

ELECTRICITY IN THE HOUSEHOLD.

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GENERAL ADOPTION OF ELECTRIC HOUSEHOLD APPLIANCES—THE BELL—COMPLICATED ANNUNCIATOR SYSTEMS—AUTOMATIC REGULATION OF TEMPERATURE—ELECTRIC FIRE-ALARM SYSTEM—A DOOR-OPENER—THE REGULATION OF CLOCKS—ELECTRIC TIME-DETECTOR—THE TELEPHONE ON LARGE ESTATES,—DOMESTIC USES OF THE INCANDESCENT LIGHT—A MEANS OF DECORATION—ILLUMINATED FOUNTAINS—CONVENIENT ARRANGEMENT OF LIGHTS AND WIRES—THE HAND GAS-IGNITER—SMALL MOTORS FOR HOUSEHOLD USES—ELECTRIC FANS, PUMPS, LAWN-MOWERS, SHOE-POLISHERS—THE PHONOGRAPH—ELECTRIC HORTICULTURE—HEATING BY ELECTRICITY—PLAN OF WIRING A HOUSE.

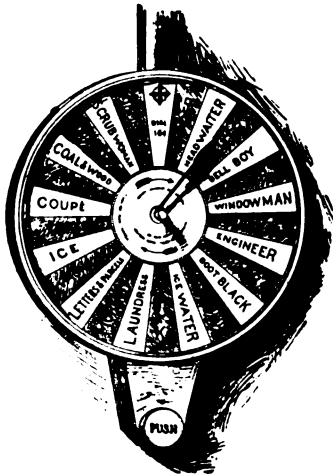
IT would be strange, indeed, if so readily controlled an agent as electricity, an Ariel before whom time and space seem to vanish, did not cross the threshold of our homes and enter into our household life. We find, in fact, that the adoption of electrical household appliances is daily becoming more widespread, here adding a utility, and there an ornament, until in the near future we may anticipate a period when its presence in the homestead will be indispensable.

The first application of electricity to household purposes was presented by the electric bell early in the century, and annunciators of various kinds soon followed. For many years this was the only convenience it afforded; but the discoveries of the telephone, the electric light, and the electric transmission of power within the last thirteen years have given it a tremendous impetus whose ultimate consequences are not yet within view. Even if, as seems unlikely, these brilliant

achievements are destined to stand alone, not succeeded by further discoveries, many years must elapse before their full use shall have been reached; just as in the case of the pianoforte, which took more than a hundred years from its first invention to become the common guest we find it in the household of to-day.

In the electric bell, the pressure of the finger on a button brings two strips of metal into contact and completes a circuit, forming, as it were, an electrical endless chain from the battery through the wires, bell, and annunciator. The whole circuit instantly gives passage to a current of electricity, and in consequence becomes endowed with magnetic properties throughout. By means of an accumulation of wire, as a coil round a horseshoe bar of iron, the magnetism is locally intensified to an extent necessary for the attraction of the iron hammer bar, and by a simple automatic device the blow on the bell is reduplicated. A similar electro-magnet in the annunciator releases by its pull a shutter, indicat-

ing the room whence the call has come. No system can be imagined more simple, and in spite of many an overtaken battery or dust-invaded indicator, it everywhere holds its own. To put mechanical pull-bells into a modern dwelling is an anachronism.



An Electrical Call.

The same principle is the basis of every annunciator system, with such modifications as improvement in the particular direction of the design may have suggested. Even those complex-looking annunciators to be met with in large hotels, which by means of a dial in every chamber enable its inmate to

call for almost any common requirement, from a newspaper to a complicated beverage, differ from the general plan only in their power to signify a particular summons by the aid of a definite

number of successive contacts and corresponding electro-mechanical impulses. A good example is afforded by the burglar-alarm apparatus. Every door and window through which entrance could be forced is fitted with a simple clip, adjusted to make, on the least opening, a metallic contact which sets an alarm bell in operation, and at the same time indicates the room where the invasion is being made. By means of a small key, or "switch," the battery is cut off during the day. Such a system adds greatly to the security of a household, and only needs occasional regular supervision, since all the contacts are necessarily somewhat exposed to dust and moisture. A trial once a week is a matter of a few minutes only, and is amply repaid by the greater sense of security it gives. It has been said that a burglar would soon ascertain whether a house were so guarded, and that before opening a window he could, by removing a pane, find means to cut the electrical wire connection at the sash. This objection is, however, invalid, for the system can be easily arranged to give the alarm equally well for any disconnection so made.

Another most useful system, on the same plan, controls the automatic regulation of temperature. How much discomfort and indisposition would be saved in many a household if the temperature were constantly maintained in every apartment at the desired point, both in summer and winter, independent of irregularities of the season! So far as concerns our winters, this is quite within practicable limits, while in summer the temperature can always be moderated, if not actually kept uniform, by utilizing the controlling power of electricity. Thus in winter time, whether a house be warmed by water, hot air, or steam, it is only necessary to place in each room an automatic thermometer which makes a contact as soon as the temperature reaches the desired point, and to arrange that the contact so made shall electro-magnetically cut off the supply of heat from that chamber. The subsequent cooling of the room below the limiting temperature causes the thermometer to break the circuit and readmit the heat, and it is only necessary to keep an abundant supply in reserve in order to obtain a practically equable

temperature. Such a thermometer, generally called a thermostat, is made by riveting side by side two strips of different materials—generally brass and rubber—which expand differently at the same degree of heat. The composite strip so formed is warped by changes of temperature, which unequally affect the lengths of the components; and being free at one extremity while firmly fixed at the other, the effect of this warping is magnified into an appreciable range of movement at the free end. This enables a contact to be made at any point within that range, while a screw adjustment and dial arrange for the contact to take place at any temperature within desirable limits. The parlor thermostat can therefore be set at 70° while that in the hall is fixed for 60° . It is generally claimed by those who have adopted the system that a decided saving in fuel is effected, in addition to the comfort gained through the absolute prevention of overheating in any part of the house. The thermostats are so sensitive as to respond to the change of a single degree in temperature. The maintenance of the equilibrium, then, depends on the supply of heat and the facility for its distribution through each room when once admitted.

In the same way, during the summer months, this thermostat can, by an additional contact, control the supply of fresh or, if possible, ice-cooled air, so as to maintain a pleasant temperature within doors. Such a system has for two years been in successful operation at a large country house near Greenwich, Conn. In winter time it is warmed by fresh air drawn in through an underground pipe, and heated by passing through a reservoir in which a long steam-pipe circulates. Thence it is fanned into the different rooms through dampers, each controlled electro-magnetically by a separate thermostat. In summer the water-supply of the house, as it comes from deep wells, takes the place of the steam in the circulating pipe of the reservoir, and so cools the incoming air; the same thermostats adjusting the distribution. In this way the temperature is maintained throughout the house at 70° in winter, and does not exceed 75° in summer; while the ventilation is controlled by the same apparatus.

The fire-alarm system depends upon a similar thermostat set for higher temperatures, usually from 120° to 160°. The contact in this case rings an alarm bell and indicates the room where there is danger. It is hardly possible to overestimate the utility of a well-arranged fire-alarm household-system, which makes it possible to extinguish a fire in its beginning. Statistics certainly show a marked decrease, by the use of electrical fire-alarm systems, upon the number of serious fires in towns; but the conflagrations that have been saved by the timely local warning of domestic apparatus, report can never tell.

In some town-houses fire is not the only rebellious element over which constant watch has to be maintained, water overflow from tanks and bursting pipes being almost as much to be dreaded. The *Journal of the Franklin Institute* has called attention to an electrical device which is set in operation by a float, the contact so established cutting off the water-supply or indicating the danger as soon as a definite level is reached. An electric door-opener has also been lately designed by which visitors can be admitted without delay. The closing of the door compresses a powerful spiral spring, which is then held in check by a lever until the latter is released by an electro-magnetic impulse. The spring forces open the door, the latch at the same moment being withdrawn.

Of inferior importance to these systems, which guard the safety of the household, but yet of great interest and utility, is the clock system. Appreciation of time and its value is said to be the test of a nation's activity, and it is surely a luxury to see all the clocks in a house keeping an even pace. There are several methods in use for this purpose, and they form two distinct classes, one adopting centralized government, the other local administration. In the former a single clock as standard drives all the others electro-magnetically, their operation depending entirely on the electricity supplied during its periodic contacts. In the latter, each clock is a free and independent timekeeper, whose rate, however, is under regular electrical control from the standard. This control may be exerted continuously on the pendulums, but per-

haps the simplest and most satisfactory household system yet tried is that in which the control is effected once in each hour. Exactly at the hour the standard clock makes a contact, completing a circuit through all the controlled timepieces, and electrically exciting a magnet in each. In obedience to this impulse, a pair of arms spring from the dial at the figure XII, and meet swiftly in the centre with the minute hand tight in their embrace, and vanish the next instant behind the dial, where they await the next hourly summons. Each clock is thus mechanically corrected every hour, as the arms sweep over three minutes' space on each side of the true vertical, and the clock that fails to keep time by three minutes in the hour may well be submitted to internal examination.

Another convenience which is sometimes added to a system of time regulation is an arrangement for electrically winding up the clocks at regular intervals. So long as the electrical supply is maintained, and the clock-work continues in proper working order, such a system forms as near an approach to perpetual motion as the conditions of our planet give us the right to expect.

The electrical time-detector is an instrument much used in large buildings over which continual supervision is needed. It serves to register the time at which visits are paid to any particular part of the premises, and, in fact, successfully solves the problem of keeping watch upon the custodian. A dial, rotating by clock-work once in twelve hours, carries round a paper disk over a perforated metal plate. Each push-button in the house controls, by its own pair of wires, one electromagnet, the armature of which, on attraction, punches a hole in the paper disk through a particular aperture in the plate. This hole is always in a certain ring marked for the purpose. The watchman going round the building pushes the various buttons on his way, thus registering his progress on the paper disk by punched holes; the rings marking the buttons and the angular position indicating the time.

The discovery and introduction of the electric telephone has marked

an era in the annals of household affairs, as the existence of four hundred thousand in the United States to-day amply attests. The economy of time its use has effected is incalculable. Its greatest fault is perhaps an occasional tendency to mingle the speech of one interlocutor with the conversation of less interested neighbors. Within the limits of a residence, no better interior communication can generally be had than by the ordinary speaking-tube; but in connection with outbuildings on an estate, the telephone is a great advantage. When several such houses are connected by telephone with the main building, it is possible to arrange that any two can communicate with each other on the same wire without calling the attention of the rest, a system saving much time and trouble. As many as eight telephones are sometimes worked in this way on the same wire, and although only two can employ the line at one time, the calling of any particular person is not heard by the others.

Among the greatest gifts that electricity has bestowed on domestic life is the incandescent electric light. There can be little doubt that, when experience shall have given confidence in its trustworthiness, while time shall have rendered its many excellences familiar, it will be adopted in all households. It neither consumes nor pollutes the air in which it shines, whereas the ordinary sixteen candle-power gas-burner vitiates the atmosphere with its products of combustion to the same extent as the respiration of five persons. Besides, those products ultimately injure books, paintings, and ceilings continually exposed to their influence. As the gas-jet develops some fifteen times as much heat as the electric lamp of equivalent power, the latter adds greatly to the comfort of a house in warm weather. In the nursery it is particularly welcome, for it requires no matches, cannot set fire to anything, even if deliberately broken while lit, and effectually checks the youthful tendency to experiment with fire.

In addition to this, its complete amenability to control, and submission to all change of position or equilibrium, render it everywhere admirably adapted to the purposes of adornment. Some of the most charming

effects can be produced by good taste in the choice of centres of illumination, together with appropriate surroundings. In the parlor an illuminated painted vase, lighted from within, may vie in attractiveness with the pictures on the walls, whose colors are almost as readily appreciated by incandescent as by day light, while opalescent globes of varied shade tone the brightness everywhere into subdued harmony. In the billiard room the table is brilliantly lit, without danger of soot or oil marring the baize, and on the veranda the lamps shine heedless of the wind. A very pretty effect can be also produced in conservatories, by suspended lamps of different colors half hidden in the foliage.

The electric light can also be made to give a very beautiful effect in illuminating garden fountains. For this purpose a chamber has to be excavated beneath them, and immediately under the jet a thick plate of glass is inserted, water-tight. An arc-lamp directs its light directly through this plate into the column of water rising vertically above it, and the enclosed air, together with the broken surfaces of the jet, scatters this light in all directions, thus giving the liquid the appearance of being self-luminous. The color of the illumination is varied by means of tinted slides passed horizontally beneath the glass plate in the roof of the vault. A very handsome display of this description was made at the Paris Exhibition this year.

The steps in the development of an incandescent lamp during manufacture have been traced in the chapter on "Electricity in Lighting." When the completed lamp is placed in circuit, the carbon filament conducts electricity but only imperfectly, and the latter thus requires a certain pressure to force it through the lamp. The work done in overcoming the resistance so offered is developed into heat proportional to the square of the velocity of flow. The frictional opposition of a pipe to the passage of water it conveys, generates heat at greater rate than the square of the velocity; but these two cases of motion present many analogies, although the pipe deals with the transmission of matter itself, while the filament deals with the transmission of a condition of matter only.

At a certain electrical pressure on the filament the right quantity of electricity flows through it to bring its temperature to the incandescent point of due candle power. At this pressure the lamp will last probably two thousand five hundred working hours. If our best microscopes had a magnifying power perhaps ten thousand times greater than that they now reach, and it were possible to subject the glowing filament to their examination, we might expect to find the ultimate particles or molecules of carbon vibrating and colliding with an intensity that now baffles the imagination. We can fancy that at the surface of the filament an occasional molecule, projected outward with more than usual force, would bound beyond the range of retractive influence, and be hurled past recall (like the celebrated projectile of M. Jules Verne) against the distant inner surface of the glass globe. Gradually the latter would be darkened by the thickening meteoric accumulation, while the filament would weaken, as its dwindling substance (enduring such tremendous internal commotion) suffered structural decay, until at some point disruption would ensue, followed immediately by loss of conduction and extinction of the light.

The greater the electrical pressure brought to bear upon the lamp, the higher the incandescence attained. The lifetime of a lamp, endowed at the outset with average vitality, thus depends entirely on its treatment, and can be made almost what we please, from a few moments to even many years, according to the degree of incandescence it is called upon to produce.

In fitting up a house with the electric light, a little consideration is required to obtain the greatest convenience. The switches by which the lamps are turned on and off should usually be placed just inside the door, where they can be reached on entering or leaving the apartment. In the bedrooms, however, they should be suspended from the ceiling in such a manner as to be accessible on first entry, over a bracket by the door, and then movable to within easy reach of the bedside; or, better still, there may be two alternative switches—one at the door and the other by the bedstead. One test of a well-designed installation is the

householder should be able to visit the entire building, commencing with the hall door, from attic to cellar and back, without once being left in the dark, or leaving lamps burning on any floor behind him as he makes the journey. A good plan, that has been carried out in more than one instance, is to have a spare lamp in each room under sole and direct control of the burglar and fire-alarm systems, in such a way that the forcing of any window, or any dangerous excess of temperature, may not only ring the alarm, but also light up the whole house.

In many cases where electricity is not itself the illuminant, the electric spark is often adopted for the purpose of lighting the gas. In theatres, for example, a frictional electrical machine is employed which, when rotated by hand, is connected in succession to the various wires leading to different jets or clusters, and the sparks, passing between two metallic points set close to the burner, ignite the gas. Similar arrangements on a smaller scale are in household use. The pull on a pendent chain or the pressure on a button allows the current to pass from a battery through a small induction coil, the spark of which flashes at the burner.

The most ingenious apparatus of all, however, is the hand gas-igniter which, without any battery, produces a spark between two points in its tip on the simple pressure of a button on its side. This compact instrument is, in fact, an electrical rotating influence machine (acting on similar principles to some of the most powerful generators of high-tension electricity), and it is difficult to realize that this safe and simple apparatus can produce sufficient electricity to light the gas, when the electrical pressure between the points at the moment of emitting a spark must be many times greater than that exerted upon an incandescent lamp. Its operation depends upon the rotation of an internal cylinder which causes the initial charge to be augmented at a rapid and increasing rate until the tension is sufficient to create a spark between the opposed points.

The transmission of power is another application of electricity

which has practically been evolved only within the last decade, and which is still in its infancy. Its usefulness in the household is second only to that of illumination. Ignorant as we still are of the real nature of this marvellous agent, we know at least that electricity implies power; all the evidences by which we are rendered sensible of its presence are manifestations of energy.

The electric motor is the machine by which electrical power is rendered mechanically available. Its principle is entirely magnetic; the pull that a wire conveying an electric current is seen to exert upon a compass needle in its vicinity being here enormously intensified by having a large horseshoe electro-magnet for the compass needle, and many turns of wire close up within its grasp instead of the single conductor. The revolving cylinder of separated copper segments on which the brushes rest, called the commutator, is nothing more than an electric treadmill, by which the current is cut off each wire in turn as it reaches the point of most powerful attraction, so that the current is always kept advancing toward the magnetic pole, but never reaches it.

The qualifications which peculiarly fit the electric motor for household use are its compactness, perfect control, silence, and cleanliness. It is a wonderfully compact piece of mechanism, for in domestic sizes it weighs under one hundred pounds per horse-power, and its amenability to control is evident from the fact that the turning of a switch will stop or start it. One great secret of this compactness lies in the fact that the motion is rotary, and not oscillatory like that of a piston; hence the great speed it can attain, as also the absence of jar and noise in its work. A small motor may thus become an ornament, as well as a useful instrument. The illustration, on page 250, shows a Diehl motor attached to a sewing-machine spindle. In any house supplied with the electric light it is only necessary to connect the motor with the electric mains, like a lamp, and turning the switch sets the machine at work, thereby saving the hundredth part of a horse-power, which is the usual amount of energy needed to drive it by treadle, not to mention the comfort gained and nerve-force conserved.



Sewing-machine Run by Electricity; the entire motor concealed in the wheel-case at the left.

As another example of use and ornament united, circular fans driven by motors are not uncommon, and are luxuries in hot weather,

when even the exertion of waving a fan counteracts the comfort so produced.

The electric motor is destined to enter largely into the operation of



The Electrical Fan.

elevators in town-houses, all its good qualities being in this case shown to advantage. In dwellings supplied with the electric light it is only necessary to fix in position a motor fitted with the requisite

and connect the same to the elevator with wire ropes, the power being taken direct from the electric mains. In this respect, also, electricity, as a power-distributor, contrasts favorably with other sources in the reach of modern engineering. For, if elevators were to be operated from a central station by hydraulic power supplied to each house through pipes, then an elevator in motion would take as much energy from the station when empty as when fully occupied by passengers—unless, indeed, complicated devices were introduced to avert this waste. The electric motor, on the contrary, would, if properly selected, only draw from the mains the proportional amount of power required for the load to which it was subjected, in addition to what little it expended in overcoming the friction of its own mechanism, and consequently, so far as the supply of power was concerned, would be much more economical.

Another suitable task for the electric motor in country-houses is pumping. Where water has to be elevated from wells or cisterns to the attic level for household distribution, art and science lend the means, while electricity supplies the power. By the use of the rotary pump, the plant, which may be placed in the cellar, can be made wonderfully compact and quiet in its performance. How vivid is the contrast between this simple apparatus and the blindfolded horse, that, for the same purpose, has so often been condemned to describe endless circles, with a long trail-beam as radius and a well as centre. A float in the reservoir above breaks a contact as soon as the level of water there has reached the desired limit, and so automatically stops the motor until further supply is demanded.

In the same way motors have been applied to lawn-mowers, to carpet-sweepers, to shoe-polishers; and, in fact, there is no household operation capable of being mechanically performed, of which, through the motor, electricity cannot become the drudge and willing slave. It has even been applied to serving at table. A miniature railroad track runs round the table within easy reach of each guest, and thence, by ornamented trestlework, to the wall, disappearing through a shutter. The dishes, as electrically signalled for by the hostess, are laid on little

trucks fitted with tiny motors, and are started out from the pantry to the dinner-table. They stop automatically before each guest, who, after assisting himself, presses a button at his side and so gives the car the impetus and right of way to his next neighbor. The whole journey having been performed, the cars return silently to their point of departure.

The electric motor is also perhaps the most nearly perfect means known of obtaining steady, smooth, and continuous mechanical motion, and largely, with this object in view, it has been introduced into the Edison phonograph, an instrument destined to play the very important parts of music preserver, recorder, and amanuensis in the household of the future. On the surface of its cylinder the delicate wavelets that the voice has impressed sometimes cannot exceed the fifteen-thousandth part of an inch, and on their due representation in vibrations of the air the reproduction of the stored-up sound has to depend. The electric motor enables all these to be reproduced in a manner that would not be possible if there was any unsteadiness or tremor in the movement of the working parts.

The motor also supplies parlor organs with air, and has been applied to automatic pianos. A bright prospect also opens for the application of electricity in country-houses, in the direction of artificial horticulture. Among the conditions that differentiate vegetable and animal life there seems to be this remarkable fact, that plants do not essentially require sleep or periods of intermittence in growth and activity. This is evidenced by the continuous and rapid growth of plants in the far north during that brief but happy summer in which the sun never sets. The electric arc lamp has been found, by the late Sir William Siemens and others, to practically replace the sun in its effects on plant life, over a somewhat contracted range, so that an extensive conservatory lit by powerful arc lamps would be efficiently supplied for night growth by some two candle-power per square foot of area. A hot-house in reality artificially represents latitude in all respects save sunlight, which the electric light is ready, in part at least, to replace.

Public attention has latterly been drawn to the question of electric heat-supply to houses, and it has been frequently supposed that the apparent novelty of the plan favored its commercial success. The fact is, however, that of all the practical applications of electricity there are none whose limits and possibilities are more clearly defined and better understood than heat distribution, for the simple reason that it has been attentively studied for the last ten years. This is apparent from the fact that the problem and task of electric lighting is, primarily and essentially, electric heating. Almost all the energy supplied electrically for the purposes of illumination is dispensed in the form of heat, and this heat is expended with the maximum economy that the engineering of the day permits in maintaining our carbon filaments at incandescent temperature. Despite the high economy in the consumption of power that the electric lamp possesses in comparison with combustible sources of illumination, it has lately been shown, by experiments at Cornell University, that only some five per cent. of this heat is yielded in rays of light, the remainder (at present essential to securing this result) being spent in raising the temperature of the air and surrounding objects. Consequently, whatever improvements the art of electric lighting may effect in economizing this large heat expenditure, and raising it into visible radiance, science appears to have determined that a given supply of electrical power can only yield the same amount of heat that it now develops in passing through our lamps. One form of electric heater operating within narrow limits might bring a piece of metal to melting-point, while another only slightly raised the temperature of a large volume of water; still, the total quantity of heat developed in each for a given supply of electrical energy would be precisely the same. The only economy that can be looked for in the distribution of heat lies, therefore, in saving the waste incurred by forcing electricity through the mains, and this is a margin that modern engineering has already rendered comparatively narrow.

Heat, being already distributed electrically on a large scale to houses for the operation of incandescent lamps, can be, and already has been,

applied for heating purposes exclusively. The difficulty of carrying out this plan on a large scale, in order to replace household stoves and furnaces, is a purely economical one. The question ultimately reached is, whether labor can be saved to a community if all the coal necessary for their heat-supply through the medium of electricity be burned in one central station, and the electrical power so obtained distributed generally, instead of continuing the usual custom of burning the coal in each house locally. On the one hand, the local process of combustion is at present a wasteful as well as a dirty one, most of the heat escaping by the chimneys; while, on the other hand, the steam-engine is necessary in the central station to convert the furnace heat into electricity, and the best modern engines are only capable of utilizing twelve per cent. of the heat developed from the combustion of coal under their boilers; so that, when the machinery and conducting system of mains are taken into account, the verdict (notwithstanding household smoke and waste) has been hitherto against the economic possibility of the electrical distribution of heat on a large scale. But every improvement effected in the machinery for the conversion of furnace heat into electricity, every advance made in the progress of electrical engineering, modifies in proportion the balance of advantages in this great social problem, and it is well within the reach of possibility that electric heating may be as successful at some future date as electric lighting itself. Even now there are many occasions where heat is required to be applied very locally, in culinary purposes, for instance, and where the cleanliness and convenience of the electrical method might outweigh the objection of slight extra expense. The advantage to a man whose duties call him out during the night of being able, from his bedroom, to set an electric coffee-heater at work in his dining-room, so that by the time he is ready to leave the house he finds hot coffee awaiting him, and all without arousing any person in the house, far outweighs the three or four cents for electrical power that the beverage has probably cost him. Similarly, there are times when a foot-warmer is worth many times over the expense of electrically preparing it at a few minutes' notice.

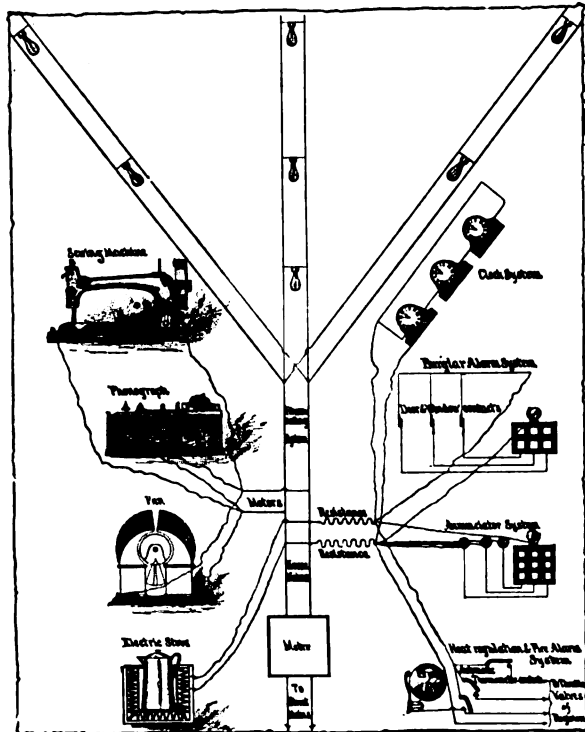
Both of these commodities are in actual use. The stove is an ornamental case enclosing a coffee-pot, or, in another form, it may be a kettle in an asbestos lining, round which circulate coils of wire, the passage of the electric current through these coils generating the heat. In one convenient form the current that would feed fifteen ordinary incandescent lamps will produce hot coffee in ten minutes.

For the working of all the electrical household appliances that have been mentioned some source of electrical supply is, of course, required, and the best to adopt must depend upon the position of the house, its size, and the precise amount of duty that electricity will perform in it. The different bell-annunciator and alarm systems generally require surprisingly little power to operate them, and no difficulty will be found in supplying each system from a battery; or it may even be possible to let one battery suffice for all. Three or four cells of the Leclanché type will sometimes work a bell system continuously for two years without any attention, but it is always well to replenish a battery in time before its activity is exhausted, lest at some important moment it fail in its duty.

When, however, it is desired to supply a house with electric light, heat, or motive power, batteries for these purposes, unless on a very small scale, are hardly to be recommended. In the first place they would necessarily be troublesome to maintain, and in the second they would, in the present state of the art, be very costly. Power is obtained from a battery by the slow combustion of the zinc in its plates, and as metallic zinc is not found like coal, ready prepared in nature, the process for obtaining it is by comparison expensive. Probably no battery in existence can furnish electrical power at theoretically less than twenty-five cents per horse-power per hour in material alone, while actually the best cost, as a rule, thirty-five cents; and a horse-power is well applied locally if it gives illumination equivalent to two hundred candles. The only prospect that seems open to the extended successful application of the primary battery to light and power is in the possibility of its chemically producing, during its work, compounds

which have directly or indirectly a commercial value. If this end, which has long been striven for, could be successfully attained, and a sufficiently large market found for the produce, the battery might come forward as the most advantageous source of electrical supply.

At present, however, recourse is had to mechanical sources of electricity—dynamo-machines driven by steam-engines—and it is no exaggeration to say that the practical success of electric lighting is due to the dynamo-machine as a source of electric supply.



Plan of Wiring a House for its Various Electrical Appliances.

It will be seen that the house mains are connected through an electricity meter direct with the street mains; that the lamps, heaters, and motors, wherever they may be situated, are operated directly from the house mains or their ultimate ramifications; while the annunciator, clock, and alarm systems are all operated from sub-mains connected to the central mains through simple regulating coils of wire, termed resistances. Their object is to reduce the electrical pressure on these sub-systems to the desired limit for their effective operation, since the whole electrical supply they need probably does not exceed that given to one incandescent lamp burning continuously. In this way electrical economy is obtained and the safety of the more delicate apparatus insured.

like gas or water—a plan that will always be more economical and convenient than local production. Large buildings, or groups of

buildings, may sometimes be lighted advantageously by a local plant, but for a town dwelling a separate engine and dynamo is generally out of the question. The great convenience attending electrical supply from the street mains is the absence of all batteries and their attendant requirements. The arrangement of the different interior systems on this plan is illustrated in the accompanying diagram.

The diagram [p. 259] shows that the house mains receive their supply through a meter which keeps a register of all the electricity traversing it. The electricity on entering the meter has two paths open to it, one by wavy metal strips above, and the other through coils of wire and bottles beneath. The proportions of these are so arranged that the strips conduct, let us say, one thousand times better than the coils and bottles, and, as electricity always divides between two paths in the exact ratio of their conductivity, the quantity which passes through the strips will be just one thousand times as great as that passing through the bottles. These latter are filled with a weak solution of zinc sulphate, and each contains two zinc plates about one inch square. In obedience to laws discovered by Michael Faraday fifty-five years ago, the electricity which passes through this bottle from one zinc plate across to the other through the solution, causes a certain quantity of zinc to be dissolved from the plate it leaves, and the same quantity to be deposited on the plate it reaches—the quantity of metal so transferred bearing an invariable known ratio to the electricity that has passed. These bottles are removed and replaced every month, and the change of weight in the dried plates compared after the lapse of that term. The amount of zinc found to have been transferred then determines the quantity of electricity that has passed through the bottle, and one thousand times this quantity has entered the house through the metal strips during that time. There is thus no machinery to get out of order, no moving parts to clog, or friction to overcome and with the bottles exchanged every month the meter itself is almost imperishable.

For country-houses beyond the limits of central-station distribution, electricity must be locally produced to furnish light and power. For installations not exceeding fifty lamps, the gas-engine advantageously replaces steam when coal gas is obtainable at a moderate rate, as there is then no boiler, and less attention is also required. A gas-engine and dynamo in a barn or neighboring outhouse form a very convenient electrical supply, and, as a matter of fact, a given quantity of gas so burned in a good engine not only expends its vitiating products of combustion out-of-doors, but will also yield from twenty-five to thirty per cent. more illumination through the medium of electricity than when furnishing light directly. That is to say, the electric lamp is so much more economical in energy that it gives this excess notwithstanding the necessary loss in the engine and dynamo inherent to the conversion of heat into electrical power.

The mistake is sometimes committed of sealing up wires in the plastering of walls, as though they were not liable to a mortality from which even the electricity they convey does not render them exempt. It is certainly best to have wires placed out of sight, but where access to them can always be had if needed; and generally, if an electric system is worth introducing into a household, it is worth carrying out, not lavishly, but thoroughly and well. It is also unfair to suppose that an appliance needs no supervision or repair because it is electrical. Every such instrument is essentially of mechanical nature and inevitably subject to the requirements our knowledge of mechanism leads us to expect. On the other hand, when proper care and judgment have been exercised upon the introduction of these appliances, the superiority of electricity for domestic purposes over every other known power (even in the matter of independence from supervision) is incontestably exemplified.

Nor is it to be supposed that any of the applications above alluded to are visionary, for all are in actual use. Some are still regarded in the light of luxuries, it is true, but almost all necessities were once in that favored class. Even tobacco is regarded to-day as a necessity of exist-

ence, and if history tells truly, table knives and forks were luxuries of the most extravagant type two hundred years ago.

Considering, then, that the household is in itself the condensed history of a nation's past, the centre of its present, and the cradle of its future, it is doubtful whether, among the many triumphs of the age that electricity may claim, any can be quoted of brighter renown than the rapid progress it has already made in the cultivation of the arts of life, and its adaptation to the needs and graces of the household.