THE AGE OF ELECTRICITY.

By WILLIAM HENRY PREECE, F.R.S.

II.

ELECTRIC LIGHTING.

Of all the purposes to which electricity has been applied there is perhaps none which is more likely to be beneficial in our domestic relations than that of illumination. Hitherto we have been content to submit either to the dulness of the ordinary candle, or to the trouble of oil lamps, or to the vitiation of gas; but now there is a prospect of, even in our houses, being freed from danger to health and to property by the introduction of the steady, bright and beautiful electric globe. The objections to gas are so very great that its adoption in our dwelling rooms has been by no means universal; hence the introduction of electricity into our houses rather fills a want than forms a rival to gas. Doubtless gas must to a great extent be displaced, but in the great majority of cases it will probably be retained for other purposes than illumination, and electricity will rather supplant oil and candles. Gas, like electricity, as a source of light, is a child of the present century. It has very great advantages of its own, it needs no personal supervision and is under easy control. It is always ready at our bidding, at any hour of the day or night, to enable us to light up our rooms by the aid of a simple match or any other ordinary means for raising temperature. But the objections to gas are very serious. In the very act of producing light it also produces water, and this water is found of great detriment to delicate objects that are exposed in shop windows. It not only produces much heat itself, but it throws into circulation the heated products of combustion. It also produces various gaseous acids which act injuriously upon gilded ornaments, and the ornamental bindings of our books and picture frames, and which are sadly detrimental to the air we breathe. It hastens the decay of many materials, and its influence on brass is well known in the frequent falling of pictures when they are hung by means of brass wire. Again, its fitfulness or variation is destructive to the eyes, so that constant writing, reading or studying by its means has proved injurious; in fact, it is questionable whether it has not led more to shortsightedness than any other known cause. It, moreover, introduces into our houses a certain source of danger, taps are left unturned, meters get out of order, gas escapes into our rooms, and when it mixes with air in certain proportions it produces one of the most explosive agencies known, and wrecked houses and lost lives witness to this unfavourable side of the use of gas.
Now the great advantages which electricity offers are, first, by the entire absence of any products of combustion it enables us to breathe pure air, and, secondly, by producing a steady light, it enables us to study and read without fatigue; in fact, instances have occurred of those who using the electric light have found that they have been able to lay aside their spectacles. On the other hand it must not be forgotten that there are certain objections to the use of electricity. It needs personal supervision, and we all hate personal supervision when it has to be exercised in our own homes. Its economy, compared with the present means of illumination, is still questionable, and though doubtless when electricity can be supplied to our homes and used as gas is employed now it may be supplied at no greater cost than gas, nevertheless at the present moment such a supply is not obtainable, and we have to deal with the question as we find it. Moreover, the employment of electricity is not unaccompanied by danger; several lives have already been lost in England, and many more in America, by the careless handling of the conductors that convey the electricity; and its liability, when improperly conducted, to produce heat, and thereby to produce fire, have raised the serious attention of the insurance offices, so much so that the premium paid by the Crystal Palace authorities, owing to the holding of an electrical exhibition there, has been raised to an absurdly exaggerated amount. I hope however, further on, to show that there need be no danger whatever with electricity, in fact that the dangers attending its installation in houses are considerably less than those attendant on gas. I should be very sorry to say one word against the employment of gas. It has in its day done good service. But I hold that if it be possible to produce in our houses an equally efficient light at a similar cost, no one would hesitate one moment to employ electricity instead of gas. The proper function of gas is not to produce light, it is to produce heat, and the future of gas lies in this direction, not only for cooking and manufacturing purposes but for the production of power in engines, even though they be employed to generate the electric light.

It is a curious fact that gas and electricity as illuminant agents were born very nearly about the same time, viz., at the commencement of the present century. It was in the year 1813 that Sir Humphrey Davy discovered the voltaic arc with the aid of a very powerful battery that had been presented to him by the members of the Royal Institution, and with which he made several noted discoveries. He found when he brought together two pieces of carbon and gently separated them, that the electric current was maintained across the air space separating them in a very brilliant flame of fire, which, because it took the form of an arch, was called originally the voltaic arch, or subsequently, the voltaic arc. This voltaic arc remained a scientific curiosity for more than a quarter of a century. Its production was difficult and costly, owing
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to the necessity for the employment of very large and expensive batteries; but, in 1831, Faraday made his great discovery of magneto-electricity, by which he showed how currents of electricity could be produced by the mere motion of conductors in a magnetic field, and which led to its production in quantities that were previously undreamt of. His brilliant scientific discovery rapidly took a practical form. In the subsequent year, Clarke and Pixii constructed the first magneto-electric machines, which, under the paternal care of Nollet and Holmes, enabled such powerful currents of electricity to be produced, that, in 1857, Faraday was able to recommend the Elder Brethren of the Trinity House to apply his own child to the illumination of the lighthouse on the South Foreland.¹

It is only within the present day that electricity as an illuminant can be said to have reached its practical stage. At certain fitful periods considerable excitement has been created in the public mind by certain inventors proposing this much wished for mode of lighting. As far back as 1821 it was mentioned in a book on "Practical Economy" as a probable mode of illumination; but the first patent was not taken out until 1840, by Pinkus. Starr, an American, came over to England in 1845, and proposed the earliest incandescent lamp, the parent in fact of the lamp (which will be subsequently described) that has now rendered domestic lighting practicable; and in the year 1846, Mr. W. E. Staite patented the first arc lamp, and made the first public demonstration of electric lighting in Sunderland, in the Hanover Square rooms, and in other places. Mr. Staite was long before his day. He spent much money, and much time, in trying to force upon an unwilling public that which they were not ready to receive, and which indeed was then not in a practical form. It was, however, applied for scenic illumination at the Paris Opera on the production of Meyerbeer's Opera "The Prophet," in 1846, by M. Duboseq, who is still to be found in Paris as the electrician attached to the Grand Opera. From this period most of the improvements in the mechanical details and working of the electric light were made in France by Foucault and Serrin, and indeed the Serrin form of arc light remains still that which is best known in our laboratories and wherever the electric light is used for purposes of investigation.

A considerable show of electric lighting was made at the International Exhibition in London, in the year 1862, but in 1876 there was an Exhibition held at South Kensington Museum, which did not receive the support that it deserved, called the Special Loan Exhibition, at which there was brought together a collection of scientific apparatus that had never been seen together before, and probably never will be collected together again. There were

¹ Faraday said:—"I beg to state that, in my opinion, Professor Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned."
several very fine displays of the electric light, but the electric light was not then much thought of, and the Loan Exhibition itself received more ridicule than praise. At the Paris Exhibition of 1878, however, a very different state of affairs occurred. In the previous year, 1877, M. Paul Jablochhoff, a distinguished Russian officer, startled the whole world by bringing out that which is now so well-known as the Jablochhoff candle. In this apparatus he showed how a lamp of comparatively small power could be produced by distributing the electric current, and he, in fact, maintained twenty candles burning with a very brilliant light from one machine. But the principal merit of his invention was that he threw aside altogether the complicated mechanism that was required in the Foucault and Serrin lamp to maintain the carbons apart, at the proper distance, while they consumed away, and, by simply separating the two carbons from each other by a layer of plaster of Paris, he simplified the construction of the lamp and produced that which burned away very much like a candle, and hence gave it its name. Few will forget the scare amongst gas shareholders produced by this invention, and few of those who visited the Paris Exhibition of 1878 will forget the magnificent display made in the Avenue de l'Opéra and in the Exhibition itself. This exhibition led to the adoption of the system upon the Thames Embankment, which was illuminated by it that year and has continued ever since that date to lend a charm to this boulevard of London. It is a remarkable fact that Paris has not maintained the start it made in 1878, for at the present moment the lights in the Avenue de l'Opéra are out, and a visitor to Paris has difficulty in finding a display of electric lighting anywhere in that city. Another great scare occurred in 1879, through some exaggerated reports received through the press of Mr. Edison's doings in America.

The success of the introduction of the electric light in Paris and the great strides made in the practical applications of electricity led to the formation of the Paris Exhibition of 1881, and no one who was there will ever forget the magnificent blaze of light which was made by the more than 2,000 electric lamps that illuminated the small space occupied by the Palais de l'Industrie.

This magnificent exhibition at Paris has led to the rather weak imitation of it at the Crystal Palace, but, nevertheless, though the imitation is weak, the Crystal Palace as an electric light show, pure and simple, compares most favourably with that held in Paris. There were a greater number and a greater variety of lamps in Paris, but the building there cannot be compared with the Crystal Palace for a display of electric lighting. The graceful contour of the building, the light and shade of the luxuriant foliage, the sparkling fountains and the brilliant courts eminently adapt the Crystal Palace for an exhibition of the kind. It is not in fact, as was the case in Paris, an exhibition of electric lighting.
so much as an illustration of the way in which such a building as the Crystal Palace can be illuminated, i.e. it is not so much an exhibition of lamps, per se, as an exhibition of systems of illumination.

I have alluded to the fact that the production of electricity for the electric light is a child of Faraday’s. I described in my first paper how it was produced. The machine used for the purpose is known as a dynamo machine, and it has reached its present stage of perfection in the combined and united efforts at different times of Hjorth in 1855, Paccinotti in 1860, Wilde in 1886, Siemens, Wheatstone, and Varley in 1867, and especially of M. Gramme, who, in 1872, quite independently brought out a machine which embraced all the merits and advantages of the different machines that preceded him.

Sufficient credit has scarcely been given to Mr. Wilde, of Manchester, for the part he has played in the improvements of dynamo machines. He first showed in 1866 how it was possible to accumulate electro-magnetic action so as to make a small magneto-electric machine produce a powerful electro-magnet, which in its turn operated another electro-magnet, and so by a process of accumulative action led to the production of enormous currents of electricity. His principle, practically carried out by himself, and modified by subsequent workers, lies very much at the root of the great success of the dynamo machines of the present day.

Broadly speaking there are but two systems of electric illumination, which may be said to be still on their trial. The one based on Davy’s original discovery of the arc, and the other based on that which is known as incandescence. I have already pointed out that the arc is due to a flame of fire which passes between two pieces of carbon when an electric current passes between them. This brilliant flame is produced by the destruction or burning of the two pieces of carbon, and hence the arc light may be said to produce its effects through a species of combustion. On the other hand, the incandescent light is one entirely independent of any combustion or destruction or waste of matter. Matter is said to be incandescent when it is raised to such a high temperature as to emit rays of light. An incandescent lamp is permanent in its character. But both systems of light—the arc and the incandescent—are due to the intense heat which is produced by the flow of electricity through poor conductors. There are many people who imagine that in the electric light we have light produced without heat; but there is no known case where light and heat are independent of each other. The intensity of light is simply due to the intensity of heat, and in the case of the arc the heat is produced by the passage of electricity through such a poor conductor as air; but in the incandescent light the poor conductor is a fine filament of carbon, placed in vacuo to prevent destruction, which is raised to a high state of temperature.
by the electricity flowing through it. It is difficult to say why the mere passage of electricity through such a poor conductor as carbon should produce such brilliant effects; but as it is known that heat is simply due to the movement of the particles of a body, and that light is due to this motion raised to a very high state of intensity, it is easy to conceive that the passage of electricity through bodies is accompanied by that tremendous commotion of their parts that leads first to heat and then to that brilliant light that sheds its rays all around us. Owing to the fact that the arc light is dependent upon the consumption of the carbon points that are opposed to each other, it is necessary to devise some means to maintain these two carbons (which are usually cylindrical rods of about \( \frac{1}{4} \) inch to \( \frac{1}{2} \) inch in diameter) opposed to each other at a fixed and regular distance; and hence it is that numerous forms of regulators have been devised, based originally on Staite’s and Foucault’s plan, and which in the present day are known as the Siemens’, the Crompton, the Weston, the Brush, the Brockie, the Pilsen, and other regulators.

Now, the light given by one of these regulators depends primarily on the quantity of electricity that is flowing; and it is possible, by so regulating the flow of electricity, to regulate the light in any desired proportions. Perhaps the greatest light that has yet been seen is that which is occasionally shown by the Anglo-American Brush Electric Light Company, in the winter garden of the Crystal Palace. There of an evening can be seen a Brush regulator, with carbons two inches in diameter, which gives a light that is said to be equal to 150,000 candles.

This mode of indicating the illuminating power of any lamp is a subject very little understood and very much abused. The standard light with which all other lights are compared is a sperm candle, which burns away 120 grains per hour. Such a standard is a very useful unit when we wish to measure an oil lamp or a gas burner, and to measure such lights the operation is a comparatively simple one. We simply have to find at what distance the standard candle and the lamp to be measured cast equal shadows. In that case we deal with lights of the same character, emitting the same kind of rays and we are not troubled by any interference from colour or from other causes. But when we come to use the same standard to measure the electric arc, which emits rays of a totally different character to a gas lamp, we flounder in difficulties. The difficulties are so great that different observers measuring the same lamp have made it vary in light-giving power from 250 to 2,000 candles. I have proposed to abandon the standard candle as the unit by which electric lights should be measured, and to take instead the amount of illumination distributed over a given area, say a square yard. This idea has not yet received adoption, though indications are given that
some of our practical men are beginning to see its advantage. If, for instance, we take as a standard a square yard illuminated by a standard candle at one foot distance away, we should have a better unit to guide us than that now given by the flame of the candle. When we compare the relative intensity of different sources of light, we have not only to deal with the intensity of the light but with the volume of flame given out by it. This is one source of the great discrepancies that are made by different observers.

There are many lamps at the Crystal Palace that are excellent examples of brilliant arc lights. One, a Crompton lamp, suspended in the centre of the central transept, is remarkably brilliant, and so is one by Messrs. Siemens suspended over the old Crystal Palace Fountain of 1851.

Capital examples of arc lights are to be seen in our streets, and in fact in the City of London and in the Crystal Palace are now to be seen arc lights in every stage of power, variability, efficiency, and inefficiency.

The opinion appears to be gaining ground very fast that the arc light is only available for external purposes. It is used in the reading-room of the British Museum with great effect, and it is also used at several of our railway stations, but for domestic and internal purposes the light of the future is unquestionably that of incandescence.

There are various other forms that deserve a passing notice before we come to the incandescent lamp. Besides the candle of Jablouchkoff, there is a capital candle by Mr. Wilde, and also another by Professor Jamin. Other forms of light, bordering closely on the incandescent lamp, have been proposed by Werdermann and improved by Joel; but, in my opinion, the days of electric candles and Werdermann lamps are past, and the question now is simply one of arc or incandescence.

Incandescent lighting, in its present form, is due entirely to the exertions of Mr. Edison. On the 7th March, 1879, I had the honour of delivering a lecture at the Albert Hall, before the Prince of Wales and the Duke of Edinburgh, when nearly all electrical machines and lights then in existence were exhibited, and on that occasion there was only one exhibition of a truly incandescent system of lighting, and that was a mode of raising a thin bar of iridium to a very high state of incandescence. The result was extremely soft, brilliant and beautiful, and it led everyone to hope that the exertions of our inventors and discoverers would be directed to utilising this form of illumination. The wish was speedily responded to by the action of Edison in America and Swan in England. The two have been working on opposite sides of the Atlantic independent of each other, and the result has been to produce an electric lamp that leaves little or nothing to be desired. It is well that I should describe such an electric lamp, and I take as my example that of Mr. Edison, because I
believe it to be the best. The lamp consists of a fine filament or carbon inserted as part of the electric circuit in a glass globe, which has been exhausted of air to the utmost limit of workshop skill. A fine, uniform quality of Japanese bamboo has been selected as that which gives the finest filament for carbonising. The bamboo is cut by special machinery into the required dimensions and inserted in a mould, which is placed in a furnace, and raised to a very high temperature, and from which the filament comes out shaped and carbonised. Naturally grown vegetable fibre has been found to give a more uniform texture than any artificially formed carbon. The ends are cut flat and squeezed inside copper clamps, which are then welded together by electro-plating. The copper clamps are then soldered to platinum leads, that are sealed through the glass and are connected to the conductors. Perfect sealing is obtained by flattening the mass of the tube, through which the fine platinum wires pass, into a solid bar, so as to well fuse the wires and glass together. It is a fortunate thing for the permanence of the incandescent lamp that the coefficient of expansion, due to heat, of glass and platinum is practically the same. The normal lamp consists of a filament six inches long, which, on account of the resistance it offers to the passage of a certain current of electricity, gives a light equivalent to sixteen sperm candles. The half lamp is constructed with a carbon filament of just half the length and half the resistance, and gives eight candles. Other lamps are made with two and four horseshoe filaments, so as to increase the light-giving power. The features of carbon which render it so highly adaptable for incandescence are its electrical resistance, its high refractory character, and its stability. The illumination of a filament and its durability are functions of the current that passes; the more intense the current the higher the temperature, and therefore the brighter the light, and the shorter its life. At a temperature of 1,000° carbon becomes red, at 2,000° it is white, and the higher the temperature the whiter it gets, until fusion takes place. A lamp of this kind, whose carbon is at a temperature of 2,000° gives a light of sixteen candles, and will last on an average for 1,000 hours. A better light can be obtained by a greater temperature consequent on a stronger current, but the life of the carbon will be proportionately shortened. If it were possible to find a form of carbon or any other material which would be so refractory that we could transmit through it very strong currents of electricity, the incandescent lamp would rival the arc lamp in brilliancy and power. The destruction of the carbon in incandescent lamps is due to a very slow transference of carbon in a molecular shower from one heel of the horseshoe-shaped carbon to the other heel until a break down takes place at the former point. The better the vacuum the slower this effect. Certain machines are said to lengthen the life of the carbons by the use of alternate currents of elec-
tricity, each succeeding current being reverse in direction to that which precedes it, and thus equalising the distribution of molecules on each heel, but that is done at the expense of efficiency.

The present condition of electric lighting is in a very hopeful state. In France, where one would have thought that greater progress would have been made than anywhere else, I have already pointed out that the progress seems retrograde, but in America and England the progress has been immense. In England we have street lighting carried out on a very large scale by the authorities of the City of London. Three districts were selected for the trial of three distinct systems. One portion has been allotted to the Brush system, one to the Siemens', and the third to the Weston system. More than twelve months have elapsed since the trial was first commenced, and in the case of the Brush Company the contract has been renewed for another twelve months. The works at which the electricity is generated are situated at Lambeth, over one mile from the city, and forty lamps are maintained in action over a circuit of more than two miles in length. Other towns have followed the good example of London. Chesterfield has been illuminated since October last, also by the Brush system. Here we have a town which was left without gas, employing twenty-two arc lights, and about one hundred incandescent lamps for the illumination of their streets; and although I have not seen the installation there, I am told that since the 8th October last, the lights have burned with the greatest regularity, and that there has been none of those breakdowns which unfortunately characterised installations made at York, during the Meeting of the British Association, and at Edinburgh, for a period of three months. One Brush machine works twenty-two arc and one hundred incandescent lights through a circuit of fifteen miles in length, a feat, perhaps, unparalleled in electric lighting. Godalming also is a town that has cast aside gas and taken to electricity; but there at first the experiment was a failure, although now, I believe, thanks to the skill of the house of Siemens, it has been made a success.

There is no one to whom the success of electric lighting is due more than to Mr. Crompton, and to whom has been entrusted by the authorities at Norwich the illumination of a great portion of their town. Mr. Crompton has entered into a contract for twelve months, and there is no doubt that his well-known energy will make the lighting of Norwich a great success. Among the foremost of those who have led the way in the introduction of the electric light is the Times newspaper. The offices of this gigantic undertaking have been illuminated now for more than three years, by a combination of the incandescent and the arc systems; and the result upon the work done and upon the health of the employés fully justifies the authorities of Printing House Square in carrying out the experiment. Not behind hand have been the authorities
of the Post Office. They have long recognised the advantage which the electric light must have upon the health of their telegraphists and clerks, who are frequently more hardly worked at night than they are by day; and at Glasgow, Edinburgh and London experiments have been made on various systems with the view of ultimately adopting that which shall prove itself the most efficient for the Department's purposes. A remarkable installation of electric lighting has recently been made on the Holborn Viaduct. 938 lamps are distributed along the viaduct and among the shops, hotels and offices of that important thoroughfare, by the Edison Light Co., and are all lit by one machine. It is the most successful example of domestic lighting ever attempted.

One of the most interesting applications of the electric light is that to photography. At the Paris Exhibition, and now daily at the Crystal Palace, photographs are taken by the electric light, and Mr. Van der Weyde, who was the first to work in this direction, has for a long time been taking portraits by this means in his studio in Regent Street.

The introduction of the electric light in England has been unfortunately accompanied by gross ignorance, as might necessarily occur in the introduction of any new system; but the ignorance displayed by the electric light installers has been of the very worst character, for they have ignored in many instances the plainest teachings of experience. A very marked case took place at the Marquis of Salisbury's seat at Hatfield. Here, bare wires, conveying the most dangerous currents of electricity, were allowed to remain exposed, and a poor workman who incautiously touched a wire was struck dead on the spot. Several deaths from similar causes have taken place both in England and in America, and it is perhaps fortunate that they have occurred so early in the history of electric lighting, for they have done more than the warnings of experienced men to direct the attention of the electric light authorities to the danger of the commodity they handle. Several fires have also taken place, not only in England but in Paris, and it has been stated (I cannot vouch for the truth of it) that owing to four fires having taken place at the Paris Opera House, the systems on trial there were ordered out of the place.

In America the fires have been so frequent that the Board of Fire Underwriters there have issued the most stringent rules which they insist upon being carried out. These rules are worth extracting and are as follows:—

The regulations of the underwriters, embracing the latest revisions, as adopted at a meeting held January 12th, 1882, are as follows:—

**Capacity of Conductors.**

*For Arc Lights.*—The conductor must have a weight per running foot at least equal to that of the wire (or parallel group of wires) constituting the main circuit of the magnetic regulator of the electric lamps, or of the armature of the machine employed, whichever of these is the largest.
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For Incandescent Lights. — Wherever a connection is made between a larger and a smaller conductor at the entrance to or within a building, some approved automatic device must be introduced in the circuit of the smaller conductor, whereby it shall be interrupted whenever the current passing through it is in excess of its safe carrying capacity. The safe carrying capacity of a wire is that current which it will convey without becoming painfully warm when grasped in the closed hand.

Insulation.

All wires, machines, and lamps to be so mounted and secured as to insure complete and continuous insulation, with the exception of those parts (such as portions of the lamps or machines, for example) where insulation is impossible, and in this case accidental contact with exterior objects must be prevented by appropriate screens or the like. In no case must "ground circuits" be employed, or any portion of the system be allowed to come into conducting connection with the earth through water or gas pipes, or otherwise. Exposed wires must be covered with at least two coatings, one of insulated material next the wire, of a thickness and material approved by the Board, and another outside of this, of a material calculated to protect the former from abrasion or other mechanical injury. Where there is a possible exposure to water, the first or second coating must be impervious to that fluid. Wherever electricity is carried into a building by conductors from an exterior source, a "cut out" must be provided at a point as near as possible to the entrance to such building. The outgoing and returning wires for arc lights should enter and leave each building at points at least one foot from each other. The wires passing through the exterior walls of a building should be firmly inclosed in substantial tubes of non-conducting material, not liable to absorb moisture, and placed in such a manner as to prevent rainwater from entering the building along the wire. In running along walls and the like wires should be rigidly attached to the same by non-conducting fastenings (the wires themselves being well insulated), and should not be hung from projecting insulators in loose loops. All wires should be placed at a distance of eight inches for arc lights and two and one-half inches for incandescent lights from each other, and wherever they approach any other wire or conducting body capable of furnishing another circuit or ground connection, they must be rigidly secured and separated from the same by some continuous solid non-conductor, such as dry wood, of at least one half inch in thickness. Wherever wires are carried through walls, floors, or partitions in buildings, they must be surrounded by a special insulating tube of substantial material. All joints in wires must be made in such a manner as to secure a perfect and durable contact. Continuous wires (without joints) to be used as far as possible.

Globes.

Arc lights must be protected by glass globes, inclosed at the bottom to prevent the fall of ignited particles, and where inflammable materials are present below the lamps, a wire netting must be added, to keep the parts of the globe in place, in case of its fracture during use. All broken and cracked globes to be at once replaced by perfect globes. In show windows and other places where inflammable materials are near the lights, spark arresters shall be placed at the top of the globes.

Automatic Shunt.

Wherever a current of such high electro-motive force is employed that if concentrated on one lamp of the series it would produce an arc capable of destroying or fusing parts of such lamp, an automatic switch must be introduced in each lamp, by which it will be thrown out of circuit before the arc approaches any such dangerous extent. Companies furnishing electricity from central stations must enter into an agreement with the New York Board of Fire Underwriters, binding themselves to test their lines for ground connections at least once every day (and preferably three times per day), and to report the result of such tests to the Board weekly. Means by which those in charge of the dynamo-electric machines will be warned of an excessive flow of current, or means whereby the same will be automatically checked, must in all cases be provided.

There is no doubt that if these simple rules be carried out by qualified men, there need be no fear of danger from electric lighting.

On this point, it is worth mentioning that Mr. Edison has applied to his system a "safety catch," which consists in inserting in every branch wire a short piece of lead wire, of the same dimensions as the conducting wire, which instantly melts if the strength
of the current passing through the conductor exceeds a certain value. Every conductor has certain dimensions which are designed for the special purpose that it is intended to fulfil, but if the current flowing through be increased beyond the desired amount, then heat must be generated somewhere. If the current acquire an undue amount, then the conductor becomes heated and leads to fire; but if this lead wire be inserted, the lead will fuse away long before the copper conductor becomes heated; the circuit is ruptured, the flow of electricity instantly ceases and safety is the result.

A good deal of attention has been directed to what has been very improperly called the "Storage" of electricity. A considerable amount of sensation was created by a gentleman, who travelled from Paris to Glasgow with what is known as the Faure accumulator, which he handed to Sir William Thomson, and from which that gentleman was able to extract a considerable quantity of electricity. This was brought forward with much sensation, and has secured more attention to accumulators (as they are called) than they deserve. The parent of electric accumulators is M. Planté, who was working at the subject as far back as 1859. Planté produced what is properly known as a secondary battery, in which two lead plates are opposed to each other in a diluted solution of sulphuric acid. When a current of electricity is made to pass through this solution, it covers one of the lead plates with an oxide of lead leaving the other plate pure and clean; the result is that when the current is withdrawn we have a secondary battery consisting of a negative plate of peroxide of lead and a positive plate of pure lead, and when the two poles of the battery are brought together there is a current of electricity which lasts as long as the peroxide continues, but ceases the moment the peroxide has been reduced. The forming of this peroxide of lead was a question of time, and Planté's instrument, notwithstanding his long-continued, persistent and determined efforts scarcely passed the bounds of a scientific toy. But M. Faure, by coating the faces with red lead, which is an oxide, considerably expedited the formation of the battery and added materially to its power and to its practicability. For certain purposes the Faure accumulator is a very useful instrument. It is now daily used on the London, Brighton and South Coast Railway, in lighting up a Pullman train that runs upon that line, but I am no great believer in the ultimate value of this instrument for lighting railway trains, because of its weight and dimensions. In the Brighton train there are no less than 80 Faure cells, each weighing nearly 100 lbs., fixed in the guard's van, which have to be charged at the end of each double journey. The Faure battery may, however, prove of great utility in acting as a governor to dynamo machines, when engines run irregularly and when belts slip, and it also affords a very convenient means of enabling electric illumination to be maintained at night when our gas or steam engines have ceased to
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run. When, however, the happy times arrive that electricity is laid on through our streets and roads, and supplied to our houses as gas is supplied now, then it is difficult to see where the practicability of accumulators exists. Doubtless it is a very charming idea to have electricity delivered at our doors as now we have milk, but the cans that contain electricity are many hundred times heavier than those required for milk. There remains a great deal to be done before a practical secondary battery can be supplied.

It is very difficult, as I have said, to answer the question so very often put, What is electricity? And it is a still more difficult thing to disabuse one's mind of the idea that it must be a kind of fluid, especially when we know that in most of its phenomena it obeys the laws of an incompressible fluid, and also when most of its terms in daily use are based upon the idea that it is a fluid. But there is no practical difficulty in laying it on into our houses as we lay on gas; and, more than that, it is a matter of great simplicity, to measure with accuracy the amount of electricity that may be consumed in any place, for electric illumination or for any purpose whatever.

In Mr. Edison's "ampère meter," as it is called, a glass cell contains two copper plates, immersed in a solution of sulphate of copper. A definite portion, exactly one-thousandth, of the current that passes into the house passes also through this cell, and removes copper from one plate and deposits it on the other plate. The weight of copper deposited is an exact measure of the current used. There are two such cells, the one in charge of the consumer and the other of the supplier. The one checks the other. There are other devices designed for the same purpose, and therefore there is no more difficulty in registering the quantity of electricity consumed, than there is in registering the quantity of gas.

One great desideratum, remaining to be solved, to hasten the introduction of electricity into our houses, is the production of an efficient gas engine. Of course when electricity is laid on like gas all difficulties disappear, but there are innumerable places where even now people would be only too glad to adopt electricity, if some simple and efficient motor could be offered to them, utilising gas for the purpose. Where water is available, as it is in the grounds of Sir William Armstrong, near Newcastle-on-Tyne, there is little difficulty in producing electricity and using it on one's property, but where there is no water few people would incur the dangers and expense of a steam engine; but no one would hesitate long in employing a gas engine, if a simple and efficient one involving little supervision, could be supplied to our houses. Messrs. Crossley and Co., of Manchester; Thomson, Sterne, and Co., of Glasgow, and others, are working in this field, and we are looking forward with much interest to the time when a practical instrument will be offered for the purpose.