SOME POSSIBILITIES OF ELECTRICITY.

By William Crookes.

We know little as yet concerning the mighty agency we call electricity. "Substantialists" tell us it is a kind of matter. Others view it, not as matter, but as of a form of energy. Others, again, reject both these views. Professor Lodge considers it "a form, or rather a mode, of manifestation of the ether." Professor Nikola Tesla demurs to the view of Professor Lodge, but thinks that "nothing would seem to stand in the way of calling electricity ether associated with matter, or bound ether." High authorities cannot yet even agree whether we have one electricity or two opposite electricities. The only way to tackle the difficulty is to persevere in experiment and observation. If we never learn what electricity is, if, like life or like matter, it should always remain an unknown quantity, we shall assuredly discover more about its attributes and functions.

The light which the study of electricity throws upon a variety of chemical phenomena—witnessed alike in our little laboratories and in the vast laboratories of the earth and sun—cannot be overlooked. Without going into transcendental speculations as to the origin of all things, it may be mentioned that the theory which now meets with most favor as best representing the genesis of the chemical elements is, that at the time each element was differentiated from the all-pervading *protyl*, it took to itself definite quantities of electricity, and upon these quantities the atomicity of the element depends. Professor Oliver Lodge expresses this when he says, "Every monad atom has associated with it a certain definite quantity of electricity; every dyad has twice this quantity associated with it; every triad three times as much, and so on."* Helmholtz considers it to be probable that electricity is as atomic as matter, and that an electrical atom is as definite a quantity as a chemical atom. This, however, must not yet be regarded as a certainty, for it is possible that all the facts at present known may be explicable in another way. If an atom of matter is endowed with the property of taking to itself one, two, three, or more units of electricity, it does not follow that electricity is atomic. Imagine the atoms of matter to act like so many bottles, capable of holding one, two, three, or more pints. Imagine electricity to be like water in the ocean, which for the purposes of this argument may be considered inexhaustible and structureless. One of the atomic "bottle" elements dipped into the ocean would certainly take to itself one, two, three, or more pints of water, but it would by no means follow that the ocean was atomic in that it was capable of being divided up into an infinite number of little parcels, each holding a pint or its multiple.

For this and other reasons I think we must accept the hypothesis of the atomic character of electricity as not yet definitely proved, although it is not improbable.

I have spoken of the "ether"—an impalpable, invisible entity, by which all space is supposed to be filled. By means of the ether theory we can explain electrical phenomena, as well as those appertaining to the phenomena of light.

Until quite recently we have been acquainted with only a very narrow range of ethereal vibrations, from the extreme red of the solar spectrum on the one side to the ultra violet on the other—say, from three ten-millionths of a millimeter to eight ten-millionths of a millimeter. Within this comparatively limited range of ethereal vibrations and the equally narrow range of sound vibrations, all our knowledge has been hitherto confined.

Whether vibrations of ether, longer than those which affect us as light, may not be constantly at work around us, we have, until lately, never seriously inquired. But the researches of Lodge in England and of Hertz in Germany give us an almost infinite range of ethereal vibrations or electrical rays, from wave lengths of thousands of miles down to a few feet. Here is unfolded to us a new and astonishing world—one which it is hard to conceive should contain no possibilities of transmitting and receiving intelligence.

Rays of light will not pierce through a wall, nor, as we know only too well, through a London fog. But the electrical vibrations of a yard or more in wavelength of which I have spoken will easily pierce such mediums, which to them will be transparent. Here, then, is revealed the bewildering possibility of telegraphy without wires, posts, cables, or any of our present costly appliances. Granted a few reasonable postulates, the whole thing comes well within the realms of possible fulfillment. At the present time experimentalists are able to generate electrical waves of any desired wave length from a few feet upward, and to keep up a succession of such waves radiating into space in all directions. It is possible, too, with some of these rays, if not with all, to refract them through suitably shaped bodies acting as lenses, and so direct a sheaf of rays in any given direction; enormous lens-shaped masses of pitch and similar bodies have been used for this purpose. Also an experimentalist at a distance can receive some, if not all, of these rays on a properly constituted instrument, and by concerted signals messages in the Morse code can thus pass from one operator to another. What, therefore, remains to be discovered is—first, simpler and more certain means of generating electrical rays of any desired wave length, from the shortest say of a few feet in length, which will easily pass through buildings and fogs, to those long waves whose lengths are measured by tens, hundreds, and thousands of miles; secondly, more delicate receivers which will respond to wave lengths between certain defined limits and be silent to all others; thirdly, means for darting the sheaf of rays in any desired direction, whether by lenses or reflectors, by the help of which the sensitiveness of the receiver (apparently the most difficult of the problems to be solved) would not need to be so delicate as when the rays to be picked up are simply radiating into space in all directions, and fading away according to the law of inverse squares.

Any two friends living within the radius of sensibility of their receiving instruments, having first decided on their special wave length and attuned their respective instruments to mutual receptivity, could thus communicate as long and as often as they pleased by timing the impulses to produce long and short intervals on the ordinary Morse code. At first sight an objection to this plan would be its want of secrecy. Assuming that the correspondents were a mile apart, the transmitter would send out the waves in all directions, filling a sphere a mile in radius, and it would therefore be possible for any one living within a mile of the sender to receive the communication. This could be got over in two ways. If the exact position of both sending and receiving instruments were accurately known, the rays could be concentrated with more or less exactness on the receiver. If, however, the sender and receiver were moving about, so that the lens device could not be adopted, the correspondents must attune their instruments to a definite wave length, say, for example, fifty yards. I assume here that the progress of discovery would give instruments capable of adjustment by turning a screw or altering the length of a wire, so as to become receptive of wave lengths of any preconcerted length. Thus, when adjusted to fifty yards, the transmitter might emit, and the receiver respond to, rays varying between forty-five and fifty-five yards, and be silent to all others. Considering that there would be the whole range of waves to choose from, varying from a few feet to several thousand miles, there would be sufficient secrecy; for curiosity the most inveterate would surely recoil from the task of passing in review all the millions of possible wave lengths on the remote chance of ultimately hitting on the particular wave length employed by his friends whose correspondence he wished to tap. By "coding" the message, even this remote chance of surreptitious straying could be obviated.

This is no mere dream of a visionary philosopher. All the requisites needed to bring it within the grasp of daily life are well within the possibilities of discovery, and are so reasonable and so clearly in the path of researches which are now being actively prosecuted in every capital of Europe, that we may any day expect to hear that they have emerged from the realms of speculation into those of sober fact. Even now, indeed, telegraphing without wires is possible within a restricted radius of a few hundred yards, and some years ago I assisted at experiments where messages were transmitted from one part of a house to another without an intervening wire by almost the identical means here described.

The discovery of a receiver sensitive to one set of wave lengths and silent to others is even now partially accomplished. The human eye is an instance supplied by nature of one which responds to the narrow range of electro-magnetic impulses between the three ten-millionths of a millimeter and the eight ten-millionths of a millimeter. It is not improbable that other sentient beings have organs of sense which do not respond to some or any of the rays to which our eyes are sensitive, but are able to appreciate other vibrations to which we are blind. Such beings would practically be living in a different world from our own. Imagine, for instance, what idea we should form of surrounding objects were we endowed with eyes not sensitive to the ordinary rays of light, but sensitive to the vibrations concerned in electric and magnetic phenomena. Glass and crystal would be among the most opaque of bodies. Metals would be more or less transparent, and a telegraph wire through the air would look like a long narrow hole drilled through an impervious solid body. A dynamo in active work would resemble a conflagration, while a permanent magnet would realize the dream of mediæval mystics and become an everlasting lamp with no expenditure of energy or consumption of fuel.

In some parts of the human brain may lurk an organ capable of transmitting and receiving other electrical rays of wave lengths hitherto undetected by instrumental means. These may be instrumental in transmitting thought from one brain to another. In such a way the recognized cases of thought transference, and the many instances of "coincidence," would be explicable. I will not speculate on the result were we eventually to catch and harness these "brain waves."

Whatever be the length of the electric wave, the velocity with which it travels is constant, and is equal to the velocity of light, or about one hundred and eighty thousand miles a second. Professor Oliver Lodge, who has worked for some years on these subjects, gives* formulæ for calculating the frequency of vibration and the wave length of the electrical rays given by the discharge of Leyden jars of different capacities. The bigger the jar and the greater the size of the circuit the longer will be the waves. Thus a pint jar discharging through a two yard circuit will give waves of a length of fifteen or twenty meters, and they will follow each other at the rate of ten millions a second. A jar the size of a thimble will give waves only about two or three feet long, and they will succeed one another at the rate of two hundred and fifty or three hundred millions a second. With every diminution in size of the apparatus the wave lengths get shorter, and could we construct Leyden jars of molecular dimensions, Professor Lodge considers the rays might fall within the narrow limits of visibility. We do not know the intimate structure of a molecule sufficiently to understand how it could act as a Leyden jar, yet it is not improbable that the discontinuous phosphorescent light emitted from certain of the rare earths, when excited by a high tension current of electricity in a good vacuum, is really an artificial production of these electric waves, sufficiently short to affect our organs of vision. If such a light could be produced more easily and more regularly, it would be far more economical than light from a flame or from the arc or incandescent lamp, as very little of the energy is expended in the form of heat rays. Of such production of light Nature supplies us with examples in the glow-worm and the fire-flies, whose light, though sufficiently energetic to be seen at a considerable distance, is accompanied by no liberation of heat capable of detection by our most delicate instruments.

By means of currents alternating with very high frequency, Professor Nikola Tesla has succeeded in passing by induction, through the glass of a lamp, energy sufficient to keep a filament in a state of incandescence without the use of connecting wires. These lamps possess one interesting feature; they can be rendered at will more or less brilliant by simply altering the relative position of the outside and inside condenser coatings. If exhausted glass tubes are used as the source of light, very beautiful effects are produced. The electric generator is capable of exciting the tubes at a considerable distance, and the luminous effects are very striking. For instance, if a tube be taken in one hand, the observer being near the generator, it will be brilliantly lighted, and will remain so, no matter in what position it is held relatively to the observer's body. Even with tubes having no electrodes there is no difficulty in producing by this means sufficient light to read by, and the light will be considerably increased by the use of phosphorescent materials, such as yttria, uranium glass, etc.

The ideal way of lighting a room would be by creating in it a powerful, rapidly alternating electrostatic field, in which a vacuum tube could be moved and put anywhere, and lighted without being metallically connected with anything. Professor Tesla has obtained such a condition by suspending, some distance apart, two sheets of metal, each connected with one of the terminals of the induction coil. If an exhausted tube is carried anywhere between these plates it remains always luminous. In such a room, in addition to the luminous phenomena mentioned, it is observed that any insulated conductor gives sparks when the hand or any other object is approached to it, and the sparks may often be powerful.

Alternating currents have at best a somewhat doubtful reputation; but it follows from Tesla's researches that, as the rapidity of the alternation increases, they become incomparably less dangerous. It further appears that a true flame can now be produced without chemical aid—a flame which yields light and heat without the consumption of material and without any chemical process. To this end we require improved methods for producing excessively frequent alternations and enormous potentials. The energy required is very small, and if light can be obtained as efficiently as theoretically it appears possible, the apparatus need have but a very small output. For the production of light at least, the heavy machinery at present in use would seem to be unnecessary. There being a strong probability that the illuminating methods of the future will involve the use of very high potentials, one of the problems in the near future will be to perfect a contrivance capable of converting the energy of heat into energy of the required form. The extent to which this new method of illumination may be practically available experiment alone can decide. In any case our insight into the possibilities of static electricity have been extended, and the ordinary electrostatic machine will cease to be regarded as a mere toy.

Another tempting field of research, scarcely yet attacked by pioneers, awaits exploration. I allude to the mutual action of electricity and life. No sound man of science indorses the assertion that "electricity is life;" nor can we ever venture to speak of life as one of the varieties or manifestations of energy. Nevertheless, electricity has an important influence upon vital phenomena, and is in turn set in action by the living being, animal or vegetable. We have electric fishes—one of them the prototype of the torpedo of modern warfare. There is the electric slug, which is reported to have been met with in gardens and roads about Hornsey Rise, and which, if touched, occasioned a momentary numbness of the finger tip. There is also an electrical centipede. In the study of such facts and such relations the scientific electrician has before him an almost infinite field of inquiry.

If we take a bird's eye view of the solid work that lies ahead, the first requisite is certainly a source of electricity cheaper and more universally applicable than the tedious conversion of chemical energy into heat, of heat again into mechanical power, and of such power into electric current. It is depressing to reflect that this roundabout process, with losses at every step, is still our best means of obtaining a supply of electricity. Until this is accomplished, we are still haunted by the steam engine with its clouds of smoke and its heaps of cinders and ashes. Water power to set dynamos in action is only available in exceptional cases, and very rarely indeed in our country. While we are seeking for cheaper sources of electricity, no endeavor must be spared to tame the fierceness of those powerful alternating currents now so largely used. Too many clever electricians have shared the fate of Tullus Hostilius, who, according to the Roman myth, incurred the wrath of Jove for practising magical arts, and was struck dead with a thunderbolt. In modern language, he was simply working with a high tension current, and, inadvertently touching a live wire, got a fatal shock.

We know that the rays of the arc light, allowed to act judiciously on plants, may, to a more or less extent, compensate for lack of solar heat and light; but so long as electric energy is so costly, we cannot bring this interesting fact into industrial practice. In respect to vegetation, it is still uncertain whether electrical currents exercise any decided or uniform influence upon growing crops of grain or fruit; or whether such influence would be favorable or the reverse. Experiments tried by the late Sir W. Siemens lead to the opinion that electricity may induce earlier and better harvests; but much further study is here needed. Nor have we yet solved the equally important and closely connected question, whether we may by electrical action rout the parasitical insects and fungi which in some seasons rob us of no less than the tenth of our crops. A moderate estimate puts the mean loss in the home kingdoms at £12,000,000 per annum. In India and some of the colonies, a number of destroyers, which it is not my business to specify, are less easily contented. Like Falstaff, in the words of Dame Quickly, they seek to take, "not some, but all." The attacks of the phylloxera have cost our French neighbors more than did the Franco-Prussian war.

It has been found in not a few experiments that electric currents not only give increased vigor to the life of the higher plants, but tend to paralyze the baneful activity of parasites, animal and vegetable. Here, then, is unlimited scope for practical research, in which the electrical engineer must join forces with the farmer, the gardener, and the vegetable physiologist. We have definitely to decide whether, and under what circumstances, electricity is beneficial to our crops; and whether, and under what conditions, it is deadly to parasitic pests.

With regard to the possible applications of electricity to agriculture, I may mention that the total amount

* "On Electrolysis," British Association Reports, 1885.

* *Modern Views of Electricity*, pp. 246-7.

of *vis viva* which the sun pours out yearly upon every acre of the earth's surface, chiefly in the form of heat, is 800,000 horse power.* Of this mighty supply of energy, a flourishing crop utilizes only 3,200 horse power, so that the energy wasted per acre of land is 796,800 horse power. We talk loudly of the importance of utilizing the refuse of our manufactures; but what is the value of alkali waste, of furnace slags, of coal tar, or of all of them together, compared to the loss of 796,800 horse power per acre?

The application of electricity to sanitary improvements is another possibility, turning again mainly on a cheap supply of current. The electrical treatment and purification of sewage and industrial waste waters is a demonstrated reality which merely requires a reduction in the cost of the agent employed.

The sterilization, *i. e.*, the destruction of disease germs by electrical means, of the water supply of cities has been proposed and discussed. Theoretically, it is possible, but the practical difficulty of dealing with the vast volumes of water required for the daily consumption of London is prodigious. But, "a difficulty," said Lord Lyndhurst, "is a thing to be overcome." There is a still more important consideration; the living organisms in water are by no means all pathogenic—many are demonstratively harmless, and others are probably beneficial. Pasteur proposed to bring up young animals on sterilized food and drink with a view to determine whether their health and development would be affected for the better or for the worse. Decisive results are not yet forthcoming. Before the sterilization of our water sources can be prudently undertaken, this great question must be first decided by experimental biologists.

Another point at which the practical electrician should aim is nothing less than the control of the weather. We are told that these islands have no climate—merely samples—that an English summer consists of three fine days and a thunderstorm, and that the only fruit that ripens with us is a baked apple. There is more than a grain of truth in this sarcasm. The great evil of a thunderstorm in this country is not that the lightning may kill a man or a cow, or set barns or stacks on fire. The real calamity consists in the weather being upset. The storm is followed by a fall of temperature; and a fit of rain, clouds and wind, which rarely lasts less than a week, sadly interferes with the growth and ripening of grain and fruits. The question is, Cannot the accumulations of electric energy in the atmosphere be thwarted, dispersed, or turned to practical use? In like manner we may hope to abate the terrible fog nuisance, which is now in point of time no longer confined to the month of November, and by no means limits its attacks to London. It has been shown that during a genuine London fog the air is decidedly electro-positive. What the effect would be of neutralizing it would not be very difficult to show.

We hear of attempts at rain-making, said to have been more or less successful. Shall we ever be able, not to reduce our rainfall in quantity, but to concentrate it on a smaller number of days, so as to be freed from a perennial drizzle?

I shall, perhaps, be styled a dreamer, or something worse, if I remotely hint at still further amending the ways of nature. We all know, too well, that cloudiness and rainfall occur chiefly by day, and clear skies at night. This is precisely the opposite distribution to that which our crops require. We need clear heavens by day, that the supply of sunshine may not be interfered with, and we want clouds at night to prevent the earth losing by radiation the heat which it has gained in the day. As we have just seen, nature supplies energy amply sufficient. How is this enormous quantity of power to be made available? These are problems which may safely be left to the devices and the inspirations of our electrical engineers.

I have thus glanced at some of the intricate electrical problems to be solved—some of the enormous difficulties to be surmounted. Progress, a word now in the mouth of every one, may—as Dean Swift observed—be too fast for endurance. Sufficient for this generation are the wonders thereof!—*Fortnightly Review.*

HOW TO MAKE A STORAGE BATTERY.

By GEORGE M. HOPKINS.

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 6 × 7 in. and 1/16 in. thick, placed in a glass jar 6 × 9 in., with a depth of 7½ in. Each plate is provided with an arm 1½ in. 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 8½ × 14 in. 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 in. on each side of the plate. The perforated and imperforate plates are arranged in alternation, with all of the arms of the perforated plates extending 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 a 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.

FIG. 2.—ROUGHENING THE PLATE.

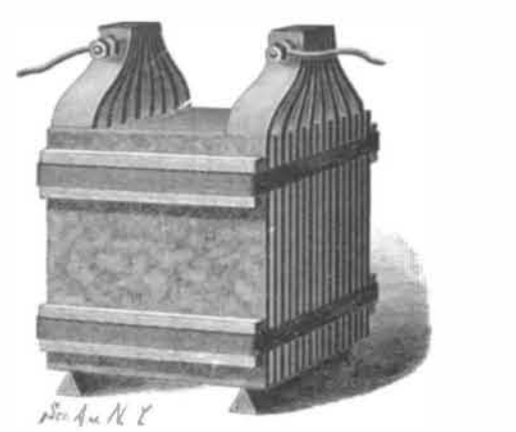

FIG. 3.—PLATES CONNECTED.

The arms of each series of plates are bent so as to bring them together about three or four 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 cell are thoroughly washed, and the cell is filled with a solution formed of sulphuric acid 1 part, water 9 parts.

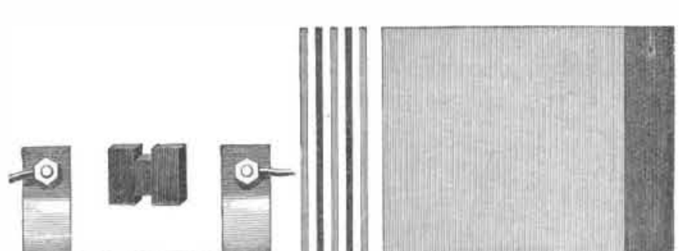

FIG. 1.—PLATES OF SECONDARY BATTERY.

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 current 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 se ies of cells would be the number of cells × 2. It is a simple manner 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 sixty. It will, therefore, require a battery having an E. M. F. of sixty volts to operate even a single lamp. This being the case, at least thirty 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 thirty-two 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 seventy-five volts.

FIG. 4.—COMPLETE CELL.

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 twenty or thirty 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.

ACTION OF ELECTRIC CURRENTS UPON THE GROWTH OF SEEDS AND PLANTS.

By DR. JAMES LEICESTER.

A.—ZINC plate buried in the soil and about 1 sq. ft. in size.

B.—Plate of copper having the same dimensions as the zinc plate, and connected at the top by a copper wire above the surface, C, with the copper plate, B.

D.—A box about 3 ft. long and about 2½ ft. wide filled with soil.

By means of the apparatus shown in Fig. I. a weak

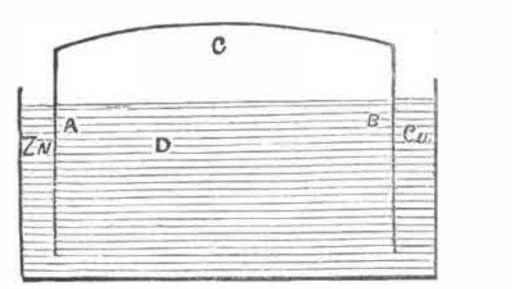

FIG I.

current can be passed through the soil. The strength of the current will vary with the amount of organic acids in the soil. A series of experiments were conducted with the object of finding out whether these weak currents would in any way affect the growth of seeds and plants. In order that there could be good comparative tests, a number of glass vessels were obtained, all of the same size, filled with similar soil, and exposed to the same conditions, such as temperatures and sunlight. In some of these were placed earth plates, as shown in A (Fig. II.), whereas the others only contained the soil.

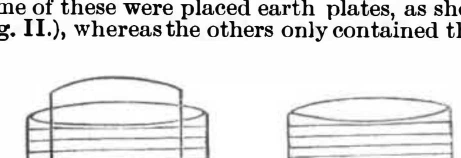

FIG II

They were watered each day at the same time and with equal quantities of water. Various seeds were obtained, and the same number of seeds sown in both vessels at the same time and under the same conditions. In all cases the seeds grew very much quicker in the vessels containing the earth plates. In the case of hemp seed it was fully an inch above the surface before there was any sign of it in the ordinary vessels.

Larger plates have been made connected as before and buried in the ground a few feet apart. In these larger experiments the same results were obtained. Seeds were sown in drills as shown in Fig. III. Those in the zones, *a*, *b*, *b'*, were the first to appear. Next came those in the zones *c* and *c'*. Those sown at *d* and *d'* came up nearly a week later than the others.

In order to vary this experiment the earth plates were next buried where *d* was, and fresh seeds sown. The greatest fertility was then noticed to be in the

* "The Perplexed Farmer," by George Ville. English edition, by W. Crookes.