausted. It is probably unnecessary to rock the tray. We are glad to know that eikonogen is to be supplied to the trade here in large quantities. As a universal developer for dry plates, it stands at the head.—*Scientific American.*

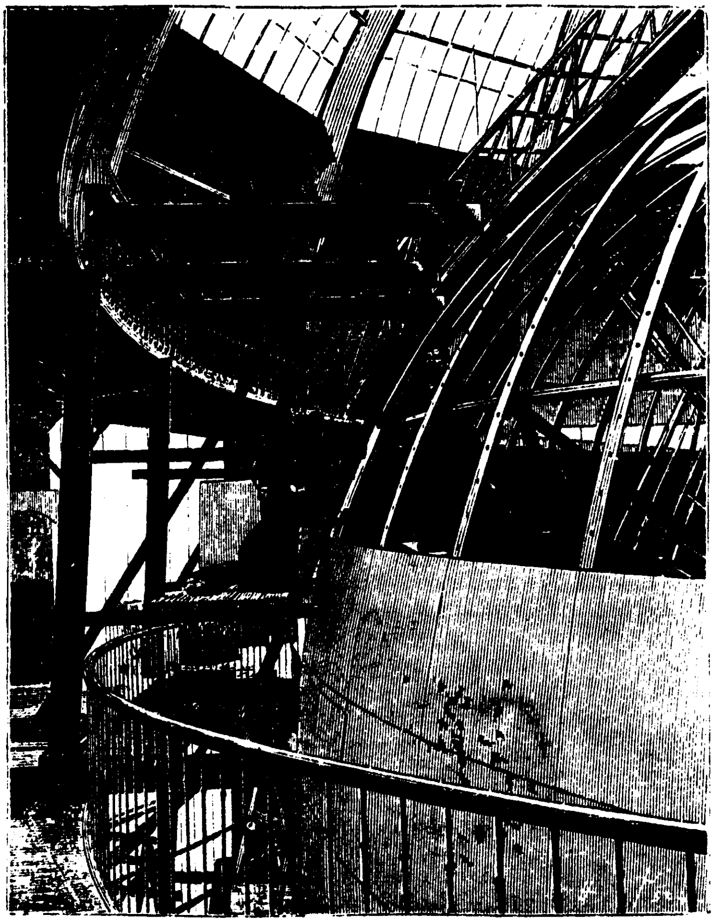


Fig. 1.

THE TERRESTRIAL GLOBE AT THE PARIS EXHIBITION.

Some time before the opening of the Paris Exhibition it was announced that one of the attractions of the show would be a great terrestrial globe, one-millionth of the actual size of the earth. This globe is now exhibited in a building specially erected, near the Eiffel Tower, for the purpose, and it excites the warmest interest among all visitors who have devoted the slightest attention to geographical science. It was designed by MM. Villard and Cotard, and these gentlemen, who have received many congratulations on their success, have lately issued an account of the manner in which their project has been realized.

Maps on a plane surface give, of course, a very inadequate impression of the real appearance of our planet; and ordinary globes are too small to indicate, even vaguely, the extent of the spaces represented on them. The idea of making a globe one-millionth of the size of the earth deserves, therefore, to be described as a "happy thought," for although the meaning of a million may not be fully appreciated, it is not absolutely inaccessible to the human mind. When we see a place or a district marked on a globe, and learn that the reality is a million times larger, the proportions are impressively suggested, with at least some approach to accuracy.

The diameter of the globe constructed by MM. Villard and Cotard is 12·73 metres. It has a circumference of 40 metres, and a millimetre of its surface represents a kilometre. The globe consists of an iron framework made chiefly of meridians united to a central core. This structure is carried by a pivot resting on an iron support. To the meridians pieces of wood are attached, and on these are fixed the panels composing the surface of the globe. These panels are made of sheets of cardboard bent by hand to the required spherical shape, and covered with plaster specially hardened. Fig. 1* shows how they are applied to the underlying structure. The total surface is divided into forty spindle-shaped spaces, the breadth of each

* We are indebted to the editor of *La Nature* for the figures here reproduced.

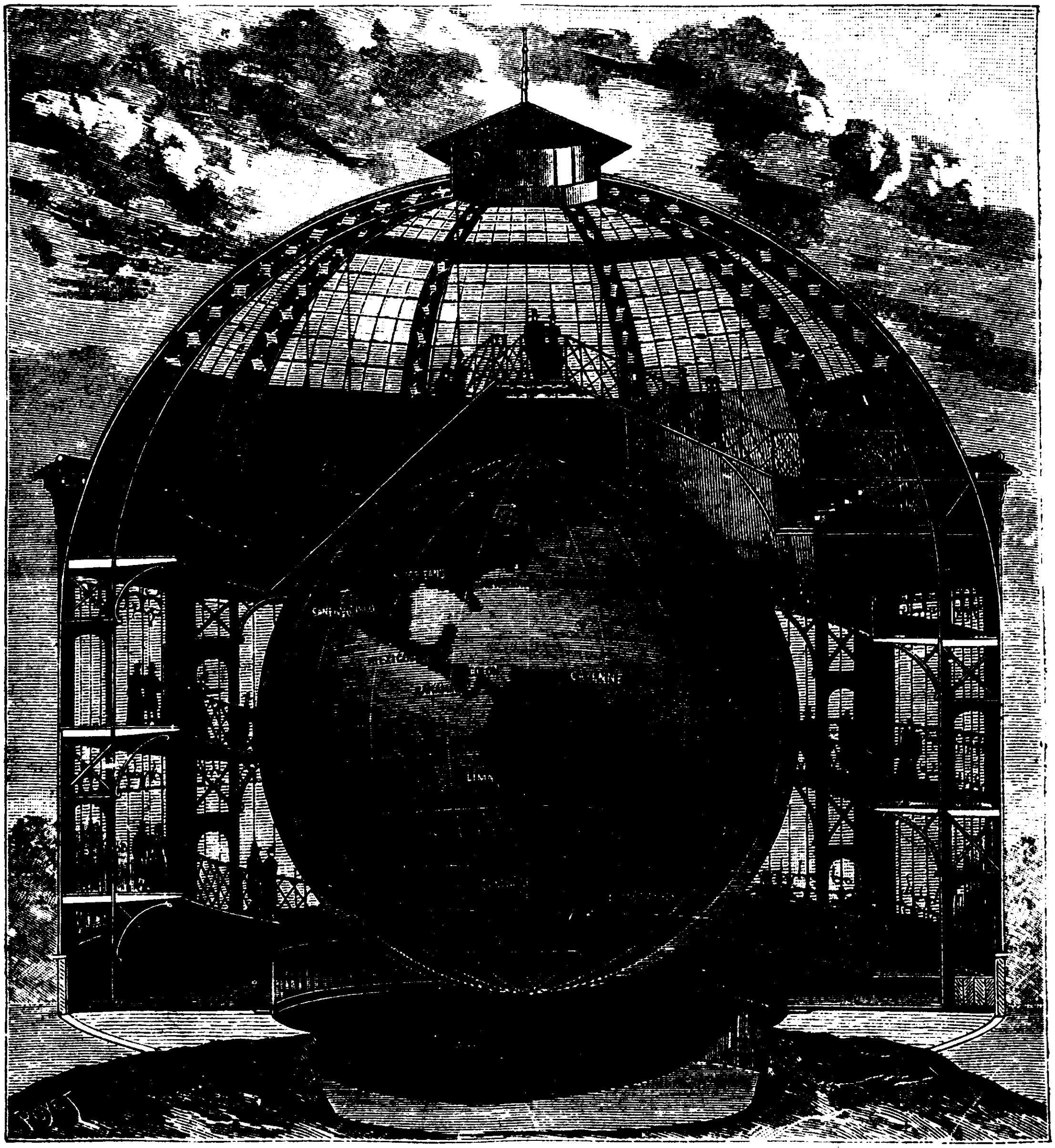
of which at the equator is exactly one metre. Each "spindle" is itself subdivided, so that there are 600 panels of various dimensions. The designs are painted on the panels before they are put in their place, in order that the globe may ultimately be easily dismantled and removed.

The edifice in which the globe is shown has a metallic framework forming a cupola. It is lighted from above, and by the great glass frames of the sides. From a terrace or narrow foot-bridge at the upper part the visitor can see the polar and temperate regions of the northern hemisphere. As he descends, he is able to see in succession all the regions of the globe to the south pole. At the bottom he comes to the support of the globe with the apparatus for putting it in motion (Fig. 2).

Even the loftiest mountains, if shown in relief, could only have been represented by elevations a few millimetres in height. Consequently the various mountain ranges have been painted on the surface. The various depths of the ocean are indicated in a similar manner.

To facilitate the study of the globe, it has been mounted with its axis vertical, and it may be turned upon the pivot which carries it. If its rotation were made to equal that of the earth, at its equator, a point of its surface would move at the rate of half a millimetre in the second. This movement would scarcely be visible, but it would, of course, represent an actual movement of the earth over half a kilometre in the same time.

A figure of the moon, corresponding to this one of the earth, would have a diameter of 3·50 metres, and would be 384 metres distant. A like figure of the sun would have a diameter of 1,400 metres, and be distant about 150 kilometres. The diameter of a globe representing Jupiter on the same scale would be one-half, that of a globe representing Saturn on the same scale would be a little more than one-third, of the height of the Eiffel Tower.



This is not the first occasion on which an attempt has been made to suggest by means of a great globe the size of the earth, and the extent of its oceans and land-masses. The globe of the Château of Marly, which is still to be seen in the National Library of Paris, excited much admiration in the age of Louis XIV., but it has only a diameter of about 5 metres, and is much less effective for its purpose than its successor in the Paris Exhibition.

It is significant of the present stage of our knowledge of the interior of Africa that the makers of the globe, in preparing their maps, had twice to alter their representation of that continent in order to indicate the results of the most recent geographical discoveries.—*Nature.*

THE REMOVAL OF ROOF WATER FROM BUILDINGS.

BY DWIGHT PORTER, PH. B., OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON.

In most cases roof water will soon take itself off without assistance, but its manner of doing this, and the final disposal thus made of the water, are not always satisfactory. Dripping eaves projecting over city sidewalks would be an intolerable nuisance; and whether in city or in country, rain water allowed to fall freely from the roof to the ground next the building tends to dampen the cellar, foundations and walls, and thereby to injure the health of inmates of the building, as well as to harm the structure itself and property contained within. It therefore becomes essential to direct the course of water falling upon the roof, and to convey it away to a proper point of discharge. To effect these purposes various arrangements have been employed, some of which will be mentioned.

For directing the course of the water, as it is received upon the roof, to a suitable point of discharge, we have gutters. On old-fashioned country houses these were often made from a log of moderate diameter, sawed lengthwise, gouged out, and supported by hooks or brackets under the eaves. In modern construction the gutter is very commonly made angular in cross section, formed upon a wooden cornice, with a protecting sheathing of tin, galvanized iron, or copper. Half round or angular gutters of these metals are also used hung at the eaves.

Leaders, conductors, or rain spouts, as they are variously termed, receive the discharge from the gutters, and, descending toward the ground, convey the water a stage farther in its journey. The problems connected with rain leaders are not very intricate, but yet they have not always been well solved. It is not a difficult matter to arrange a few leaders for receiving the roof water of a building; but from mistaken economy, or from lack of knowledge or of forethought in the matter, they often prove inefficient when most needed, and are a constant source of trouble and expense.

Their size, which is commonly determined by experience and judgment, and not by calculation, ranges in diameter from two to six inches. Two-inch pipes are too small to serve to advantage as main leaders on almost any building, being easily choked. Three-inch and four-inch pipes are suitable and common sizes for ordinary dwellings and small commercial buildings. The five-inch and six-inch sizes find employment on large structures.

The Produce Exchange building, in New York city, with a roof area of three-quarters of an acre, roughly speaking, has twelve leaders, of about five inches diameter. The roof, which is paved with fire bricks, is graded with slopes of perhaps one in fifty toward the points at which the leader openings are placed, most of these draining surfaces being about 40 to 70 feet each. The provision here made is equivalent to about one square inch of leader opening to 140 square feet of roof surface. On the Sloane building, at Nineteenth Street and Broadway, with a roof area of 18,000 or 20,000 square feet sloping 1 in 25, there are two leaders of about six inches diameter and a third rectangular, four inches by six inches. This gives an allowance of 240 square feet of surface to the square inch of leader opening; while on the Massachusetts Hospital Life Insurance Co.'s building, and the Hemenway building, in Boston, the proportion is only from 60 to 70 square feet to the square inch of opening:—

	Approximate Roof Surface.	Approximate Surface per sq. in. of Leader Opening.	
Produce Exchange Building, New York	33,000 sq. ft.	140 sq. ft.	Twelve 5-inch leaders.
Sloane Building, New York	19,000 "	240 "	Two 6-inch leaders, and one 4 × 6 inch.
Mass. Hospital Ins. Co.'s Building, Boston	6,000 "	70 "	Seven 4-inch leaders.
Hemenway Building, Boston	4,000 "	60 "	Five 4-inch leaders.

Whether a roof slope steeply or gently, there is a certain amount of water falling per second or per minute in storms, which must be removed; but I have learned of no generally recognized rule among architects as to the leader provision which should be made for it.

A vertical rain leader does not, of course, run full bore, even in the hardest storms, and yet, if carried down from the roof with its course unbroken by sharp bends, and if given a suitable opening at the top, there is probably little danger of its proving inadequate. It is very common, however, to introduce abrupt changes of direction to suit peculiarities of architecture, by which the carrying capacity of the pipe is curtailed, and the liability of choking by leaves, rubbish, and ice is greatly increased. On a business block on Sudbury Street in Boston, may be seen a rain leader which within a few feet of the point of leaving the gutter makes four abrupt and nearly right-angled changes of direction. It will frequently be noticed on buildings, also, that the immediate connection between the gutter and a 4-inch leader of ample capacity is effected by a very much smaller pipe of lead.

In connection with important buildings there is perhaps more need of caution in designing the drain of suitable size than in fixing upon the size of leaders. Formerly house drains were made entirely too large—an error which has come to be recognised, and has led to the practice of using comparatively small sizes. These are advantageous for procuring an effective scour of the pipes by the slight flow of ordinary house drainage, but have in numerous instances proved practically insufficient for managing the volume of water furnished by heavy storms, which is doubtless often hundreds of times as great as that coming from interior house drainage. In the Sloane building, to which reference has already been made, I am informed that it was found necessary, on this account, to enlarge the main drain from 8 inches diameter to 10 inches, considerable damage having been suffered, two or three summers ago, from a flood of rain water during a severe storm.

A practical difficulty connected with the delivery of roof water to the house drain has also been experienced under certain circumstances, in the apparent carrying along by friction, and imprisonment, of a large amount of air by the descending column of water, and a consequent pressure upon the traps of connecting pipes, and even a serious interference with the flow in the main drain itself, unless relieved by ample venting. An instance was mentioned to the writer by John C. Collins, Chief Inspector of Plumbing for the New York Board of Health, in which very considerable injury to property resulted in this way, the rain water bursting out near the bottom of a leader and flooding the basement of a building. The leader ran down the rear of the building, the main part of galvanized iron, succeeded near the bottom by a cast-iron shoe connecting with the drain. In the drain was a running trap near the foot of the leader, and another near the front of the building. Two stacks of waste pipe and a stack of soil pipe joined the drain between the traps, and there was near the front of the building the usual four-inch fresh air inlet. Still, the five-inch drain appeared incapable of serving the leader in heavy rains, and water would back up 10 or 12 feet high in the leader and overflow at the top of the cast-iron shoe. That the trouble was due to the interference of imprisoned air was indicated by the fact that it was partly relieved by inserting a two-inch air vent between the leader and the first trap, and entirely overcome by a three-inch vent.

Now and then we find the roof water carried to the street sewer in an independent line of pipe, but the usual, and what is generally considered the preferable, practice is to conduct it directly into the house drain, sometimes at the back end, sometimes at the front, just inside the main trap, and again at both these or at intermediate points, according to circumstances.

On a large proportion of city buildings the rain leaders run down the outside of the walls, but yet in a considerable number they are carried down within the walls, in which case it is evidently desirable that the same care should be taken to prevent the escape of drain or sewer air through defective material and joints that would be taken with stacks of soil or waste pipe, consequently we find in the public regulations in force in large cities, requirements that the leaders shall be constructed of iron (in New York copper may also be used), if carried within the walls. In New York city it is permitted that leaders of iron or copper shall be without traps, unless the top is near a window, in which case a trap is required at the base. In Boston, however, all leaders must be trapped in new construction.

The troubles encountered in the practical service of leaders and gutters are occasioned in part by their becoming choked with leaves or rubbish, but principally by their being clogged and burst by accumulations of ice in winter. Leaves and rubbish may be largely excluded from leaders by the use of wire strainers or iron gratings, though these of course do not prevent accumulations outside and near the tops of the leaders. In the midst of a large city, however, leaves are usually strangers, and in a cold climate the trouble with gutters and leaders comes from ice. It is very common to see a tin or a galvanized iron leader brought from the roof down the face of the building and terminating in an iron "pipe shoe," as it is called. Such an arrangement will be found on the brick blocks of tenement houses on Nashua and Billerica streets, for example, in Boston, and walking through these streets it will be noticed that nearly every one of the cast-iron shoes has been split by ice. Leaders often become incased in ice to the size of a barrel, from top to bottom, while from gutters and eaves depend huge icicles which threaten the heads of passers below.

These troubles from ice cannot in all cases be conveniently and entirely avoided, but on important buildings it is perfectly practicable to escape them by proper location of leaders and gutters, by the use of pipes of suitable material and shape, and by the supplementary employment, in some cases, of steam.

On steeply pitched roofs, gutters are naturally found at the eaves, either built out or suspended, as has before been mentioned, with leaders running down on the face of the walls. But large business blocks are now very commonly built with tolerably flat roofs, a long slope from front to rear being succeeded by a short rise to the edge of the roof, the V-shaped channel between the two slopes serving as an ample gutter. Sometimes, indeed, as on the Morse and the Wilde estate buildings, on Washington street, in Boston, the roof is given a slope from both front and rear toward the centre, where the gutter channel is thus formed. In either of these constructions, the gutter being entirely upon the main part of the roof, it is natural and easy to carry down the leader within the building, and where this is done, little or no difficulty is experienced from ice. Rain, snow, and ice then take care of themselves, and the heat of the building, supposing it to be occupied, is found sufficient in this climate to prevent accumulations within the leader.

As has already been said, the regulations in large cities would prescribe for such cases iron or copper pipes, which indeed would naturally be employed. The same materials may be, and often are, utilized also for outside leaders, but galvanized iron and tin are far more common. The choice of material is important chiefly in connection with the lasting qualities of the pipe; the shape of the cross section, and the mode of making the longitudinal seam, are important as regards protection against bursting by ice.

In some parts of the country zinc was once almost exclusively employed for leaders; in other parts, tin. Tin pipes are still perhaps the most commonly used, on the whole, of all kinds, on account of cheapness in first cost; but galvanized iron pipes are considered superior, and being not greatly more expensive than tin are given the preference in good work. Either material, however, is subject to gradual corrosion from the water which comes in contact with it, more rapid corrosion from the moist salt air along the coast, and still more rapid corrosion from steam and from sewer air. In New York city, for instance, there are many leaders having untrapped connection with drain or sewer, and these leaders, whether of tin or of galvanized iron, are said to withstand corrosion generally but a very few years.

There are two principal varieties of tin in use for roofing and leader purposes. The old-fashioned or bright tin is "black iron," as it is called, or more and more commonly at the present time a mild steel, covered with a coating of pure tin. The dull tin which is now largely made, has the coating of tin with an admixture of lead. The bright tin, which alone of these varieties is safe for culinary articles, and which is often also supposed to be best suited to use on buildings, is considered by many whose experience is of value to be inferior for this purpose to a good dull or "leaded" tin. The latter material, when re-dipped in the process of coating, resists corrosion from moist, and especially from salt air, much better than the former.

The so-called galvanized iron is either black sheet iron covered directly with a coating, consisting chiefly of zinc, or it is sheet tin so covered, the iron in this case receiving a double coating.

Far superior to either tin or galvanized iron is copper, which is practically unaffected by the ordinary agents producing corrosion of roof coverings and leaders. It has been very considerably employed in first-class work, but its cost is at present a serious bar to extensive use. Galvanized iron leaders cost perhaps twenty per cent more than tin leaders of the same size. Two or three years ago, before the rise in copper, leaders of the latter material cost approximately half as much again as those of galvanized iron, but I am informed that they now (September, 1888) cost about two and one-third times as much as the galvanized iron.

Copper leaders are made of all shapes and sizes used for other materials. Hot rolled copper was the variety formerly employed on buildings, but prejudice was aroused against it because of its softness and the ease with which it loses its shape. Cold-rolled copper, which is now utilized in good work, is harder and stiffer, and if selected of a grade weighing 18 or 20 ounces per square foot, is found to be a superior and satisfactory material. Copper expands and contracts under changes of temperature much more than iron, and allowance often has to be made for this when the metal is used in construction. In a long vertical rain leader of copper, provision for change of length is often made by introducing one or more slip joints, at which there is a lap of perhaps three inches, and at which solder is omitted. The slip joint of course offers some opportunity for the escape of sewer air, if that is allowed to enter the leader; but if well made, the joint is claimed to be soon rendered fairly tight by a slight coating which forms on the metal. The protection afforded to tin and galvanized iron pipes by their distinctive coatings may be further increased by coating with tar and asphalt or by use of the adamanta or other coverings.

But while a suitable material is essential to the endurance of the pipe against corrosion, its protection against bursting by ice is to be obtained partly by the mode of joining the material, but chiefly by the shape given the pipe in cross section. The common tin pipe is made in short lengths soldered together at the transverse joints, each length having a straight longitudinal seam, which is either a soldered lap joint or a simple locked joint. The lap joint is not so strong as the rest of the pipe, and under the great expansive pressure of ice is opened. Whatever, then, tends to strengthen the longitudinal jointing of the pipe gives greater resistance against moderate ice pressure, although no plain pipe of ordinary thickness is proof against rupture by ice. The locked joint is an improvement upon the plain soldered lap joint, and is used for galvanized iron and copper as well as for tin. The plain lap joint can be strengthened by riveting, and I have seen copper leaders made with a straight soldered and riveted seam which is claimed to be stronger than the main body of the pipe, the latter yielding first to ice. Galvanized iron leaders are also made with a patented spiral and riveted seam, which renders them very strong.

Economy of material for a given cross section of pipe demands the use of a plain circular form; but it is evident that no shape would be more unyielding against the expansive power of ice, and in order to accommodate the latter and prevent rupture, the expedient of a fluted or corrugated pipe was hit upon some fifteen or twenty years ago, and patented. This form of pipe has been very extensively used and appears to have been generally satisfactory in resisting ice, readily changing its shape under pressure. Tin, galvanized iron, and copper pipes are all to be had of the corrugated form, being usually circular in general shape, but often made rectangular as being more ornamental. A good corrugated copper pipe would appear, all things considered, to be the best available construction. The patent upon corrugated pipes expired a year or two since and they are now manufactured by a number of competing firms.

Even if a leader pipe be used which will not be ruptured, it is, if exposed, liable to become so chocked with ice as to be unable to carry off water, and the same thing also happens in the case of gutters. Hence, in a climate as cold as that of Boston, resort is frequently had to the use of steam, not so much, however, for the purpose of preventing the formation of ice in freezing weather as to clear a passage for the water when a thaw comes on. Most large buildings at the present time have a supply of steam, either for heating or for power, which can without much difficulty be drawn upon during the day time for use in the way that has been mentioned.

The most common method of using steam for thawing out leaders, is to introduce a small jet from perhaps a ⅜-inch or a ½-inch pipe at the base, and allow the steam to rise up through the leader. This plan is followed at the Wakefield building, on Canal street, in Boston; and as a precaution steam is thus at times introduced also into the base of an iron leader in the Wilde estate building. At the Sloane building, in New York, the same plan has been successfully tried, but has practically been superseded by allowing hot water to drip into the tops of the leaders. Waste steam from the heating and elevator systems passes into small drum-shaped condensers on the roof, and the hot water of condensation is conducted through drip pipes to the leaders. The climate of New York city is so much milder than that of Boston that comparatively little trouble from ice is experienced; and the common practice of an untrapped connection with drains and sewers, the air of which is warm, tends to prevent serious accumulations within the leaders.

Another method which is sometimes, but less commonly, used, is to carry up a steam pipe through the interior of the leader. At the Cheney building in Hartford, Conn., a ¾-inch steam pipe is thus employed.

This pipe has an iron cap a foot or so above the roof, the cap being perforated by a small hole to permit some circulation of steam, but the hole quickly becomes stopped by rust. The condensation of steam within the pipe, and the freezing of the water thus formed, has split the pipe at various points; but the steam escapes all the more readily in consequence, and the arrangement is entirely successful in clearing out the leaders.

Even if the leaders are kept open, the gutters are very likely to become clogged with ice, and then fail to perform their duty. Attempts have therefore been made to clear these also by the aid of steam, and on the Studio and Museum buildings in Boston may be seen arrangements of steam pipes for this purpose. The gutters are of the common half-round metallic type, projecting out from the edge of the roof, the steam pipes extending along over the centre of the gutters and about on a level with the top. On the Studio building the pipes are pierced beneath with small holes at intervals of say six inches, with the object of directing downward into the ice of the gutter a great many small jets of steam. This device is not satisfactory, however. A hole is melted in the ice by each jet, but ridges are left between the adjacent holes that have to be chopped away. Water also enters from the gutters into the steam pipe, freezes there, and bursts the pipe.

It seems probable that if steam pipes are to be used in gutters, they should either be arranged with jets closer together than in the case just mentioned, and perhaps directed obliquely into the gutter; or they should be tight pipes laid on the bottom of the gutters, with a circulation of steam assured by an opening at the end or by a properly arranged return pipe, and with sufficient grade so that the water of condensation may readily flow off.

On the Wakefield building, and to some extent on the Studio building, steam is brought on to the roof from the nearest convenient point in a hose, and that way directed at will upon the ice in the gutters. In the latter building the steam employed is that used for heating, is at a pressure of six or eight pounds only, and is found not very efficient in cutting out ice; but on the Wakefield building the steam is that used for power, is delivered under a pressure of fifty or seventy-five pounds, and is considered very satisfactory in cleaning the gutters.

In conclusion, it may be said that in the case of large buildings, at least, it is possible by some of the methods that have been pointed out to avoid all inconvenience from roof water, from whatever source; and on private buildings, if the water is brought down from the roof in a vertical and unbroken descent, and a corrugated pipe is used, there will be but little trouble.

In most cities the destination of the water, whether it be directly discharged into the house drain or into the street gutter, must quickly be the public sewers. To what extent, if at all this water shall be excluded from the sewers which convey the other house drainage, is a question of importance in certain cities, but its discussion need not be entered upon here.—*The Manufacturer and Builder*.

"GEWERBE SCHULEN"—TRADE SCHOOLS.

BY DR. L. R. KLEMM, PRINCIPAL OF TECHNICAL SCHOOL, CINCINNATI, O.

There is a vital difference between the trade schools in Europe and those in New York. Nowhere in Europe did I find plumbers', stone-masons', bricklayers', and similar shops in which actual work was done; but the trade schools there are schools of design—draughting schools. The pupils get their theoretical knowledge in school, and do the practical work in their own home shops. When a pupil brings finished pieces of work to school, they are criticised and made the basis of new plans, but the technique of the trades—the tricks of the trades, so to speak—are not considered so much as their principles.

Among the many souvenirs of my extended journey through the European schools, I have a number of drawings furnished by the pupils of a trade school in Southern Germany. The class I saw at work was a class of stone-masons. All the members of the class were apprentices in some shops, and attended school in the evening. Here they studied the theoretical parts of their trade, by examining drawings, plans and sketches, and by reproducing them on an enlarged scale.

I can in no better way show what is done in that school than by reproducing two exercises done in my presence. One ad was told to produce three drawings of front steps—a

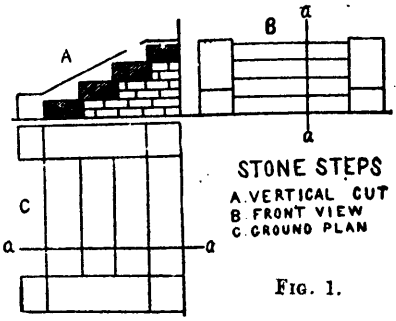


FIG. 1.

FIG. 2.

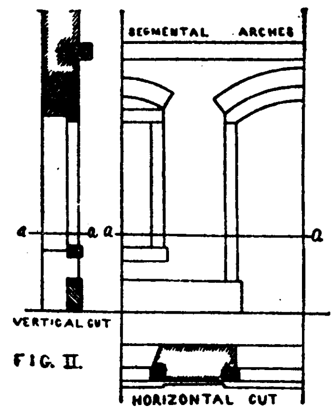


FIG. II.

ground plan, a front view, and a vertical section. Another to draw the details of segmental arches for doors and windows, showing in a front view the general setting of the stone arches, in a vertical section their vertical placement, and in a horizontal cut their proper basis.

The sketches which are here reproduced on a smaller scale, are interesting, inasmuch as they show what clear ideas the boys had in their minds, and how well they must have studied similar lessons. It does not need great penetration to see at once, that a young man who can thus plan a piece of work, is not apt to sink to the level of the humdrum laborer who works for so much a day, but, on the contrary, will soon be found among the foremen, superintendents, masters, etc. In fine, he will represent thinking labor, which always and everywhere commands its own price.—*The Manufacturer and Builder*.


DON'T.