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THE VACUUM AN ABSOLUTE NON-CONDUCTOR OF ELECTRICITY.

The passage of electricity through rarefied air constitutes a well known experiment in the lecture room of physical science. The oldest style of performing it is to attach, by means of a stopcock connection, a long glass tube to the air pump, each end of the tube being provided with brass caps. The electricity may be made to flow through its interior as soon as the exhaustion of the air has proceeded to a certain extent; then a most beautiful exhibition is produced in the dark, resembling the aurora borealis; hence such a tube is called an aurora tube, and the aurora borealis has been ascribed to a discharge of electricity from the polar regions to the equator, through the stratum of rarefied air above the clouds. Another form of this experiment is the so-called electric egg, which differs from the preceding in nothing but that, in place of a long tube, an egg-shaped glass globe is employed, into which brass knobs or points project from both ends.

Lately this same experiment has been modified, so that the vessel filled with rarefied air is always ready for the experiment. Gassiot and Geissler first conceived the idea of manufacturing small and large glass tubes, melting pieces of platinum wire into their extremities, so as to introduce the electric current, exhausting the air in them to the proper degree, and then sealing them hermetically.

As it had been found that rarefied gases of different natures produce different colors of light in the dark when the electric current was passed through them, and later that different kinds of glass and liquids, when illuminated in this way, produced a great variety of effects (due to fluorescence), a very extensive assortment of these tubes was soon in the market; and they may now be bought, under the name of Geissler tubes, from the dealers of philosophical instruments in our large cities, at different prices, varying according to their size and the elaboration of their construction.

Experiments prove that electricity is retained on the surface of bodies by the presence of the atmosphere, which is an isolating substance; and that when its pressure decreases, the escape of electricity becomes easier; while, in a good vacuum, the resistance to escape becomes zero, and the electricity flows off and cannot be retained at all. This has for a long time been the accepted theory, and is still taught in most text books on physics, and is believed in by most electricians; but that it is an error was proved by Bécquérel, Hawksbee, Gray, and Snow Harris, as they showed that even the weakest electric discharges could be retained in vacuo. Bécquérel even went so far as to show that the charge was retained for fifteen days, provided that the vacuum was so perfect as to be equal to a mercurial pressure of one millimeter (the twenty-fifth part of an inch); and he concluded that, in a perfect vacuum, the body would retain the charge for ever: in other words, that electricity could not be transmitted through an absolute vacuum.

Du Moncel, in his lately published French work on the Ruhmkorff coil, gives an account of his experiments in passing a powerful electric current through a tube in which the air was being more and more rarefied, and states that, when the vacuum was made very nearly perfect by the continued operation of a good air pump, the passage of electricity through the tube continually diminished; so that at last, when the pressure had decreased to less than a half millimeter (one fiftieth of an inch), the light had almost disappeared, while tests proved that very little electricity passed; when, however, a little air was gradually admitted into the tube, the electric current was re-established, and the light appeared again.

Gassiot was the first who attempted to make an absolute vacuum, deprived of all traces of air or gas. He first made a barometer of the easily fusible alloy made of lead, tin, bismuth, and cadmium, which melts below 150° Fah., contains no mercury, and which would not contaminate the vacuum with mercurial vapors. He did not, however, succeed in this way, as the vacuum thus made always contained traces of air or gas. He tried then another method; he filled the vacuum with pure carbonic acid gas; and after exhausting by the air pump, he left the remnant to be absorbed by caustic potassa, which, by its well known great affinity for this gas, removed the last traces. He produced in this way a vacuum much more perfect than any one ever did before; while his manner of procedure allowed the experiment to be extended over several days, and even weeks. When the vacuum had been made with the air pump on carbonic acid, an electric discharge, which, in the air, would not pass over a distance of half an inch, traversed twenty inches with the greatest ease. In proportion as the vacuum became more perfect by the absorption of the carbonic acid, the discharge tended to fill the tube with a more and more pale luminous vapor. The vacuum becoming more perfect in the course of several days, the luminosity became confined to the sides, where the platinum wires, which conducted the electricity, entered into the vacuum; and a certain space, half way, became dark, and this darkness extended itself, so that, in a tube of twenty inches length, it occupied nearly ten inches. When a galvanometer was placed in the circuit, it indicated that there was no longer a constant discharge as before, but occasionally alternate discharges: when also the tube showed light flashes, and the so-called stratification of the light. When at last the absorption went on, and formed a perfect vacuum, perfect darkness was obtained in the tube, and no trace of light showed itself, even with strong electric charges, while neither the galvanometer nor an ordinary vacuum tube, when introduced into the circuit, would manifest a trace of any current, notwithstanding that this other ordinary vacuum tube showed luminosity with feeble currents. From all this, it is therefore evident that it is practically demonstrated that the absolute vacuum is not only a non-conductor, but that it is absolutely impenetrable by electric discharges.

De la Rive studied the phenomena observed. As soon as, during the attempts to pass the electric current, a small amount of gas is introduced, corresponding with a mercurial pressure of $\frac{1}{4}$ millimeter ($\frac{1}{100}$ inch), he found that the phenomena vary, according as the gas is admitted near the positive or the negative side; and he gives a very detailed description of the so-called stratification, the succession of colors, the rose-colored mist, etc., phenomena which are always repeated under the similar circumstances, depending, of course, upon certain laws governing the relation between the electric and luminous vibrations.

The writer of this article possesses a strong glass tube in which, after the method of Gassiot, the vacuum has been produced by the absorption of carbonic acid. The ends of the platinum wire intended to introduce the electric current are only one quarter inch distant from each other. But notwithstanding this short space, the strongest possible charge cannot be made to traverse this distance of vacuum, while the same charge will pass through a distance of six inches in common air, and of as many feet through a glass tube in which the air is rarefied. In the Stevens Institute, Hoboken, the experiment with a similar tube can be shown to any visitor, and excites the surprise of many who still persist in the faith in an electric fluid, notwithstanding they have abandoned the doctrine of a caloric fluid, being advanced enough in their ideas to be satisfied that heat is a mere mode of motion of ponderable matter.

Now the fact is that the whole science of thermotics cannot produce a single experiment upsetting the old doctrine of a caloric fluid, so conclusive as the experiment above described. Nobody has ever succeeded in producing an empty space or vacuum through which heat could not pass; but having done so for electricity, it proves conclusively that this subtle agent cannot be of the nature of a fluid, as a fluid would not be arrested by a vacuum. It proves that electricity must be a mode of motion (wave vibration or molecular rotation) of ponderable matter, which cannot be propagated except by such matter, and will be as effectively arrested in its propulsion, when ponderable matter is absent, in the same way as is the the case with the sound waves when the medium by which they can be transmitted is wanting.

DON'T KISS THE BABY!

The promiscuous kissing of children is a pestilent practice. We use the word advisedly, and it is mild for the occasion. Murderous would be the proper word, did the kissers know the mischief they do. Yes, madam, *murderous*; and we are speaking to you. Do you remember calling on your dear friend Mrs. Brown the other day, with a strip of flannel round your neck? And when little Flora came dancing into the room, didn't you pounce upon her demonstratively, call her a precious little pet, and kiss her? Then you serenely proceeded to describe the dreadful sore throat that kept you from prayer meeting the night before. You had no designs on the dear child's life, we know; nevertheless you killed her! Killed her as surely as if you had fed her with strychnin or arsenic. Your caresses were fatal.

Two or three days after, the little pet began to complain of a sore throat too. The symptoms grew rapidly alarming: and when the doctor came, the single word *diphtheria* sufficed to explain them all. To-day a little mound in Greenwood is the sole memento of your visit.

Of course the mother does not suspect, and would not dare to suspect, you of any instrumentality in her bereavement. She charges it to a mysterious Providence. The doctor says nothing to disturb the delusion; that would be impolitic, if not cruel: but to an outsider he is free to say that the child's death was due directly to your infernal stupidity. Those are precisely his words: more forcible than elegant, it is true; but who shall say, under the circumstances, that they are not justifiable? Remember

"Evil is wrought by want of thought
As well as by want of heart."

It would be hard to tell how much of the prevalent sickness and mortality from diphtheria is due to such want of thought. As a rule, adults have the disease in so mild a form that they mistake it for a simple cold; and as a cold is not contagious, they think nothing of exposing others to their breath or to the greater danger of labial contact. Taking into consideration the well established fact that diphtheria is usually if not always communicated by the direct transplanting of the malignant vegetation which causes the disease, the fact that there can be no more certain means of bringing the contagion to its favorite soil than the act of kissing, and the further fact that the custom of kissing children on all occasions is all but universal, it is not surprising that, when the disease is once imported into a community, it is very likely to become epidemic.

It would be absurd to charge the spread of diphtheria entirely to the practice of child-kissing. There are other modes of propagation, though it is hard to conceive of any more directly suited to the spread of the infection or more general in its operation. It stands to diphtheria about the same relation that promiscuous hand-shaking formerly did to the itch.

It were better to avoid the practice. The children will not suffer if they go unkissed; and their friends ought for their sake to forego the luxury for a season. A single kiss has been known to infect a family; and the most careful may be in condition to communicate the disease without knowing it. Beware, then, of playing Judas, and let the babies alone.

POSTAL DETECTIVE SERVICE.

It is rather more the custom to abuse the officials of the post office, for losses, irregularities, and other difficulties happening in the mails, than to give them credit for their skill in the detection of crime and recovery of missing property. We hasten, therefore, to put on record a recent instance of a prolonged search for lost money in which we have been directly interested, and which has resulted in a remarkable and praiseworthy success on the part of the post office detectives. On the first of May last, a correspondent in a village in Louisiana mailed a registered letter to this office, and enclosed therein the sum of sixteen dollars. The missive failed to reach us, and we notified both our correspondent and the post office authorities. The latter placed the case in the hands of special agents, and for the past seven months the detective officials have been actively at work tracing the lost missive. We, and doubtless the sender of the money, had given up hope of its recovery, and hence our astonishmnet was all the greater at the reception, a few days ago, of a terse communication, signed L. M. Terrell, Superintendent Railway Mail Service, Fourth Division, and dated from Chattanooga, Tenn., citing the above facts, and stating that the writer had arrested the guilty party, and recovered the funds, which we found enclosed. When the immense number of letters which pass through the mails is considered, this regaining of a single missive, the abstraction of which had probably been carefully concealed, exhibits a brilliant piece of detective ability, which redounds highly to the credit of our postal service.

TEMPERATURE OF IGNITION OF CHARCOAL.

Some months ago, as our readers will remember, an interesting discussion arose in our columns in reference to the possibility of igniting charcoal or over-seasoned wood, by the heat radiated from steam pipes. A well known engineer stated that he had collected conclusive evidence, proving the possibility of fires occurring in consequence of the ignition of wooden beams by contact with steam pipes, in cases where the wood had lain for a long time in contact with the pipe, and had thus been submitted to a process of charring at a very low temperature. We stated at the time that we were not convinced of the possibility of such action by any evidence which had then been given, and asked for more proof.

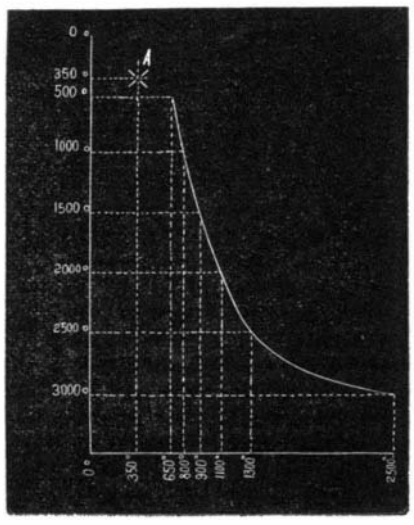
It is a well known fact that the lower the temperature at which charring occurs, the lower the temperature of ignition. The question is, however, whether the temperature of charring can ever become so low as to cause the temperature of ignition to become equally low, or nearly as low. In such cases as were above referred to, it was supposed that the wood lay in contact with the steam pipe for months, or even years, and that finally the wood, having become thoroughly charred, actually took fire at steam heat.

We have some evidence which has just been received, which may assist in settling the question, and in setting at rest the apprehensions of the authorities of our insurance companies, who are now acting upon the assumption that the possibility of this source of fire is so well supported by evi

dence that they are justified in imposing very severe restrictions upon the use of steam pipes.

Mr. Robert Harper, some time ago, contributed, to the collection of the Engineering Department of the Stevens Institute of Technology, a piece of wood, which, as he states, "stood during sixteen years and one month on top of and in contact with a one inch steam pipe, containing steam at fifty pounds in cold weather, used for warming the First United Presbyterian Church of Hoboken, N. J." The wood seems to be spruce. It is well seasoned, but no sign of injury or of charring is perceptible, and there is nothing to indicate that it might not have remained on the steam pipe an indefinite length of time without injury.

The accompanying diagram is interesting, and gives valu-



able evidence in this connection. We gave, at the time when this subject first came up, a table showing the temperatures of preparation and the corresponding temperatures of ignition of charcoal for a wide range on the scale.

Mr. Stahl, a student of the graduating class of the Stevens Institute of Technology, has prepared for us, at the request of Professor Thurston, this diagram, in which the vertical scale is one of temperatures of preparation and the horizontal scale is one of temperatures of ignition, and the curve shown contains the points of correspondence as given in our table.

It will be seen that the curve is apparently nearly hyperbolic. The lowest temperature of preparation was 500° Fah., but it is seen at a glance, even that at 350°, the temperature of steam under a pressure of over 125 lbs. per square inch, the temperature of preparation and of ignition cannot coincide unless some marked change of law should occur at so low a temperature, carrying the curve, which here represents that law, abruptly inward to reach the point A. We need hardly state that such a phenomenon would be quite improbable, and is probably impossible. Our readers will find this little diagram very interesting and instructive.

SCIENTIFIC FACTS AND SPECULATIONS.

Addressing a Glasgow society the other day—his subject being the relations of Science to religion—the Earl of Shaftesbury was pleased to be very patronizing to Science. No possible harm could come to his hearers' faith, he assured them, through the advancement of true Science. The speculations of scientific men might be misleading and mischievous, but facts never; and the function of true Science was simply the observation and registering of facts. Therefore, if he had the wealth of Glasgow, he would send fifty thousand pounds to Max Müller to help on his explorations at the fountain head of Aryan civilization. The learned professor's opinions on many things were far from sound; nevertheless, he was doing good work and ought to be encouraged. For like reasons, this champion of English orthodoxy would send another quarter of a million dollars to Professor Tyndall, and say to him: "Accumulate your facts; I don't care about your theories, but turn your powerful intellect to the pursuit of facts."

The evil that men do lives after them; and probably the worst legacy left by Francis Bacon—that pretender in Science, time-serving politician, insidious lawyer, corrupt judge, treacherous friend, and bad man, as Dr. Draper justly styles him—is this very theory of Science which Earl Shaftesbury echoes. According to this school of superficial thinking, the man who turns his powerful intellect to the recording of the temperature of the air, the direction of the wind, and the state of the sky three times a day is a meteorologist worthy of the name; but the man who leaves the recording of facts to other men, or to automatic machinery, and busies himself with suggesting and testing hypothetical interpretations of the recorded facts is a mere theorist, not to be acknowledged by "true Science." Similarly, the greatest astronomer is he who makes the greatest number of observations and discovers the most asteroids or comets; the greatest geologist, he who finds the most fossils. To seek the law within the law, by investigation guided by hypothesis, is to destroy one's right to the title of a true son of Science!

It is the fallacy of the French Academy, which rejected Darwin as an unscientific theorist because he turned from the blind accumulation of facts to the development of an hypothesis whereby to account for the facts. The very important truth that Darwin's hypothesis had given life to millions of otherwise fruitless facts, and still more had given purpose and direction to the observations of hundreds of naturalists, thus accomplishing more for the substantial enrichment of natural history than all their Academy had ever done, was ntirely overlooked.

We are far from deprecating the accumulation of facts. No great truth was ever discovered without them, and the masters of Science have ever been zealous in their pursuit. But their service to Science did not end in barren observations, nor were they made at haphazard. In every case where great discoveries were the result, point and purpose were given to their investigations by hypothesis. Indeed, there can be no true inductive investigation without a marriage of hypothesis and experiment; and it is by such investigations only that Science has come to be what it is. The secret of the successful career of Faraday lies not less in his fertility in inventing hypotheses than in his patient observation and conscientious determination to prove all things. Without his genius for guessing, he would never have been able to add so much to our knowledge of electricity and magnetism. The first observer of the transit of Venus tells how he tried theory after theory, in order to discover one in accordance with the motions of Mars. So, too, Kepler submitted guess after guess, hypothesis after hypothesis, to computations of infinite labor, in determining the laws of planetary distance and motion. The writings of every great man in Science afford confirmation of the necessity of hypothesis in the pursuit of facts, as well as in the pursuit of scientific truths. But probably there cannot be found in the whole history of Science a more striking example of the worth of investigation guided by hypothesis, and the worthlessness of investigation without such guidance, than is afforded by the labors of Sir Isaac Newton. In his case we may see a great man studying chemistry, unaided by any theory: studying the phenomena of light under the influence of an utterly erroneous hypothesis: and again, incited by a bare suspicion that the attraction of the earth might extend as far as the moon, spending his ripest years mathematically testing hypotheses of the most stupendous reach, having for their object nothing less than the laws of the physical government of the solar system, if not of the Universe.

It is easy to imagine how a patronizing Earl of Shaftesbury, a brother alchemist, a Baconian philosopher, might have reproached him for wasting his precious time in theoretical investigations, advising him to stick to his laboratory and bend his powerful intellect to the accumulation of facts. But what says history of the days and nights which he spent in his laborious chemical experiments?

"While his hypothetical and deductive investigations have given us the true system of Nature, and opened the way in almost every one of the great branches of natural philosophy, the whole results of his tentative experiments are comprehended in a few happy guesses given in his celebrated 'Queries.'"

Aided by the insight into the principles of Nature which chemical theory affords, the student of to-day is able to discover more useful facts in a year than Newton could in a lifetime. So it is in every department of Science; and though weak men are apt to mistake hypothesis for final truth, resting on it instead of using it as a means of further progress, the hypotheses formed by powerful intellects are the stepping stones of true Science, without which there could be no advancement. If it were possible and necessary to confine our great men to one department of their work, we should therefore say, not "accumulate facts," but "give us theories. There are men enough, of smaller caliber, to observe and register: men enough to test your hypotheses and to follow their lead; do you give us theories. The guesses of genius are more valuable than the demonstrations of mediocrity."

Fortunately, however, there is no great need of such division of labor. Genius for sound hypothesis is very apt to be seconded by superior skill in devising means for subjecting hypotheses to the test of experiment.

SEEING THROUGH COLORED GLASSES.

A child, or an adult not accustomed to critical observation, looks through a bit of colored glass, and straightway declares that it makes everything green, or blue, or red, as the color of the glass may be. The first impression is that the glass somehow throws a flood of colored light upon the scene; and such, for many ages, was the universal belief.

The ancients explained the phenomena of sight by supposing that the eyes shot forth rays which passed through space to the objects seen: that they saw by means of these rays, much as one might explore by touch the bed of a pond by using material rods. From this standpoint there could be no apter explanation of the action of colored media than to say that they changed the character of the rays proceeding from the eye, and so changed the aspect of the objects looked upon through such media. Nearly eight hundred years ago this view was shown to be erroneous by the Mohammedan philosopher Alhazen, who taught the true theory, since adopted by the christian world, namely, that the light proceeds from the object to the eye. The old theory is practically forgotten; yet its influence is still seen in common speech. To most people a colored glass colors a landscape by adding color to it, though it is well enough known that it really takes more or less away from the color of the several objects, or at least the most of them. Even educated people will say that a green glass, for example, gives its color to objects seen through it. More than that, they will say, as Professor Clifford does in his able essay on the Philosophy of the Pure Sciences, printed in a late number of the *Contemporary Review*, that a colored medium will give its color to *everything*. Thus: "If a man had on green spectacles, he would see everything green. And if he found out the property of his spectacles, he might say with absolute certainty that everything he saw, without exception, would be green."

Surely Professor Clifford can never have looked through a pair of green spectacles! It is equally sure that he could have given no thought to the actual phenomena of color in writing the illustration we have quoted, else he would have stayed his hand. Even if it were possible to make a glass which would be transparent to all green rays and opaque to all others, the asserted result would not happen. All things would not look green through it, but only those which emitted or reflected green light. All objects colored red, orange, yellow, blue, violet, or showing any combination of these hues, would furnish no rays capable of passing through the supposed glass, and would consequently look black, not green.

But the transparency of colored glasses is marked by no such exact chromatic limits, so that the effect of them is still less likely to be as Professor Clifford assumes, as any one may readily see by looking through a pair of green spectacles. If the observer has paid but little attention to the matter before, he will be surprised to see how slightly the natural aspect of things is affected by the glasses. Still more will he be surprised to see how many objects show neither their natural tint nor the tint of the glasses, but a color bearing no apparent relation to either. We happen to have on our table samples of red, green, and blue glass. Probably the colors are as perfect as glass can be made to receive, yet neither specimen shows a pure color. For instance, all allow a little yellow light to pass through them; the green transmits blue rays quite freely, and the blue glass fails to arrest some of the red rays. Seen through the red and green together, the golden clouds above the setting sun show a pale canary-yellow tint, and so does a bright white cloud in another part of the sky. Through the blue glass, the golden clouds have a fainter hue, approaching orange, yet are distinctly visible. The clouds change to orange, then to red. No change can be observed through the green glass, save a gradual fading, the clouds becoming invisible when they have attained their brightest tint of red, the green glass being opaque to all rays below the yellow. Through the blue glass, however, the reddening sky grows purple, the final hue being exceedingly rich and beautiful. Through the red glass, the sky appears lurid, like the reflection of a great fire. The blue glass seems perfectly opaque only to green and yellow; the green is opaque to red rays alone, the red glass to green only.

These observations give a clue to the changing hues of colored objects when looked at through the several glasses in bright daylight, a few instances of which may be cited to show how widely Professor Clifford's assertion varies from fact. The salmon-colored cover of the *Contemporary* looks yellowish brown through green glass, and a dead brown through blue. Through the red it shows the palest possible orange tint. A yellow envelope shows a brighter yellow through the green glass, bright orange through red glass, and salmon color through blue. Some cherry colored silk appears a lustrous brown through green glass, pale pink through red, and an almost invisible purple through the blue. A piece of light blue silk appears a light drab through green glass, a pale brown through red, and bluish gray through the blue glass. A red spot in the carpet seems brown through green, pale red through red glass, and wine color through blue. A deep green band on a water pitcher shows lead color through the green, slate color through red, and brown through blue. Curiously, any color in the glass, instead of enhancing, as one would naturally suppose, the corresponding color in objects, invariably makes it less bright and clear. It is only as objects emit or reflect white light that their color approaches that of the medium through which they are seen.

Single Rail Steam Towage on the Belgian Canals.

We learn from the *Moniteur Industriel Belge* that a system of steam towage is about to be established on the Bourgogne canal, over a distance of about 150 miles. The tow path will be laid with a single rail weighing some 16 pounds to the yard, and fixed on traverses placed 3·2 feet apart. The locomotive has four wheels, two of which are placed directly along the axis of the vehicle, one in advance of the other, and two, one at either side. The former pair are directing, the latter driving, wheels. The directing wheels are grooved, and fit the rail: the others have rubber ties which give purchase on the macadamized road, and which press thereon only to the extent of 0·07 pounds per square inch. By means of simple mechanism, the weight of the machine may be thrown either upon the driving or directing wheels at will. In the first case the maximum and in the last the minimum of adherence is obtained, to suit the conditions of a loaded or an empty boat. A single road is to be used, with relay engines provided at suitable distances. Each locomotive tows one boat; and when a meeting takes place of two traveling in opposite directions, the engines change boats and retrace their paths.

This single rail system has already been satisfactorily tested for short distances on the Belgian Canals, and the projector, M. Larmangat, has obtained a government concession for its extended construction for forty years. The locomotives are to weigh 4 tuns each, and will travel at the rate of 3·1 miles per hour, with full boats carrying, a cargo of 150 tuns each.

Proposed Utilization of the Hudson River Sources.

The Legislature of New York, last year, ordered a survey in order to determine whether the immense accumulation of water on the great Adirondack plateau could be held in reserve and drawn upon as needed for State purposes. A report on the subject has recently appeared, from which we learn that this storage can be safely and economically effected. At the present time this water runs to waste, and is productive of much damage during the spring freshets. If confined, it could be obtained in sufficient quantities, when needed, to supply deficiencies in the river during the dry summer season for at least one hundred days.