Finally, the pipes, R and R', provided with valves, L and L', are connected with a chimney.

The generator, A, is provided at its upper part with a feed hopper. The doors, S and S', of the ash box close the apertures through which the ashes are removed.

When it is desired to use the apparatus, the pipes, P, Q, and R, are closed by means of their valves, J, K, and L, and the valve, I, of the pipe, O, is opened. The pipes, M and N, are likewise closed, while the flue, E, is opened. On the other side of the generator the reverse order is followed, that is to say, the flue, E', is closed, the pipes, M' and N', are opened, the pipes, O', P', and Q', are closed, and R' is opened.

A current of air is introduced through the pipe, O, and this traverses the regenerators, B, enters the chamber, T, and the generator, A, through the flue, E. As this air rises through the mass of incandescent fuel, its oxygen combines with an atom of carbon and forms carbonic oxide. This gas that is disengaged from the upper part of the fuel consists chiefly of nitrogen and carbonic oxide, mixed with volatile hydrocarbons derived from the fuel used. This gas, through the action of the air upon the fuel, is called "air gas," in order to distinguish it from the "water gas" formed in the second period of the process.

The air gas, on issuing from the generator through the pipe, M', in order to pass into the chamber, F', meets in the latter a second current of air coming in through the pipe, N', and which burns it and produces, in doing so, considerable heat. The strongly heated gases resulting from the combustion traverse the regenerators, B', and give up to the bricks therein the greater part of their heat, and finally make their exit, relatively cool, through the pipe, R', which leads them to the chimney. When the operation has been continued for a sufficient length of time to give the refractory bricks in the chamber, B', next the regenerator a high temperature, the valve, I, is closed, thus shutting off the entrance of air through the pipe, Q. The valve, F, of the flue, E, is also closed, and that of the pipe, M, is opened. The valves, G', H', L', of the pipes, M', N', R', are closed, and that, F', of the flue, E', is opened. The valve, J', of the pipe, P', is then opened, and a jet of steam is introduced through the latter.

The steam becomes superheated in traversing the regenerators, B', and in this state enters the bottom of the generator through the flue, E'. In passing into the incandescent fuel that fills the generator, the steam is

from the generator, passes through the pipe, M', and the chambers, T' and B', and the pipe, R, and enters the gasometer through the pipe, Q'.

When the chamber, B, and the generator, A, are again in so cool a state that the fuel no longer decomposes the steam easily, the valves are so maneuvered as to stop the entrance of the latter, and to send a current of air into the apparatus in the same direction that the steam had just been taking. The temperature thereupon quickly rises in the generator, A, while, at the same time, the combustion of the air gas produced soon reheats the chambers, B'. The cooled products of combustion go, as before, to the chimney. The position of the valves is then changed again so as to send a current of steam into the apparatus in a direction contrary to that which the air took in the last place, and the water gas obtained again is sent to the gasometer.

As will be seen, the process is entirely continuous, each current of air following the same direction in the apparatus (from left to right, or right to left) that the current of steam did which preceded it, while each current of steam follows a direction opposite that of the current of air which preceded it.

The inventor estimates that the cost of the coal necessary for his process will not exceed a tenth of a cent per cubic foot of gas.

One important advantage of the apparatus is that it can be made of any dimensions. Instead of giving the generator the limited size and form shown in the engraving, with doors at the bottom for the removal of the ashes by hand from time to time, it may be constructed after the general model of the shaft of blast furnaces, with a hearth at the base. Upon adding to the fuel a small quantity of flux, all the mineral parts thereof can be melted into a liquid slag, which may be carried off just like that of blast furnaces. There is no difficulty in constructing regenerators of refractory bricks of sufficient capacity, however large the generators be; and a single apparatus might, if need be, convert one thousand tons of anthracite per day into more than five million cubic feet of gas.

LIGHTING AND VENTILATING BY GAS.*

By WILLIAM SUGG, of London.

EVER since the introduction of electric lighting, the public have been assured, by those interested in the different kinds of lamps—arc, glow or otherwise—that

WATER-GAS APPARATUS.

decomposed, and there forms carbonic oxide, while hydrogen is liberated. The mixture of these two gases with the hydrocarbons furnished by the fuel constitutes water gas. This gas on making its exit from the generator through the pipe, M', passes through the chambers, B, and abandons therein the greater part of its heat, and enters the pipe, R, whence it passes through Q into the purifiers, and then into the gasometer.

As the production of water gas implies the absorption of a large quantity of sensible heat, it is accompanied with a rapid fall of temperature in the chambers, B, and eventually also in the generator, A, while at the same time the chambers, B, are but moderately heated by the sensible heat of the current of gas produced. When this cooling has continued so long that the temperature in the generator, A, is no longer high enough to allow the fuel to decompose the steam with ease, the valve, J', of the pipe, P', that leads the steam is closed, as is also the valve, K, of the pipe, Q, while the valves, L and H, of the pipes, R and N, are opened. After this the valve, I, is opened, and a current of air is let in through the pipe, O'. This air, upon traversing the chambers, B' and T', is raised to a high temperature through the heat remaining in these chambers, and then enters at the bottom of the generator, through the flue, E'. The air gas that now makes its exit from the pipe, M, in the chamber, T, meets another current of air coming from the pipe, N, and is thus burned. The products resulting from such combustion pass into the chambers, B, and then into the chimney, through the pipe, R. The temperature then rapidly lowers in the chambers, B', and rises no less rapidly in the generator, A, while the chambers, B, are soon heated to the same temperature that first existed in the chambers, B'. As soon as the desired temperature is obtained in the generator, A, and the chambers, B, the air is shut off by closing the valve, I', of the pipe, O'; the valve, F', of the flue, E', is also closed, the valves, G' and K', of the pipes, M' and Q', are opened, the valves, G, H, and L, of the pipes, M, N, and R, are closed, and the valve, F, of the flue, E, and the valve, J, of the pipe, P, are opened. A current of steam enters the apparatus through the pipe, P, traverses the chambers, B, and enters the generator through the flue, E. The gas produced makes its exit

henceforth, by means of such lamps, rooms are to be lighted without heat or baneful products such as they assert attend the use of gas, lamps, or candles. But I think it must not be implied, from what any one has said in favor of the electric light as a means of lighting our dwellings, that gas is unsuitable for the purpose, or that the glow lamp is a perfect substitute for gas, or that there is a very large difference throughout the year on the points of health, convenience, or comfort, or that the balance in favor rests with electric light upon all or any of these points. The fact is, the glow lamp is only one more means (not without certain disadvantages) of producing light added to those which already exist, and of which the public have the choice. Now, looking to best means of lighting rooms, and particularly the principal rooms of a small dwelling-house, I beg to say that the arguments which can be adduced in favor of gas lighting in preference to any other means greatly preponderate, and that it can be substantiated that, light for light, under the heads of convenience, health, comfort, reliability, readiness, and cheapness, gas is superior to all.

As a scientific means for the purposes mentioned, gas is comparatively untried. This assertion may sound somewhat astounding; but I think it is a true one. More than that, even in the crude and unscientific way in which it has most frequently been used up to the present, it has been far from unsuccessful in comparison with electricity or other means of lighting; and in the future it will prove the best and cheapest practical means, although, for effect, glow lamps may be used in palatial dwellings in conjunction with it.

It must be remembered that, in laying down a system of artificial lighting, we have to imitate, as well as we can, that most beautiful and perfect natural light which, without our aid, and without even a thought from us, shines regularly every day upon all, in such an immense volume, so perfectly diffused, and in such wonderful chemical combination, that it may safely be said that not one atom of the whole economy of Nature is unaffected by it, and that we and all the animal kingdom, in common with trees and plants, derive health and vigor therefrom. This glorious natural light leaves our best gas, electricity, oil lamp, and

all our multiplicity of candles, immeasurably behind. But although we cannot hope to equal, in all its beneficent results, the effects of daylight, or to perfectly replace it, we can more perfectly make the lighting of our homes comfortable (and as little destructive to the eyes and to the general health) by the aid of gas than by any other means. It must also be borne in mind that, in this country at least, we have to fulfill the conditions of artificial lighting under frequent differences of temperature and barometric influence, exaggerated by the manner in which our homes are built; and that for at least nine months of the year we require heat as well as light in our dwellings, and that for the other three months (excepting in some few favored localities) the nights are often chilly, even though the days may be hot. Therefore, independently of any effect produced by the lighting arrangements, there must be widely different effects produced in the temperature and conditions of the air in rooms by influences entirely beyond our control.

As an example of what I mean, a short time ago I had to preside over a meeting which was held in a large room—one of two built exactly alike, and in communication with each other by means of folding doors. These rooms formed part of one of the best hotels in London—let us call it the "Magnificent." Of course, it was lighted by electric glow lamps, in accordance with the latest fashion in that department of artificial lighting, viz., suspension lamps, in which the glow lamps grew out of leaves and scrolls, twisted and twirled in and out, very much after the pattern of our most æsthetic gas lamps, which, of course, are in the style of the most artistic (late eighteenth century) oil lamps, which were in imitation of the most classic Roman lamps, which followed the Persian, and so on back to the time of Tubal Cain, the great arch-artificer in metals, who most likely copied in metal some lamps he had seen in shells or flints. Both rooms were heated by means of the good old blazing coal fire so dear to a Briton's heart; and they were ventilated with all due regard to the latest state of knowledge on the subject among architects and builders. In fact, no pains had been spared to make these rooms comfortable in the highest acceptance of the word.

There were, some of our members remarked, no gas burners to heat and deteriorate the atmosphere, or to blacken the ceilings; and therefore, under the brilliant sparkle of glow lamps, the summit of such human felicity as is expected by a body of eighteen or twenty business men, intent on dispatching business and restoring the lost tissue by means of a nice little dinner afterward, ought, according to the calculations of the architect of the building, to have been reached. I instance this case because it is a typical one, which, under most aspects, does not materially differ from the conditions of home life in such residences as those whose occupants are likely to use electric lighting. The rooms were spacious (about 20 feet by 35 feet, and about 15 feet high); and they were lighted during the day by means of large lantern ceiling-lights, with double glass windows. The evening in question was chilly, not to say cold.

Upon commencing our business, we all admired the comfort of the room; but as time went on, most of the company began to complain of a little draught on the head and back of the neck. The draught, which at first was only a suspicion, became a certainty, and in another hour or so, by the time our business was over, notwithstanding a screen placed before the door, and a blazing fire, we were delighted to make a change to the comfortable dining-room, which communicated with the room we had just left by means of folding doors, closed with the exception of just sufficient space left at one end of the room to allow a waiter to pass in and out. Very curiously, before the soup was finished, we became aware that the candles which assisted the electric glow lamps (merely for artistic effect) began to flare in a most uncanalike manner—the flames turning down, as if some one were blowing downward on the wicks; and at the same time the complaints of "Draughts, horrid draughts!" became general, and from every quarter. Finding that, as the dinner went on, the discomfort became unbearable, even although the doors were shut and screens put before them, I gave up dining, and took to scientific discovery. The result of a few moments' observation induced me to order "those gas jets," which I saw peeping out from among the foliage of the electroliers, to be lighted up. In two or three minutes the flames of the candles burned upright and steadily, and in less than ten minutes the draughts were no longer felt; in fact, the room became really comfortable.

The reason of the change was simple. The stratum of air lying up at the ceiling was comparatively cold. The column of heated air from the bodies of the twenty guests, joined to the heat produced by the movements of themselves and the waiters, together with the steam from the viands and respiration, displaced the colder air at the ceiling, and notably that coldest air lying against the surface of the glass. This cold air simply dropped straight down, after the manner of a douche, on candles and heads below. The remedy I advised was the setting up of a current of hotter steam and air from the gas burners, which stopped the cooling effect of the glass, and created a stratum of heated steam and air in slow movement all over the ceiling. The effect was a comfortable sensation of warmth and entire absence of draught all round the table. Later on, to avoid the possibility of overheating the room, the gas was put out, and the electric lights left to themselves. But before we left, the chilliness and draughts began to be again felt.

The incident here narrated occurred at the end of the month of April last, when we might reasonably have hoped to have tolerably warm nights. It is therefore clear that in this instance neither electricity nor candles could effectually replace gas for lighting purposes. They both did the lighting, but they utterly failed to keep the currents of air steady. I have always remarked draughts whenever I have remained any length of time in rooms where the electric light is used. On a warm evening the electric light and candles would undoubtedly have kept the room cooler than gas, with the same kind of ventilation; I do not think they would have put an end to cold draughts. This the steam from the gas does in all fairly built rooms.

It is a well-known fact that dry air parts with its relatively small amount of specific heat, in an almost incredibly rapid manner, to anything against which

* A paper read before the Gas Institute, Manchester, June, 1885.

it impinges. Steam, on the contrary, from its great specific heat, remains in a heated state for a much longer time than air. It is not so suddenly reduced to a low temperature, and in parting with its own heat it communicates a considerable amount of warmth to those bodies with which it comes in contact. Thus the products of the combustion of gas (which are principally steam) serve a useful purpose in lighting, by keeping at the ceiling level a certain stratum of heated vapor, which holds up, as it were, the carbonic acid and exhalation from the lungs given off by those using the room. The obvious inference, therefore, is that if we take off these products from the level of the ceiling, we shall take off at the same time the impure and vitiated air. On the other hand, if we make use of a system of artificial lighting, which does not produce any steam, then we shall have to adopt means to keep the air at the ceiling level warm, in order to prevent the heated impure air from descending in comparatively rapid currents, after having parted with its heat to the ceiling. It may very frequently be observed on chilly days that a number of currents of cold air seem to travel about our rooms, although there may be no crevices in the doors and windows sufficient to account for them; and, further, that these currents of cold air are not noticed when the curtains are drawn and the gas is lighted. The reason is that there is generally not enough heat at the ceiling level in a room unlighted with gas to keep these currents steady. Hence the complaints of chilliness which we constantly hear when electric lights are used for the illumination of public buildings. For example, at the annual dinner of the Institution of Civil Engineers, held at the end of April last in the Conservatory of the Horticultural Gardens, the heat from the five hundred guests, and from an almost equal number of waiters and attendants, displaced the cold air from the dome of the roof, and literally poured down on the assembly (who were in evening dress) in a manner to compel many of them to put on overcoats. If the Conservatory had been lighted with gas suspended below the roof, this would not have been the case, because sufficient steam would have been generated to stop these cold douches, and keep them up in the roof. In fact, if electric lights are to be used in such a building, it will be necessary to lay hot-water pipes in the roof, to keep warm the upper as well as the lower stratum of air, and thus steady the currents.

Having pointed out difficulties which arise under certain conditions of the atmosphere in rooms built with care, to make them comfortable when electric lighting is substituted for gas, I will lay before you some few particulars relative to the condition of small rooms of about 12 ft. by 15 ft. by 10 ft., or any ordinary room such as may be found in the usual run of houses in this country. The cubical contents of such a room equals 1,700 cubic feet. If the room is heated by means of a coal fire, we shall for the greatest part of the year have a quantity of air taken out of it at about 2 feet from the floor by the chimney draught, varying (according to atmospheric conditions and the state of the fire) from 600 to 2,000 or more cubic feet. This quantity of air must, therefore, be admitted by some means or other into the room, or the chimney will, in ordinary parlance, "smoke;" that is, the products of combustion, very largely diluted with fresh air, will not all find their way up the flue with sufficient velocity to overcome the pressure of the heavy cold air at the top of the chimney. If no proper inlets for air are made, this supply to the fire must be kept up from the crevices of the doors and windows. In the line of these currents of cold air, or "draughts" as they are usually called, it is impossible to experience any comfort—quite the contrary; and colds, rheumatism, and many other serious maladies are brought on through this abundant supply of fresh air in the wrong way and place.

According to General Morin (one of the best authorities on ventilation), 300 cubic feet of air per hour are required for every adult person in ordinary living rooms. Peclet says 250 cubic feet are sufficient; less than this renders the atmosphere stuffy and unhealthy. It is generally admitted that an average adult breathes out from 20 to 30 cubic inches of steam and vitiated air per minute, or, as Dr. Arnott says, a quantity equal in bulk to that of a full-sized orange. This vitiated air and steam is respired at a temperature of 90° Fahr.; and therefore, by reason of this heat, it immediately ascends to the ceiling, together with the heat and carbonic acid given off from the pores of the skin. This fact, by the bye, can be clearly demonstrated by placing a person in the direct rays from a powerful limelight or electric lamp, and thus projecting his shadow sharply on a smooth white surface. It will be observed that from every hair of the head and beard, and every fiber of his clothing, a current of heated air in rapid movement is passing upward toward the ceiling. These currents appear as white lines on the surface of the wall; the cause probably being that the extreme rarefaction of the air by the heat of the body enables the rays of light to pass through them with less refraction than through the denser and more moist surrounding cold air. An adult makes, on an average, about 15 respirations per minute, and therefore he in every hour renders to the atmosphere of the room in which he is staying from 10 to 15 cubic feet of poisonous air. This rises to the ceiling line, if it is not prevented; and thus vitiates from 100 to 150 cubic feet of air to the extent of 1 per cent. in an hour. General Morin thought that air was not good which contained more than $\frac{1}{2}$ per cent. of air which had been exhaled from the lungs; and when we consider how dangerous to health these exhalations are, we must admit that he was right in his view. Therefore in one hour the 15 foot by 12 foot room is vitiated to more than 2 feet from the ceiling by one person to the extent of $\frac{1}{2}$ per cent., and it will be vitiated by two persons to the extent of 1 per cent. in the same time.

It must be remembered here that the degree of diffusion of the vitiated air into the lower fresh air contained in the remaining 8 feet of the height of the room depends very materially on the difference of temperature between these upper and lower strata and the movements of air in the room. The heavy poisonous vapors and gases fall into and diffuse themselves among the fresh air of the lower strata—very readily if they are nearly the same temperature as the upper, but scarcely at all if the air at the ceiling line is much hotter. Hence it occurs that, in warmed rooms of such size as I have mentioned, where one or two petroleum

lamps are used for lighting them, after two or three hours of occupation by a family of three or four persons in winter weather, the air at the ceiling line has become so poisonous that a bird dies if allowed to breathe it for a very short time—sometimes, indeed, for only a few minutes. With candles, if the illumination of the room is maintained at the same degree as in the case of lamps, the contamination of the air is very much worse. It is doubtless the case that poisonous germs are rapidly developed in atmospheres which are called "stuffy;" and although, in a healthy state of the body, we are able to breathe them without perceptible harm, yet even then the slight headache and uneasiness we feel is a symptom which does not suffer itself to be lightly regarded, whenever, from some cause or other, the general condition is weak.

The products of combustion from coal gas (which are steam and carbonic acid mixed with an infinitesimal quantity of sulphur) are, proportionately, far less injurious to animal life than the products from an equal illuminating power derived from either oil or candles. They are, however, it is certain, destructive to germ life; and therefore, if taken off from the ceiling level, where they always collect if allowed to do so, no possible inconvenience or danger to health can be felt by any one in the room. But in our endeavors to take off the foul air at the ceiling, we encounter our first serious check in all schemes of ventilation. We draw the elevation and section of the room, and put in our flues with pretty little black arrows flying out of the outlets for vitiated air, and other pretty little red arrows flying in at the inlets; but when we see our scheme in practice, the black arrows will persist in putting their wings where their points ought to be; in other words, flying into instead of out of the room.

One of the best ways of finding the true course of all the hot and cold currents in a room is to make use of a small balloon, such as used to be employed for ascertaining the specific gravity of gases; and, having filled it with ordinary coal gas, balance it by weights tied on to the ear till it will rest without going up or down in a part of the room where the air can be felt to be at about the mean temperature, and free from draught. Then leave it to itself, to go where it will.

As soon as it arrives in a current of heated air, it will ascend, passing along with the current, and descending or rising as the current is either warm or cold. The effect of the cold fresh air from windows or doors, as well as the effect of the radiant heat from the fire, can be thus thoroughly studied. Some of our pet theories may receive a cruel shock from this experiment; but, in the end, the ventilation of the room will doubtless be benefited, if we apply the information obtained. It will be discovered that the wide-throated chimney is the cause of the little black arrows turning their backs on the right path and our theoretical outlets for vitiated air becoming inlets. The chimney flue must have an enormous supply of air, and it simply draws it from the most easily accessible places. From 1,000 to 2,000 cubic feet of air per hour is a large "order" for a small room. Therefore, until we have made ample provision for the air supply to the fire, it is quite useless to attempt to ventilate the upper part of the room, either by ventilating gas lights or one of the cheap ventilators with little talc flappers, opening into the chimney when there is an up draught, and shutting themselves up when there is any tendency to down draught. The success of these and all other ventilators depends upon there being a good supply of air from under the door or through the spaces round the window frames. These fresh air supplies are, of course, unendurable; but if one of the spaces between the joists of the floor is utilized to serve as an air conduit, and made to discharge itself under the fender (raised about two inches for the purpose), quite another state of things will be set up. Then the supply of air thus arranged for will satisfy the fire, without drawing from the doors and windows, and at the

same time supply a small quantity of fresh air into the room. But the important fact that the radiant heat from the fire will pass through the cold air without warming it all must not be lost sight of. In reality, radiant heat only warms the furniture and walls of the room or whatever intercepts its rays. The air of the room is warmed by passing over these more or less heated surfaces; and as it is warmed, it rises away to the ceiling. Therefore, if we desire to warm any of this fresh air supplied to the fire, it must be made to pass over a heated surface. The fender may be used for this purpose by filling up the two inch space along the front, as shown in the drawing, with coarse perforated metal. This will also prevent cinders from getting under it. It will be found that for the greater part of the year the chimney ventilator and the supply to the fire will materially prevent "stuffiness," and keep those disagreeable draughts under control, even although the room be lighted with a 3 light chandelier burning a large quantity of gas.

With improvements in gas burners, we may expect to light rooms perfectly with a less expenditure of gas than we now do. But we cannot light a room without in some measure creating heat; and I think I have shown that we want this heat at the ceiling line for the greater part of the year.

In summer we do not use gas for many hours; but, on the other hand, it is more difficult, with an outside temperature at 65° to 70° Fahr., to keep the air in pro-

per movement in small rooms. There are also times in the fall of the year, and also in spring, when the nights are unusually warm; and, with a few friends in our rooms, the lighting becomes a "hot" question, not to say a "burning" one. On these occasions we have to resort to exceptional ventilation, which for ordinary every-day life would be too much. It is then, and on summer nights, that the system of ventilation by diffusion is most useful. To explain it, when two volumes of air of different temperatures or specific gravities find themselves on opposite sides of a screen or other medium, of muslin, cloth, or some more or less porous substance, they diffuse themselves through this medium with varying rapidity, until they become of equal density or temperature. Therefore, if we fill the upper part of a window (which can be opened downward) with a strained piece of fine muslin or washed common calico, the air in the room, if hotter than the external air, will, when the window is more or less opened, pass out readily into the cooler air, and the cooler air will pass in through the pores of the medium. The hotter air passing out faster than the cooler air will come in, no draught will be experienced; and the window may be opened very widely without any discomfort from it.

It is, of course, quite impossible, in the limits of a paper, to do more than indicate a means of ventilation which will be effective under most circumstances

of lighting with those gas burners and fittings usually employed, and which will lend itself readily to modifications which will be necessitated by the use of some of the newest forms of burners and ventilating gas lights.

In conclusion, I wish to draw attention to an important discovery I have made in reference to blackened ceilings, for which, up to the present time, gas has been chiefly blamed. I have long entertained the belief that with a proper burner it is possible to obtain perfect combustion, without any smoke; and a series of experiments with white porcelain plates hung over some burners used in my own house proved conclusively that the discoloration which spread itself all over my whitewashed ceilings arose from the state of the atmosphere, which in all large towns is largely mixed with heavy smoky particles, and from the dust or dirt created in rooms by the use of coal fires as well as from the smoke which, more frequently than one is at first supposed to imagine, escapes from the fireplace into the room. I therefore, in two of my best rooms, which required to have the ceilings whitened every year, substituted varnished paper ceilings (light oak paper, simply put on in the usual way, and varnished) instead of whitewash. I also changed the coal fires for gas fires. These alterations have gone through the test of two winters, and the ceilings are now as clean as when they were first done. The burners have been used every night, and the gas fires every day, during the two winters. No alteration has been made in the burners employed, and no "consumers" have been used over them. If the varnished paper ceilings are tried, I am sure that every one will like them better than the time honored dirty whitewash, which is simply a fine sieve. This fact is clearly shown by the appearance of the rafters, which, after a short time, invariably show themselves whiter than the spaces between.

ANDERS' TELEPHONE.

MR. G. L. ANDERS' telephone, shown in the accompanying cut, combines in a single apparatus a transmitter, A, a receiver, B, and a pile, C. The transmit-

ANDERS TELEPHONE

ter consists of a felt disk, *a*, containing several large apertures, and fixed by an insulating ring, *c*, to a metallic disk, *d*, situated within the box, D. The apertures, *b*, are filled with powdered carbon, *e*, and are covered by a thin metal plate, *f*, which is fixed to the insulating ring, *c*, by means of a metallic washer, *g*. Back of the transmitter is arranged the receiver, B, which consists of an ordinary electro-magnet with a disk in front of its poles. The pile, C, placed behind the receiver, consists of a piece of carbon, *h*, held by a partition, *i*, and covered with a salt of mercury, and of a plate of zinc, *l*, which is held at a distance from the mercurial salt by a spring, *m*, fixed to the insulating piece, *n*.