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

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 $\frac{1}{8}$ 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

FIG. 2.—ROUGHENING THE PLATE.

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 ¼ 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

FIG. 3.—PLATES CONNECTED.

at the top and bottom, and the rubber bands extend lengthwise of the strips.

The arms of each series of plates are bent so as to bring them together about 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,

an electro-motive force of two volts, and the voltage of the series 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

FIG. 4.—COMPLETE CELL.

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.

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. 1. a weak

FIG. 1.

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

FIG. 1.—PLATES OF SECONDARY BATTERY.

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

and the cell is filled with a solution formed of sulphuric acid 1 part, water 9 parts.

The desired number of cells having been thus prepared, are connected in series, and the poles of each cell are marked so that they may be always connected up in the same way. The charging current, from whatever source, should deliver a current of ten amperes with an electro-motive force ten per cent. above that of the accumulator. Each cell of this battery has

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

neighborhood of d , that is to say, between the two plates.

With regard to plant life, experiments are now being conducted, but so far no distinct difference has been noticed in the case of those under ordinary conditions and those with the earth plates. If the soil is watered with a little very dilute acetic acid, the growth of the seeds is much quicker in the case of the earth plates,

Fig. III

but no difference is noticed in the ordinary vessels. The latter result is probably due to the slight increase in the strength of the current due to the action of the acetic acid.

These earth plates are hardly practicable on a large scale, but might be used in frames or for forcing under glass.—*Chem. News*.

THE ACTION OF HEAT FROM OPEN FIRE GRATES, STOVES, AND HOT WATER PIPES.

By F. DYE.

THOSE who make a profession of hot water works, or heating by hot air or by stoves, almost invariably make it a point to deprecate the use of open grates, and to show that with these articles very irregular results are the general rule, and for a given amount of heat they are not very economical in fuel. On the other hand, the maker of the open fire grate can claim advantages for his manufactures which the other methods of heating do not possess, and he can just as readily deprecate these other methods in question, owing to their having disadvantages which are absent when the open grate is used.

Speaking as favorably of the open grate as possible, it has to be admitted that, with the average of those that are now in use, the heat evolved is very irregular indeed, and even with careful stoking the effect, by way of heat distributed into the room, for a given quantity of fuel, is less than with either of the other methods referred to. Let it be clearly understood, however, that this last paragraph is intended to apply to the average grate now in use, as quite the majority consist of what are commonly termed "registers," having a register flap at back, and no provision to reduce the speed of combustion. This is an old pattern grate, and is very greatly improved upon by many new grates, more lately introduced, and which will be alluded to directly as they more nearly approach perfection. These latter, however, are not yet in the majority by any means.

From this it will be gathered that the heat evolved from open grates is different in action and results to that obtained from stoves and water pipes, and requires to be treated distinctly in these papers. In the same way the two methods usually form two distinct trades or callings, and the one deprecates the other as a rule, as just mentioned.

The mode by which heat is transmitted from the fire of an open grate to the persons or objects in a room is termed "radiation." Now, radiant heat acts in a manner peculiar to itself, first in sending its rays in direct lines from the source of the heat, and anything that does not come within the area or focus that the rays cover will not get heated by them, and would remain quite cold were it not that other indirect agencies cause the radiated heat to ultimately raise their temperature. The rays or lines of heat from the glowing fuel travel, as just stated, in direct lines from this source; but they diverge, or spread out, somewhat as they get away. The exact sum of their divergence is stated as follows: "The amount of radiant heat received by a given surface varies in the same proportion or ratio as the inverse of the square of the distance from the source of heat."

Fig. 1 illustrates and makes this technical rendering

Fig. 1

clear (a being the source of heat). It will be seen by this figure that as the rays of heat get further and further from their source they become more distributed as to the area they act upon, and a moment's thought will show that as they thus widen out they lose in power or intensity, and this is why it is that as we get further and further away from a fire the heat gets less and less. It is nothing else, for even if the fire were outdoors and the air in motion, it must not be thought that air or wind would make any difference to the direct course of radiant rays of heat. As an instance, to show that these rays travel in such distinctly direct lines, let any one place a screen between them and the fire, and see how instantly the heat is cut off. The same with a sunshade and the sun's rays. The heat does not curl round the edge of these screens and strike the person who is shielded behind them, for it will be found that the shadow cast by a sunshade is wanting in heat, the same as it is wanting in light.

Now when radiant rays of heat (more frequently called radiant energy, for heat has been found to be nothing more or less than motion) strike or impinge upon an object, the temperature of this object is raised; it is made warmer, more or less, as it is capable of quickly or slowly absorbing heat. When it has received heat it at once commences to reradiate, to redistribute it by radiation. This second radiation of heat is not so strong as the first from the fire, but is none the less certain, and it travels in the same direct lines. The lines of heat may, however, in this case proceed to some part of a room where the primary rays do not reach, and here they go to warm other objects, which in their turn distribute the heat again in different directions, and so it goes on. We might say the heat is tossed from one article to another about the room and so distributed; but this process goes on rather slowly, and when a fire is first lighted in a room, it is some time after the direct radiant heat is felt before the parts that do not receive these first, and more powerful, rays are warm. This reradiation of heat is one of the causes of the distant and remote parts of a room becoming ultimately warm.

If the direct rays of heat from a fire encounter a polished surface, there is instantly an active dispersal or deflection of the warmth. The action is essentially the same as with a ray of light that encounters a polished object. By an arrangement of mirrors, or such surfaces, it would be possible to divert the heat as desired, but this arrangement is neither practical nor probable.

Another and most active source of heat diffusion is the action of "convection." The word diffusion is correct here, as the way in which convected heat acts has no straight lines, or such rules governing it, but causes the heat to transfer itself here, there, and everywhere in a rapid, and effective, and independent manner.

"Convection" is derived from the word *conveho*, to carry up, and is the act of conveying heat by the ascent of heated particles of air or liquids. It is this action that we depend upon in a hot water apparatus, and without it we could have no circulation of water. It acts in the same manner with air, only more rapidly. The action of convection is as follows: The air, or atmosphere, is composed (like water) of an innumerable quantity of minute particles or molecules, these minute particles all being quite distinct and independent of one another, and, furthermore, being wholly devoid of friction or resistance of this kind in their movements. In all solid substances we look for friction to manifest itself more or less according to the surface of the particles of the substance; for instance, if we piled up jagged pieces of stone, we could make the heap a considerable height, owing to the friction brought to bear by the rough shape of the pieces preventing their slipping. If we attempted to make a heap with, say, billiard balls, we should not get along so well; but, to give an idea what absence of friction there is among the particles of liquids and gases, let any one try and make a heap of water.

Most authorities agree that there is not only absence of friction among fluids (liquids and gases) but also a positive repelling influence, for it is found in exhausting the receiver of an air pump that although the air gets more and more diminished as the pumping is continued, yet, when the quantity is very reduced, it still pervades the whole of the space, though in an attenuated form. What remains in the receiver does not collect in one spot; but the particles spread themselves about, getting as far apart from one another as possible, it would seem, and this phenomenon is just as noticeable when the air left in the glass is only about 1/1000 its original contents.

Having shown that air is composed of exceedingly small particles, ready to move freely in any direction that they may be impelled, the actual process of convection can be explained as follows: When air comes in contact with a heated object, those particles which have contact become heated also (for air absorbs heat readily), but directly the particles increase in temperature they also increase in size; they expand with heat, like every other substance, solid or fluid, does. Now, when a substance or particle is increased in bulk without increase in weight, it is rendered lighter than its smaller fellows. If we had a piece of cork 2 in. square, and a piece of wood 1 in. square, both weighing exactly the same, we should call the cork the lighter material, owing to its having greater bulk for a given weight. The particles of air, therefore, that are warmed and rendered lighter than their fellows are instantly displaced and caused to rise by the superior weight of the latter, and as the new cold particles come in contact with the heated object, so they are warmed and lightened, and caused to rise also.

Fig. 2 illustrates a heated ball, and the arrows indi-

Fig. 2.

cate the action of the air as the particles touch and are carried up in the way explained. The action is so rapid that there will be a constant stream of cool air to the ball, and an equally constant stream of hot air rising from it so long as it remains heated. If any heated object is taken, and some cigar smoke gently blown upon it, it will be seen how quickly the smoke takes an accelerated upward direction when it comes over the source of heat; the heated up current of air carries it with it. This is rather a long explanation devoted to convection, but it is a subject little known, or, at any rate, less known than its kindred subject—

radiation. In stove and hot water works the subject of convection is all important, as will be seen directly.

It will now be understood that air coming in contact with furniture and objects in the room which have received warmth by radiated heat instantly sets up convection currents, and this transfers heat to the distant or obscure parts of the room just as readily as the reradiation explained, if not more so in some cases. These convection currents also bring fresh air for respiration, and nature has provided many things which induce these currents of air to our benefit. There is a circulating motion of air induced by everything that has warmth—even the human body itself. If a cold object were introduced into a hot room, this also would induce the action explained, but the movement would be reversed. The warm air particles would be contracted by contact, and they would fall—just the opposite to the explanation given, but just as certain and rapid.

THE ACTION OF HEAT FROM OPEN FIRE GRATES.

An open fire heats the objects near it by radiant rays of heat, and this heat is reradiated about, and also transferred to the air by contact with the warmed objects. The reradiation and the convective action of the air ultimately distributes the heat about the room where the first direct rays do not reach. It will be seen from this that the greatest source of heat is the primary radiant rays from the glowing fuel, next the

Fig. 3

secondary rays (reradiated from warmed objects), and next and least, warmth imparted to the air by contact with warmed objects. Now, this order of precedence is the great feature of the open grate, it heating a room chiefly by radiant heat, and least by warming the air.

All authorities agree that the plan of heating most conducive to health is to provide a fully sufficient heat to the body, but at the same time to have a cold or cool air to breathe. This can be proved in many ways; for instance, by the ease or actual pleasure with which we can breathe the wintry air, provided the body is warmly clothed (and in health). It might have been more plainly stated earlier that radiant heat possesses the peculiar property of passing through air without increasing its temperature, and only heats objects that it strikes or comes in contact with. It is sometimes a little difficult to grasp this, but the common instance adopted by writers to prove its accuracy is to refer to the atmosphere at some distance from the earth; the atmosphere in high regions is always exceedingly cold (as snow-capped mountains prove), yet these high regions are nearer the sun, the source of heat, than the general surface of the earth is. The sun's rays have no warming effect upon the air however hot they may strike persons or objects upon the ordinary surface of the earth.

Now, in addition to the fact that the open grate contributes heat to a room by the most natural way possible, it has two other good features: first, the cheerful appearance of its fire cannot be overvalued. This one feature is a sufficient cause for its still being in favor, without the other advantage just given. In fact, among the general users of the open grate its hygienic value is unknown, and the pleasure the sight of the fire incites gives it preference over other methods of heating. Secondly, there is no more effective (non-mechanical) ventilator than the open fire grate. The chimney, with its wide opening into the room, is a most effective foul air extractor, and cause of fresh air inlet. This can be instantly proved by holding the hand to the crevice of a door or any point where air can find an entrance, and a keen inrush of air will be instantly detected. This inflow of air is wholly due to the up-draught in the chimney. Let the fire go out, and then close the chimney opening (the register flap), and the draught through the crevices will disappear.

There is no denying that the average grate is not capable of giving the effective results that other methods of heating can, and neither do we under any circumstances get such a regular or controllable temperature, but, notwithstanding this, the open grate exists, and its existence bears no signs of being terminated, for the improvements introduced of late years have as nearly as possible quite obliterated some of its ill features.

The first attempts in this direction were made with a view of checking the speed at which the fire burnt, and the outcome of this is the many forms of open fire "slow combustion" grates now to be obtained. This is a most desirable improvement, for with the old pattern grates the fire burnt unnecessarily fast when it had once become bright, and the great heat evolved went partly up the chimney and partly to make the heat of the room too great. This was the usual result. With the modern grates the speed of combustion is greatly reduced, and when the fire is bright it remains so for a longer period, giving out a regular heat and other satisfactory results, with a lessened quantity of coal.

This is excellent as far as it goes, but some of these grates have the disadvantage of being slow burning at all times, and a slow rate of combustion is a positive source of annoyance when the fire is first lighted, or at any of the times that it may be required to burn quickly. The fire should, to secure the most agreeable re-