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MEANS OF PRODUCING COLD.

The approach of summer, with a possible accompaniment of heat, induces ideas respecting the production of cold. Of the many uses of refrigeration during a torrid, sultry, tropical state of the atmosphere it is needless here to speak; those who work with gelatine plates, and especially those who have to manufacture them when the thermometer is in the vicinity of the nineties, appreciate full well the desirableness of being able to convert dog day heat into hyperborean chill, and the great value of any means by which such conversion may be effected. The production of cold is merely the abstraction of heat from the body that is being operated upon. The means for effecting this have of late been undergoing advances toward perfection. It is only the other day since we saw in a well heated manufacturing engineering shop a considerable quantity of mercury frozen quite solid while it was exposed to the warm atmosphere of the workshop. This, it must be admitted, indicates a high advance in the art of congelation.

Concerning methods of producing cold, there are three of which we shall here speak. The first is the well known one of imparting cold to water by dissolving in it certain substances, of which there are none which in our estimation can vie with nitrate of ammonia for general efficiency and undoubted convenience. In addition to this, it is also the most economical of all saline bodies, as it is not wasted during use, but may be employed over and over again. If a thermometer is placed in a tumbler of water, at say 50° Fah., and some crushed crystals of the nitrate of ammonia are then thrown into the water, the column of mercury will be found to descend with singular rapidity until it reaches 26° to 27° below the freezing point, or about 5° Fah. There are several mixtures which can be made by which a much greater degree of cold can be obtained, but these when once used cannot be used again. But with the ammonium nitrate it merely suffices to pour the solution out into an evaporating dish after being done with, and having driven the water off by heat, or otherwise, place the crystals into a bottle, when they are ready for future use in a similar way.

We here give an illustration of one way by which the knowledge of the above mentioned fact may be serviceable. We had once some gelatine plates to develop in a semi-tropical country at a time when the heat was intense and the water so warm as to endanger the film during development. We placed the developing solution in a japanned tin developing tray, and placed that tray inside of another slightly larger, and in the bottom of which we scattered a few crystals of nitrate of ammonia, afterward pouring in a little water. This reduced the previously high temperature of the developer to one that could not possibly affect the too soluble gelatine of which the film was composed.

A second system for the production of cold consists in the compression of air. Thus compressed, and forced into a reservoir, it becomes heated, as every one knows who is familiar with the working of an air gun. But when cooled down again, before it is suffered to escape, its expansion is attended by great cold. "If when compressed it is allowed to cool down to the ordinary temperature and then to escape, it will be cooled below that temperature just as much as it was heated by compression. Thus, if in being compressed it had been heated 100°, say from 60° to 160°, and then allowed to cool to 60°, on escaping it will be cooled 100° below 60°, or to 40° below zero, which is the temperature at which mercury freezes." This is the principle of the cold air chambers now so extensively employed on shipboard for the transport of frozen provisions from Australia and New Zealand.

The ingenious photographer who dreads the preparation of gelatine plates in hot weather will in this discover the means by which he may be enabled to keep his coating room at fifty degrees or sixty degrees during the most sultry months of the summer, aided by a small gas or petroleum engine. We have devised a most perfect means of effecting this, by manual power if desired, and that only applied at occasional intervals, but a detailed description of it would be out of place in this article.

It is well known, by some at any rate, that the condensation of certain vapors is attended by extreme cold. Of the principles actuating this phenomenon we do not here enter, but confine ourselves to giving a brief description of one of the machines—if machine it may be called—by which the principle has obtained its latest outcome. This apparatus, which has received the trade name of "The Arktos," consists, roughly speaking, of a tube bent ∩-shape, at the end of one limb being a reservoir which contains strong liquor ammonia. This ammonia should be as strong as possible; although that so well known among photographers as 880 will do, yet Mr. Loftus Perkins, the inventor of the apparatus, informs us that he prefers it much stronger, say 875, a strength he certainly manages to obtain. This bent tube has its air abstracted and is hermetically sealed, and heat is applied to the ammonia reservoir, by which the ammonia liquid parts with its gas. When the source of heat is removed and the gas re-enters the water, the cold is produced at the farther limb of the apparatus in a degree of such intensity as to cause a deposition of the moisture in the atmosphere in the form of dry snow. So great is the cold produced that, as previously hinted, we have seen, and that too, in a warm room, the solidification of mercury in the vessel into which the end of the tube was dipped. One end of this tube may be called the boiler, and the other the refrigerator, and a condition of success is that the connecting pipe between the two shall be kept cooled while the boiler is being heated, so that all gas passing to the refrigerator may enter it in a comparatively cool state. When this is used on a large scale, it suffices that a fire be applied for two or three hours once a day, by which the refrigeration is rendered singularly perfect. There are minor mechanical details connected with this apparatus, but the general principle is as above stated.

Thus is solved the problem of a process for attaining cold and ice without mechanical aid, and as the inventor says, "Its abounding efficacy is most evident in its freezing of mercury in the open air."—*British Journal of Photography.*

ELECTRIC-TECHNICS.

The progress of electric science and its rapid practical application to various lines of work, have made electricity a subject of so general an interest that numbers of our readers no doubt take pleasure in any matter we may give in that line.

The productions of the electrical current by way of the dynamo, the weaving of those invisible magnetic threads, as we may call them, or the revolving of the invisible magnetic power curves, is a purely mechanical thing, subject to the general principles of construction of machinery. Mechanical engineers are therefore the natural heirs to any electric invention applied in this way. Their knowledge and experience of their own department forms the most reliable basis for the success in the management of an Electric Light or Power Station. Moreover, there are a great number of manufacturers who are having a surplus of water or steam power which can be conveniently turned to account by applying it to furnishing electric current for various purposes.

In reviewing the existing methods of producing and distributing this current, we are not partial to any special system, but in discussing their claims of usefulness, our attention is naturally limited to those which are in command of sufficient figures and facts in proof of the actual results obtained during a longer period of the practical test. It will not answer for our purpose to refer to every new thing which may indicate the possibility of some new kind of improvement.

The history of the electric light is another proof that the experiment of the laboratory takes a long time before maturing into a public benefit. It is generally admitted that the electric light, in spite of the first very enthusiastic reception, has not made such a headway as might be expected. This is not due to want of appreciation. Everybody is aware of its importance for health and general culture, and one comparing glance suffices to make one realize that our present mode of furnishing light by distilling coal and pumping the poisonous gases into the houses through a vast system of underground pipes will be ridiculed by the coming generation. There is no doubt about the final victory, and there is a general disposition among the people of doing away with gas even at a financial sacrifice. But in this hard fight between the Dragon that blows the poisonous vapors from the nostrils, and the Knight in silvery armor, who makes his brave attacks, you will find that the Knight has been laboring extremely hard. To extend this comparison to a description of the mechanical resources of the two opponents, one might say that the Gas is all bowels, the Electric Light all muscles and nerves, there the bowels filled with a material which is literally had at no cost, here a coupling together of various machinery and all sorts of fine mechanical devices, requiring great skill and the most perfect discipline for handling them. The electric light business is of a very complicated nature, compared with the making of gas, which is made through the simple process of heating. Boilers, engines and dynamos are required to produce the current, a line of copper wire to conduct it, which must be kept so perfectly insulated that the current cannot escape, and a vacuum finally in which the filament can be made to glow without being consumed. Anyone can understand that the making of an incandescent lamp is a very fine piece of work. It is a matter of securing a perfect vacuum, of making a perfect connection between the line wire and the filament without causing a leak; of making all filaments uniform and suitable to the current, and of preparing them so that the continued effect of the current will not change them.

In addition to all these contrivances which are required for the distribution of the light, an automatic control of the current is needed in case of lamps being turned on or off, in order to have a strong enough current at all times, and to prevent injury to the machine and lamps from an over charge. It is plain that with such a variety of difficulties to overcome, the different light systems vary a great deal in their methods and accomplishments, regarding the quality of the light, cost of producing same, etc. The Multiple Arc System of which Mr. Edison is the principal promoter (most of the eastern systems bing mere side issues of the same), had the great disadvantage of being limited to a very small area, and therefore only suited for isolated plants, and thus the further progress of the electric incandescent light for public use in place of gas was naturally barred by the inherent defects of this method.

A new issue was made about five years ago by Chas. Heisler of St. Louis, who invented the first original long distance system which enabled him to supply entire cities from one central station. We have never yet seen a complete description of the same, although its practical success has been demonstrated in a number of large plants throughout this country, from the Pacific to the Atlantic Ocean. The importance which is due to the Heisler System may be characterized by the general falling in line of the older systems in copying certain original ideas of its inventor. Mr. Heisler first advocated the use of low resistance lamps, and he first changed the quotation of standard candle power from 16 to 30, as being more suitable for commercial lights. His most important move, however, was the introduction of the incandescent light for the illumination of the streets on a large scale, which, we believe, will prove the turning point in the warfare on the gas monopoly.—*American Engineer.*

THE VANILLA.

Of the many admirers of vanilla, and of vanilla-flavoured confectionery, but few know that it is produced from a species of orchid. This plant seems to require very little soil for its nourishment, and it generally attaches itself by means of its little aerial rootlets to walls, trees, and other suitable objects. It has a somewhat long and fleshy stem, and the leaves are alternate, oval, and lanceolate (shaped like a lance). The flower is of a greenish white, and forms axillary spikes. The fruit, which is a pod, when full grown measures from ten to twelve inches, and is about half an inch in diameter. The commercial vanilla (from the Spanish, *vainilla*, diminutive of *vaina*, a pod) is generally produced from the plant *Vanilla plainifolia* (Andrews), a native of Eastern Mexico. It is also extensively cultivated in Réunion, the Seychelles, and Java, but the Mexican vanilla is thought to be the best. The quality of a vanilla pod can always be determined by the presence or the non-presence of a crystalline efflorescence called *givre*, and also by the colour of the pod, which in the best varieties is of a dark chocolate brown. But it is the crystalline efflorescence which contains the substance to which the fragrance of vanilla is due. This substance is called *vanillin*, and is chemically known by the formula $C_8H_8O_3$. The pods contain also vanilla acid, oily matter, soft resin, sugar, gum, and oxalate of lime. The choleraic effects that sometimes occur through eating ices flavoured with vanilla may not be due to the vanilla, but to putrefactive changes in the milk; but it is known that the vanilla plantations are subject to the attack of a little pest known as *Bacterium putredinis*, and it is quite likely that the poisonous effects from ice-eating can be accounted for by the presence of some microscopic fungi in the vanilla.

In the plantations the vanilla plant is generally fertilised by hand, but, like other orchids, there is no doubt its fertilisation is promoted by insects when in its natural state. The wild plant yields a smaller fruit, and is distinguished in Mexico as *Baynilla cimarona*, while the cultivated vanilla they call *Baynilla corriente*.—A. J. F., in *Knowledge*.

A SUGGESTED NEW USE OF PHOTOGRAPHY.

Prof. John Trowbridge, in the May *Scribner's*, calls attention to the importance, from an engineering point of view, of making careful photographs of steel and timber at the point of rupture under a breaking load, suggeeted that in this way we may learn something important on the much vexed question of elasticity.

This is a suggestion worthy the attention of our metallurgists, some of whom have made a critical study of the behaviour of iron and steel under strains.

A FAR-SIGHT MACHINE.

Mr. Edison is reported, in a conversation with an interviewer who solicited his ideas on the subject of the projected World's Fair in New York (says *Iron*), as saying that he would take an acre of space in such a fair and completely cover it with his inventions, of which he has no less than 70 now under way. "One of the most peculiar, and now promising good results," said Mr. Edison, "is what I may call a far-sight machine." By means of this extraordinary invention he hopes to be able to increase the range of vision by hundreds of miles, so that, for instance, "a man in New York could see the features of his friend in Boston with as much ease as he could see a performance on the stage. That," he added, "would be an invention worthy a prominent place in the World's Fair, and I hope to have it perfected long before 1892."

The saw is largely used now instead of the axe in bringing down the giant redwoods in California. The tree is sawed partly through, and then is forced over by wedges.

EXPERIMENTS ON THE INEXPANSIBILITY OF WATER AND CONTRACTION OF ICE.

BY T. O'CONOR SLOANE, PH.D.

When ice melts, the water produced is of considerably less volume than was the original ice. This is obvious from the fact that ice floats upon water. The reverse is a fact but too well known to housekeepers, who trace many broken vessels and fractured water pipes to the expansion of freezing water. The change in volume is a sudden one for the most part. At 39·2° F. water attains its greatest density. If the temperature is lowered it expands slightly, until 32° F. is reached, when it freezes, if there are no causes to prevent. In freezing it suddenly expands about one-eleventh of its bulk with almost irresistible power. A pressure as high as 28,000 pounds to the square inch has been estimated as having been exerted by it.

Many other substances in solidifying experience the same change. Thus solid cast iron floats on melted iron as ice does on water, and for the same reason.

This sudden expansion is the more impressive in the case of water, because it is ordinarily of comparatively constant volume. Its change of bulk by alterations of temperature or pressure is but slight. It resists compressive or expansive strains, yielding but little to very high pressures.

Both of these phenomena—the reduction in volume experienced by melting ice and the slight expansibility of water—are illustrated by the simple experiments shown in the cuts. Nothing in the way of apparatus is required to perform them, unless a couple of wineglasses or goblets and an India rubber band can be termed such.

The simplest one may be first described, the illustration of the slight expansibility of water. If two empty wineglasses are placed mouth to mouth, and a rather wide India rubber band is sprung around the junction, they will resist separation with some force. The glasses in separating slide, like the members of a telescope, through the band, and in doing so cause the air within to be slightly rarefied. A partial vacuum is produced, and some exertion is required to separate them. When they part, a slight report is produced by the inrush of the outer air. It is evident that if the glasses were filled with a non-expansible substance, they would adhere much more strongly. For air, therefore, water may be substituted.

The glasses are immersed in a vessel of water large enough to hold them mouth to mouth. The band is sprung over them and is worked up as near the lip of one of them as possible. It is important that it should be wet, to facilitate its sliding. The glasses, immersed so as to be filled with water, are next brought mouth to mouth beneath the surface. The band is adjusted by sliding so as to cover the junction as evenly as possible. Care must be taken to exclude all bubbles of air. The glasses are then removed from the water, when they will be found to adhere loosely yet strongly. They can be worked from side to side, but will resist a direct pull with great force. A very heavy weight can be sustained before they come apart. The water contained within them is practically inexpansible, and permits no telescoping of the band and glasses.

The second experiment may now be tried. The glasses are separated and emptied, and the band is sprung around one of the glasses and is brought down below the edge, so that only half of its width surrounds the body. The other half will now spring inward and form a horizontal diaphragm through which a large aperture extends. It represents a flat perforated washer. The glasses are again immersed in water and filled. A lump of ice as fre· from air bubbles as possible is introduced into one of them, and they are as before brought together under the surface of the water. The ice is, of course, rapidly melting. The instant they touch, they adhere strongly. The shrinkage of the water as it changes from the solid into the liquid state produces a vacuum, and the atmospheric pressure forces the glasses strongly together. They are now removed from the vessel. It will be found that they can be laid on their sides and rolled about; that they can be held by the base of one in a horizontal position, and that they will sustain a very heavy weight before pulling apart. They will adhere thus for a number of days, until gradually enough air has leaked in to destroy the vacuum. The other arrangement of band could be used, and is to be advised when the edges of the glasses are not true; but the flat surface of connection makes it much more impressive, and by doing away with any chance of telescoping, restricts the experiment to an illustration of the shrinkage of frozen water on melting.

The glasses should be selected of equal diameter at the mouths, and if ground and polished, they are much better. There is no trouble in finding such glasses at any dealer's. Even if the mouths fit poorly, the experiments can be performed by having a wide enough band and by not attempting to use the flat washer arrangement.—*Scientific American.*

THE INEXPANSIBILITY OF WATER.

THE CONTRACTION OF MELTING ICE.

A UNIVERSAL TELEGRAPH INSTRUMENT.

Some improvements have recently been made in the Neale Acoustic Dial used by the Postal Telegraph Department by Mr. H. Pomeroy, superintending engineer, Southern Ireland District, of which we propose giving a few particulars.

These alterations (see sketches below) have been made so as to constitute what may well be called a universal instrument; it is now available as a single or double current sounder, a single needle, or a Bell instrument, the chief gain of the whole arrangement being the entire absence of any adjustment to be made by the clerk working the instruments on any of these systems.

The improvements consist of:—

1. The reversing of the inducing magnet, M (fig. 4), to allow the dials to be fitted into the old needle galvanometer cases, thus saving the expense of providing new cases.

2. A considerable lengthening of the needle, N (fig. 2), as it was found that the slightest angular movement of the short needle rendered the visual signals very obscure, making it difficult to read by sight.

3. The replacing of the old adjusting gear by a simple switch (S, figs. 2 and 4), the moving of which brings the needle into its proper position for working, shown by the directions against the pointer in fig. 1.

Fig. 1 gives a general view of the complete instrument.

Fig. 2 gives a front view, fig. 3 a back view, and fig. 4 a side view of the dial removed from the case. Fig. 5 shows the needle removed from the dial. "D D" is the ordinary dial plate to which the two metal tubes, t and t^1, are secured by means of screws passing through flanges at their ends. Fixed

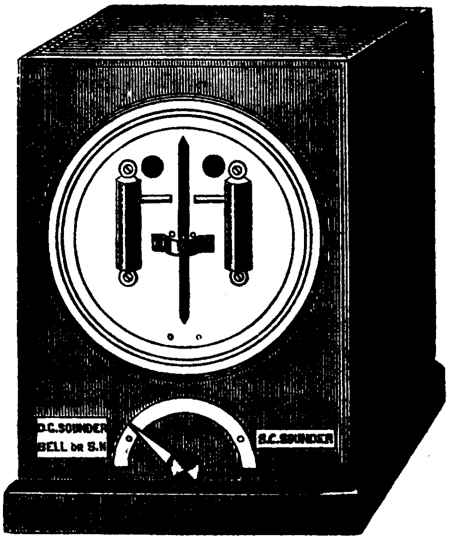


FIG. 1.

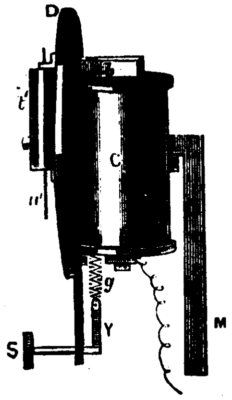


FIG. 4.

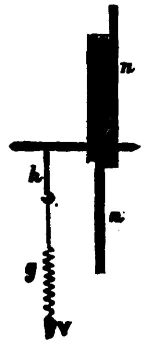


FIG. 5.

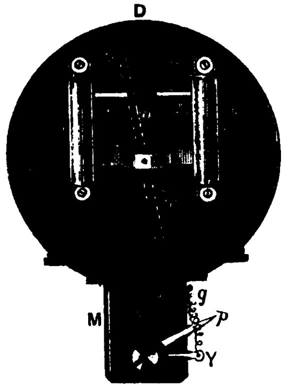


FIG. 2.

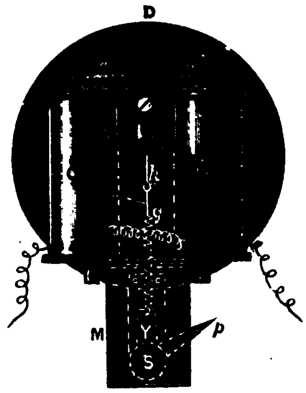


FIG. 3.

to these tubes are metal pins, *e*, e^1, against which the needle, *n*, strikes. The two tubes are made of different thicknesses of metal, so that they emit different notes.

The needle is made to move by the electro-magnet, *c*, *c*, (fig. 3), the pole pieces of which, *a* and *b*, project through the dial, as shown in fig. 2.

M (fig. 4) is a permanent magnet, the upper end of which is bent at right angles to the lower. This end, which is forked, passes a short distance through the face of the dial, its prongs being in close proximity to the bottom of the upper half, *n*, of the indicating needle. The back part of *n* (fig. 5) is formed of a broad piece of soft iron (shown by the shaded portion), through which the axle of the needle passes. This portion of the needle is magnetised by the inductive action of the magnet, *n*, already mentioned. Consequently, its upper part is attracted and repelled by the pole pieces, *a*, *b*, according to the direction of the current, and is thus made to strike against the stop pins, *e*, e^1.

The axle of the needle, *n* (fig. 5), is fitted with a small hook, to which a spiral spring, *g*, is attached, the other end of the spring being attached to the elbow, *r* (figs. 2 and 4), of the switch, *s*. The switch is fitted with a milled screw, *s*, and a pointer, *p*; it has only two positions, one shown in figs. 1 and 3, where the needle remains in a vertical position without bias, and the other, as fig. 2, in which the needle is pulled to the left stop, and thus forms the spacing signals for single current sounder working by the action of the spring, *g*.

For bell or single needle signals the needle remains vertical, and strikes either of the stop pins, according to the direction of the current through the instrument, always returning to the centre position when current is off.

For double current sounder working the needle also remains in the centre, without any bias; then when the sending station puts on a spacing current by turning the switch of the key, the needle strikes the left stop pin, immediately going to the right, when the key is depressed, reversing the current, the signals being remarkably loud and clear.

It will be seen that with the same battery power double current working has an advantage over the single current system, as no bias in the needle has to be overcome.

This instrument when used as a sounder replaces the relay, local battery, sounder, and galvanometer at present supplied—an enormous saving in the cost of apparatus at small country offices where the traffic can now be equally as well performed on the single universal instrument.

The absence of any adjustment, too, will be valued by those who are aware of the inability usually displayed by inexperienced telegraph clerks to adjust their apparatus, and trouble will be less likely to arise from loose or broken connections, the total number of terminals, exclusive of key, being reduced to two.

Another gain will be that clerks who are acquainted with one system only, *i.e.*, either needle or Morse sounder codes, if transferred to an office where one of these universal instruments is fixed, can send and receive on either plan, and those anxious to learn both methods can readily do so on the same circuit. In cases of special arrangements, too, it will be unnecessary to have a sounder fixed at an office on a needle circuit, as the instrument will be able to work to any larger office when extended on a sounder circuit.

The universal instrument has been successfully tried on a double current sounder circuit of over 120 miles in length, and on a bell circuit of 35 miles with five instruments on it, signals being read without the slightest difficulty in both instances.

To make the universal set complete, a key for use with the receiving instrument has also been designed which will send single or double current, as well as bell or needle signals, without alteration. A description of this key will shortly appear.—*Electrical Review.*

ARGENTINE.—"Argentine," says *Iron*, is a name given to tin precipitated by galvanic action from its solution. This material is usually obtained by immersing plates of zinc in a solution of tin containing about 60 grains of the metal to the quart. In this way tin scrap can be utilized. To apply the argentine, according to H. P. Marino's process, a bath is prepared from argentine and acid tartrate of potash, rendered in soluble by boric acid. Pyro phosphate of soda chloride of ammonium or caustic soda may be substituted for the acid tartrate. The bath being prepared, the objects to be coated are plunged therein, first having been suitably pickled and scoured, and then subjected to the action of an electric current. But a simple immersion is enough. The bath for this must be brought to ebullition, and objects of copper or brass, or coated therewith, may be immersed in it.

A GOOD WORD FOR THE ENGLISH SPARROWS.

When so much has been said against that now familiar bird, the English sparrow, we are constrained to give circulation on this coast to the following little word in his favor, which is taken from a recent number of the Ogdensburg, N.Y., *Journal*:—"Spare the sparrows, for they sometimes do valiant service in destroying destructive worms. The army worm has done a great deal of damage to the oats and corn in this vicinity the past spring. Charles Dubois was obliged to resow a 5-acre patch of oats and 3 acres of corn—the first planting having been destroyed by the army worm. While discussing the subject with his neighbor, John Paul, during the prevalence of the worm, Paul, who is a very observing man, called the attention of Mr. Dubois to the operations of a few sparrows which came into the field and gorged themselves on the army worm, and took hundreds to their young. He remarked to Mr. Dubois: "See there!" pointing to a sparrow, "you need not talk to me any more about shooting sparrows, for I am convinced that they do more good than harm. That bird had his mouth full of worms that have been destroying the oats." The bird flew away to feed its young and then came back. Mr. Paul again called attention to him. "See there!" said he to Mr. Dubois, "he is back after more." Mr. Dubois is now satisfied that the sparrow is worth more than he costs.

NITRATE OF SODA AND THE NITRATE COUNTRY.

BY RALPH ABERCROMBY.

Till lately, nitrate of soda has only been known to the few who dealt in manures, or who were engaged in chemical manufactures; but within the last two years the British public have invested vast sums of money in the shares of Nitrate Companies, while the presence in society of live millionaires who have made their money in Tarapaca, and the strong personality of a "Nitrate King," have made "nitrates" a household word.

Deposits of nitrate of soda are known along the west coast of South America for a distance of 500 miles at least, from a little south of Taltal up to the River Camerones; and it is reported that beds have been discovered 150 miles further north, in the province of Arequipa (see Fig. 1).

The physical structure of the coast is identical throughout all that great length. Everywhere an arid range of hills 4,000—6,000 feet high rises abruptly out of the sea; while, behind them, a flat, waterless desert Pampa slopes gradually up for 50—100 miles to the foot of the snowy Cordillera. Nitrates are only found on this desert Pampa, but under somewhat variable conditions. On the Tamarugal Pampa—where all the great English companies have their factories—the nitrate is found exclusively on the western or seaward edge of the Pampa, on the first slopes of the coast range; in the Noria district, on the lowest portion of a district surrounded by hills; and above Antofagasta on the sides of a dry river-bed.

The aspect of the Pampa is always essentially of the desert type. Above Iquique, the plain is sparsely covered with Tamarugal bushes; and the bold features of the Cordillera above Tarapaca form a sufficiently pleasing landscape. Inside from Antofagasta, on the desert of Atacama, there is no view of the mountains, and nothing greets the eye but a sloping plain of brown earthy sand, whose distant outlines can scarcely be distinguished through the quivering air. No cloud on the sky tempers the rays of a nearly vertical sun, blue mirage lakes tantalize the thirsty traveller, the hand can scarcely touch the scorching sand at 130°, the parched air may indicate 90°, and a light south-west wind raises whirlwinds of dust in every direction. Not a bird, nor a beast, nor a plant of the lowest type can live on these barren wastes; and yet the hidden wealth below has led to the erection of villages which contain more than 500 people, whose every necessary of life has to be brought from a great distance.

The absence of water has always been a great difficulty in the way of carrying on any industry in these deserts. Fifteen years ago, water sold on the Atacama desert for $20 the *arroba*—say 10s. a gallon—and a drink for a mule cost 15s. At Carmen Alto, in the same district, a sun condenser, with 50,000 square feet of glass, was employed to distil fresh from salt water; and though this was afterwards wrecked by a whirlwind, a smaller apparatus, on the same principle, is now working at a profit at Sierra Gorda, though the water is sold at only 30 cents. the *arroba*, or about 1½d. a gallon.

Fresh water is now supplied to most of the towns on the coast, and to the factories inland, by means of condensed steam. Some of the condensers can produce no less than 25 tons of good water for every ton of coal burnt in the boilers; and some are even reported to have attained an efficiency of 30 tons of water for the same amount of fuel.

More recently, schemes have been started for the water supply of the towns on the coast by pipes from springs at the foot of the mountains beyond the Pampa; and Mollerdo, Iquique, Antofagasta, and Taltal are either actually supplied with drinking water by this means, or works are in progress for the same purpose.

Very few Indians can have lived on the Pampa before the arrival of Europeans. A few Changos still survive along the seaward face of the coast range, who live by fishing, and who till recently had no knowledge of metals. The Aymara language is still spoken in Tarapaca, and all the place-names on the Tamarugal Pampa—such as Paccha, Jaz Pampa, Puntunchara, etc.—belong to that idiom. In the Antofagasta and Taltal districts, on the contrary, though further to the south, the place-names, such as Cachinal, etc., are Quichua, and any Indians of the Cordillera speak in that tongue. A good many of the *peons*, or labourers, who work in the *maquinas*, are Bolivians from Cochabamba, who talk Quichua, and some of the words used in the factories, such as *cancha*, etc., are derived from that language. These men chew *coca*, and though not so strong, are more laborious than the Chillenos from the south.

Passing from these generalities, we will now examine in more detail the structure and climate of the Tamarugal Pampa, between Iquique and Pisagua, in which most English people are interested. Fig. 2 is a diagrammatic section from the sea across the Cordillera, through the nitrate beds of Tarapaca. To the left we see the barren coast range rising from the sea and falling again to the level of the Tamarugal Pampa. The nitrate beds are marked in their proper place at the first spring of the hill; then comes the level Pampa, sloping gently not only from the Cordillera, but also slightly in a south-west direction. This slope is of course enormously exaggerated in the diagram.

Next the counterforts of the Sierra of Huatacondo rise abruptly above the plain. Here and there the barren slopes of these moutains are intersected by narrow valleys or *quebradas*, each of which carries down a small stream of water that is eventually lost in the sand of the Pampa. Artificial irrigation at the side of each affords sustenance for a very scanty population, and only one village is of sufficient importance to form anything approaching to a small town. This is the town of Tarapaca, in a valley of the same name, which gives its name to the province in which Iquique and the nitrate beds are situated.

A high cold upland, or Puna, some 20 miles across, separates the crests of the outer Sierra of Huatacondo from the rather higher range of the Cordillera Silillica, and then the mountains slope steeply down to the plateau of Bolivia, some 12,000 feet above the sea. None of the crests of the outer Sierra retain any snow on their summits during the summer months, but a few of the crests of the inner Cordillera are white throughout the year.

Allusion has been already made to the Tamarugal bushes which are found in places on the Pampa. These owe their existence to the floods, or *avenidas* as they are called locally, which every few years rush down from the Sierra, and run over the plain almost to the edge of the nitrate grounds. The soil of the Pampa is just what might have been expected under such circumstances, for the surface is not sharp sand, but really dry earth with a certain proportion of sandy particles, and only irrigation is required to turn the desert Pampa into a fertile plain. Below ground, numerous sections which have been made in sinking wells, show alternating layers of gravel, sand, mud, and as each series of layers represents the sequence of a single flood, it follows that the Pampa has been subject to periodical inundations for a very long period.

The labours of Signor Don Guillermo Billinghurst have made us acquainted both with the *régime* of underground waters on the Pampa, and with their chemical constitution. From his researches it appears that water is found almost anywhere under the Pampa, at depths varying from about 50 to 150 feet, but that nowhere are the conditions necessary for artesian wells fulfilled. The well water from the centre of the Pampa contains too great a proportion of salts to be considered drinkable; and that from the western margin of the plain, but not in the nitrate beds, belongs to the calcareo-magnesian class, which is totally unfit for domestic or culinary purposes. The following examples will make this very clear, and also the remarkable fact that *the underground waters of the Pampa do not contain the slightest trace either of nitrate of soda, or of iodine*, though they contain a greater proportion of mineral salts the further westward they run.

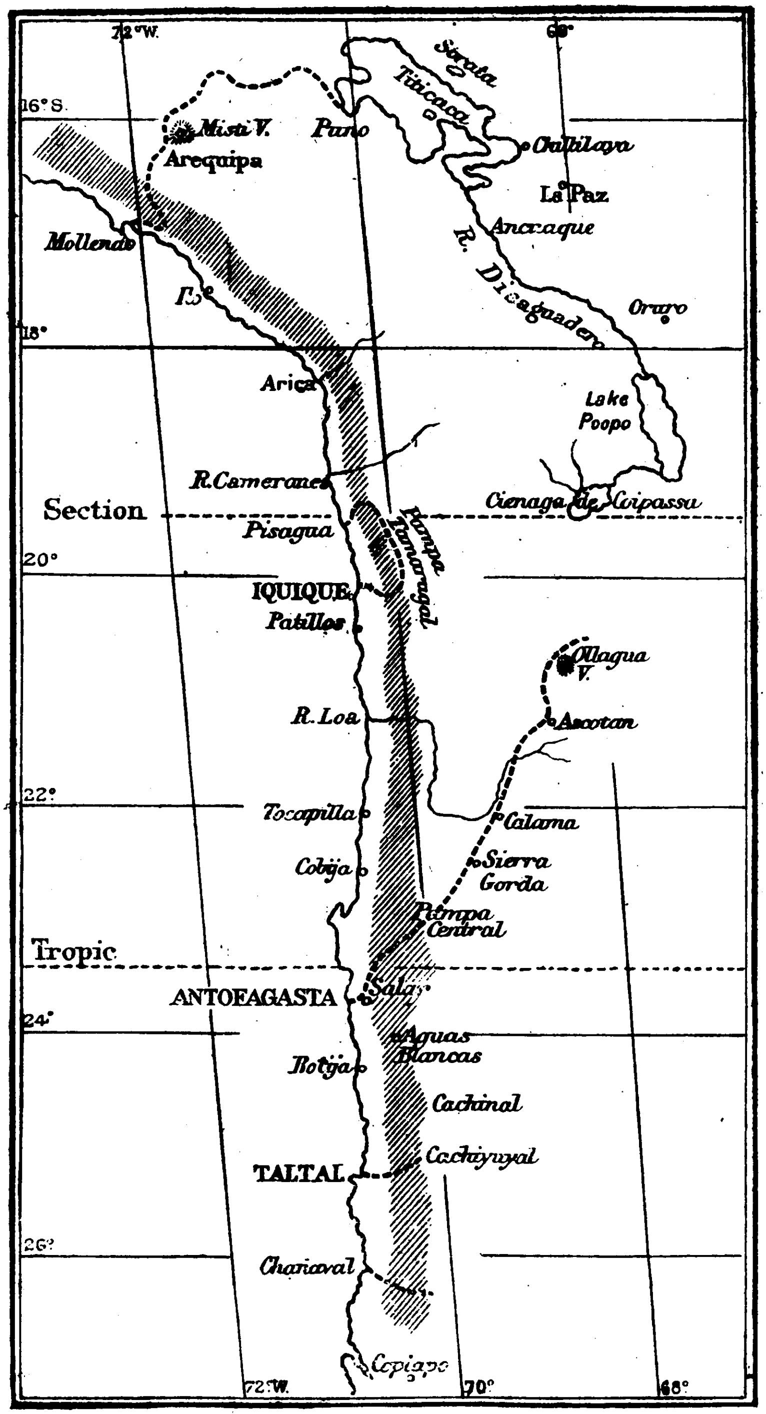
The two subjoined analyses are those (1) of well water from Cerro Gordo, situated 7 miles from the nitrate beds, on the open plain of the Tamarugal Pampa; and (2) of the Pozo de Almonte, quite close to the nitrate beds, and from which a large proportion of the water used by the Nitrate Railway Company is derived:—

	Cerro Gordo. Grammes per litre.		Pozo de Almonte. Grammes per litre.
Carbonate of lime......	0·01500	....	0·2499
" magnesia..	0·00300	....	0.0323
Sulphate of lime.......	0·12920	....	0·9843
" magnesia...	0·08166	....	——
" potash.....	0·00860	....	——
" soda.......	0·18062	....	0·0735
Chloride of sodium.....	0·62261	....	1·5799
" magnesium..	——	....	0·1737
Oxide of iron and alumina	0·01000	....	——
Silica, and insolubles...	0·00500	....	0.0200
	1·05569		3·1136

In connection with underground waters we may as well dispel for ever the fiction so commonly believed that some of the overflow from Lake Titicaca filters under the Cordillera and reappears on the Tamarugal Pampa. This idea was started in a pre-scientific age, more than 300 years ago, in 1550, by the celebrated historian Cieza de Leon ("La Cronica del Peru," p. 445); but unfortunately for such a supposition the facts of the case are as follows: The only outlet of Lake Titicaca is the River Disaguadero (Span. drain), and the water at starting contains about 1 gramme of salts in every litre. By the time the river has reached the shallow lake of Poopo or Aullagas (see map, Fig. 1), the water is so salt as to be undrinkable, and then the river runs out for a short distance till it is finally lost in the salt mud marsh, or Ciénaga de Coipasa. No doubt this marsh is due east of the Pampa near Pisagua, and is marked "Sink of Titicaca" in Fig. 1; but still it is impossible to believe that salt water can come out fresh on the other side of the Cordillera. The water of the Tamarugal Pampa must be derived from the rainfall on the slopes of the Sierra, immediately above the plain.—*Nature.*

WORSTEDS AND WOOLENS.

The question is asked, what is the difference between worsted cloth and woolen cloth? The answer is: Worsted goods are composed of wool that has been carded and combed, while woolen goods are made of wool that has been carded but not combed.


72°W.
68°
Sorata
Titicaca
16° S.
Misti V.
Arequipa
Puno
Chililaya
La Paz
Ancaraque
R. Desaguadero
Mollendo
Ilo
Oruro
18°
Arica
Lake Poopo
R. Camerones
Section
Pisagua
Pampa Tamarugal
Cienaga de Coipassa
20°
IQUIQUE
Patillos
Ollagua V.
R. Loa
Ascotan
22°
Tocopilla
Calama
Cobija
Sierra Gorda
Pampa Central
Tropic
ANTOFAGASTA
Salar
24°
Aguas Blancas
Botija
Cachinal
TALTAL
Cachiyuyal
26°
Chañaral
Copiapo
72°W.
70°
68°

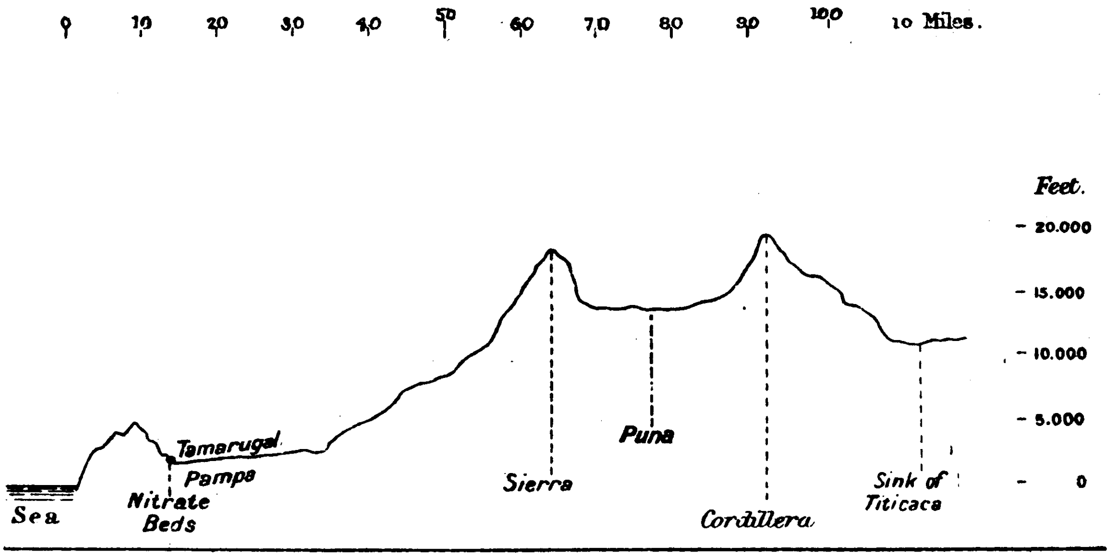


FIG. 2.—Section across the Cordillera, through the nitrate beds of Tarapaca.

NAILS FROM TIN-SCRAP.

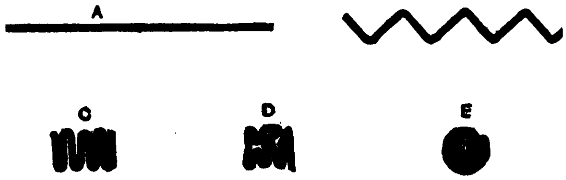
READ BEFORE THE AMERICAN INSTITUTE OF MINING ENGINEERS.

BY OBERLIN SMITH, BRIDGETON, N.J.

It may surprise metallurgists who read this paper, to learn that, by a recent discovery, nails of good quality can be made at one operation, directly from the ore, at the rate of, say, sixty per minute for each operator. It should be stated, however, that the raw material referred to does not answer strictly the ordinary assayer's definition of an ore. It is found, in strata of various thicknesses, in Harlem, N.Y., and other localities where the *debris* from restaurants and from sheet-metal factories of various kinds has been dumped. In other words, it is old and new tin-scrap—one of the few substances which this generation, mainly occupied in exhausting the accumulated resources of the past, seems to have laid up, by way of atonement, for the benefit of posterity. In speaking of this material as *ore*, we are simply looking forward, prophetically, to the time when our descendants may dig it up and write learned papers for the American Institute of Mining Engineers, upon the best methods of assaying and smelting it.

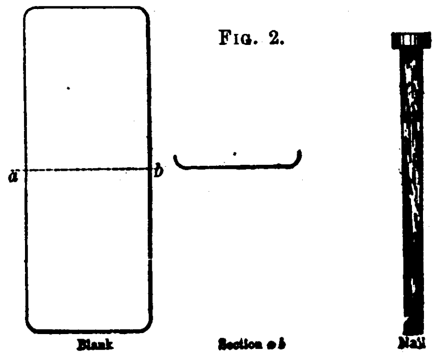
At least such has seemed to be its destiny hitherto. It may fairly be said that the many attempts which have been made to utilise it by separating, through chemical or electrolytical processes, its two valuable constituents, metallic tin and first-class wrought iron, have failed, either technically or commercially. The reasons for such failure need not here be discussed. Either the separation has been incomplete, the iron still retaining enough tin to spoil it for the sinking-fire or other use short of re-melting (perhaps even for that), or the manipulations of the process have been too expensive to make its results profitable—or both. Meanwhile the great tin-scrap deposits have gone on growing faster than any other strata of our Post-Tertiary, Psychical Era; given up by metallurgists, not yet attacked by geologists, and explored only by that mining engineer of the transitional period, *Gulielmus Caper.*

FIG. 1.



NAILS FROM TIN-SCRAP. SECTIONS SHOWING DIFFERENT WAYS OF COMPRESSING BLANK.

FIG. 2.



NAILS FROM TIN-SCRAP. BLANK AND FINISHED NAIL. FULL SIZE.

Before leaving these heaps of tin-scrap, however, to become mere mineral deposits for future ages, it may be well to consider a novel plan for their immediate utilization—novel, not only in its means but in its principle. For it undertakes to use this material just as it is without trying to separate its constituents at all, and to use it, moreover, for a purpose in which the qualities of both these constituents, namely, the tensile strength and ductility of the iron and the resistance of the tin to corrosion, are directly employed with advantage. I refer to the manufacture, by mechanical pressure, of nails.

This nail was invented, in its original shape by Geo. H.

Perkins, of Philadelphia, and has been developed, through various forms, until it has almost reached a commercial stage —the machine in which it is to be made, in marketable shape, being nearly completed. The writer has been associated with Mr. Perkins in its development, and can, perhaps, make interesting a brief description of the troubles we have gone through in order to produce it quickly, at one operation, in a reasonable manageable and durable machine. The first scheme tried was to cut "blanks" from ordinary tin-plate and sheet-iron scrap, for an approximately rectangular form, about three-quarter inch wide by one and three-quarter inches long, similar to the plan shown in actual size, Fig. 2, but having the end section A, Fig. 1 (drawn about twice its real size). This was done in an ordinary press. By a second operation, it was corrugated into the form B, Fig. 1, in another press, with a special automatic die, which corrugated the middle grooves first and the side grooves afterwards; much of the metal used not proving strong enough to stand the friction of being pulled into the corrugations of the die without cracking. At a third operation, the embryo nail was crushed together into the form C, Fig. 1 (but more tightly closed), something after the manner of closing an accordion bellows. These headless nails were then fed by hand into a revolving dial, to carry them under a heading machanism, after the operation of which they were ejected from the machine automatically.

Obviously, this series of separate operations made the nails far too expensive for the market; and, moreover, some trouble occurred from their splitting in the tightly folded corrugations. We afterwards built an automatic machine which performed all the above operations in succession, delivering a complete nail at each stroke. It was, however, far too complicated for practical use, and simply served to show what could not be none.

Our second nail machine proper constructed to receive blanks, which had been already cut in an ordinary press, worked fairly well. It was likewise an experimental machine, built "piece-meal" and not strong enough for continual hard work; but it served this time to show what could be done. Instead of working upon the principle of regular corrugations, it simply crushed up the blank edgewise into any form which they chose to assume—the end sections appearing somewhat as shown at D, Fig. 1. The blank and finished nail are shown in Fig. 2.

The machine now under construction has been very much simplified and made enormously strong and heavy. It is adapted to cutting, crushing gripping and heading the nails at one operation, and can be run as fast as an expert operator can feed the material. Its feed probably varies, with jagged, irregular scrap, from thirty to ninety nails per minute, although straight strips of sheet metal can easily be fed by hand into a machine running as high as 240 strokes per minute.

During the course of our experiments, various forms of nails have been tried. Among others were straight cylindrical nails with conical points; straight square nails with pyramidal and with wedge-shape points; hexagonal nails, etc. The most practical form, however, seems to be the square taper nail shown in Fig. 2, which has about the same shape as the ordinary cut nail, but is somewhat stronger and a good deal tougher. It is well adapted for all ordinary purposes, but is especially suitable for a roofing nail, since the tin coating prevents much rusting, and is good to solder to.

Among other processes, we have tried winding the blank upon itself, after the manner of a window shade, but minus a mandrel. This, however, was difficult in execution, and was not found available in practice.

The economy of this system of nail-making is obvious. The scrap can be bought for about seventeen cents per 100 pounds, and a boy can make perhaps 100 pounds of nails per day. The most economical system of manufacture will probably be to run one or more nail machines at each large "tin-shop," set as close as possible to the presses which produce the scrap, so as to avoid the expense of unnecessary handling, and the extra tangling-up incident thereto.

REMOVING PAINT.

The ordinary process of scraping old paint, or burning it off, is hardly expeditious enough for general purposes, and is also laborious. Soda and quicklime are far more thorough, and the paint is more quickly removed. The solution of half-soda and half-quicklime is thus made. The soda is dissolved in water, the lime is then added, and the solution can be applied with a brush to the old paint. A few minutes is sufficient to remove the coats of paint, which may be washed off with hot water. Many preparations are sold for the removal of paint, all of them having some basis of alkali. A paste of potash and strong lime is far more effectual in operation, and the oldest paint can be removed by it. Afterwards a coating of vinegar or acid should be used to cleanse the surface before repainting. One authority on the subject recommends the gasoline lamp, a quart of oil being sufficient to last 3½ hours. The method is considered superior to gas as the flame is stronger and the cost less, besides which the lamp can be carried to any part, which cannot be done conveniently with a gas-jet. For removing varnish, spirits of ammonia is used, but it is a slow process, and several applications are necessary. Scraping and sandpapering can be employed; but it must be done carefully by experienced hands, or the surface of wood will be injured. The chemical process of removal has the advantage of leaving the surface in a better condition that burning off or scraping, and for large surfaces of paintwork is to be preferred.—*Building News.*

GRANITE.

The essential components of the true granites are quartz and potash feldspar. Although the essential minerals are but two in number, the rocks are rendered complex by the presence of numerous accessories which essentially modify the appearances of the rocks, and those properties render them of importance as building stones. These additional minerals are either present in such amount as to be conspicuous and to exercise an influence upon the appearance and structure of the rock, when they are called characterizing accessories, or they are present in such small amount as to be invisible to the naked eye, when they are called microscopic accessories. If all the minerals which by careful examination have been found in granites should be considered as constituents of the rock, then the latter would appear as very complex. At least two-thirds of all the known elements exist in granitic rocks, and the number of minerals that are liable to be present in special cases is very large.

The following list does not include all of those minerals which have been identified in this rock, for many have been found under circumstances which are so isolated that their occurrences is entirely exceptional. All of the minerals in this list are liable to be found at any time, and may therefore be considered as common constituents of the rock, although the presence of them altogether is not to be expected, and some of them may be present in such minute amount as to be of no practical importance. Any one of them, save the two essential constituents mentioned above, may be absent from an individual specimen or from a given locality; and any one may be present in the specimens from a given locality in such amount as to give a character to the rock. Thus almost any one of those minerals which are given as microscopic accessories may assume the character of a characterizing accessory; this is especially true of the iron oxides, which sometimes are present in such amounts as to become characteristic:—

Essential:
- Quartz.
- Feldspar.
  - Orthoclase.
  - Microcline.
  - Albite.
  - Oligoclase.
  - Labradorite.

Microscopic accessories:
- Sphene.
- Zircon.
- Garnet.
- Danalite.
- Rutile.
- Apatite.
- Pyrite.
- Pyrrhotite.
- Magnetite.
- Hematite.
- Titanic iron.

Characterizing accessories:
- Mica.
  - Muscovite.
  - Biotite.
  - Phlogopite.
  - Lepidolite.
- Hornblende.
- Pyroxene.
- Epidote.
- Chlorite.
- Tourmaline.
- Acmite.

Decomposition products:
- Chlorite.
- Epidote.
- Uralite.
- Kaolin.
- Iron oxides.
- Calcite.
- Muscovite.

Inclosures in cavities:
- Water.
- Carbon dioxide.
- Sodium chloride(salt).
- Potassium chloride.

—Prof. G. P. Merrill, in *Gov. Report.*

ADVANTAGE OF A TRADE MARK.

Last year, says the *Canadian Manufacturer*, a firm in London, Ont., inserted in the papers an advertisement of a stove polish, to which they gave the name "Nonsuch," and which they recommended in a card headed "Hello! Nonsuch." A gentleman who desired to write to the firm forgot their name entirely, but remembered distinctly the "Hello! Nonsuch." So he risked the consequences and addressed his communication to "Hello! Nonsuch, London, Ont.," and the fame of the article, combined with the quick intelligence of the postal authorities, triumphed over every obstacle, and the letter reached its destination.

When two or more colors are used, it is necessary to keep in mind the laws governing the combination of colors. All colors in combination are beautiful, provided only that the combination is artistically managed. If, however, a few light tints of red, yellow, and green are used, we are not likely to go very far wrong in the matter of combination.

SENSITIVE FLAMES.

BY GEO. M. HOPKINS.

The sensitive flame observed by Dr. Le Conte and afterward developed by Tyndall exhibits some of the curious effects of sound. For its production it is necessary that the gas be under a pressure equal to that of a column of water six or eight inches high. The common method of securing the required pressure is to take the gas from a cylinder of compressed illuminating gas, such as is used for calcium lights. Another method is to take the gas from a weighted gas bag, and still another is to fill a sheet metal tank with gas and displace it with water in the manner illustrated in Fig. 4.

The burner is shown in Figs. 1, 2, and 3. It consists of a small tip inserted in the end of a suitable tube. The tip in the present case is made of brass, but those commonly used for this purpose are of steatite. They are superior to the metal ones, but quite expensive. The writer is indebted to Professor W. Le Conte Stevens, of Brooklyn, for a hint on this point. Professor Stevens has found that some of the lava pinhole burner tips used in certain kinds of gas stoves answer admirably for this purpose, and cost very little. A tip with a round, smooth hole is to be selected. The bore of the tip is here shown tapering. Its smaller diameter is 0·035 inch. The burner is supported in the manner shown in Figs. 1 and 2 or in any other convenient manner, and gas under a suitable pressure flows through and is ignited. The flame will be tall and slender as shown in Fig. 1. By regulating the gas pressure carefully, an adjustment will be reached at which the flame will be on the verge of flaring. A very slight increase of pressure beyond this point will cause the flame to shorten and roar. When the flame is at the point of flaring, it is extremely sensitive to certain sounds, particularly those of high pitch. A shrill whistle or a hiss will cause it to flare. The rattle of a bunch of keys will produce the same result. It will respond to every tick of a watch held near it.

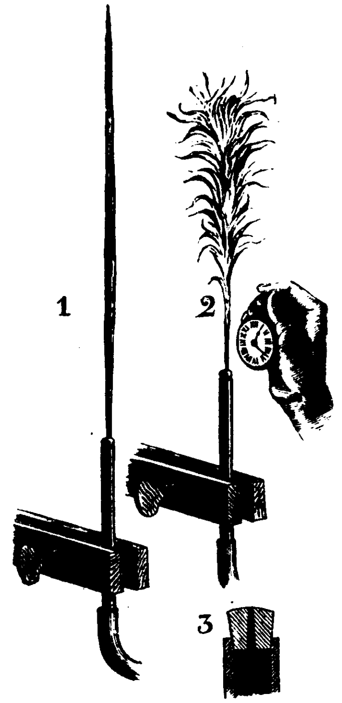
Tyndall says that when the gas pressure is increased beyond a certain limit, vibrations are set up in the gas jet by the friction of the gas in the orifice of the burner. These vibrations cause the flame to quiver and shorten. When the flame burns steadily, any sound to which the gas jet will respond will throw it into sympathetic vibration. Experiment has demonstrated that the seat of sensitiveness of the flame is at the base of the flame, at the orifice of the burner.

The method of producing the required gas pressure illustrated in Fig. 4 is available when gas bags or cylinders of compressed gas are not to be had. A tin cylinder of about 15 gallons capacity is provided at the top and bottom with valves. The lower valve is connected with a hydrant, and the cylinder is filled with water, while the upper valve is left open to allow of the escape of air. When the cylinder is filled with water, the supply is shut off and a tube from a gas burner is connected with the upper valve and the gas is turned on. Then the water is allowed to escape from the cylinder, thereby drawing in the gas. When the cylinder is filled with gas, the valves are closed and the lower one is again connected with the hydrant, while the upper one is connected with the pinhole burner. The valves on the cylinder are again opened and water is admitted at the rate required to produce the desired gas pressure. Only two precautions are necessary in this experiment; one is to avoid a mixture of air and gas in the cylinder by driving out all the air, the other is to avoid the straining of the cylinder by water pressure.

Another sensitive flame, which has several advantages over the one described, is shown in Fig. 5. It requires no extra

gas pressure, and it is more readily controlled than the tall jet. It was discovered by Mr. Philip Barry, and the discoverer's letter to Mr. Tyndall concerning it is found in Tyndall's work on sound. In the production of this flame a pinhole burner, like that already described, is employed. Two inches above the burner is supported a piece of 32-mesh wire gauze, about 6 inches square. The gas is turned on and lit above the wire gauze. It burns in a conical flame, which is yellow at the top and blue at the base. When the gas pressure is strong, the flame roars continuously. When the gas is turned off, so as to stop the roaring altogether, the flame burns steadily and exhibits no more sensitiveness than an ordinary flame. By turning on the gas slowly and steadily, a critical point will be reached at which almost any noise will cause it to roar and become non-luminous. Any degree of sensitiveness may be attained by careful adjustment of the gas supply. A quiet room is required for this experiment. The rustle of clothes, the ticking of a clock, a whisper, a snap of the finger, the dropping of a pencil, or in fact almost any noise, will cause it to drop, become non-luminous, and roar. It dances perfect time to a tune whistled *staccato* and not too rapidly.

The flame at its base presents a large surface to the air, so that any disturbance of the air sets the flame in active vibration.—*Scientific American.*



BURNER FOR SENSITIVE FLAME.

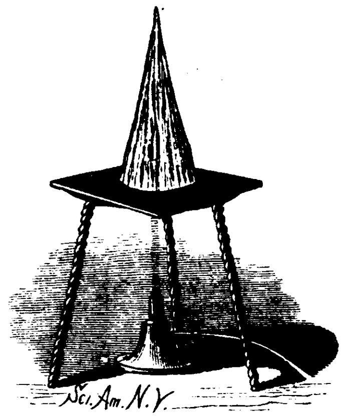


FIG. 5.—SENSITIVE FLAME WITH GAS AT ORDINARY PRESSURE.

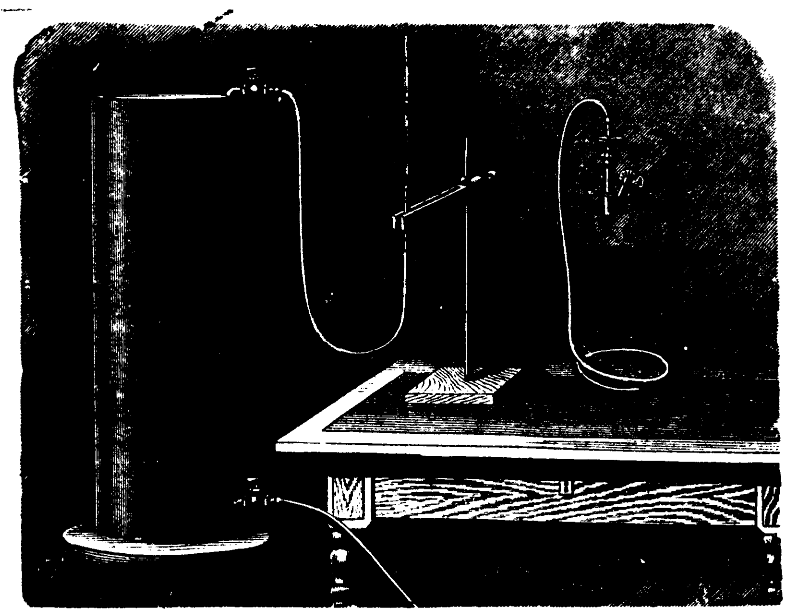
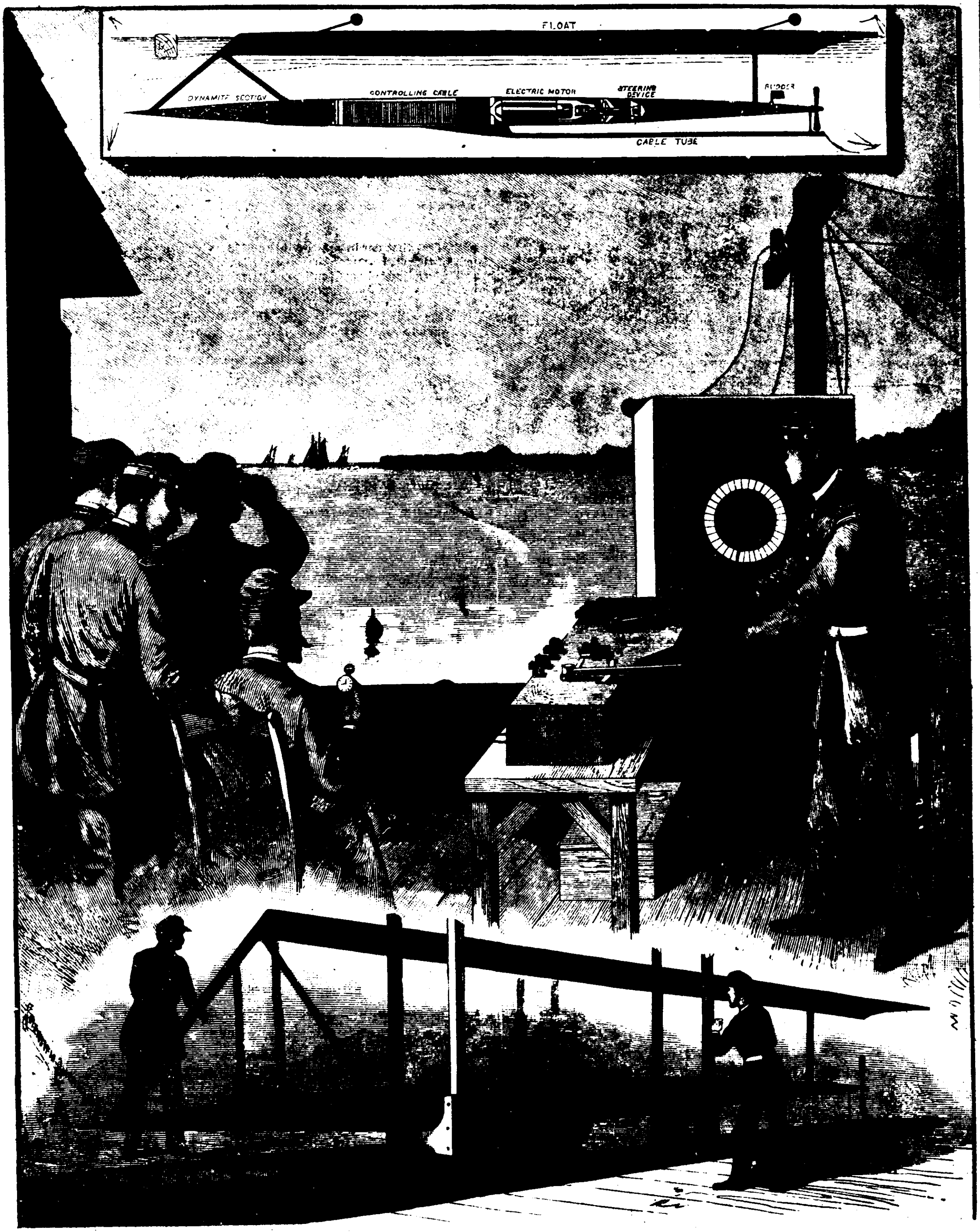


FIG. 4.—APPARATUS FOR PRODUCING GAS PRESSURE FOR THE SENSITIVE FLAME.



THE SIMS-EDISON ELECTRIC TORPEDO.

SIMS-EDISON TORPEDO.

It has been stated on good authority that the property exposed to destruction in the principal seaports of the Atlantic and Pacific coasts cannot be less in value than five thousand millions of dollars. To this must be added an incalculable amount of property dependent for its use and value on these seaports. It would be impossible to estimate the damage that might be done to New York City alone by a hostile naval attack, notwithstanding all the fortifications and offensive and defensive appliances within and around the city.

It is now pretty generally admitted that fortifications, of whatever nature, are of no great value in coast defense. Resort must be had to mines, torpedoes, and floating batteries, but it cannot be assumed that New York or any other port of the United States is adequately protected by any of these means. It is equally true that, should an emergency arise which would demand immediate and powerful coast defenses, the seaports would be practically at the mercy of the enemy. It would be impossible with the available facilities to construct additional batteries, gun boats, or even heavy guns within the space of several years. It is therefore evident that resort must be had to some other means for coast defense.

It is, perhaps, unnecessary to describe the different projects proposed from time to time for the protection of our harbors and cities, as all or nearly all of them have been illustrated and described in the pages of this journal. There is one device, however, which seems eminently worthy of the attention of the authorities, since it has novel features which distinguish it from all other devices for the same purpose. We refer to the Sims-Edison electric torpedo, the invention of Mr. W. Scott Sims and Mr. Thomas A. Edison.

This invention forms the subject of our front page illustration, in which the lower figure is a perspective view of the torpedo, the upper figure a longitudinal section, and the central figure is a sketch of one of the experiments with the torpedo.

The torpedo consists of a submerged portion attached to a float having the form of a boat. The submerged portion is a spindle-shaped copper shell containing the propelling machinery, a cable by which the current is conveyed to the electric motor and steering apparatus, and a charge of dynamite or other explosive.

The spindle-shaped shell is connected with the float at the bow by means of a triangular steel frame, and at the stern by a post and an angled bar. The float, which is of copper, is made air tight and filled with buoyant material, so that if it should be perforated it will still be able to sustain the submerged part. The triangular frame which connects the two parts at the bow extends up over the top of the float, and serves to either lift obstacles with which the torpedo comes in contact or to depress the torpedo, enabling it to run underneath the obstruction.

The spindle-shaped shell is divided into four compartments by transverse bulkheads. The forward compartment contains dynamite, the second is vacant, the third contains the electric cable which conveys the current to the propelling and steering apparatus, also to the mechanism for exploding the dynamite. The fourth compartment contains an electric motor of 40 horse power, also the electric steering apparatus. The armature shaft of the motor is connected through a system of gearing with the shaft of the propeller, which extends through the stern of the shell, and is provided with a two-bladed screw.

The float is provided with a pair of short folding masts having spherial heads, the masts, when elevated, serving as guides to the manipulator on shore in steering and discharging the torpedo. The cable is carried by the torpedo, and one of its ends is permanently connected with the various electrical parts of the torpedo, while the other end is connected with the switch upon the shore or upon a vessel or float from which the torpedo is launched and managed. By this arrangement the dragging of the cable by the torpedo along the bottom is avoided.

The amount of dynamite carried by this torpedo is from 250 to 500 pounds, according to the size, and the length of the electric cable varies from 6,000 to 11,000 feet. The screw propeller is thirty inches in diameter, and the motor has sufficient power to drive the torpedo at a high speed. The electrical steering gear perfectly controls the movements of the torpedo, and the speed is regulated by a rheostat on shore. It is stated, not officially, however, that this torpedo has attained a speed of over twenty miles per hour during some of the tests.

When the torpedo arrives at its destination, it is exploded by the manipulator through the medium of the electric current.

The several points of superiority claimed for the Sims-Edison torpedo, as regards its thorough adaptability to offensive and defensive naval warfare, are as follows:

It is moved by a practically inexhaustible power generated outside of the torpedo itself and transmitted from a place of comparative safety from the shore or on shipboard. Its movements, whether ahead, to port or starboard, in the direction of the altered or changing course of an enemy, or on its return, are directed and controlled by the intelligent will of an operator in a place of safety, nothing being left to blind chance.

It cannot be stopped by obstructions, as it may be deflected to the right or the left, or it may be made to return at will, while by its own automatic action it clears the way of cables, chains, spars or rafts, or passes under the obstructing object. It is portable, light, and of a convenient size, and being made in four small sections, is easily stored on land or on shipboard, and it can be taken apart and put together in a few minutes.

The explosive charge being submerged, it is out of the way of shot and shell.

For land fortification, it is proposed to have the Sims-Edison torpedo anchored by means of electric cables, at different parts of ports, or in bomb-proof canals with lock-gates, where also will be placed the steam engine, boiler, dynamo machine, and the operators for working them. The operators will receive orders by telephone or otherwise from sentinels, pilots, or watchmen stationed for that purpose. In such cases the operators and the machinery for generating and transmitting the power will at all times be in a place of safety, and the torpedo and its appurtenances under complete control.

For naval offensive purposes, it is proposed to have one or more of the Sims-Edison torpedoes travel with its own power, about 100 feet ahead of or off from the side of a steam war vessel, the torpedo being attached to the vessel by electric snap cables, the pilot of the vessel having control of the movements of the torpedo. By this arrangement the Sims-Edison torpedo may travel any required distance at sea, and when wanted for action, it may be released and sent off at once and under full speed, saving the time that would be consumed in launching from a vessel when preparing for action or when under fire. This maneuver is possible only with this torpedo, for the reason that its propelling power is not within itself, but with the operator, and being without limit as to quantity, is never exhausted. All other torpedoes contain their propelling power within themselves, which, being limited in amount, is soon expended. They must therefore, be launched while the vessel is in front of an enemy at short range, and while preparing for action or actually under fire. Although the Sims-Edison torpedo can be used for any war-vessel, it is desirable that naval vessels should be built whose principal armament should consist of these torpedoes, and which should have sufficient speed to overtake the heavy ironclads and then easily destroy them with the torpedo. Such a vessel would also form a valuable agency for clearing a channel or coast line of fixed mine torpedoes, by the process known as countermining.—*Scientific American.*

AN EVIL SYSTEM.

BY ARTHUR LEE.

The manner in which a nation is housed has a direct effect upon the physical condition and the moral tone of the people. It needs no argument to prove that a badly-built house is injurious to the health of its inmates, or that a home with squalid surroundings is a direct incentive to intemperance. It seems a mere platitude to assert that the houses in which we live should be built well and under the most economical conditions. If this assertion seems a too self-evident proposition to be further laboured, it is somewhat wonderful that the system which we have adopted tends directly to an opposite result. The great mass of the houses which are built as residences for the middle and lower classes are the work of men who are known as speculative builders. Many of them are men of experience and capital who are quite worthy of the trust which is confided to them. But it is not too much to say that they are so in spite of the system under which their business is generally conducted. This system is one which discourages the builder with capital, and encourages the man of straw. It invites men to embark in a trade of which they have no knowledge, to the injury of men of experience and proper training. It encourages the dishonest schemer at the expense of the honest trader. It enormously increases the cost of the housing of the people. It sets a premium upon bad building. It is wasteful and extravagant to the last degree, and the injury which it works can hardly be overestimated.

The root of the evil lies in the fact that the builder is usually only the nominal owner of the houses which he builds. The real owner is, in the first place, the financier who finds the money for wages and material which cannot be obtained on credit, and eventally the capitalist who invests in what is known as a permanent mortgage, and who relieves the financier of the responsibility which he has temporarily assumed. The mischief is that the nominal owner is sufficiently owner to build practically as he likes, provided that a certain outside appearance is kept up, and the temporary real owner is not sufficiently interested to employ the same amount of skilled supervision which is found necessary in ordinary building operations which are carried out by contract. Thus it is that our warehouses and places of business are better built than the houses in which we live. But if skilled supervision is needed in the one case, it is much more needed in the other. The average contractor who builds under the supervision of an architect and clerk of works is a skilful man with some knowledge of his business. The speculating builder is too often a half-taught mechanic, who is entirely without capital or proper experience. His principal aim is to obtain as much money by way of mortgage for as little expenditure in the form of ready money as possible.

The extravagance of the present system is frightful. The nominal owner is the catspaw of the real speculator, and is the instrument through whom the latter rakes in his gains. Goods obtained on credit by the one are at once pledged to the other for something less than their real value. So long as investors can be found to lend money upon mortgage who will provide sufficient funds to repay the financier the amount of his advances plus his profits, and so long as this arrangement will provide the catspaw with enough to pay his creditors, so long may the process be repeated, to the certain profit of the middleman. But there comes a time when the investor gets shy of endeavouring to obtain an income out of houses which cost their rent in repairs, or the catspaw can no longer obtain the credit which alone makes him useful to the speculating financier. Then the latter seizes the property of his unfortunate debtor, who seeks shelter in the Bankruptcy Court to pay no dividend to his trade creditors. The result is that a trade which is one of the most important in the country, one in which the annual turnover amounts to many millions sterling, is rotten to the core. Every description of material which is used for building purposes is raised in price by the percentage of risk, which is added to the ordinary trade profit. Houses are badly built. The services which could be rendered to the nation by our skilled professional men are lost. Every householder pays more for a badly-built house than he would pay for one properly constructed, if our building operations were carried on under better conditions. No single class is benefited except the army of speculating financiers, whose gains amount to a tax upon the whole community. The evil of the present system must be admitted. What is the remedy?

Something might be done by an Act of Parliament which would make it compulsory for all houses to be built under skilled supervision. The administration of drugs for the cure of diseases is placed in the hands of duly qualified practitioners. The building of dwellings for human habitation is fenced about by no such safeguard, although badly-built houses are too frequently the cause of the disease which the medical man is called in to cure.

The comfort and health of the people are concerned in this question, which demands the attention of the Legislature. Intimately connected with it is the whole status of the architectural profession. It is manifest that if skilled supervision is made compulsory there must be no doubt about the qualification and good faith of the men to whom so important a trust is given. The examination of architects and the infliction of penalties for non-professional conduct should be vested in some authority in which confidence can be placed, and it should be made as illegal for non-qualified persons to act as architects as it is for them to act as lawyers or as medical men. But the most effective remedy would be to make a mortgage of unfinished house property void against trade creditors. Under the existing law every stick and stone put into a building may be promptly pledged to one creditor to the exclusion of all others. It is this fact which affords opportunity to penniless men to engage in large speculations, to the injury of a great industry. Take away the facility for the pledging of building materials, and a great step is gained.

The colossal character of the building trade of this country may be gathered from the fact that during the twenty years between 1861 and 1881 one-fifth of the whole number of inhabited houses now in existence have been built. The result of the doing away of the present evil system would be that this magnificent industry would get into proper hands, to the benefit of all classes, except a small one which deserves no sympathy. Houses might be still built as a speculation, but they would be built by capitalists who would employ experienced and respectable men to build by contract. The skill possessed by trained members of the architectural profession, which is now, in great measure, a wasted power, would be brought into full requisition. The class of people who now invest money upon mortgage would know that they did so upon property which would be worth the holding. The reputation of the architect engaged in the transaction would be at stake. The people would be better and more cheaply housed. The cost of proper supervision and of work which was not scamped would be more than compensated for by the increased economy of a system which would make credit given to a builder an ordinary trade risk. The change would be beneficial to every respectable member of the building trade, to whom the penniless speculator is an unmitigated evil.

It is nothing short of a scandal that a trade of such vast proportions—of such importance to the health and comfort of every man, woman, and child in the country—should be allowed to remain in its present evil plight.—*Building News.*

FIG. 5.

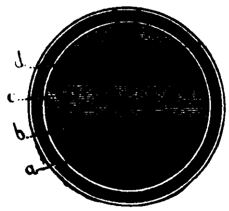
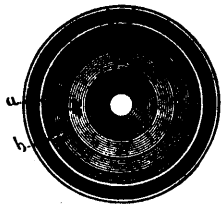


FIG. 6.



ACTION OF CENTRIFUGAL FORCE ON LIQUIDS.

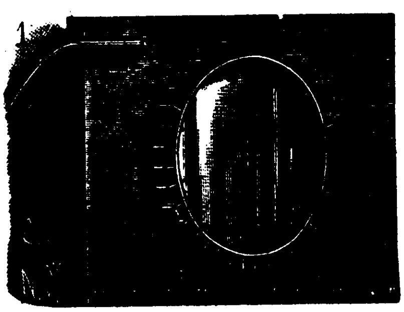


FIG. 1.—ROTATOR FOR THE LANTERN.

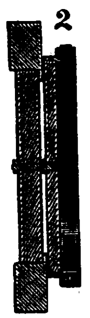


FIG. 2.—SECTION OF ROTATOR.

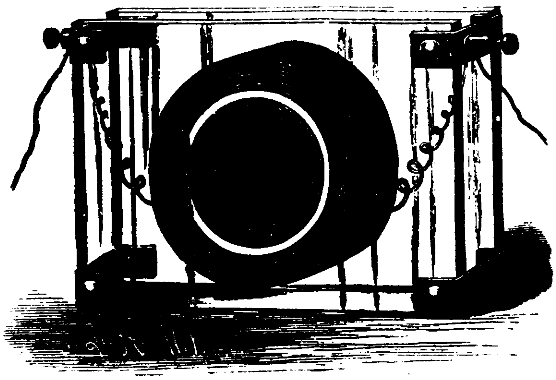


FIG. 7.—EFFECT OF A HELIX ON SUSPENDED PARTICLES OF IRON.

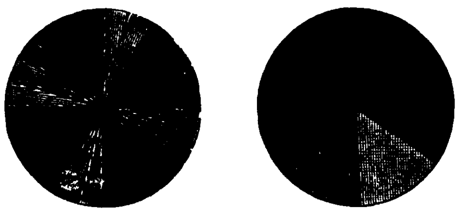


FIG. 3.—NEWTON'S DISKS.

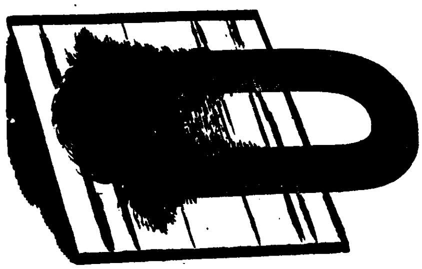


FIG. 8.—THE MAGNETIC FIELD.

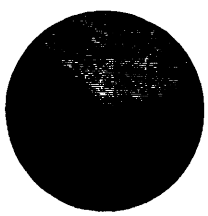


FIG. 4.—BREWSTER'S DISK.

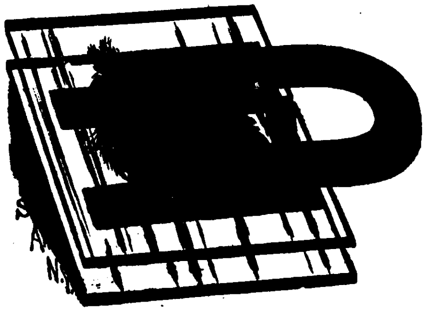


FIG. 9.—EFFECT OF AN ARMATURE ON THE MAGNETIC FIELD.

FIG. 10.—MAGNETIZATION BY LOADSTONE.

SIMPLE EXPERIMENTS IN PHYSICS.

BY GEO. M. HOPKINS.

A simple and efficient rotator, in which the means of communicating rotary motion does not appear on the screen, is shown in Figs. 1 and 2. In this apparatus a glass wheel, provided with a brass rim, is furnished with a shaft, which turns in a hole bored in the centre of a thick glass supporting disk. The brass rim of the wheel is provided with a series of radial vanes, also with three clamping screws bearing on springs in the interior of the rim for clamping the objects to be rotated. A nozzle attached to the back piece is arranged to direct a jet of air upon the vanes, and thus cause the glass wheel to revolve. A Fletcher blow-pipe bellows furnishes a suitable blast for this purpose.

To the rim of the glass wheel are fitted disks for blending colors. Among these are Newton's disks, Fig. 3, in one of which the colors of the spectrum are four times repeated, also a Brewster's disk. These disks are made by attaching colored films of gelatine to glass, or by tinting the glass by means of colored lacquer. The rotator is also provided with a circular cell filled with the liquids of different densities, to which allusion has been made in a previous article. This cell, when at rest, appears as in Fig. 5, and when in motion as in Fig. 6, the different liquids being compelled to assume certain relations with each other by centrifugal force, the heavier liquid, *a*, taking the position as far from the centre of rotation as possible, the liquids, *b c d*, arranging themselves in the order of their densities.

The effect of a helix on particles of magnetic material suspended in a liquid is shown in the experiment illustrated by Fig. 7, which is arranged for projection or for individual observation. A short section of glass tubing, 2¼ inches in diameter and ⅝ inch long, is ground true and smooth at its ends and clamped between two plates of glass with intervening rings of elastic rubber. Before clamping the parts together, one end of the glass tube is cemented to the packing ring, which in turn is cemented to the glass, and a small quantity of fine iron filings is placed in the cell, the cell is filled with a fifty per cent. solution of glycerine and alcohol, and a helix formed of five or six layers of No. 16 magnet wire is placed upon the glass tube. The remaining packing ring is placed on the end of the glass tube, the second glass plate is put in position, the clamps are applied, and the apparatus is ready for use. This method of making the cell leaves an air bubble, which is needed to allow the liquid to expand freely.

By thoroughly agitating the liquid, the iron filings will be evenly distributed throughout the cell, and they will be prevented from falling immediately by the viscid nature of the solution.

When four or five battery cells are connected with the helix, the iron particles arrange themselves radially or at right angles to the wire surrounding the cell.

The effect produced in the magnetic field by the presence of an armature is shown by the lantern experiments illustrated in Figs. 8 and 9.

In Fig. 8 is shown a permanent magnet having the form of a field magnet of a dynamo. This magnet is cemented to a plate of glass. When the magnet thus arranged is placed in a vertical lantern, with the glass uppermost, and a few fine iron filings are sprinkled on the glass, the usual magnetic curves are formed. The lines will extend straight across from one polar extremity of the magnet to the other, and at the ends will be formed symmetrical, approximately semi-circular curves. When a cylindrical piece of iron, representing the armature core of a dynamo, is inserted between the poles of the magnet in the place usually occupied by the armature, the lines are deflected inward, becoming perpendicular to the periphery of the armature. The iron representing the armature is cemented to a second plate of glass. The iron particles arrange themselves in a more pronounced figure if the glass plate upon which they are sprinkled be jarred slightly.

A very simple, pleasing, and at the same time instructive lantern experiment is illustrated in Fig. 10. A loadstone, supported by a brass wire from the baseboard is arranged to project into the field of the lantern without showing the wire. Under the loadstone is placed a small cup filled with fine iron filings, and also in the field of the lantern. An unmagnetized needle is dipped in the filings and removed, showing that it has no power to lift the filings; then while it is still in th field of the lantern, the needle is rubbed across the end of the loadstone and dipped the second time into the filings. This time the needle takes up a quantity of the filings, showing that the loadstone has imparted magnetic properties to the needle.

To render this experiment complete, an erecting prism must be used to cause the image to appear right side up on the screen.—*Scientific American.*

TETANUS TREATED BY ABSOLUTE REST.

Prof. Renzi, of Naples, records several cases of tetanus successfully treated by absolute rest. The method advocated is as follows:

The patient's ears are closed with wax, after which he is placed in a perfectly dark room far from any noise. He is made to understand that safety lies in perfect rest. The room is carpeted heavily in order to relieve the noise of stepping about. The nurse enters every quarter of an hour with a well shaded lantern, using more the sense of touch than sight to find the bed. Liquid food (milk, eggs in beef tea, and water) are carefully given, so that mastication is not necessary. Constipation is not interfered with. Mild doses of belladonna or secale are given to relieve pain. This treatment does not shorten the disease, but under it the paroxysms grow milder, and finally cease. Numerous physicians attest to the value of this treatment.—*Bulletin Med.*

Copper may be hardened by melting with it and thoroughly stirring into it from one to six per cent of manganese oxide. The other ingredients for bronze may then be added.

THE QUEST OF GOLD.

Independent researches in many parts of the world have conclusively shown that much so-called "alluvial" gold has not been deposited by flowing water, but by water in its solid form, viz., by glaciers. In British Columbia, in the Northwest Territory of Canada, in Nova Scotia, and in New Zealand are many gold placers formed by glacial action. In North Carolina, Professor Kerr, the State geologist, attributes square miles of auriferous gravels to "frost drift" or "earth glaciers," *i.e.*, to the effects of repeated frost and thaw in decomposing the rocks, and then by alternate expansion and contraction causing their detritus to rearrange its component parts. Even in tropical Brazil, the golden *canga* represents what is left of the glacial moraines and *debris* of a past geological epoch. Finally, to come nearer home, gold is found in the "till" on the flanks of the celebrated Lead hills of Scotland. Quite recently it has been claimed that some of the Californian "gravels" are not gravels in the true sense of the word, but that they are partly due to mud volcanoes, much of the accumulated matters being angular instead of rounded, as they are in riverine deposits.

Whatever the means by which the placer gold has been conveyed to its present bed, it can only have had one source—mineral veins. At one time it was the fashion to suppose that vein gold would be found only in quartz rocks of Silurian age, but though such formations do afford a large proportion of vein gold, there are many other minerals which carry gold—notably calcite—and scarcely a rock formation in which one could safely predict its absence. As to how the gold got into the mineral veins there are many plausible theories—in solution, by decomposition, by condensation of vapors, etc. Probably all these may have had their share in its production. Certain it is that gold has been found in solution in sea water, and in native crystals, in the pores of lava which has been ejected within historic fame.

Vein mining entails greater expense than gravel mining, because the underground workings are more extensive and more difficult, and when the vein stuff has been mined, the hidden gold can only be got out by the aid of costly machinery, designed to execute in a few hours that which, if left to natural agencies, would occupy many years. Thus a percentage of gold that would be remunerative in a placer would not pay in a vein, but veins are more enduring, and now afford the chief supplies of the precious metal.

When all the circumstances are favorable, gold mining and milling are sufficiently simple operations, but a vast number of enemies arise to trouble the mill man. Two of the worst are known as "float gold" and "floured mercury," and so many shareholders have been robbed of their dividends by these obstructive agents that they will probably be glad to know something of their birth and history. It must be told, then, that sometimes the gold occurs in particles so infiniteismally minute that they will actually float on running water, and thus get carried away with the refuse, despite all contrivances devised to arrest them. In the case of vein gold, this evil is often increased by the hammering action of the stamps, which flattens the grains and augments their buoyancy. By the stamping process also the surfaces of the grains get covered with a silicious coat, due to impalpable quartz powder which is hammered into the yielding metal. This skin prevents proper contact between the gold and the mercury, hence such grains escape amalgamation ; even gold which has been simply hammered shows, for some inscrutable reason, a very reduced affinity for mercury. Much gold is naturally coated with oxide of iron, or contaminated with a talcose mineral, or with shale oil, or with steatitic matter, all which are more or less inimical. Even dirty water used in the mill will cause an objectionable sliminess which must be guarded against. Then no ore is quite free from sulphurets (compounds of sulphur with the base metals—iron, copper, lead, zinc, antimony), which rapidly destroy the activity of the mercury by dulling its surface and causing it to break into tiny particles, known as "flouring" or "sickening." Frequently these sulphurets form a considerable portion of the product and contain much of the gold, whose extraction from them is no longer a mere mechanical process, but involves roasting, treating with chemical solutions, and other intricate and delicate operations known to metallurgists. Many a mine really depends for its success upon the adoption of the most suitable method for dealing with the sulphurets, and that method is not always discovered in time to save the company from liquidation.

Sufficient has been said to show that modern gold mining is a highly scientific industry, demanding capital and skill. A rich ore is by no means synonymous with large profits. The presence of gold is a necessary element of success, but equally essential elements are the tractable character of the ore, the situation of the mine, the supply of water and fuel, and the labor question. The problem is a commercial one, how much gold can be got from a ton of ore, and at what cost? To illustrate this by one example. Many mines assaying over 1 ounce (20 pennyweights) of gold per ton have failed to pay. On the other hand, a well known Australian mine since 1857 has raised over a million tons of quartz, the bulk of which averaged only 6½ dwt. per ton, and some less than 4 dwt., yet it has yielded gold to a value approaching two million pounds sterling, and has repaid the original capital many times over in dividends.

One of the great charms of gold mining as an investment is that the market value of the product is constant, there are no fluctuations in the price of gold as there are in those of other metals, hence a soundly established undertaking can never fail through depressed markets. Only get your gold, and it will sell itself.—*Gentleman's Magazine.*

THE BRAIN IN SLEEP.

BY DR. FELIX L. OSWALD.

Sleep is a process of restoration and readjustment, and physicians well know that the healing powers of nature assert themselves most effectually during the entire suppression of volitional control characterizing a deep slumber. In dreams, too, the absence of direct sense impressions and volitional interference seem to favor an automatic function of the brain which, in that respect, might be defined as a method of mental digestion. And just as the process of physical digestion and assimilation eliminates the superfluous elements of food, retaining only those needed for the special purposes of the organism, the brain, during sleep, appears to deal specially with topics of direct concern for the personal interests of the sleeper, and to assort and adjust the store of empiric impression (the mental *ingesta*, as it were) after eliminating all unessential and inconsequential elements. Withal, the suspense of conscious cerebration by no means implies an eclipse of the intellectual faculties.

Dreams are not limited to plays of fancy ; the brain in slumber may deal with philosophical and abstrusely scientific speculations, or resolve moral doubts which perhaps have puzzled the mind for days, and it is a common experience that the distressing problems of practical life adjust themselves, as it were, in sleep, by a more or less conscious process of the cerebral laboratory. In short, there is no doubt that the instinct guarding the welfare of the individual presides over dreams as it presides over the automatic functions of the physical organism. The very suspension of the will-power, with its passions and prejudices, seems, indeed, to enable an inner monitor to decide vexing doubts in accordance with the best permanent interests of the sleeper.

The saving crisis of dangerous diseases which often supervenes in deep slumber may be explained by the circumstance that the complete repose of the volitional faculties enables the organism to concentrate all its energies upon a needed work of repair, and for similar reasons the non-interference of waking prejudices may give the instinct of self-preservation a long-desired chance for removing a baneful delusion as to our best interest in a proposed mode of action, or as to the true character of designing fellow-men. Something or other in the looks or actions of a marked rascal may have suggested a suspicion of his secret motives, though at the time collateral circumstances observed that misgiving, leaving only a vague, unexplained uneasiness as the direct result of such experiences. But in sleep that impression reasserts itself with a force free from the interference of prejudice, and for a moment removes the mask of false appearances ; "the sleeper receives a warning." Similar warnings often correct the impression of false hope. Impending perils may cast a shadow persistently ignored in a waking state, while the mind is calmed by the influence of a self-deluding optimism—the wish that is father to the belief in the insignificance of the threatening danger. But in sleep the voice of the monitor cannot be silenced by such illusions, and warning forebodings often take the form of distinct visions, repeated with a vividness and frequency which at last cannot fail to influence the actions of the individual, in spite of all waking sophisms.

ATMOSPHERIC PRESSURE ON STEAM PRESSURE.

The question of the effect which the pressure of the atmosphere exerts on the walls of a steam boiler having excited considerable interest in certain circles in the East, a correspondent of the Boston *Journal of Commerce* propounds the following questions to that journal :—

1. Suppose that a boiler is placed near the level of the sea, and fired up, and the safety valve set to blow off at 60 pounds, weight of atmosphere 15 pounds. If this boiler is transported to Denver, Col., without changing the weight on the lever, would it blow off at 60 pounds as before, assuming the pressure of the atmosphere to be nine pounds ?

2. If a boiler is just strong enough to withstand a pressure of 50 pounds near the sea, if taken to Denver, would it burst under the same pressure by gauge ?

3. Would the ordinary spring steam gauge register the same pressure at both places, provided it was the same in the boiler, or would the weight of the atmosphere make a difference ?

The editor of the *Journal* answers as follows : A steam gauge indicates the unbalanced pressure in a boiler, the difference between the absolute pressure inside and out, and 60 pounds unbalanced pressure is the same no matter where a boiler is situated. A boiler is exploded by the unbalanced pressure, and if sunk to the bottom of the ocean it would require an enormous absolute pressure to explode it, because the pressure outside would be so great. The same unbalanced pressure would explode it, however. It is by a difference in pressure or unbalanced pressure that we make steam do work, consequently it is idle to consider the question in any other way. Replying then to your first inquiry, a safety valve blows off at a certain unbalanced pressure, and will blow off when gauge indicates 60 pounds at Denver, Col., as at the sea coast ; the absolute pressure required, however, would be by your figures six pounds less. To your second question, yes. Third question : The gauge would register the same unbalanced pressure, but if you intend the words "same pressure" to mean same absolute pressure, the gauge would register higher an amount equal to the difference in weight of the atmosphere at the two places. It is like weighing one's self on a pair of scales on which a weight is already standing, and then on another pair on which stands a less weight. Our weight does not change although the beam records a greater weight in one case than the other. A steam gauge records, a safety valve blows off, and a boiler explodes at a corresponding net pressure in one place as another.

THE FUTURE OF ELECTRICITY.

Thomas A. Edison said in an interview with a reporter of the Pittsburg *Despatch* : "You ask me about the future of electricity. It is the coming motive power. It will be used on all the railroads some day, but the point is to get an economical engine. My theory is to have immense dynamos located all along the line of the road, and have the electricity conveyed from these stationary engines to the locomotives by wires through the rails. For example, I would put two big engines between New York and Philadelphia, and enough power could be furnished to whisk the limited at the rate of 100 miles per hour.

"But this is the point I have been working on for years—to convert heat directly into electricity without the intervention of boilers, steam and all that. What an enormous amount of expense could be saved if this could be done ! Think of putting something into the heat of that natural gas fire and making electricity out of it. It can be done. I feel it in my bones, and just now I have a suspicion that I am on the right track ; but it is a pesky problem—one that can be worked out only in time.

"I have been experimenting with an electric road in New Jersey. I had rails laid as they put them down on railroads, but the machine would run off the track in going around the curves. I then raised the curve to an angle of 40 degs., and the motor went around all right. It looked as if the engine would topple over, but it didn't. You know in a centrifugal machine you can make a car go clear around a circle in the air without leaving the track.

"At the present time the phonograph is occupying my time. I have been improving it, and it is more perfect to-day than ever. In speaking into the phonograph it was soon found that the sibilants were not recorded. For instance, if I were to say 'species' the 'sp' sound would be lost. Well, I have about solved the problem now, and the sound of 's' is inscribed with the other letters. I run the phonograph or graphophone in three ways—with a treadle, a battery, or with the ordinary incandescent light by attaching the machine with a wire to the lamp. Business people can have their choice. I shouldn't want to be bothered with a treadle, and I think the best plan is to use the electric light, since they are now so commonly distributed. The battery is made to last for a month, three months, or six months, without being renewed. Let every man take his choice. I am making the three kinds."

SECONDARY BATTERY.

BY GEO. M. HOPKINS in the *Scientific American*.

Probably no secondary battery can be more readily made or more easily managed than the one invented by Plante. It is therefore especially adapted to the wants of the amateur who makes his own apparatus. It takes a longer time to form a Plante battery than is required for the formation of some of the batteries having plates to which the active material has been applied in the form of a paste, and its capacity is not quite equal to that of more recent batteries, but it has the advantage of not being so liable to injury in unskilled hands and of allowing a more rapid discharge without injury.

Each cell of the battery consists of 16 lead plates, each 6x7 inches and 3-32nd inch thick, placed in a glass jar 6x9 inches, with a depth of 7½ inches. Each plate is provided with an arm 1½ inches wide and of sufficient length to form the electrical connections. The plates are cut from sheet lead in the manner indicated at 3 in Fig. 1, *i.e.*, two plates are cut from a sheet of lead 8½x14 inches. This method of cutting effects a saving of material. The plates after being cut and flattened are roughened. One way of doing this is shown in Fig. 2. The plate is laid on a heavy soft wood plank and a piece of a double cut file of medium fineness is driven into the surface of the lead by means of a mallet. To avoid breaking the file, its temper is drawn to a purple. After the plate is roughened on one side it is reversed and treated in the same way upon the opposite side. If a knurl is available, the roughening may be accomplished in less time, and with less effort, by rolling the knurl over the plate. Half of the plates are provided with four oblong perforations into which are inserted H-shaped distance pieces of soft rubber, which project about ⅛ inch on each side of the plate. The perforated and imperforate plates are arranged in alternation, with all of the arms of the perforated plates extended upward at one end of the element and all of the arms of the imperforate plates similarly arranged at the opposite end of the element. The plates are clamped together by means of wooden strips—previously boiled in paraffine—and rubber bands. The strips are placed on opposite sides of the series of plates at the top and bottom, and the rubber bands extend lengthwise of the strips.

The arms of each series of plates are bent so as to bring them together about 3 or 4 inches above the upper edges of the plates. They are perforated to receive brass bolts, each of which is provided with two nuts, one for bending the arms, the other for clamping the conductor.

The element thus formed is placed in a glass cell, and the formation is proceeded with as follows: To hasten the process, the cell is filled with dilute nitric acid (nitric acid and water equal parts by measure), which is allowed to remain for twenty-four hours. This preliminary treatment modifies the surface of the lead, rendering it somewhat porous, and in connection with the roughening, reduces the time of formation from four or five weeks down to one week. The nitric acid is removed, the plates and cells are thoroughly washed, and the cell is filled with a solution formed of sulphuric acid 1 part, water 9 parts.

The desired number of cells having been thus prepared, are connected in series, and the poles of each cell are marked so that they may be always connected up in the same way. The charging current, from whatever source, should deliver a cur-

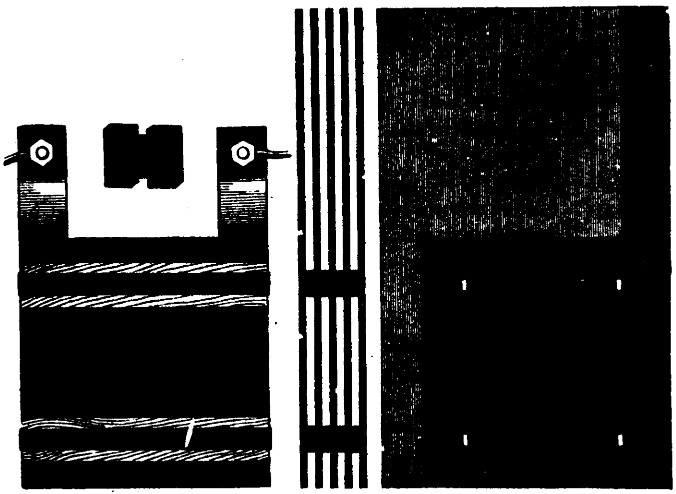


FIG. 1.—PLATES OF SECONDARY BATTERY.

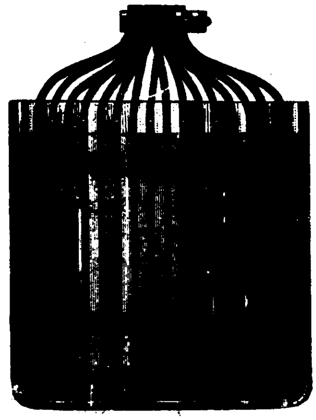


FIG. 4.—COMPLETE CELL.

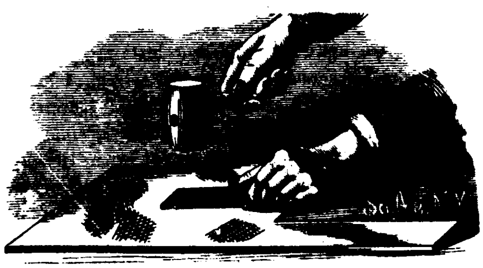


FIG. 2.—ROUGHENING THE PLATE.

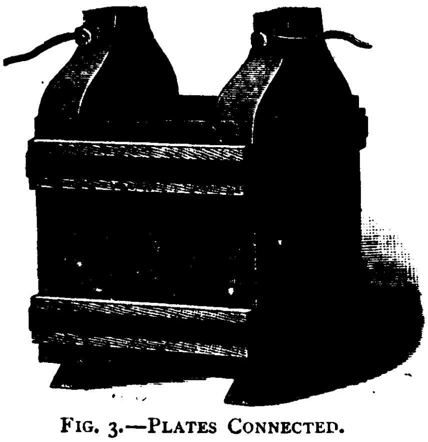


FIG. 3.—PLATES CONNECTED.

rent of ten amperes with an electro-motive force ten per cent. above that of the accumulator. Each cell of this battery has an electro-motive force of two volts, and the voltage of the series of cell would be the number of cells ×2. It is a simple matter to determine the amount of current required to charge a given series of cells. For example a battery is required for supplying a series of incandescent lamps. It has been found uneconomical to use lamps of a lower voltage than 60. It will, therefore, require a battery having an E. M. F. of 60 volts to operate even a single lamp. This being the case, at least 30 cells of battery must be provided, and on account of a slight lowering of the E.M.F. in use, two extra cells should be added. It will, therefore, require 32 cells for a small installation, and the machine for charging such a battery should be able to furnish a current of ten amperes, with an E.M.F. of 75 volts.

To form the battery, it is placed in the circuit of the dynamo and kept there for thirty hours continuously, or for shorter periods aggregating thirty hours. It is then discharged through a resistance of 20 or 30 ohms, and again recharged, the connections with the dynamos being reversed, so as to send the current through the battery in the opposite direction. The battery is again discharged through the resistance, and again recharged in a reverse direction. These operations are repeated four or five times, when the formation is complete. It will require from five to seven hours to charge the battery after it is thoroughly formed. It must always be connected with the dynamo as connected last in charging.

Although amateurs may find pleasure in constructing and forming a secondary battery, there is no economy in securing a battery in this way. It is less expensive and less vexatious to purchase from reliable makers.

REGISTERED DESIGNS FOR FIRE-PROOF RESISTANCE FRAMES.

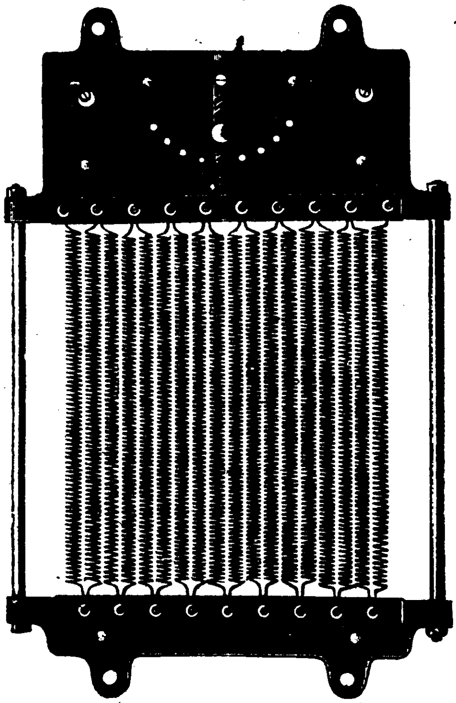
To meet the growing demand for resistance frames for regulating currents of electricity, W. T. Goolden & Co. have recently introduced some new designs of the same.

Two sizes are made, the largest about 1 foot 6 inches wide by 6 feet long, and the smallest about 1 foot wide by about 2 feet 6 inches long, the lengths of both varying, of course, according to the resistance they are required for. In the construction of the large pattern two cast iron "end frames" have wrought iron pins cast in, which carry porcelain insulators, the frames being connected by two side rods. On the porcelain insulators are hung the coils of wire, either German silver, platinoid, or galvanised iron, etc., and these are connected by screw connectors which admit of branch wires being taken from them to the regulating switch in centre. This regulating switch is an ordinary switch bar and handle, moving over a number of points fixed upon a slate disc, the whole being carried by a cast iron "bridge" piece, perfectly clear of the wire coils.

In the small pattern shown in the illustration, two cast iron end pieces and side rods form a rectangular frame, as in the larger pattern, but no pins or insulators are used. The end frames are cast hollow to receive slate tablets, the projecting edges of which carry the wire coils, and these are connected by screw bolts through the slate.

The bottom "end frame" has a semi-circular slot cast in, and the contact points are arranged therein, the switch bar being moved over these points as desired.

The small pattern is designed for dissipating 1,000 to 1,200



watts without becoming hot, and the larger pattern can be made for any current up to 8,000 to 10,000 watts.

A number of these frames are now in use, and giving satisfaction, the large pattern being used principally for shunt-wound dynamos, exciting currents for alternating machines, etc., and the small size for regulating transmission of power in motors, and for regulating the current between sets of accumulators charging in parallel, etc.

These resistance frames fully meet the requirements of the insurance companies, and in addition to being strong and substantially built, are of a neat and pleasing appearance.—*Electrical Review.*

An excellent polishing powder for gold and silver consists of burnt and finely pulverised rock alum, five parts, and levigated chalk, one part. Mix and apply with a dry brush.

If flour costs $6 a barrel, what is the value of one pound? Now to divide $6 by 196, the number of pounds in a barrel, is a tedious operation. The result may be accomplished as follows: Divide 6 by 2, calling the result cents; double this result, writing it underneath, and two places to the right of the last number; and then add the results. It is evident that with most numbers the writing of the numbers alone performs the addition. For illustration, take one example given: Divide 6 by 2, then writing the results in cents, we have .03. Doubling this and carrying it two places to the right we have .006; doubling this in turn and carrying it two places to the right we have .000012. Adding these amounts we have the following: .03061224, which is the cost per pound. This rule will be found correct to a number of places of decimals. Those of our readers who desire to test its accuracy can do so by simple division.

ON MODERN VIEWS WITH RESPECT TO ELECTRIC CURRENTS.*

BY PROFESSOR H. A. ROWLAND.

As, a short time since, I stood in a library of physical books and glanced around me at the works of the great masters in that subject, my mind wandered back to the time when the apparatus for a complete course of lectures on the subject of electricity consisted of a piece of amber and a few light bodies to be attracted by it. From that time until now, when we stand in a magnificent laboratory with elaborate and costly apparatus in great part devoted to its study, how greatly has the world changed and how our science of electricity has expanded both in theory and practice until, in one the case, it threatens to include within itself nearly the whole of physics, and in the other to make this the age of electricity.

Were I to trace the history of the views of physicists with respect to electric currents it would include the whole history of electricity. The date when the conception of an electric current was possible was that when Stephen Gray, about 170 years ago, first divided bodies into conductors and non-conductors, and showed that the first possessed the property of transmitting electric attractions to a distance. But it was only when the Leyden jar was discovered that the idea of a current became very definite. The notion that electricity was a subtle fluid which could flow along metal wires as water flows along a tube, was then prevalent, and, indeed, remains in force to-day among all except the leaders in scientific thought. It is not my intention to depreciate this notion, which has served and still serves a very important purpose in science. But, for many years, it has been recognized that it includes only a very small portion of the truth and that the mechanism by which energy is transmitted from one point of space to another by means of an electric current is a very complicated one.

Here, for instance, on the table before me are two rubber tubes filled with water, in one of which the water is in motion, in the other at rest. It is impossible, by any means now known to us, to find out, without moving the tubes, which one has the current of water flowing in it and which has the water at rest. Again, I have here two wires, alike in all respects, except that one has a current of electricity flowing in it and the other has not. But in this case, I have only to bring a magnetic needle near the two to find out in which one the current is flowing. On our ordinary senses the passage of the current has little effect; the air around it does not turn green or the wire change in appearance. But we only have to change our medium from air to one containing magnetic particles to perceive the commotion which the presence of a current may cause. Thus this other wire passes through the air near a large number of small suspended magnets, and, as I pass the current through it, every magnet is affected and tends to turn at right angles to the wire and even to move toward it and wrap itself around it. If we suppose the number of these magnets to become very great and their size small, or if we imagine a medium, every atom of which is a magnet, we see that no wire carrying a current of electricity can pass through it without creating the greatest commotion. Possibly this is a feeble picture of what takes place in a mass of iron near an electric current.

Again, coil the wire around a piece of glass, or, indeed, almost any transparent substance, and pass a strong current through the wire. With our naked eye alone we see no effect whatever, as the glass is apparently unaltered by the presence of the current; but examined in the proper way, by means of polarized light, we see that the structure of the glass has been altered throughout in a manner which can only be explained by the rotation of something within the glass many millions of times every second.

Once more, bring a wire in which no current exists nearer and nearer to the one carrying the current, and we shall find that its motion in such a neighborhood causes or tends to cause an electric current in it. Or, if we move a large solid mass of metal in the neighborhood of such a current we find a peculiar resistance unfelt before, and if we force it into motion we shall perceive that it becomes warmer and warmer, as if there was great friction in moving the metal through space.

Thus, by these tests, we find that the region around an electric current has very peculiar properties which it did not have before, and which, although stronger in the neighborhood of the current, still extend to indefinite distances in all directions, becoming weaker as the distances increase.

How great then the difference between a current of water and a current of electricity. The action of the former is confined to the interior of the tube, while that of the latter extends to great distances on all sides, the whole of space being agitated by the formation of an electric current in any part. To show this agitation, I have here two large frames with coils of wire around them. They hang face to face about 6 feet apart. Through one I discharge this Leyden jar, and immediately you see a spark at a break in the wire of the other coil, and yet there is no apparent connection between the two. I can carry the coils 50 feet or more apart, and, yet, by suitable means I can observe the disturbances due to the current in the first coil.

The question is forced upon us as to how this action takes place. How is it possible to transmit so much power to such a distance across apparently unoccupied space? According to our modern theories of physics there must be some medium engaged in this transmission. We know that it is not the air, because the same effects take place in a vacuum, and, therefore, we must fall back on that medium which transmits light and which we have named the ether. That medium which is supposed to extend unaltered throughout the whole of space, whose existence is very certain but whose properties we have yet but vaguely conceived.

I cannot, in the course of one short hour, give even an idea of the process by which the minds of physicists have been lead to this conclusion, or the means by which we have finally completely identified the ether which transmits light with the medium which transmits electrical and magnetic disturbances. The great genius who first identified the two is Maxwell, whose electro-magnetic theory of light is the centre around which much scientific thought is to-day revolving, and which we regard as one of the greatest steps by which we advance nearer to the understanding of matter and its laws. It is this great discovery of Maxwell which allows me, at the present time, to attempt to explain to you the wonderful events which happen everywhere in space when one establishes an electric current in any other portion.

In the first place, we discover that the disturbance does not take place in all portions of space at once, but proceeds outwards from the centre of the disturbance with a velocity exactly equal to the velocity of light. So that, when I touch these wires together so as to complete the circuit of yonder

* A lecture given at the College of the City of New York, May 22, 1889, before the American Institute of Electrical Engineers.

battery, I start a wave of etherial disturbance which passes outward with a velocity of 185,000 miles per second, thus reaching the sun in about eight minutes, and continuing to pass onwards forever or until it reaches the bounds of the universe. And, yet, none of our senses inform us of what has taken place unless we sharpen them by the use of suitable instruments. Thus, in the case of these two coils of wire, suspended near each other, which we have already used, when the wave from the primary disturbance reaches the second coil, we perceive the disturbance by means of the spark formed at the break in the coil. Should I move the coils further apart, the spark in the second coil would be somewhat delayed, but the distance of 185,000 miles would be necessary before this delay could amount to as much as one second. Hence the effects we observe on the earth take place so nearly instantaneously that the interval of time is very difficult to measure, amounting, in the present case, to only $\frac{1}{150,000,000}$th of a second.

It is impossible for me to prove the existence of this interval, but I can at least show you that waves have something to do with the action here observed. For instance, I have here two tuning forks mounted on sounding boxes and tuned to exact unison. I sound one and then stop its vibrations with my hand, instantly you hear that the other is in vibration, caused by the waves of sound in the air between the two. When, however, I destroy the unison by fixing this piece of wax on one of the forks, the action ceases.

Now, this combination of a coil of wire and a Leyden jar is a vibrating system for electricity and its time of vibration is about 10,000,000 times a second. This second system is the same as the first, and therefore its time of vibration is the same. You see how well the experiment works now because the two are in unison. But let me take away this second Leyden jar, thus destroying the unison, and you see that the sparks instantly cease. Replacing it, the sparks reappear. Adding another on one side and they disappear again, only to reappear when the system is made symmetrical by placing two on each side.

This experiment and that of the tuning forks have an exact analogy to one another. In each we have two vibrating systems connected by a medium capable of transmitting vibrations, and they both come under the head of what we know as sympathetic vibrations. In the one case, we have two mechanical tuning forks connected by the air; in the other, two pieces of apparatus, which we might call electrical tuning forks, connected by the luminiferous ether. The vibrations in one case can be seen by the eye or heard by the ear, but in the other case they can only be perceived when we destroy them by making them produce a spark. The fact that we are able to increase the effect by proper tuning demonstrates that vibrations are concerned in the phenomenon. This can, however, be separately demonstrated by examining the spark by means of a revolving mirror, when we find that it is made up of many successive sparks corresponding to the successive backward and forward movements of the current.

The fact of the oscillatory character of the Leyden jar discharge was first demonstrated by our own countryman, Henry, in 1832, but he pursued the subject only a short distance, and it remained for Sir William Thomson to give the mathematical theory and prove the laws according to which the phenomenon takes place.

Thus, in the case of a charged Leyden jar whose inner and outer coatings have been suddenly joined by a wire, the electricity flows back and forth along the wire until all the energy originally stored up in the jar has expended itself in heating the wire or the air where the spark takes place and in generating waves of disturbance in the ether which move outward into space with the velocity of light. These etherial waves we have demonstrated by letting them fall on this coil of wire and causing the electrical disturbance to manifest itself by electric sparks.

I have here another more powerful arrangement for producing electro-magnetic waves of very long wave length, each one being about 500 miles long. It consists of a coil within which is a bundle of iron wires. On passing a powerful alternating current through the coil, the iron wires are rapidly magnetized and demagnetized and send forth into space a system of electro-magnetic waves at the rate of 360 in a second.

Here, also, I have another piece of apparatus (a lamp) for sending out the same kind of electro-magnetic waves; on applying a match, we start it into action. But the last apparatus is tuned to so high a pitch that the waves are only $\frac{1}{50,000}$ inch long, and 55,000,000,000,000 are given out in one second. These short waves are known by the name of light and radiant heat, though the name radiation is more exact. Placing any body near the lamp so that the radiation can fall on it, we observe that when the body absorbs the rays it is heated by them; the well-known property of so-called radiant heat and light. Is it not possible for us to get some substance to absorb the *long* waves of disturbance, and so obtain a heating effect? I have here such a substance in the shape of a sheet of copper, which I fasten on the face of a thermopile, and I hold it where these waves are the strongest (near the coil while the alternating current is passing through it). As I have anticipated, great heat is generated by their absorption, and soon the plate of copper becomes very warm, as we see by this thermometer, by feeling of it with the hand or even by the steam from water thrown upon it. In this experiment the copper has not touched the coil or the iron wire core, although if it did they are very much cooler than itself. The heat has been produced by the absorption of the waves in the same way as a blackened body absorbs the rays of shorter wave length from the lamp; and, in both cases, heat is the result.*

But in this experiment, as in the first one, the wave-like nature of the disturbance has not been proved experimentally. We have caused electric sparks, and have heated the copper plate across an interval of space, but have not in either of these cases proved experimentally the progressive nature of the disturbance.

For a ready means of experimenting on the waves, obtaining their wave length and showing their interferences, has hitherto been wanting. This deficiency has been recently overcome by Professor Hertz, of Carlsruhe, who has made a study of the action of the coil, and has shown us how to use it for experiments on the etherial waves whose existence had before been made certain by the mathematics of Maxwell.

I scarcely know how to present this subject to a non-technical audience and make it clear how a coil of wire with a break in it can be used to measure the velocity and wave length of etherial waves. However, I can but try. If the waves moved very slowly, we could readily measure the time the first coil took to affect the second, and show that this time was longer as the distance was greater. But it is absolutely inappreciable by any of our instruments, and another method must be found. To obtain the wave length Professor Hertz

* The thermopile was connected with a delicate minor galvanometer, the deflections of which were shown on a screen.

used several methods, but that by the formation of stationary waves is the most easily grasped. Mr. Ames holds in his hand one end of a spiral spring, which makes a very heavy and flexible rope. As he sends a wave down it, you see that it is reflected at the further end, and returns again to his hand. If, however, he send a succession of waves down the rope, the reflected waves interfere with the direct ones, and divide the rope into a succession of nodes and loops, which you now observe. So a series of sound waves, striking on a wall, form a system of stationary waves in front of the wall. With this in view, Professor Hertz established his apparatus in front of a reflecting wall, and observed the nodes and loops by the sparks produced in a ring of wire. It is impossible for me to repeat this experiment before you, as it is a very delicate one, and the sparks produced are almost microscopic. Indeed, I should have to erect an entirely different apparatus, as the waves from the one before me are nearly $\frac{1}{4}$ mile long, the time of vibration of the system being very great, that is, $\frac{1}{10,000,000}$th of a second. To produce shorter waves we must use apparatus, tuned as it were, to a higher pitch, in which the same principle is, however, employed, but the etherial waves are shorter, and thus several stationary waves can be contained in one room.

The testing coil is then moved to different portions of the room, and the nodes are indicated by the disappearance of the sparks, and the loops by the greater brightness of them. The presence of stationary waves is thus proved, and their half wave length found from the distance from node to node, for stationary waves can always be considered as produced by the interference of two progressive waves advancing in opposite directions.

However interesting a further description of Professor Hertz's experiments may be, we have gone as far in that direction as our subject carries us; for we have demonstrated that the production of a current in a wire is accompanied by a disturbance in the surrounding space; and, although I have not experimentally demonstrated the etherial waves, yet I have proved the existence of electric oscillations in the coils of wire and the ether surrounding it.

Our mathematics has demonstrated, and experiments like those of Professor Hertz have confirmed the demonstration, that the wave disturbance in the ether is an actual fact.

The closing of a battery circuit, then, and the establishment of a current of electricity in a wire is a very different process from the formation of a current of water in a pipe, though, after the first shock, the laws of the flow of the two are very much alike. But even then the medium around the current of electricity has very strange properties, showing that it is accompanied by a disturbance throughout space. The wire is but the core of the disturbance, which latter extends indefinitely in all directions.

One of the strangest things about it is that we can calculate with perfect exactness the velocity of the wave propagation and the amount of the disturbance at every point and at any instant of time; but as yet we cannot conceive of the details of the mechanism which is concerned in the propagation of an electric current. In this respect our subject resembles all other branches of physics in the partial knowledge we have of it. We know that light is the undulation of the luminiferous ether, and yet the constitution of the latter is unknown. We know that the atoms of matter can vibrate with purer tones than the most perfect piano, and yet we cannot even conceive of their constitution. We know that the sun attracts the planets with a force whose law is known, and yet we fail to picture to ourselves the process by which it takes our earth within its grasp at the distance of many millions of miles and prevents it from departing forever from its life-giving rays. Science is full of this half knowledge, and the proper altitude of the mind is one of resignation toward that which it is impossible for us to know at present and of earnest striving to help in the advance of our science, which shall finally allow us to answer all these questions.

The electric current is an unsolved mystery, but we have made a very great advance in understanding it when we know that we must look outside of the wire at the disturbance in the medium before we can understand it. A view which Faraday dimly held fifty years ago, which was given in detail in the great work of Maxwell, published sixteen years since, and has been the guide to most of the work done in electricity for a very long time. A view which has wrought the greatest changes in the ideas which we have conceived with respect to all electrical phenomena.

So far we have considered the case of alternating electric current in a wire connecting the inner and outer coatings of a Leyden jar. The invention of the telephone, by which sound is carried from one point to another by means of electrical waves, has forced into prominence the subject of these waves. Furthermore, the use of alternating currents for electric lighting brings into play the same phenomenon. Here, again, the difference between a current of water and a current of electricity is very marked. A sound wave, traversing the water in the tube, produces a to and fro current of water at any given point. So, in the electrical vibration along a wire, the electricity moves to and fro along it in a manner somewhat similar to the water but with this difference: the disturbance from the water motion is confined to the tube and the oscillation of the water is greatest in the centre of the tube, while, in the case of the electric current, the ether around the wire is disturbed and the oscillation of the current is greatest at the surface of the wire and least in its centre. The oscillations in the water take place in the tube without reference to the matter outside the tube, whereas the electric oscillations in the wire are entirely dependent on the surrounding space, and the velocity of the propagation is nearly independent of the nature of the wire, provided only that it is a good conductor.

We have then, in the case of electrical waves along a wire, a disturbance outside the wire and a current within it, and the equations of Maxwell allow us to calculate these with perfect accuracy and give all the laws with respect to them.

We thus find that the velocity of propagation of the waves along a wire, hung far away from other bodies and made of good conducting material, is that of light or 185,000 miles per second; but when it is hung near any conducting matter, like the earth, or inclosed in a cable and sunk into the sea, the velocity becomes much less. When hung in space, away from other bodies, it forms, as it were, the core of a system of waves in the ether, the amplitude of the disturbance becoming less and less as we move away from the wire. But the most curious fact is that the electric current penetrates only a short distance into the wire, being mostly confined to the surface, especially where the number of oscillations per second is very great.

The electrical waves at the surface of a conductor are thus, in some respects, very similar to the waves on the surface of water. The greatest motion in the latter case is at the surface while it diminishes as we pass downward and soon becomes inappreciable. Furthermore, the depth to which the disturbance penetrates into the water increases with increase of the length of the wave, being confined to very near the surface for very short waves. So the disturbance in the copper penetrates deeper as the waves and the time of oscillation are longer, and the disturbance is more nearly confined to the surface as the waves become shorter. I have recently made the complete calculation with respect to these waves, and have drawn some diagrams to illustrate the penetration of the alternating current into metal cylinders. The first diagram represents the current at different depths in a copper cylinder 45 cm. diameter, or an iron one 14½ cm. diameter traversed by an alternating current with 200 reversals per second. The first and second curves show us the current at two different instants of time, and show us how the phase changes as we pass downward into the cylinder. By reference to the third curve we see that it may even be in the opposite direction in the centre of the cylinder from what it is at the surface. The third curve gives us the amplitude of the current oscillations at different depths, irrespective of the phase, and it shows us that the current at the centre is only about 10 per cent. of that at the surface in this case. The second diagram shows us the distribution in the same cylinders when the number of reversals of the current is increased to 1,800 per second. Here we see that the disturbance is almost entirely confined to the surface, for at a depth of only 7 mm., the disturbance almost entirely vanishes.

There are very many practical applications of these theoretical results for electric currents. The most obvious one is to the case of conductors for the alternating currents used in producing the electric light. We find that when these are larger than about half an inch diameter they should be replaced by a number of conductors less than half an inch diameter, or by strips about a quarter of an inch thick, and of any convenient width. But this is a matter to be attended to by the electric light companies.

Professor Oliver J. Lodge has recently, in the British Association, drawn attention to the application of these results to lightning rods. Almost since the time of Franklin, there have been those who advocated the making of lightning rods hollow, to increase the surface for a given amount of copper. We now know that these persons had no reason for their belief, as they simply drew the inference from the fact that electricity at best is on the surface. Neither were the advocates of the solid rods quite correct, for they reasoned from the fact that electricity in a state of steady flow, occupies the whole area of the conductor equally. The true theory, we now know, indicates that neither party was entirely correct and that the surface is a very important factor in the case of a current of electricity so sudden as that from a lightning discharge. But increase of surface can best be obtained by multiplying the number of conductors, rather than making them flat or hollow, and, at the same time, Maxwell's principle of enclosing the building within a cage can be carried out. Theory indicates that the current penetrates only one-tenth the distance into iron that it does into copper. As the iron has seven times the resistance of copper, we should need 70 times the surface of iron that we should of copper. Hence I prefer copper wire about a quarter of an inch diameter and nailed directly to the house without insulators, and passing down the four corners, around the eaves and over the roof, for giving protection from lightning in all cases where a metal roof and metal down spouts do not accomplish the same purpose.

Whether the discharge of lightning is oscillatory or not, does not enter into the question, provided it is only sufficiently sudden. I have recently solved the mathematical problem of the electric oscillations along a perfectly conducting wire joining two infinite and perfectly conducting planes parallel to each other, and find that there is no definite time of oscillation, but that the system is capable of vibrating in any time in which it is originally started. The case of lightning between a cloud of limited extent and the earth along a path through the air of great resistance is a very different problem. Both the cloud and the path of the electricity are poor conductors, which tends to lengthen the time. If I were called on to estimate as nearly as possible what took place in a flash of lightning, I would say that I did not believe that the discharge was always oscillating, but more often consisted of one or more streams of electricity at intervals of a small fraction of a second, each one continuing for not less than $\frac{1}{100,000}$ second. An oscillating current with 100,000 reversals per second would penetrate about $\frac{1}{80}$ inch into copper and $\frac{1}{800}$ inch into iron. The depth for copper would constitute a considerable proportion of a wire ¼ inch diameter; and, as there are other considerations to be taken into account, I believe it is scarcely worth while making tubes, or flat strips, for such small sizes.

It is almost impossible to draw proper conclusions from experiments on this subject in the laboratory, such as those of Professor Oliver J. Lodge. The time of oscillation of the current in most pieces of laboratory apparatus is so very small, being often the $\frac{1}{100,000,000}$th of a second, that entirely wrong inferences may be drawn from them. As the size of the apparatus increases the time of oscillation increases in the same proportion, and changes the whole aspect of the case. I have given $\frac{1}{100,000}$th of a second as the shortest time a lightning flash could probably occupy. I strongly suspect it is often much greater, and thus departs even further from the laboratory experiments of Professor Lodge, who has, however, done very much toward drawing attention to this matter and showing the importance of surface in this case. All shapes of the rod with equal surface are not, however, equally efficient. Thus, the inside surface of a tube does not count at all. Neither do the corrugations on a rod count for the full value of the surface they expose, for the current is not distributed uniformly over the surface; but I have recently proved that rapidly alternating currents are distributed over the surface of very good conductors in the same manner as electricity at rest would be distributed over them, so that the exterior angles and corners possess much more than their share of the current, and corrugations on the wire concentrate the current on the outer angles and diminish it in the hollows. Even a flat strip has more current on the edges than in the centre.

For these reasons, shape, as well as extent of surface, must be taken into account, and strips have not always an advantage over wires for quick discharges.

The fact that the lightning rod is not melted on being struck by lightning is not now considered as any proof that it has done its work properly. It must, as it were, seize upon the discharge, and offer it an easier passage to the earth than any other. Such sudden currents of electricity we have seen to obey very different laws from continuous ones, and their tendency to stick to a conductor and not fly off to other objects depends not only on having them of small resistance but also on having what we call the self-induction as small as possible. This latter can be diminished by having the lightning rod spread sideways as much as possible, either by rolling it into strips, or better, by making a network of rods over the roof with several connections to the earth at the corners, as I have before described.

Thus we see that the theory of lightning rods, which appeared so simple in the time of Franklin, is to-day a very complicated one, and requires for its solution a very complete knowledge of the dynamics of electric currents. In the light of our present knowledge the frequent failure of the old system of rods is no mystery, for I doubt if there are a hundred buildings in the country properly protected from lightning. With our modern advances, perfect protection might be guaranteed in all cases, if expense were no object.

So much for the rod itself, and now let us turn to other portions of the electrical system, for we have seen that, in any case, the conductor is only the core of a disturbance which extends to great distances on all sides. Were the clouds, the earth and the streak of heated air called the lightning flash all perfect conductors we could calculate the entire disturbance. It might then consist of a series of stationary waves between the two planes, extending indefinitely on all sides but with gradually decreasing amplitude as we pass away from the centre. The oscillation, once set up, would go on forever, as there would be no poor conductors to damp them. But when the clouds and the path of the lightning both have very great resistance, the energy is very soon converted into heat and the oscillations destroyed. I have given it as my opinion that this is generally the case and that the oscillations seldom take place, but I may be wrong, as there is little to guide me except guess work. If they take place, however, we have a ready explanation of what is sometimes called a back stroke of lightning. That is, a man at the other end of the cloud a mile or more distant from the lightning stroke sometimes receives a shock, or a new lightning flash may form at that point and kill him. This may be caused, according to our present theory, by the arrival of the waves of electrical disturbance which might themselves cause a slight shock or even overturn the equilibrium then existing and cause a new electric discharge.

We have now considered the case of oscillations of electricity in a few cases, and can turn to that of steady currents. The closing of an electric current sends etherial waves throughout space, but that after the first shock the current flows steadily without producing any more waves. However, the properties of the space around the wire have been permanently altered, as we have already seen. Let us now study these properties more in detail. I have before me a wire in which I can produce a powerful current of electricity and we have seen that the space around it has been so altered that a delicately suspended magnetic needle cannot remain quiet in all positions but stretches itself at right angles to the wire, the north pole tending to revolve around it in one direction and the south pole in the other. This is a very old experiment but we now regard it as evidence that the properties of the space around the wire have been altered rather than that the wire acts on the magnet from a distance.

Put, now, a plate of glass around the wire, the latter being vertical and the former with its plane horizontal, and pass a powerful current through the wire. On now sprinkling iron filings on the plate, they arrange themselves in circles around the wire and thus point out to us the celebrated lines of magnetic force of Faraday. Using two wires with currents in the same direction we get these other curves, and, testing the forces acting on the wire, we find that they are trying to move toward each other.

Again, pass the currents in the opposite directions and we get these other curves and the currents repel each other. If we assume that the lines of force are like rubber bands which tend to shorten in the direction of their length and repel each other sideways, Faraday and Maxwell have shown that all magnetic attraction and repulsions are explained. The property which the presence of the electric current has conferred on the luminiferous ether is then one by which it tends to shorten in one direction and spread out in the other two directions.

We have thus done away with action at a distance, and have accounted for magnetic attraction by a change in the intervening medium as Faraday partly did almost fifty years ago. For this change in the surrounding medium is as much a part of the electric current as anything that goes on within the wire.

To illustrate this tension along the lines of force, I have constructed this model which represents the section of a coil of wire with a bar of iron within it. The rubber bands represent the lines of force which pass around the coil and through the iron bar, as they have an easier passage through the iron than the air. As we draw the bar down and let it go, you see that it is drawn upward and oscillates around its position of equilibrium until friction brings it to rest. Here, again, I have a coil of wire with an iron bar within it with one end resting on the floor. As we pass the current and the lines of magnetic force form around the coil and pass through the iron, it is lifted upwards although it weighs 24 pounds and oscillates around its position of equilibrium exactly the same as though it were sustained by rubber bands as in the model. The rubber bands in this case are invisible to our eye but our mental vision pictures them to us as lines of magnetic force in the luminiferous ether drawing the bar upward by their contractile force. This contractile force is no small quantity as it may amount, in some cases, to one or even two hundred pounds to the square inch, and thus rivals the greatest pressure which we use in our steam engines.

Thus the luminiferous ether is, to-day, a much more important factor in science than the air we breathe. We are constantly surrounded by the two, and the presence of the air is manifest to us all; we feel it, we hear by its aid and we even see it, under favorable circumstances, and the velocity of its motion as well as the amount of moisture it carries, is a constant topic of conversation with mankind at large. The luminiferous ether, on the other hand, eludes all our senses and it is only with imagination, the eye of the mind, that its presence can be perceived. By its aid in conveying the vibrations we call light, we are enabled to see the world around us, and by its other motions which cause magnetism, the mariner steers his ship through the darkest night when the heavenly bodies are hid from view. When we speak in a telephone, the vibrations of the voice are carried forward to the distant point by waves in the luminiferous ether, there again to be resolved into the sound waves of the air. When we use the electric light to illuminate our streets, it is the luminiferous ether which conveys the energy along the wires as well as transmits it to our eye after it has assumed the form of light. We step upon an electric street car and feel it driven forward with the power of many horses, and again it is the uminiferous ether, whose immense force we have brought under our control and made to serve our purpose. No longer a feeble uncertain sort of medium but a mighty power, extending throughout all space and binding the whole universe together, so that it becomes a living unit in which no one portion can be changed without ultimately involving every other portion.

To this, ladies and gentlemen, we have been led by the study of electrical phenomena, and the ideas which I have set forth constitute the most modern views held by physicists with respect to electric currents.—*Electrical Engineer.*

SOME VALUABLE INFORMATION ABOUT HOW IRON RUSTS.

The necessary conditions for the production of rust are—first, metallic iron ; second, liquid water ; third, oxygen ; and fourth, carbonic acid—both the latter being dissolved in the liquid water. Water in the vaporous condition, even in the presence of carbonic acid and oxygen, does not affect the metal, except at high temperatures, as in the formation of magnetic oxide of iron. Liquid water with oxygen dissolved in it does not act at ordinary temperatures on iron. This is shown by the fact that ordinary water exposed to the air does not rust iron if the water contains a substance such as lime or caustic alkali. As soon, however, as the lime or alkali is carbonized, the water and carbonic acid begin to act upon the iron, the first result being the formation of ferrous carbonate, which subsequently is changed to bicarbonate and dissolves, and then to reddish-brown ferric hydrate. As in this process the carbonic acid gas is first absorbed and then given off again, the continuation of the process of rusting is not dependent on new carbonic acid absorbed from the air, but the original carbonic acid can carry on the process indefinitely as long as liquid water is present and oxygen is supplied from the air. Once the process is started, it goes on rapidly, because the porous rust not only does not protect the iron, but favors, by its hygroscopic character, the condensation of water vapor from the air as liquid water. A piece of iron, therefore, which has begun to rust will continue rusting in an atmosphere not saturated with water vapor, an atmosphere in which a piece of clean iron will not rust, because liquid water will condense from such an atmosphere on the hygroscopic rust, but not on the bright iron.—*Kansas City Architect.*

PHOSPHATES AS FERTILISERS.

BY D. A. LOUIS, F.I.C., F.C.S.

Phosphorus in the free state is a highly inflammable and remarkably poisonous substance ; it is familiar to every one as a material used in the manufacture of matches, and as a constituent of a paste for poisoning mice. When phosphorus is ignited in the air it burns with considerable briskness, evolving great heat and clouds of smoke. The product of the burning is a white substance, which dissolves readily in water, and has an intensely sour taste as well as other properties characteristic of a strong acid ; it is, in fact, the substance known as phosphoric acid. By mixing this acid with an alkali or base, such as soda, potash, or lime, all the acid properties and the sour taste disappear, because the phosphoric acid and the base become intimately and firmly attached to one another, forming a compound having neutral properties and known as a "phosphate." In this form not only is the phosphorus non-poisonous, but it even becomes an essential constituent of living matter, and neither animals nor plants can thrive unless they receive a proper supply of it. Phosphates must therefore be included in our food. We either directly (as from bread and vegetables) or indirectly (through meat or the flesh of animals feeding on vegetation) obtain our supply of phosphates from the vegetable kingdom ; therefore, in order to discover the source of our own phosphate supply, we must learn which plants contain phosphates, where they get them from, and how they get them. The existence of phosphates in plants is easily demonstrated, for when a plant is burnt the phosphates remain in the ash, and numerous careful analyses of plant ashes have enabled chemists to ascertain the average amount present in different plants. The numbers representing the average quantity of phosphoric acid present in some of our most useful crop plants are arranged in the second column of the following table, and in the third column are given the numbers representing the average quantity of ash which remains when 100 lbs. of the various plants are burnt ; whilst the data in the fourth column show how much of this ash consists of phosphoric acid. In the first column are placed the names of the materials to which the various numbers relate. It is interesting to notice how each plant collects a different amount of phosphoric acid, and disposes of most of it in such a way as to be of use to succeeding generations of the plant. Thus the largest proportions of phosphoric acid are accumulated in the seeds ; or when the roots store up nourishment, as in the case of turnips and potatoes, the preponderating quantity of phosphoric acid is found in the roots, which if left in the ground would serve as a store of food for the future development of the plants :—

	100 lbs. of the substance named in the first column contains the following quantities of				100 lbs. of Ash from the substance named in the first column contains the following quantities of Phosphoric Acid.	
	Phosphoric Acid.		Ash.			
	lbs.	oz.	lbs.	oz.	lbs.	oz.
Wheat, grain......		12¾	1	11	46	3¼
" straw......		3½	4	9¾	5	6½
Barley, grain......		12¼	2	3½	32	13
" straw......		3	4	2	4	5
Pea, grain.........		13¾	2	5½	36	5
" straw.........		5½	4	6½	7	13
Field beans, seed..	1	3	3	1	39	3
" straw..		5¼	4	6¼	7	13
Potatoes, tubers...		2½		15	19	1½
" haulm...		2½	1	15½	5	8
White turnips, root.		1½		11¼	17	6½
" leaves		1½	1	3	8	14½
Mangels, root......		1		12	9	9¾
" leaves....		1¼	1	6½	5	1¾
Meadow hay.......		6½	5	2½	6	3¼

All these plants, and in fact all plants, obtain their phosphoric acid from the soil, and insignificant as the amounts appear in the above table, nevertheless, when the total weight of crop is taken into consideration, the real magnitude of these quantities soon becomes manifest. It is found, for instance, that a crop of wheat yielding 30 bushels of grain per acre will take from the soil a quantity of phosphoric acid which would be represented by a dressing of over 140 lbs. per acre of a rich superphosphate containing 25 lbs. of soluble phosphate in every 100 lbs. In a similar manner a crop of barley yielding 40 bushels per acre will remove phosphoric acid equivalent to a dressing of nearly 140 lbs. per acre of this rich superphosphate, whilst the phosphoric acid removed by a crop of 6 tons of potatoes, or 17 tons of turnips, or 22 tons of mangels per acre, would be represented respectively by dressings of 162, of more than 220, and above 350 lbs. per acre of the superphosphate.

And the farmer has to produce at the present time such crops as these, or even larger ones, in order to make things pay. It must be remembered, too, that most of the phosphoric acid removed from the soil in these crops is irretrievably lost to it ; for except when crops are used for feeding cattle, horses, etc., only those portions poorest in phosphates are utilised on the farm for litter, etc., and subsequently find their way back to the land in the form of farmyard manure ;

whereas the richest portions of the crops, such as the seeds of most cereals, and edible peas and beans, the tubers of potatoes, and a good share of the roots and hay in the form of meat, are sold off the farm for human consumption, and then the phosphates, along with many other valuable constituents, find their way in the majority of cases to the nearest stream or river, and ultimately to the sea. The quantity of valuable material lost in this way is enormous.

If the supply of phosphates available for the plant falls short, then the plant thrives badly, and yields light crops and inferior produce. As an example of this, some data are arranged in the next table, embodying results obtained by Sir John Lawes and Professor Gilbert at Rothamsted. In the first column are given the names of the crops; in the second the average weights of the yield of these crops when grown on a soil containing only a small quantity of phosphates, but receiving an abundant supply of nitrogenous manure; in the third column are given the average weights of the yield of the same crops, on the same soil, with the same quantity of nitrogenous manure, and, in addition, a supply of phosphates; in the fourth column are shown the increases in crop yield obtained by supplying the requisite phosphate :—

Crops.	Yield per acre, when grown on the same soil, with ample supply of Nitrogen.		Increase in yield per acre obtained by the use of the superphosphate.
	With insufficient supply of Phosphates.	With plenty of Phosphates as superphosphate.	
	lbs.	lbs.	lbs.
Wheat	3,274	4,204	930
Barley.......	3,374	5,006	1,632
Hay.........	3,220	4,564	1,344
Turnips	1,792	10,194	8,402
Potatoes.....	5,334	17,192	11,858
Mangels	19,936	25,088	5,152
Sugar-beet ...	29,008	35,728	6,720

The figures speak for themselves as to the amount of the harvests. The quality of the produce is also improved, for example, in the case of potatoes; the percentage of good tubers is 91 with and 85 without the superphosphate. This table illustrates another point—a point to which attention was drawn in the concluding lines of the article on "Nitrates" in the March number of *Knowledge*, p. 102, and which refers to the imperfect utilisation of nitrogenous manures in the absence of other plant-foods in the soil; it must, however, be borne in mind that the above increase in crops is obtained by the addition of only two important constituents of plant-food, viz., phosphoric acid and calcium. Nevertheless, the quantity of nitrogenous manure rendered active by them is very striking.

Having thus far shown the necessity and the advantage of supplying plants with phosphates, attention will now be turned to the sources of the phosphates for the supply of plants. And here we observe one of those interesting and wonderful compensating influences which are at work everywhere in nature; for the supply of phosphates for plants is largely, almost entirely, derived from animals past and present, so that in this way animals return to the soil material in a form useless to themselves but upon which plants thrive vigorously and reconvert into a form which is then available for the requirements of animal life.

The first and, as regards origin, the simplest supply of phosphates for plants is found in farmyard manure, stable litter, sewage, and such like matters which are mainly the rejected products of living animals. The animal consumes in its food amounts of phosphoric acid considerably in excess of its requirements, and consequently when passing through the body this excess is not digested, and is ultimately rejected by the animal along with other indigestible matter and waste products produced in the animal organism. These supplies of phosphates are therefore much mixed up with all sorts of other material, and in fact contain only a small proportion of phosphates. The next source of phosphates is the dead animal, and, as in the case of plants, the phosphates are found in the ash. Now flesh contains (speaking very generally, for all kinds of flesh differ to a certain extent in the amount of ash) about 4 to 6 per cent. of ash; bone, also speaking generally, contains 60 to 70 per cent. of ash; it will therefore be seen that the latter parts of the dead animal would naturally be looked to to supply most phosphates.

Bone consists of both organic matter and inorganic matter or ash constituents. If a bone is allowed to soak in dilute hydrochloric (muriatic) acid, all the ash constituents are dissolved out, and the bone, while retaining its original shape, becomes translucent and soft, and in fact is then nothing more than a lump of jelly mixed with some fat. If, on the other hand, a bone is boiled in water, it loses all the fat present in it and some gelatin (jelly). This fat is used for making candles; the gelatin for size. By steaming the bones in closed vessels a further quantity of gelatin is extracted and furnishes a kind of glue. By subjecting bone to a still greater heat in a retort over a fire, most of the organic constituents distil off, forming what is known as Dippel's oil, and a residue of carbonised organic matter, "animal charcoal," is left in the retort. But by burning animal charcoal or fresh bones in the air, all the organic matter is consumed and the ash only is left behind. When bones in these different stages are examined chemically the amount of phosphates they contain nearly approaches the following quantities :—

100 lbs. of	Contain lbs. of Phosphates.
Fresh bones.........................	50
Boiled bones.........................	50 to 60
Steamed bones......................	60 to 70
Animal charcoal....................	70 to 80
Bone ash	80 to 85

However, as might be expected, bones in all these states show great variation in the quantities of phosphates they contain, but the value of bones as a phosphatic manure follows the order above given, bone ash being the best.

In nature, wherever animal matters accumulate they suffer changes in an order closely resembling that described above in the artificial treatment of bone; first the most delicate and volatile parts suffer decay, then the tougher portions, until the bones alone remain; then the bones decay in a similar manner until only the ash constituents remain.

In past ages such deposits have accumulated, and we find the bones buried in the earth; they have retained their shape in many cases, but almost always all the organic matter has gone, its place being taken by mineral matter. The deposits are dug up and the material comes into the market as fossil bones; large quantities come from South Carolina in the United States, also from Cambridgeshire, Buckinghamshire, and Suffolk, in England, from the North of France, and elsewhere. Sometimes the fossils have almost entirely disappeared, and the remains have become intimately mixed with the rock; such is often the case in the Belgian deposits near Mons, in some of the deposits in the North of France, and in other deposits in the neighbourhood of Bordeaux, in Nassau in Germany, and in the west of Spain. In fact, in the three latter localities, extensive masses of mineralised phosphate known as "phosphorite" occur.

Sometimes phosphates are found in a highly mineralised condition in well-defined crystals, which have evidently been deposited from solution in the rocks where they are found. Such phosphates are found in old rocks in Canada and Norway, also in Spain, and are known as apatites; they consist of calcium fluoride and phosphate, and sometimes, as is the case with Norwegian apatite, of the chloride as well. The crystals sometimes are of considerable size: some very big ones from Canada were exhibited in the Indian and Colonial Exhibition, and looked like hexagonal pillars artificially shaped.

Other sources of phosphate for the farmer are the guano deposits. They mainly originate from the excretory deposits of sea birds; when fresh or in protected places the deposits contain much organic matter, and consequently nitrogen as well as phosphates, but in old deposits or in places exposed to severe atmospheric influences, heavy rains, heat, etc., the organic matter has disappeared and only inorganic matter remains, which in course of time becomes washed into and mixed up with the rock. Nitrogenous guanos are found on the islands near to and on the coast of Peru, in Patagonia, and the Falkland Islands in South America, and on the islands of Ichaboe and Ascension in Africa. Guanos containing phosphates but no nitrogen are found on many of the West Indian islands, in Mexico, on some of the islands in the South Pacific Ocean; also on the Kuria-Muria islands in the Arabian Sea; in New Guinea, Australia, etc., etc. In some localities the guano is found deposited along with other animal remains, and bones, teeth, and shells are found mixed up with it. Curaçao and Barbadoes guanos are of this type.

Coprolites consist of nodular, spherical, and irregular lumps of phosphate, which are dug out of the earth in Cambridgeshire, Buckinghamshire, Bedfordshire, and Suffolk, in England. They are also found in the North of France, in Russia, and in Austria. They are supposed to be the fossilised excreta of huge extinct lizard-like animals, but in the majority of cases there is little or no evidence to support this supposition.

All the natural phosphates that have been here considered are insoluble, or practically so, in water; they cannot, therefore, in the raw state be easily distributed in the soil so as to be accessible and useful to the plants. Fortunately, however, simple treatment with sulphuric acid (oil of vitriol) converts them into a soluble form of phosphate and gypsum; such mixtures contain all the other fixed constituents of the original raw phosphate, and are known as superphosphates. The phosphate in superphosphates is mostly soluble, and when applied to land, is washed into the soil by rain, and becomes well distributed throughout so as to be readily accessible to the plant roots; in contact with various soil constituents it, however, soon again assumes an insoluble form, and is, therefore, not washed away like nitrates.

Before concluding, a word or two must be added about a source of phosphates which cannot be considered of animal origin. Until the year 1879 iron obtained from ores containing phosphates even in very small quantities, as a great many iron-ores do, could not be used for the manufacture of steel because the metal retained the phosphorus, which contributed undesirable and deteriorating properties to the steel. In the year 1879, however, Messrs. S. G. Thomas and P. G. Gilchrist made known to the world their discovery of lining the vessel in which the iron is melted to convert it into steel with lime, or a mixture containing much lime, and also adding lime to the molten metal. This produces wonderful changes, the lime combines with the phosphorus to form phosphate, which then separates from the mass of molten metal and floats on the top along with other impurities, forming what is known as "basic slag." By this discovery much material, which had hitherto been useless for the purpose, could be employed for the manufacture of that extremely valuable material, steel, the quality of which was greatly improved by the removal of the phosphorus. What is more, this phosphorus, which was formerly not only absolutely useless but also a nuisance, is converted in this "basic" method of making steel into a valuable source of phosphate for the supply of that all-important plant constituent to our crops.—*Knowledge.*

TEST QUESTIONS.

We are afraid there would be some grumbling if such practical questions as the following were to appear in some of our examination papers, and yet no one will deny that such questions are of the right kind. The editor of them says:—Every pupil who has studied the subject of geography should be able, without any hesitancy, to correctly answer each of the following questions:—

If you wish to be surprised, try them; you will find a number who have "bin in jog-a-fy."

1. How wide is the equator?
2. Can a person reach the North Pole by travelling N.W.?
3. If it is 4 p.m. here what time is it 165° west, east?
4. Draw two right angles with straight lines.
5. The difference in time between two places is one minute, what is the difference in longitude?
6. If your town lies on the 80th meridian, on what meridian do all other places having the same time lie?
7. Are parallels of latitude or lines of longitude straight lines?
8. Are meridians parallel lines?
9. Draw a line at an angle of 45°.
10. A straight line drawn from the centre of the earth pierces the surface 32° north of the equator. How many degrees to the South Pole? To the North Pole?
11. At what time of the year is the equator nearest the North Pole?
12. Are degrees of longitude all the same length?
13. At what point on the globe is there no latitude or longitude?
14. What is the diurnal motion of the earth?
15. When it is noon at Washington, what is the time 12° north, south?
16. Two persons are travelling *north toward* each other. How is this?
17. The news of a morning fire in New York reaches San Francisco before daylight. Explain.—*The Progressive Teacher.*

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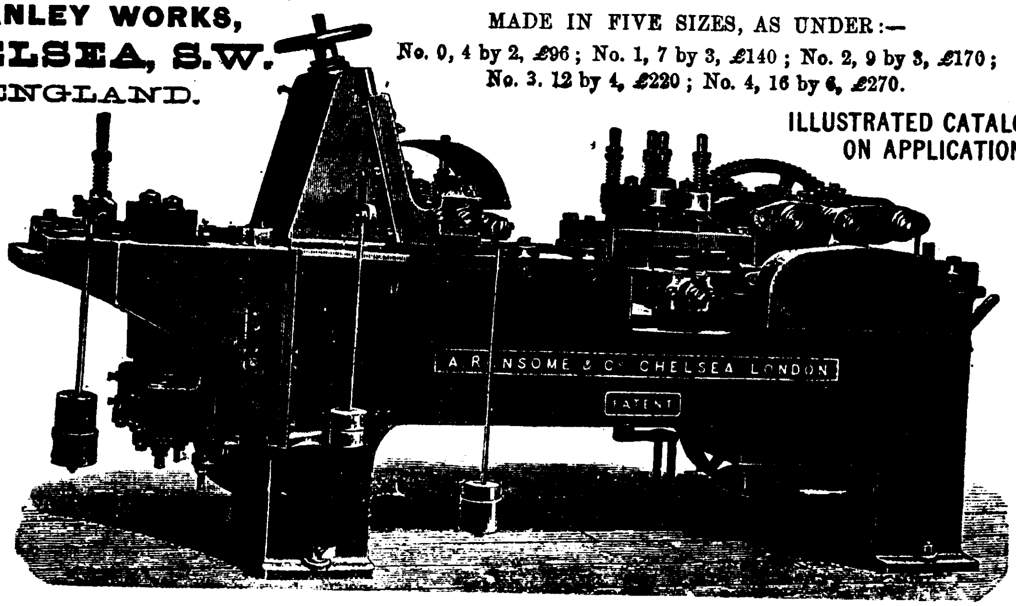

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