THE DANGERS OF ELECTRIC LIGHTING.

BY THOMAS A. EDISON.

So MUCH has of late been said and written upon the subject of high-tension electric currents and their probable or possible danger to human life, and so many different opinions have been advanced by men whose positions serve to surround their utterances with an atmosphere of knowledge of the matter under discussion, that the mind of an unscientific public has been unable to come to any definite conclusion upon the basis of "expert" testimony. It is most unfortunate that a practical demonstration in support of the real facts of the case could not have been made in a less tragic manner than was witnessed a few days ago in New York by several thousand people; and yet if the martyrdom of this poor victim results in the application of stringent measures for the protection of life in the future, if the lesson taught is appreciated to the full extent of its fatal meaning, the sacrifice will not have been made in vain. With the increase of electric lighting (which to-day is used only to a very limited extent as compared with its inevitable future use) and the multiplication of wires, these dangers which exist now in a thousand different parts of the city will be manifolded many times. In fact, the opportunities for repetitions of the accident referred to above will be practically unlimited.

I can write upon this subject only as one convinced. I cannot discuss it otherwise. The public would scarcely be interested in the details leading up to the position taken by myself and the conclusions to which I have come, for the reason that it would involve a mass of matter such as they have been attempting to digest during several months past; and, instead of explaining, I might succeed only in adding to the present confusion of popular ideas. But I may say that I have not failed to seek practical demonstration in support of such facts as have been developed,

and I have taken life—not human life—in the belief and full consciousness that the end justified the means.

The currents used for electric lighting at the present time may generally be divided into four classes :

First—The low-tension continuous current, with a pressure not exceeding 200 volts, used for incandescent lighting.

Second—The high-tension continuous current, with a pressure of 2,000 volts and over.

Third—The high-tension semi-continuous current, with a pressure of 2,000 volts and over.

Fourth—The alternating current, with a pressure from 1,000 to 3,000 volts and over.

The first is harmless, and can be passed through the human body without producing uncomfortable sensations. The second is dangerous to life. Momentary contact with a conductor of the third results in paralysis or death, as has frequently occurred ; and the passage of the fourth, or alternating, current through any living body means instantaneous death.

These are simple facts which cannot be disproved. There is a record of nearly one hundred deaths, which furnishes an unanswerable argument in support of these statements. Discussion and controversy may serve the questionable purpose of delaying popular faith in them, but they cannot change them ; and the sooner they are accepted and acted upon the less liability will there be of a recurrence of the late horror, which is still fresh in the minds of all those who witnessed or read of it.

It has often been asked why the number of accidents of this nature is larger in the city of New York than in any other city. The reason is that New York has a greater number of wires to the square mile than any other city in the United States. The percentage of deaths in other places will reach that of New York when wires are strung in like numbers ; but if electric lighting under its present conditions extends in the latter city proportionately, its death-rate will have been greatly multiplied by the time other cities reach its present high percentage.

Many suggestions have been made as to the best way in which to remedy the existing evil, and the popular cry seems to be, "Put the wires underground." But, instead of diminishing, this will increase the danger to life and property. There is no known insulation which will confine these high-tension currents for more

than a limited period, and when they are placed beneath the ground, with the present system of conduits, the result will be a series of earth-contacts, the fusion of wires, and the formation of powerful electric arcs, which will extend to other metallic conductors in the same conduit, and a whole mass of wires made to receive this dangerous current and convey it into houses, offices, stores, etc. It is thus evident that the dangers of such circuits are not confined to the wires which convey the high-tension currents, but other wires conducting harmless currents are liable to be rendered as deadly in effect as the former. It is evident, also, that a single wire carrying a current at high pressure would be a constant menace to the safety of all other wires in the same conduit. Even though these dangerous wires be placed in separate tubes in the same conduit with other tubes, the risk is not diminished.

Several instances are on record, and one I have particularly in mind, showing the possibility of serious accident through the crossing of wires. Near the corner of William and Wall Streets, New York, the underground conductors of the Edison Illuminating Company became crossed, and the current which was passing through them at a pressure of only one hundred and ten volts melted not only the wires, but several feet of iron tubing in which they were incased, and reduced the paving-stones within a radius of three or four feet to a molten mass. This system is so arranged that consumers are not affected by such accidents as this. They may and do mean expense to the company, but the public are entirely free from any possibility of danger. The crossing of wires in this way means the concentration of several hundred horse-power of energy in a small space. What would have been the effect of such a cross as I have described had the pressure been two thousand instead of one hundred and ten volts? and what also might be the effect were it to occur in a conduit in close proximity to hundreds of telephone wires and those of other electric-lighting systems? The risk, too, is greatly increased by the fact that consumers who are supplied with currents from a low-tension system are accustomed to handle their electrical appliances freely, knowing them to be harmless. If these are to be rendered at any moment dangerous to life, the result will be appalling. I say nothing of the injustice to vendors of harmless supplies of electricity.

So far, the deaths which have occurred from this source have

been chiefly confined to employees of electric-lighting and telegraph companies—men whose duties have required them to work in close proximity to the conductors of these death-dealing currents. It is true that a number of accidents, many of them attended with fatal results, have occurred to pedestrians on the streets of New York and other cities through the medium of fallen wires; but the risk incurred by the general public with the present system is really less than it would be if these dangerous conductors were placed in closer proximity to the ground. As the earth is approached the danger is multiplied. The connection and crossing of two wires by a line of moisture or liquid contact are just as effective as the contact of one wire with another when overhead.

That this error of judgment is not confined to the public, but is shared in by the officials of the city of New York, is made apparent by a resolution of the Mayor offered at a meeting of the Board of Electrical Control on Monday, October 14, and which is reported in the following form:

"That the numerous deaths caused by the electric light and power wires within the last thirty days, and the shocking manner in which they have occurred, furnish ample and sufficient proof that such wires are not being placed underground with a speed sufficient to insure the safety of the lives of the people of this city," etc., etc.

The logical inference here is that the lives of the people will be safe as soon as the wires have been placed underground. If a nitro-glycerine factory were being operated in the city of New York and the people desired to remove the danger, no one would suggest putting it underground. When it became necessary for the protection of employees and of the public to regulate boiler-pressures in the city, the authorities proceeded on lines entirely different from those which are being followed in connection with electrical pressures; and yet the cases are parallel, and the course of reasoning which resulted in a perfect system for the limitation of steam-pressure and the periodical inspection of boilers should be retraced, and the principle applied to secure safety from a pressure which, uncontrolled as at present, is far more dangerous than the former was before steps were taken to render it harmless.

The insulation of a wire carrying a high-tension current in the most perfect manner known may insure temporary safety; but time is bound to develop defects as the result of the action of the current upon the insulating material, of a change in the molecular structure of the material itself, and for other reasons. The

pulsations or vibrations in an electric conductor cause corresponding vibrations in the insulation. So powerful is this effect that the insulation gives off a sound corresponding to the oscillation of the current. So long as the insulation retains its original elasticity, the current is confined ; but the influence of the air, or of gas and other agents, tends to change the elasticity, and the billions of vibrations to which it has been subjected finally render it very susceptible of being pierced by a spark of static electricity. Thus an avenue for the ingress of moisture is formed, not only in one spot, but in many, through which the current may be communicated to any conductor of electricity near enough to make physical contact, or a circuit may be completed between the two by a line of moisture or the formation of an electric arc, with its subsequent destructive action.

The numerous accidents which have occurred in the city of New York during the past year show to a very large extent the operation of time upon the insulating material which surrounds these wires. When first erected, the current was to a certain extent successfully confined ; but the air is doing its work, abrasions are more easily made, and, without the adoption of genuine methods of control, " accidents" may be looked for in larger numbers as time goes on, due not only to deterioration of insulation, but to the multiplying of electric circuits to supply the popular demand for electric light.

The public may rest absolutely assured that safety will not be secured by burying these wires. The condensation of moisture, the ingress of water, the dissolving influence of coal gas and air-oxidation upon the various insulating compounds will result only in the transfer of deaths to man-holes, houses, stores, and offices, through the agency of the telephone, the low-pressure systems, and the apparatus of the high-tension current itself.

I have no intention, and I am sure none will accuse me, of being an alarmist. When the possibilities of the future are viewed in the light of recent developments, it must be apparent to every one that the time has come when those in authority should adopt proper and adequate measures for the protection of life and property, and my familiarity with the subject enables me to see very clearly the only true remedy which can be applied—namely, the regulation of electrical pressures. Once these pressures are reduced to a point which is harmless, the public may re-

tire in security and leave electricians to discuss the merits or demerits of various methods of insulating, the defects of which will only concern those interested in the commerce of electricity.

There is no plea which will justify the use of high-tension and alternating currents, either in a scientific or a commercial sense. They are employed solely to reduce investment in copper wire and real estate. For instance, in arc-lighting it is customary to put forty lamps on each circuit ; each lamp requires a pressure of fifty volts; therefore the total pressure on the circuit is two thousand volts. Now, if, instead of using only one wire for all these lamps, four circuits of ten lamps each were to be established, the pressure on each wire would be only five hundred volts. The weight of copper necessary for these four circuits of ten lamps each would be two and a half times greater than for one circuit of forty lamps—a question, as I have said, simply of investment.

The alternating current under high pressure and direct-current high-pressure systems are also employed, as I have intimated, to save investment in real estate as well as copper. If a certain district is to be supplied with electric light, the natural point from which the current should be distributed is the centre, with wires radiating toward the circumference of the circle of supply ; and if, instead of including in any one of these districts an area so large that resort must be had to high pressure in order to reach its limits, the distributing power of a single station be confined to a capacity consistent with safety, and other centres sought from which to furnish current to other areas, the necessity for high electrical pressure vanishes. But real estate in such centres as these is expensive, and the promoters of electric-lighting enterprises which spring into existence with the growth and stability of the mushroom, cannot afford to consider permanency, the security of the public, the requirements of small consumers, or any such questions, which would incidentally involve the investment of larger sums of money ; but, seeking the outskirts of a district, where land is cheap, or some abandoned building available for sheltering a few dynamo machines, they run small wires to the area of supply, enormous pressure being necessary to force the current through these small conductors over such long distances.

In the last issue of *The Electrical World,* page 254, is recorded a series of experiments conducted by M. d'Arsonval, a member of the French Academy of Sciences, showing "the effects of

continuous and alternating currents on animals." He says: "A living being is, above all, sensible to a variable state of the current, from which it follows that at a mean equal pressure alternating currents are more dangerous than continuous currents"; and "with a battery of four hundred and twenty volts (continuous current) death is only caused by long-repeated interruptions of the current." In other words, the continuous current of the above pressure could not be made to cause death until it was interrupted or made discontinuous—or perhaps a better expression would be semi-continuous. By a variable state of the current is meant a fluctuation of pressure between different extremes of voltage. The human nerve-system, up to a certain limit of pressure, cannot detect the flow of a continuous current if the voltage be perfectly constant. This constancy is obtained by multiplying the number of commutator bars on the dynamo. The brushes which are set upon the revolving commutator, and conduct the current from the machine to the outside system, rest alternately upon the different bars of the commutator. The greater the number of bars, the less will be the fluctation of the current, which may be likened to a wave-motion, rising and falling, and producing that variable state referred to by the French scientist.

Nearly all dynamo machines used for arc-lighting are constructed with an insufficient number of commutator bars to produce a steady continuous current. The ranges of variable pressure are not, however, nearly as great as in the alternating system. With respect to the latter, M. d'Arsonval says: "An alternating Gramme machine caused death when above one hundred and twenty volts mean potential." This is a small unit to contemplate after the glib manner in which it has been recently stated that this current is harmless at a pressure of one thousand volts. I have myself seen a large healthy dog killed instantly by the alternating current at a pressure of one hundred and sixty-eight volts. It is a simple matter to calculate the ranges of variable pressure in this system. The dynamo machine has no commutator. The armature or "bobbin" is wound in such a way that the whole of the current under a pressure, say, of two thousand volts, is sent out on the wire first in one direction, then is reversed and sent out at the same pressure in the other direction, or passes through the wire in the opposite direction; and these

reversals are generally made about a hundred times in each second.

The variable state of a continuous current at a pressure of two thousand volts means ordinarily a rise from zero point up to two thousand, after which, owing to the action of the commutator, it varies between, say, seventeen hundred and two thousand, while the variable state of the alternating current means a fluctuation from two thousand volts above the zero point to two thousand below it, or a difference of four thousand volts. The danger to life is probably proportionate to the fluctuation of pressures. When an alternating current of fifteen volts is applied to a human being in the most effective manner, the effect upon the nerve system is so violent and the pain produced so great that it is absolutely impossible for any one to stand it.

As I have said before, the only way in which safety can be secured is to restrict electrical pressures. The continuous current should be limited to six hundred or seven hundred volts, with a variable range not exceeding a few volts. As for the alternating current, it is difficult for me to name a safe pressure. Its effect upon muscular action is so great that even at exceedingly low voltage the hand which grasps a conductor cannot free itself, and it is quite possible that in this way the sensitive nervous system of a human being could be shocked for a sufficient length of time to produce death. The electric-lighting company with which I am connected purchased some time ago the patents for a complete alternating system, and my protest against this action can be found upon its minute-book. Up to the present time I have succeeded in inducing them not to offer this system to the public, nor will they ever do so with my consent. My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous. In the city of New York there are many miles of conductors beneath the streets conveying a harmless continuous electric current to thousands of consumers, the maximum pressure on this vast system never exceeding two hundred and twenty volts, which will force so weak a current through the human body that it can barely be detected. Furthermore, it is found to be commercially successful, and I can therefore see no justification for the introduction of a system which has no element of permanency and every element of danger to life and property.

This is no argument in favor of monopoly. If ever there is to be a monopoly of electric lighting in the United States, it will be neither delayed, prevented, nor circumnavigated by such subterfuges as these alternating systems, and their use cannot be justified on that score. I have always consistently opposed high-tension and alternating systems of electric lighting (although perfectly free to use them), not only on account of danger, but because of their general unreliability and unsuitability for any general system of distribution.

In contemplating the efforts of the officials of the city of New York to remedy the evils connected with electric lighting, I have been impressed in a way which must have impressed other onlookers. I refer to the apparent difficulty of determining where the authority to take action rests. The hands of those who wish to act appear to be tied, which is unfortunate, considering the exigencies and urgency of the case. In England they handle these matters better. The Electric-Lighting Act of 1882 provides in section 6

"that the Board of Trade may from time to time make such regulations as they may think expedient for securing the safety of the public from personal injury or from fire or otherwise, . . . and any regulations so made or amended by the Board of Trade shall from and after the date thereof have the like effect in every respect as though they had been originally inserted in the license, order, or special act authorizing the undertaking."

This same section also provides that

"any local authority within any part of whose district electricity is authorized to be supplied under any license, order, or special act, may, in addition to any regulations which may be made under the preceding provisions of this section for securing the safety of the public, from time to time, make, rescind, alter, or repeal by-laws for further securing such safety; and there may be annexed to any breach of such by-laws such penalties to be recovered in a summary manner as they may think necessary. Provided always that no such by-laws shall have any force or effect unless and until they have been confirmed by the Board of Trade and published in such manner as the Board of Trade may direct."

Thus to a responsible body is given discretionary power for the protection of the public, and local authorities (by which is meant any municipality) have the right to apply to this board for relief from any danger which they believe to exist in connection with electric-lighting systems. Certainly the responsibility for the protection of the people of our city should be as definitely placed, and those to whom such authority is given should adopt rigid rules for the restriction of electrical pressures. Perhaps police

control would be even more adequate than the English system. I am not altogether familiar with the details of the system of boiler inspection which prevails in New York, but I believe it is very efficient and would serve as an excellent model for the case under discussion.

When the authorities require electrical pressures to be kept within the limits of safety, and when there is an efficient corps of inspectors, as in the case of boilers, to see that the rules adopted are carried out, the security which the public demand will be attained; but until then nothing better can be looked for than a multiplication of the casualties of the past few months.

THOMAS A. EDISON.