current is great, and the wire is heated. If the resistance is sufficiently great, the wire will become white hot, and may even be melted. Some metals offer less resistance to the electric current than others, and are therefore called better conductors. From the following table it will be seen that the high price of some of the metals named, and the want of ductility and strength of others restrict, within very narrow limits, the choice of metals to be employed as electric conductors. The conductivity of silver being taken as 100, we have :—

Metal.	Electrical Conductivity.	Heat Conductivity.
Silver	100	100
Copper	80	73
Gold	55	59
Zinc	27	—
Tin	17	23
Iron	14	14
Platinum	10·5	10
Lead	7·8	11
Antimony	4·3	—
Mercury	1·6	—
Bismuth	1·2	2

Silver, which is the best conductor, is too costly for any but exceptional use. Conductors are almost wholly made of copper, of iron, and of certain alloys, such as phosphor bronze, and silicium bronze. Copper is the metal most employed in applications of electricity. Coils of electrical instruments of all kinds are almost exclusively made of it, also the cores of subterranean and submarine cables. Electric light heads are made wholly of it, either as single wires, or in cables formed of several wires twisted together.

The difference of resistance offered by various metals to the passage of electricity can be illustrated by a simple experiment.

If a short piece of platinum wire be inserted between two lengths of silver wire of equal diameter, and a strong current passed through them the platinum wire will be heated to redness, whilst no alteration will be seen in the silver wires. This is because the platinum offers six times as much resistance as the silver wire does to the flow of the current. The resistance offered by conductors to the passage of the current requires a certain amount of power to overcome it, and all power so expended represents a cost for which there is no return in light, and which is therefore, a certain waste which cannot be avoided. All wires, however thick, and of however good a conducting material, offer some resistance to the current, and, therefore, are to some extent heated; but with stout copper wire this is usually imperceptibly slight. The thin filaments of carbon used in incandescence lamps grow hot, because of the great resistance they offer to the current.

If the length of a wire is doubled its resistance is doubled. If the section is doubled the resistance is halved. If we double both length and section the resistance remains unaltered. As it is of the utmost importance that heat should not be developed in any part of the circuit, excepting the lamps, the conducting wires and the coils of the magneto apparatus that are employed to regulate the feed of the lamp, are made of stout copper wire, and the danger of fire is thereby reduced to a minimum; besides this the resistance of copper increases one-fifth per cent. for each degree, Fahrenheit, increase in temperature.

Carbon is a substance whose resistance diminishes as the temperature increases. It is not economical to use wire of a small diameter, except for very short leads, on account of the waste of power incurred in forcing the current through them, and in practice, therefore, it is not so much a question how small a conductor may be used without over-heating, but rather what size of wire will be most economical, having regard to the prime cost of the conductor, and to the annual cost of the motive power necessary to force the current through it.

All wires for conveying currents for electric lighting are well insulated, the larger wires are insulated in a number of ways, with gutta-percha, asbestos, nigrite, and with various other compounds, and are wound with tarred tape or other waterproof covering. They are sometimes enclosed in lead pipe. The finer wires are enveloped in silk or cotton.

There are two reasons for taking the greatest of care in insulating the wire conductors. First, that an electric current, especially of high tension, has the tendency to flow out at any points that give it an easy passage. A damp wall, for instance, offers a facility for leakage in conductors placed against it. The smallest contact with any moist object allowing it to escape.

The second reason is on account of the danger in leaving bare conductors within the reach of persons ignorant of the elementary characteristics of electricity. This, however, is a danger which is greatly exaggerated. Sir William Thomson has said that, there is more danger in a circular saw running at full speed in a mill, than in a dynamo-electric generator of high E. M. F. To guard against accident, however, the wires are all carefully insulated.

To prevent the wires being fused, through the current being increased, safety plugs or bridges are used which consist of easily fusible wire, composed of sixty parts of lead to forty of tin, of a thickness suitable for the probable strength of current that must be carried. If the current should by any means be increased the fusible wires are melted and the danger of the conductor being over-heated is obviated. These safety plugs are placed at points where the wires branch off from the main conductors.

The two principal methods of grouping lamps are respectively denominated, simple circuit, and compound circuit (see fig. S.) Lamps in simple circuit or in series, the current passes through from one to the other, and back to the generator, as shown by the arrows.

Lamps in compound circuit parallel arc, or multiple arc figure T) are placed as a bridge across the circuit from a main leading wire to a main return wire. This is the system adopted by Edison. Another arrangement of grouping, called "in derived circuit," "in derivation," sometimes called "in shunt circuit," is frequently adopted (figure U). The great advantage of this mode of grouping is that the failure of one lamp does not involve the extinction of the remainder, as there is still a path open for the current through the wire shunts.

Having explained the mode of producing the light, it will not perhaps be out of place to pass a few remarks as to its many advantages. An increasing amount of attention has been given to lighting by electricity, and there is a rapidly extending desire for more intimate knowledge of the laws which its phenomena involve. The subject has been treated in its scientific aspect, but its domestic side has been altogether overlooked, or I may say ignored.

There is one common fault with all forms of artificial light, and that is, they all, to a greater or lesser degree, consume the oxygen of the air. A perfect light, in the first instance, should not rob the air of its oxygen; it should not vitiate the air; there should be no danger from it; it should not be an unpleasant light, nor be difficult to control, and, above all things, it should not be expensive.

The following table shows the oxygen consumed, the carbonic acid produced, and the air vitiated by the combustion of certain bodies burnt so as to give the light of twelve standard sperm candles, each candle burning at the rate of 120 grains per hour:—

Burnt to give light of 12 candles.	Cubic feet of oxygen consumed.	Cubic feet of air consumed.	Cubic feet of carbonic acid produced.	Cubic feet of air vitiated.	Heat produced in lb. of water raised 10° F.
Common gas ...	5·45	17·25	3·21	348·25	278·6
Paraffin	6·81	34·05	4·50	484·05	361·9
Sperm candles	7·57	37·85	5·77	614·85	351·7
Wax do. ...	8·41	42·05	5·90	632·25	383·1
Stearine do. ...	8·82	44·10	6·25	669·10	374·7
Tallow do. ...	12·00	60·00	8·73	933·00	505·4
Electric Light...	None	None	None	None	13·8

It will be seen from this statement that the electric light is the nearest approach to the perfect light. The incandescent lamp is exhausted to such a high degree that there is almost a complete absence of oxygen, and, in fact, the light depends for its existence upon the absence of oxygen, which is exactly the reverse with all other forms of artificial light. If oxygen could be absorbed for only one second the carbon filament would be consumed, and the light would be extinguished. No air, therefore, is robbed from the rooms, nor are any noxious fumes thrown off. Ordinary gas is very poor in carbon, so that a very large amount has to be consumed to produce the necessary light. The illuminative portion equals 10 per cent. of the whole, the remaining 90 per cent. produces heat and throws off moisture and carbonic acid gas from their combustion, which increases the temperature of the atmosphere, and of course vitiates it in a greater degree than candle or oil light.

As to the question of danger to life and of fire. Almost daily we hear of serious accidents through the use of gas, but little or no notice is taken of them. In England and America, where the electric light is very largely used, the slightest accident in connection therewith is fully commented upon, and in this colony we are initiating the same crusade. The dangers of the use of the light are greatly exaggerated. Of course there is danger with currents of very high tenison. Continuous currents of over 300 volts and alternating currents of over 200 volts are dangerous to human life, but with the perfectly insulated wires used for house lighting it is impossible to harm life or property. Besides this, a low E.M.F. is required for lighting the insides of houses, and the danger is reduced to a minimum. So far as the lamps are concerned, the incandescent is beyond doubt the very safest form of lamp. The majority of fires, for instance, are traceable to something connected with the lighting. A candle sets fire to drapings, curtains, etc.; a kerosene lamp is overturned; a gas bracket is brought too close to the wood or paper of partitions; or the light without a globe or any protector is allowed to burn too close to a ceiling, and it ignites the woodwork or canvas lining, and the whole place is in flames immediately.

With the incandescent light, in the first place, no match, the latent source of danger, is required to light it. Simple switches are used, by one turn of which the light is turned on or extinguished, and should a lamp—that is, the glass globe—be broken, the light is immediately extinguished. No explosions can occur, as with gas, and the electric current does not leak out and charge the air with poison. The incandescent light is a very pleasant one, and is not trying or injurious to the eyes. Of course, if one gazes at the light, the eyes suffer in consequence; but this, it is well known, would occur with any strong light. Besides, it must not be overlooked that suitable globes to temper the light to any degree of brilliancy can be procured.

No scientific knowledge is required to control the electric light; switches are arranged for cutting out one or more lamps at a time, or lowering the light, as required, and the moment it is wanted it can be turned on; children can be trusted with it, and in cases of sickness it can be turned on at once. It is highly valued for large assembly rooms, ball rooms, and other places of meeting, which when lighted with gas, are perfect ovens; but when the electric light is used are perfectly cool, as the latter depends for existence on its non-combustion, instead of absorption of oxygen. It is completely free from deleterious products.

Professor Barratt, F.R.S.E., of the Royal College of Sciences, Dublin, comparing the different illuminating agents in use at the present moment, said, that for the same amount of light, gas cost 6d., the Glow, or incandescent electric light 6d., and the Arc 3d.

Parrafin oil occupied a very high position as an illuminant in cheapness and undeleterious nature of waste products, but its disagreeable smell, and the danger attending its use were against it. Electricity gave rise to no deleterious products at all, but the Arc lamp gave a dazzling though flickering light, throwing intense shadows. The Arc light was far less expensive than the Glow light. In calculating the cost of providing the electric light for a house, the chief item was the interest on the capital laid down in plant; the actual supply of electric energy was the least of the items. For two hundred lamps, lighted 500 hours a year, it was cheaper to have gas than the arc electric light, but in gas the chief cost was the consumption of gas, and when the number of hours a year in which the light burned was extended, the relative cost of the two systems was reversed. The great requisites for an artificial light were steadiness, accessibility, cheapness, safety, non-deleteriousness, and whiteness.

The Trinity House Committee, after very complete experiments in May and June, 1885, with illuminants for light-houses, sum up their report with these conclusions as regards electric light :—"That the electric light as exhibited in the A[a] experimental tower at the South Foreland, has proved to be the most powerful light under all conditions of weather, and to have the greatest penetrative power in fog. That for the ordinary necessities of light-house illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

To show the power of some lights now in use, it may be here stated that a 40,000 candle-power light on the Chicago Board of Trade tower, has been seen distinctly at Benton Harbour, Lake Michigan, 83 miles distant.

The question of the cost of production and supply of the electric light to houses is a most important one, and it depends on the conditions of the installation in the same way as the price of gas varies in the different localities, according to the quantity supplied and the facilities for manufacture.

No exact rule is laid down for calculating the cost of electric lighting generally, but when the conditions of any proposed installation are known, an exact estimate can be made.

Electric light on the arc system is less expensive than gas, and on the incandescent system, more costly.

The electric light is, as yet, little used in this colony, and it is therefore impossible to get a reliable estimate of the cost of its supply, as compared with gas. The Government has several large installations, but as these are of such a special nature and of an expensive form, to meet the requirements of the places at which the light has been adopted, it would not be fair to quote the cost as a standard for other istallations. The author is not at present prepared to go into figures, but might perhaps mention that the number of hours the light is used annually make a great difference,—for whilst the cost per hour of a gas-light remains constant whatever time it is kept burning, the cost per hour of the electric light decreases considerably as the number of hours it is used increases.

This is very easily understood when it is considered that the interest on the capital outlay and other charges remain the same whether the electric light plant is used for one or twelve hours, and that consequently the expense per hour will be materially reduced in proportion as the number of working hours are increased.

The quantity of gas required to produce a light equal to 1,000 standard candles (assuming the standard burner using five (5) feet per hour to give an illumination equal to 16 standard candles) would be 312 cubic feet, which, at 2s. 9d. per 1,000 feet, would cost in England 10½d. Certain companies in England propose to supply the light to the public in towns at ½d. per hour for each 20 C.P. lamp, or about 2s. per hour for a total light of 1,000 candles. For arc lighting large installations can be carried out as low as 3d. per hour per 1,000 candles.

At Denver, in Colorado, the streets are to be illuminated by electricity, at a cost of 28 dollars per lamp, against 35 dollars—the lowest offer of the gas company. There are 450 lamps, the system is the Edison, and the plant will cost 20,000 dollars; twenty circuits, 27 lamps to each circuit when each circuit has its full compliment; the lamps to be placed on the existing gaslight posts.
