period as ten years, and it also appoints one or more officials, as may be necessary, in the carrying on of the school.

"Of these schools I will not copy the list; it includes no less than 18, generally with from 6 to 18 students each; and situated four in the province of Prussia, three each in Posen and the Rhenish province, two each in Brandenburg, Saxony, and Westphalia, and one each in Pomerania and Silesia. One of those in Saxony, that at *Badersleben*, is in a district where the peasants are of a more wealthy class, and it has taken a character intermediate between the academies and the schools, having from 60 to 80 students, and over 1,300 acres of land. There is one in the Rhenish province which has 30 students, and another with 25. The aggregate of all these schools is over 300.

"In special branches of farming there is a school at *Treves* for the culture of meadows; one at *Eichsfeld*, on a small scale, for flaxdressers, and a well established garden school at Sansouci, near Potsdam, with 12 or 14 scholars.

"And to conclude with the lands devoted to experimental purposes, it has been already indicated that some experiments are constantly going on in connection with the four agricultural academies, under the general inspection of their directors, but having also a special manager, who is assisted by a chemist. In addition to these, at the large sheep establishment at *Frankenfelde*, in Brandenburg, where the principal object is to preserve a pure race, and where also young shepherds receive instruction, 40 acres are devoted to the purpose of particular experiments, while the whole 1,700 can indirectly be employed for larger trials. Some of the agricultural societies have given lands, erected laboratories, and appointed chemists, quite recently however, and the State is aiding their efforts with some money, but only for a few years, in order to test the results accomplished. Establishments of this kind have been instituted to the number of six, respectively by the societies of Lithuania, Pomerania, Silesia, Upper Lusatia, Brandenburg, and the Rhenish province. The investigations thus instituted are not regulated by any general system of coöperation, and their results appear from time to time in pamphlets and in the agricultural journals."

METEOROLOGY.

METEOROLOGY IN ITS CONNECTION WITH AGRICULTURE.

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ATMOSPHERIC ELECTRICITY.

In this report, we intend to give a sketch of the general principles of atmospheric electricity, a branch of meteorology which has attracted in all ages more attention and has been regarded with more interest than perhaps any other.

The vast accumulation of electricity in the thunder cloud, and the energy exhibited in its mechanical, chemical, and physical effects, have impressed the popular mind with the idea of the great efficiency of this agent in producing atmospheric changes, and have led to views of its character not warranted by cautious induction. It is frequently considered sufficient in the explanation of an unusual phenomenon to refer it simply to electricity. References, however, of this kind, are by no means satisfactory, since the scientific explanation of a phenomenon consists in the logical reference of it to a general law; or, in clearly exhibiting the steps by which it can be deduced from an established principle. Electricity is subject to laws as definite and invariable as those which govern the mechanical motion of the planetary system. Indeed, there is a great similarity between them, and it will be seen in the discussion of electrical phenomena, that these are referable to forces similar to that of gravitation, and that the mathematical propositions which were demonstrated by Newton in regard to the latter, have been applied with admirable precision to represent those of the former.

In giving a general exposition of a subject of this kind, two plans may be adopted: either a series of facts may be stated, and from these a theory gradually developed by a careful induction, or we may begin with the general principles or laws which have been discovered, and from these deduce the facts in a series of logical consequences. The first method is called induction, the second deduction, and they are sometimes known by the more scholastic names of analysis and synthesis. The first method may perhaps be considered the more rigid, and, where a systematic treatise on a subject is intended, and ample space allowed for its full discussion, it might be preferred; but where the object is to give the greatest amount of information in the shortest time, to put the reader in possession of the means through which, by his own reflection, he can deduce from a single principle, hundreds of phenomena, and declare, prior to experiment or observation what will take place under given conditions, the latter method will be the proper one to be adopted.

It is impossible, however, to state a principle of very general application without employing an hypothesis or an assumption which, though founded on strict analogy, may possibly not be absolutely true. We adopt such an hypothesis temporarily, not as expressing an actual entity, but as a provisional truth which may be modified or even abandoned when we find it no longer capable of expressing all the phenomena. All we assert positively in regard to such an hypothesis, is, that the phenomena to which it relates, and with which we are acquainted at the time, exhibit themselves as if it were true.

When an assumed hypothesis of this kind furnishes an exact expression of a large number of phenomena, and enables us beforehand to calculate the time and form of their occurrence, it is then called a theory. The two terms, however, hypothesis and theory, though in a strict scientific sense of very different signification, are often confounded and otherwise misapplied. *Theory*, in common language, is frequently used in contradistinction to *fact*, and sometimes employed to express unscientific and indefinite speculations. The cause of truth would be subserved if these terms were used in a more definite and less general sense; for example: if the term *speculation*, were restricted to those products of the imagination which may or may not have an existence in nature; the term *hypothesis*, to suppositions founded on analogy, and which serve to give more definite conceptions of laws; while the term *theory*, is reserved for generalizations which, although they are presented in the language of hypotheses, yet really furnish the exact expression of a large class of facts.

Hypotheses, well conceived and properly conditioned by strict analogy, not only enable us, as we have before stated, to embrace at one view a wider range of phenomena, but also assist us in passing from the known to the unknown. When rightly used they are the great instruments of discovery, giving definite direction as to the experiments or observations desirable in a particular investigation, and thus marking out the line of research to be pursued in our endeavors to enlarge the bounds of the science of our day. We think that the tendency of some minds, instead of being too speculative, is too positive; and while, on the one hand, there is too much of loose, indefinite, and consequently of useless speculation intruded upon science, on the other, an evil of an opposite kind, is frequently produced by attempting to express scientific generalizations of a complex character, without the aid of proper hypotheses; and to this cause we would principally ascribe the looseness of conception which frequently exists in well educated minds as to the connection and character of physical phenomena.

In accordance with the foregoing remarks, we shall make use of a theory to express the well-established principles of electrical action, and from this endeavor to deduce such conclusions as are in strict conformity with the observed phenomena. The intelligent reader who

attentively studies this theory, and exercises his reasoning faculties in drawing conclusions from it, will be able not only to explain many remarkable appearances which would otherwise be entirely isolated, but also to anticipate results, and to adopt means to prevent unpleasant occurrences or to ward off dangers.

The theory which we shall adopt is that invented by Franklin and extended and improved by Epinus and Cavendish. It is sometimes called the theory of one fluid, in contradistinction to the theory of Du Fay, of two fluids. The two theories, however, do not differ as much as at first sight might be supposed, and, when expressed mathematically, are identically the same.

No part of the writings of Franklin exhibits his sagacity and his power of scientific generalization in a more conspicuous light than his theory of electricity. The talents to discover isolated facts in any branch of science, although possessed by few, is comparatively inferior to that characteristic of mind which leads to the invention of an hypothesis, embracing in a few simple propositions, whole classes of complete phenomena.

THEORY OF ELECTRICITY.

According to the theory of Franklin, all the facts of ordinary electricity may be referred to the action of a subtle fluid, which perhaps fills all interplanetary space, and may be the medium of light and heat. In order that the phenomena of electricity may be represented by the mechanical actions of this fluid, it is necessary to suppose that it is endowed with certain properties and relations which may be expressed in the following series of postulates:

1st. The electric fluid consists of atoms so minute as to exist between the atoms of gross matter.

2d. The atoms of the fluid repel each other with a force varying inversely as the square of the distance; that is, when the distances are 1, 2, 3, 4, 5, &c., the forces are 1, $\frac{1}{4}$, $\frac{1}{9}$, $\frac{1}{16}$, $\frac{1}{25}$, &c.

3d. The atoms of the fluid attract the atoms of ordinary matter, with a force also varying inversely as the square of the distance.

4th. The atoms of gross matter devoid of electricity, tend to repel each other also with a force inversely as the square of the distance.

5th. The atoms of the fluid can move freely through certain bodies of gross matter, such as metals, water, &c., which are hence called conductors; and cannot move, or but very imperfectly, through other bodies, such as glass, baked wood, dry air, &c., which are called non-conductors.

6th. When each equal portion of space has the same amount of electricity, and each body in it has so much of the same fluid as to neutralize the attractions and repulsions, there are no indications of electrical action; and when the attractions and repulsions are thus neutralized, a body is said to be in its natural condition.

7th. The electrical equilibrium may be disturbed by friction, chemical action, change of temperature, &c., or in other words by these and other processes the fluid may be accumulated in one portion of space, and rendered deficient in another, and in this case electrical action is exhibited.

8th. The phenomena are of two classes, namely: statical or those of attraction and repulsion, in which the electricity is at rest, and dynamical, or those in which the redundant electricity of one portion of space is precipitated into that of another in which there is a deficiency.

9th. When the electrical equilibrium has been disturbed, and a body contains more than its share of electricity, it is said to be positively charged; and when it contains less, it is said to be negatively electrified.

The fourth proposition of this theory was added by Cavendish, in England, and by Epinus, in Germany, and was found to be necessary in order to render the several parts of the theory as given by Franklin logically consistent with each other. At first sight, it appears to be contrary to the general fact of the mutual attraction of all bodies, but it must be observed that when gross matter exhibits attraction it is in its normal condition, and that since the electrical force is infinitely more intense than that of gravitation, the latter may be a residual phenomenon of the former.

According to this theory, there are two kinds of matter in the universe —ethereal or electrical matter and gross, or, as it is frequently called by way of distinction, ponderable matter. The two, however, may have the same essence, and differ from each other only in the aggregation of the atoms of the latter; or, in other words, what we call gross matter, may be but a segregation or kind of crystallization of the ethereal matter in definite masses. Each kind of matter is, in itself, entirely inert, has no power of spontaneous change of place, and is equally subject to the laws of force and motion. A mass of ordinary ponderable matter, when once at rest, tends to continue at rest until put in motion by some extraneous force; so, also, the electrical fluid, when at rest, tends to remain at rest, and only moves in obedience to some impulse from without. From this theoretical inference, which is in accordance with all observation, it is an error to suppose that electricity is an ultimate power of nature, being in itself the cause of motion. Like the air, it is inert, and has no more tendency to spontaneous motion than this or any other fluid which may receive and transmit impulses, or which may have its equilibrium disturbed, and in the restoration of this equilibrium, give rise to motion, and produce mechanical effects.

Perhaps some currency is given to the idea that electricity is not subject to the mechanical laws which govern the actions of gross matter, because it is called an imponderable agent, and has thus, as it were, assigned to it a semi-spiritual character. The term imponderable, though convenient, is not properly applied, since it indicates a distinction which may possibly not exist. If electricity is, in reality, a fluid, it might exhibit weight, could it be so isolated and condensed as to become sensible to our balances. But whatever may be its nature, the phenomena which it exhibits can be referred to mechanical laws; and

it is in order that such a reference may be definitely made, that the hypothesis of a fluid is adopted. For a similar reason, the phenomena of light and radiant heat are referred to the vibrations of an ethereal medium, and it is in this way that the laws of motion which have been deduced from the study of gross matter, have been so successfully applied to them, and it is only so far as the facts of what are called the imponderable agents are brought under the category of mechanical laws, that they take the definite form which entitles them to the name of science

THEORETICAL DEDUCTIONS AND ILLUSTRATIONS.

We do not intend to deduce from the theory we have presented, a complete system of electricity, but to give such deductions from it as will put the intelligent reader in possession of the principal known facts of atmospheric electricity, and particularly those which relate to thunder storms.

In the first place, if the ethereal medium, in its ordinary state of diffusion, fills all space, then it must be evident that when a body is charged with more than its natural share, a portion must be drawn from space around, and hence what one body gains other bodies in the vicinity must lose; or, in other words, there must always be as much negative excitement as positive. To exhibit this, as well as to illustrate some of the effects of the disturbance of the electrical equilibrium, provide two strips of glass an inch in width and twelve inches long, and on the end of one of these fasten, with beeswax or sealing-wax, a piece of woolen cloth about an inch and a half long; if the glass slips are warmed and rubbed together as shown in figure 1, and afterwards separated, they will exhibit signs of electricity. If the strip of glass of which the end is naked be brought near a pith-ball *C*, suspended by a single fiber of unconducting silk, along which the electricity which may be communicated to the ball cannot escape, the ball will be attracted, and immediately afterwards repelled. If, now, the end of the other glass having the woolen cloth on it, be brought near to the same ball, attraction will take place at a considerable distance. The one slip of glass will constantly attract, while the other will as constantly repel the ball. If, however, the two glasses be placed in contact, as they were when first rubbed, and thus presented to the ball, neither attraction nor repulsion will be exhibited.

Fig. 1.

These results are in strict accordance with the theory we have adopted. By rubbing the glass and woolen cloth against each other, the electrical equilibrium is disturbed—a portion of the natural electricity of the cloth is transferred to the glass; the latter receives a positive charge of electricity, while the woolen cloth loses a portion of its natural share of the fluid, and assumes the negative state; and since the slips of glass, as well as the surrounding air, are nonconductors, the redundancy of the one can not escape, nor the deficiency of the other be supplied, and therefore the charged condition of each will continue for a considerable time, particularly if the air be perfectly dry.

When the glass plate is made to touch the ball, a portion of electricity accumulated on the surface of the former is transferred to the latter, which has then more than its natural share; and, since atoms of free electricity repel atoms of free electricity, the ball will apparently be repelled from the glass; and also because there is an attraction between free electricity and unsaturated matter, the cloth, which is in this condition, will attract the same ball. When the two slips of glass are brought together, and presented as a whole, the attractions and repulsions may still be considered as existing, but since they are equal and opposed, they entirely neutralize each other, and no external effect is perceptible.

The neutralization of the two opposite forces in this experiment, affords an illustration of the condition of a body in its natural state. Although it contains a large amount of the fluid, no action is produced on other bodies in their natural condition, because the attractions and repulsions just balance each other.

For exhibiting the most important statical phenomena of electricity, and for verifying the deductions from the theory, we may employ a solid glass rod of about fifteen inches in length, and a rod of sealing-wax or of gum shellac of the same length. If these be well dried, held by one end and rubbed with a piece of woolen cloth at the other, electrical excitement will be produced. Instead of a solid glass rod, a tube may be employed, provided the interior be perfectly dry, and well corked to prevent the access of moisture. If the end of the tube or rod be rubbed, and afterwards brought into contact with a small ball of pith, or of any light conducting matter, suspended by a silk thread, the excitement will be communicated to the ball, and if the communication be from the glass rod the electricity will be that denominated positive; if from the rod of sealing-wax or shellac, it will be what is called negative. Since the phenomena exhibited by balls charged negatively and positively are very nearly the same, it is not of much consequence which we call the positive or which the negative, provided we always apply the same name to the same kind of excitement. In the early discovery of the two kinds of electrical excitement, that which was produced by rubbing glass with a woolen cloth was called *vitreous*, and that from the friction of the same substance on sealing-wax or gum shellac was denominated *resinous*, and these terms are still retained, particularly in foreign works on the subject.

The simplest instrument for exhibiting the attraction and repulsion of electrified bodies, and determining the intensity and character of the excitement, is the gold-leaf electrometer, which any person with a little patience and some mechanical skill may construct for himself. Different forms of this instrument are exhibited in Figures 2 and 8.

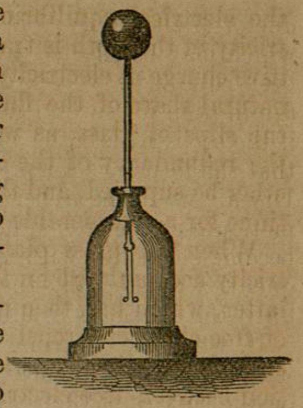

Fig. 2.

A brass wire, surmounted by a ball of the same metal, is passed through the cork of a small glass jar, or large-sized vial, from which the bottom has been removed and its place supplied by a disk of wood; and to the lower end of the wire, which may be slightly flattened, is attached, by means of any adhering substance, two narrow strips of gold leaf, so as to hang freely, and, when unexcited, parallel to each other without touching.

When we wish to ascertain if a body is electrified, or whether different parts of it are charged, for example, positively to the same degree, we bring in contact with the part to be examined, a small metallic ball suspended at the end of a very fine silk thread, (a fiber from a cocoon will serve for this purpose,) and afterwards bring the small ball, which may be called the carrier, in contact with the ball, or, as it is called, the knob of the electrometer. The electricity of the carrier will distribute itself, on account of the repulsion of its atoms, throughout the knob, the stem, and the leaves of the electrometer. The leaves being the only movable part, will diverge from each other, and will thus exhibit the electrical repulsion to the eye. We see from this experiment, as well as from that of the ball touched with the excited glass, that electricity may be transferred from one body to another, and that when it is applied to the end of an elongated metallic conductor it instantly diffuses itself over the whole mass. In the experiment we have just described, the body was supposed to have been *positively* electrified; but a similar effect would have been produced had it been negatively charged. In that case, a portion of the natural electricity of the carrying ball would have been drawn from it by the unsaturated matter of the electrified body, and the ball in turn, when brought in contact with the upper end of the electrometer, would draw from it a portion of its natural electricity—the deficiency extending to the leaves—which would therefore diverge, since, according to the theory, unsaturated matter repels unsaturated matter.

If we wish to ascertain whether a body is electrified negatively or positively, we transfer a portion of its charge to the electrometer by means of the carrying ball, and then, having rubbed a rod of glass with a piece of woolen cloth, we bring it near to the electrometer; if the leaves diverge further when the rod of glass is brought near, the original charge is of plus electricity; if, on the contrary, the leaves converge, we may consider the electricity as negative; or the same conclusion may be arrived at by rubbing a stick of sealing-wax with the woolen cloth, which, becoming negatively excited, will cause the leaves in the case of a positive charge to converge, and in that of a negative charge to diverge.

CONDUCTION AND INSULATION OF ELECTRICITY.

By means of a simple electrometer of the kind we have just described we may at once determine whether a body is a conductor or non-conductor of electricity. If a slight charge be given to the electrometer, which may be effected by touching the knob with a rod which has been rubbed by woolen cloth, the charge will remain with but little diminution for several hours, provided the air is perfectly dry; while, if the air is moist, the charge is soon dissipated. These facts show that the former is a non-conductor, and the latter a partial conductor. Dry air would be a perfect insulator of electricity, provided it were motionless; the atoms, however, which impinge against a charged body become electrified with the same kind of excitement, and are, consequently, repelled off, their place being supplied with others, and so on until the charge is gradually diminished and finally dissipated.

If, when the electrometer is charged in dry air, we touch the knob with a glass rod, the leaves will be but little affected; but, if we breathe on the surface of the rod, the glass will become a partial conductor and the leaves will slowly converge. If the ball be touched with one end of a metallic wire, the electricity will instantly be conducted off. If we make a similar experiment with a piece of dry wood, the charge will be gradually dissipated, a fact which indicates that wood is a partial conductor. By increasing the length of an imperfect conductor we shall find that the time of drawing off the charge is increased, and in this way it may be shown that there are very few bodies which are perfect conductors or non-conductors; that every body offers some resistance to the passage of an electrical current, provided we increase the length sufficiently to make it perceptible. By experimenting on various bodies in the way we have described, we may form an approximate table of the degrees in which different substances are conductors or non-conductors of electricity. The human body is a very perfect conductor of ordinary electricity, since if we touch the knob of the electrometer with the finger, the leaves instantly collapse, provided we are standing at the time on the ground. If, however, we place a non-conductor, for example, a cake of beeswax, under the feet, the whole of the charge will probably not be withdrawn but shared with the body, and the leaves will only partially converge. It may also be shown by the same instrument that in order to produce electrical excitement by friction, it is only necessary that two dissimilar substances be rubbed together, one at least of which must be a partial conductor. For example, if, while a person is standing on a cake of beeswax he place one finger on the knob of an electrometer and another person strike him on the back with a silk handkerchief, the leaves will instantly diverge, showing that the whole body has received a charge of electricity, which is prevented from escaping into the floor by the interposed non-conducting beeswax.

After the introduction of furnaces for heating rooms by warm air, the public were surprised at exhibitions of electrical excitement which previously had not been generally observed. If our shoes be very dry, and we move over the surface of a carpet, with a shuffling motion, on a very cold day, particularly in a room heated by a furnace, the friction will charge the body to such a degree that a spark may be drawn from the finger, and under favorable circumstances a jet of gas from a burner may be ignited. There is nothing new or wonderful in this experiment; it is simply an exhibition of the production of electricity by friction, which only requires the carpet, the shoes, and the air to be dry, conditions most perfectly fulfilled on a day in which the moisture of the air has been precipitated by external cold and its dryness increased by its passage through the flues of the furnace. In the ordinary state of the atmosphere, the electricity, which is evolved by friction, is dissipated as rapidly as it is developed, but in very cold weather the non-conducting or insulating power of the air is so much increased that the electricity, which is excited by the almost constant rubbing of bodies on each other, is rendered perceptible. Every person is familiar with the fact, that, on removing clothes, or shaking garments in dry weather, the electricity evolved by the rubbing exhibits itself in sparks and flashes of light. The popular idea in regard to this is, that the atmosphere, at such times, contains more electricity than at others, but these appearances are not due to the variation of the electricity in the atmosphere, but simply to the less amount of vapor which is present. When the clothes are rubbed together one part becomes positive and the other negative, and in dry air the excitement increases to such an intensity that the restoration of the equilibrium takes place by a visible spark, but in the case of moist air the equilibrium is silently restored as soon as it is disturbed, and no excitation is perceptible.

Similar effects are observed on the dry plains of the western part of our continent; in rubbing the horses or mules, sparks of electricity may be drawn from every part of the body of the animal. Persons in delicate health, whose perspiration is feebly exhaled, sometimes exhibit electrical excitement in a degree sufficient to surprise those who are not familiar with the phenomena. But these exhibitions have no connection with animal electricity, and are merely simple illustrations of the electricity developed by friction in an atmosphere too dry to permit the usual immediate and silent restoration of the electrical equilibrium.

DISTRIBUTION OF ELECTRICITY.

The mutual repulsion of the atoms of electricity, varying inversely as the square of the distance, gives rise to the distribution of the fluid in regular geometrical arrangements, the form of which may be calculated with mathematical precision. As one of the simplest cases of distribution, suppose a conductor of the form of a cylinder, with hemispherical ends—for example, one of wood, covered with tin foil—to be suspended horizontally in dry air with silk threads, and, thus insulated, to be slightly electrified by touching the middle of it with a charged body; the atoms of the fluid, by their mutual repulsion, will separate as far as possible from each other, and be found at the two extremities. If the conductor were not surrounded with a non-conducting fluid, like the air, they would be driven off by the same repulsion into space, and thus indefinitely separated.

This inference, from the theory, can readily be proved to be in accordance with the actual condition of the excitement, by bringing into contact with the middle of the length of the conductor a small carrier ball, and afterwards applying it to the knob of the electrometer. If the charge given to the conductor be small, scarcely any electricity will be found at the middle; if, however, the carrier be brought into contact with either end of the conductor, it will receive a charge of such