

within the last three days another sad loss had occurred—one who was not a member of the Council, but with whom, from 1852 to 1856, the President had worked, more as a brother than a subordinate. He had been Latimer Clark's assistant during those years, and had never worked with a more earnest, honest and faithful compeer. It was with a feeling of great regret that he had to announce his demise.

The President then delivered the following Address:—

The election to the position of President is the highest possible reward which the Institution can give to those who have endeavoured to serve it well and truly. I have often feared that my position as a specialist might have proved a bar to the attainment of my greatest ambition. It has come at last. I am very grateful, and I promise that I will continue to do my very best to merit your confidence and approbation. I am also proud, not alone for the sake of that branch of the profession to which I specially belong, but also because I am a member of the great Civil Service of this country. Twenty-eight of my forty-six years of professional work have been spent in the service of the Crown. I can speak with some authority and experience when I assert that this Service deserves a recognition for zeal, industry, and the conscientious determination to do its duty far greater than that usually accorded to it by Parliament, the public, and the press. The jealousy and contempt so freely displayed for Government work are not justified by results. It is the fashion to decry the public service. It is probably a survival of that old feeling of oppression and dissatisfaction which the ruled always felt towards their rulers. The position is now reversed—the public is the master and the official is the servant. The public servant is not to be coerced by oaths or driven by whips or deterred by scorns. His labours should be sweetened by praise, and his successes acknowledged by a grateful recognition. Two of your Vice-Presidents belong, and some of your Council have belonged, to this Service. You at any rate are free from criticism, for you have testified to my zeal by giving me the greatest reward you can confer. My successors will be able to drive home the nail I desire to insert in the coffin of the traditional general and false belief in the inefficiency of a great and growing public service.

I entered the Institution as an Associate in 1859, and am now in my fortieth year of membership. It is interesting to see the growth of the Institution during that period:—

ROLL OF THE INSTITUTION OF CIVIL ENGINEERS.

|                         | November,<br>1859. | October,<br>1898. |
|-------------------------|--------------------|-------------------|
| Honorary Members . . .  | 25                 | 20                |
| Members . . . . .       | 332                | 1,946             |
| Associate Members . . . | ..                 | 3,940             |
| Associates . . . . .    | 523                | 320               |
| Graduates . . . . .     | 14                 | ..                |
| Students . . . . .      | ..                 | 862               |
| Total . . .             | 894                | 7,088             |

The distribution of our 7,088 members over the globe is shown in this Table:—

DISTRIBUTION TABLE.

|                | United Kingdom. |               | India with Ceylon and Burma. | South and East Africa with Transvaal. | Australasia. | Canada with British Columbia, Nova Scotia, and Newfoundland. | British Possessions—Miscellaneous. | United States. | Other Countries. |
|----------------|-----------------|---------------|------------------------------|---------------------------------------|--------------|--|------------------------------------|----------------|------------------|
|                | Resident.       | Non-Resident. |                              |                                       |              |  |                                    |                |                  |
| Hon. Members.  | 12              | 4             | ..                           | ..                                    | ..           | ..   | ..                                 | 1              | 3                |
| Members . .    | 555             | 790           | 162                          | 50                                    | 140          | 45   | 25                                 | 65             | 114              |
| Assoc. Members | 970             | 1,690         | 350                          | 180                                   | 270          | 30   | 90                                 | 45             | 315              |
| Associates . . | 175             | 100           | 12                           | 4                                     | 8            | 1  | 2                                  | 5              | 13               |
| Students . .   | 275             | 417           | 60                           | 20                                    | 40           | 5  | 20                                 | 5              | 20               |
| Totals .       | 1,987           | 3,001         | 584                          | 254                                   | 458          | 81   | 137                                | 121            | 465              |

Roughly we can say that 71 per cent. are Home Members, 21 per cent. are Colonial Members, and 8 per cent. are Foreign Members. It is not alone in numbers that growth is shown; it is more so in the business of the engineer. The field of the profession has extended in all directions by the advances of practical science and by a process of evolution and agglutination. The introduction of the steam-engine, the development of the railroad, the invention of the paddle and the screw, and the evolution of the ocean greyhound; the conversion of iron into steel, and the demand for ores; the opening of coal- and oil-fields and the production of gas; the sanitation of our dwellings and

our towns, and the demand for pure air and pure water; the applications of electricity and the annihilation of distance; the rifling of ordnance, the improvement of explosives, and the armouring of great fighting, floating, moving machines; the enormous growth of manufactures and their distribution over the face of the earth; the pursuit of wealth, the roving propensities of our race, and the industrial competition of nations;—have all contributed to break up our profession into special branches and into individual groups, with their separate organizations and with their independent homes. Thus we have the railway engineer, the mechanical engineer, the naval architect, the mining engineer, the sanitary engineer, the gas engineer, the hydraulic engineer, the electrical engineer, the chemical engineer, the marine engineer, species of one genus—the civil engineer, whose home is in this building, whose Institution, like a good mother, tries to keep them all under the protection of her wings, and who is prepared to make any sacrifice to advance the knowledge of engineering, and to maintain the solidarity and reputation of the profession. The Engineering Conference held by the Institution in 1897 was undertaken in the furtherance of this aim, with results so successful as to call for its repetition in the approaching spring of 1899.

#### EXAMINATIONS.

Our great European rivals relegate the examination and selection of their engineers to their Governments, but we, under the guidance of our immediate Past-President, have taken this load on our own shoulders; not before it was needed, for the competition of highly educated engineers of other countries was becoming rather too evident. Loss of business is a potent force to effect reform. The reform itself in our case has materially strengthened the credentials of our Institution.

Our task has been a difficult one, for, while we recognise most fully that the practical training of the drawing-office, of the shop and of works in progress are the true school for the engineer, we cannot help thinking that he ought to acquire that knowledge which is the basis of his profession and those exact methods of inquiry and of thought which lead to truthful deduction and to sound judgment, before he can satisfactorily begin his professional experience.

The foundation of engineering is science. Science is not only a knowledge of the facts of Nature but of the development of her laws. It is, in the language of Huxley, organised common sense. The

man who determines to practise in the business of applying those facts and laws to add to the comfort and happiness of mankind must know something of the mental tools and weapons that mathematics and logic have placed at his disposal. His mind must be trained to habits of enquiry, and he should know something of the experience and teaching of the past. Hence the Institution, as the tutelary genius of the profession, has established a system of qualifying, not competing, examinations for admission into its ranks; not only to test the education and preparation of those who wish to recruit our numbers, and the qualifications of those who desire to improve their position in our classes, but also to enhance the standing of the modern engineer as the most scientific and advanced of all the learned professions. The result of the first examinations has been highly satisfactory. Out of 24 examined for Studentship, 3 only failed to pass. Of 40 examined for Associate Membership, 7 failed. Of 48 theses submitted in lieu of examination, 5 only failed to secure a satisfactory report. The popularity of the measure among even the examinees is shown by the entrance of 71 for this last October examination.

The examination papers which have been set are by no means of an insignificant character, yet 86 per cent. of marks have been acquired on the whole examination.

Our ancient Universities commenced their careers as mind-training establishments, with faculties of Theology, Law, and Medicine. These were called, and still are known, as the learned professions, but subsequently Arts was added, from which has sprung all modern science. Engineering as the principal outcome of this faculty has been the mother of scientific progress. A mere University training alone does not lead to invention and discovery. It is contact with the practical world, a knowledge of wants and defects, which excite discoveries and improvements. The modern method of research proceeds by making experiment subservient to hypothesis. Difficulties teach effects, effects suggest causes, a knowledge of causes leads to remedies, and finally to exact science. Practice, the home of difficulty, is thus the nursery of science. The engineer is far in advance of the pure scientist. Smeaton and Watt, Telford and Stephenson, Rankine and Kelvin, Whitworth and Froude, Regnault and Hirn, have established not only the profession of the scientific engineer, but they have laid the groundwork of science itself.

## TECHNICAL EDUCATION.

The engineer extracts matter from the earth and transforms it into purer and more serviceable forms. He finds energy lying dormant or running to waste; he converts it into active and useful forms. A knowledge of matter and of energy is the foundation of all his actions. This, combined with the power of thinking so as to enable the brain to direct and assist the hand, is the root of what is known as technical training. The modern engineer has immense advantages over his predecessors. He can commence his practical career with a University training, well charged with facts, wanting only that experience which practice alone will give.

There is a fashion in Great Britain for technical education just now. Enormous sums of money are being annually spent on secondary, intermediate, and more advanced education. It is well that it is so. It is well that the country has awakened from its conservatism and apathy, and that it is putting its schools in order. But is it doing so on a true issue, and are we distributing our money through the right channels? Our trade is suffering even in our own colonies from the competition of our continental neighbours, who are said to be beating us by their technically superior hand labour. It is true we are suffering, but is this the true cause? It is rather from the superior commercial skill of the principals at home and the accomplished polyglot and well-trained traveller abroad, as well as from a financial system that is more moral and more sound than that rampant in England through the gross abuses of the Limited Liability Act of 1862. Our law courts are almost daily the scenes of the exposure of the modern spoiling of the Egyptians. A new industry is designed by some simple, well-devised, and economical process. Capital is required to develop it. In Germany, financial support is readily subscribed by the generous and enlightened policy of its banks. In England we require a syndicate, a pioneer company, and finally an appeal to the public for an enlarged limited company. The financiers, the lawyers, the brokers, as well as the original inventor, have to be satisfied, and this satisfaction grows very much with the state of the money market and the excitement for investment with the public. The industry is established, but with a terribly overloaded capital—overloaded by the harpies who have sprung from the operations of the Limited Liability Act. The same industry could be established in Germany with probably half the capital. Its manufacture would be supervised there with greater skill, and it

would be developed as a business by better trained agents. We are thus fairly beaten on our own commercial preserves.

Our educational methods have begun at the wrong end. We ought to teach the masters first and then the men. Moreover we have to teach the teachers and those who have control of the purse-strings. The County Councils of England are scarcely qualified as yet to discharge the very serious duty of properly dealing with a question so few of them understand—though many of them have tackled the matter manfully, especially the London County Council, through its Technical Education Board on which a large proportion of co-opted experts have seats, who, by supporting existing institutions, have contributed towards the supply of teachers. But how are we to approach the masters? A fault once discovered is halfway to repair. It is difficult to remove the scales from the eyes of the man who has been successful in business and who knows not of his blindness; but the coming generation will be more enlightened, and the future masters better educated.

We are suffering from a lack of competent teachers. A teacher who has had no training in the practical world is worse than useless, for he imparts ideas derived from his inner consciousness or from the false teaching of his own abstract professor, which lead to mischief. In my own experience I have met with very serious inconveniences from this cause. The ideal professor of pure abstract science is a very charming personage, but he is a very arrogant and dogmatic individual, and, being a sort of little monarch in his own laboratory and lecture-room, surrounded by devoted subjects, his word is law, and he regards the world at large, especially the practical world, as outside his domain and beneath his notice. He is generally behind the age. These are not the men for technical institutes. Such teachers should possess the diploma of this Institution.

#### ENERGY.

The great generalization of modern days is the principle of the conservation of energy. Energy, like matter, can neither be created nor destroyed. Its form only can be changed. It is in its various transformations that it expends or absorbs work, and thus the engineer has to consider not only the various forms of matter, but the various forms of energy. He has to expend energy on matter in such a way as to supply the wants, improve the comforts, and add to the resources of mankind. He has not

only to utilize the waste energies of Nature, but he has to economize those that are in use so as to be able to apply them in the cheapest and most effective way. Every branch of engineering is thus dominated by the application of the great principle of work, which means the expenditure of energy, for energy is simply the capacity or property which Nature possesses for doing work. The engineer must be an educated man, educated not necessarily so much in the languages, arts, and history of the past, as in the changes and properties of ever-present matter, and the forms and behaviour of never-failing energy—changes and transformations directed by his will, controlled by his knowledge, and applied by his hands. Tredgold's great definition wants modification. It should read, "the profession of an engineer is to apply the great principle of work to the use and convenience of man," and his title should be rather that of *Energeer* than *Engineer*.

#### ELECTRICITY.

Day by day we are startled with some new development of electricity. We have learned the truth of the aphorism that that which is sure to occur is the unexpected. It is not of arms and of man that I propose now to sing, but of energy in its most romantic form.

A happy accident in early life placed me at the feet of our electrical Gamaliel, Michael Faraday. My boat was launched on the waters of knowledge that flowed from the rocks of Nature, opened by the strokes of the magic rod of that great master. The tide was taken at the flood, and, having rolled on for nearly fifty years, it has led me to this chair.

I learned from Faraday to regard electricity as the result of the play of the atoms and molecules of matter, that it was a mere form of motion, and that its influence through space was due to the existence and operations of a medium—since called the Ether. Maxwell crystallised Faraday's views into mathematical language, and deduced the magnificent generalization that light and electrical waves are of the same kind, moving through the Ether with the same velocity, and differing from each other only in degree. Hertz proved the existence of these waves and measured their lengths, and Marconi has now applied them to the practical purposes of telegraphy. I have carefully watched every new electrical fact wrung from Nature's storehouse without ever failing to find a simple mechanical explanation of their cause.

The term "Electricity" has even been defined by Act of Parlia-

ment (45 Vic. cap. 56, 1882) as that form of energy which we make and sell. It can be measured with the minutest engineering exactness, and its effects are explicable on the simple dynamical and mechanical principles that underlie our profession.

### LIGHTNING.

The first practical application of the science of electricity was for the protection of life and property. Franklin in 1752 showed how to secure ourselves and our buildings from the disastrous effects of a lightning stroke. Very little has been done since to improve upon his plan. A Lightning-Rod Conference, upon which I served, met in 1878, and its report, published in 1881, remains an admirable and useful standard of reference. The principle advocated by Franklin was prevention rather than protection. If a building or a ship be fitted and maintained with good continuous copper conductors, making a firm electrical contact with the earth or the sea, and be surmounted well up in the air with one or a cluster of fine points, all the conditions that determine a charge of atmospheric electricity and a flash of lightning are dissipated silently away and no terrible discharge is possible. A mischievous and baseless delusion is prevalent that protectors actually attract lightning and may be sources of danger. Every exposed building should be fitted, but a well-protected dwelling-house is the exception, not the rule. Even when protectors are fixed apathy leads to their imperfect maintenance. Their failure to act is always traceable to the neglect of some simple rule. Carelessness is the direst disease we suffer from. Telegraph and telephone wires which spread all over our towns and country are very much exposed to the influence of atmospheric electrical effects. Every instrument is now protected. Every telegraph pole has a lightning conductor. Accidents are rare, and the system itself is a public safeguard. In some countries like California and South Africa thunder-storms are very frequent and very severe, but their effects have been tamed.

The engineer has answered Job's conundrum: "Canst thou send lightnings, that they may go, and say unto thee, Here we are?" in the affirmative. I sat, on the 12th June last, in a cable hut on the Welsh coast, near Nevin, with a telephone to my ear and heard flashes of lightning in Ireland, Scotland, England and Wales on the same afternoon. The sound emitted by a telephone receiver when a discharge takes place in the neighbourhood of a telephone circuit is distinctive and characteristic. It is a



signal as clear and as comprehensible as the words, "Are you there," or, "Here you are."

Franklin's work has been beneficent. He showed successfully how to bring the lightning down from heaven and how to dissipate its causes harmlessly away in the earth.

#### TELEGRAPHY.

In 1837 Cooke and Wheatstone showed how electricity could be practically used to facilitate intercommunication of ideas between town and town and between country and country. The first line was constructed in July of that year upon the incline connecting Camden Town and Euston Grove Station, the resident engineer being Sir Charles Fox, father of the senior Vice-President. Five copper wires were embedded in wood of a truncated pyramidal section and buried in the ground. The instrument used possessed five needles or indicators to form the alphabet. A portion of this original line was recently recovered *in situ*. I call it the "fossil telegraph," and used this sample to complete five circuits between the General Post Office and the offices of the various Cable Companies on the Queen's Diamond Jubilee Day, for the transmission of Her Majesty's simple message, "From my heart I thank my beloved people. May God bless them!" to all our princes, governors, captains, and rulers scattered over the whole globe. To north, south, east, and west, over every quarter and every continent, under every ocean and every sea, these words flew with the speed of thought. When Her Majesty returned to Buckingham Palace acknowledgments and replies had arrived from every colony, the first to come being from Ottawa, Canada, 16 minutes after the message was despatched.

The pioneer line of 1837,  $1\frac{1}{3}$  mile long, has, during this period of sixty years, grown into a gigantic world-embracing system. Every man at his breakfast-table can read an account of every stirring event that has transpired on the previous day in every quarter of the world. Distance is annihilated and time overcome.

The extent of the present system of British telegraphs is shown by the following Table:—

|   | Miles of Wire.   |
|---|------------------|
| General Post Office and its Licensees . . . . . | 435,000          |
| Railway companies . . . . .                     | 105,000          |
| India and Colonies . . . . .                    | 389,760          |
| Submarine cables . . . . .                      | 183,400          |
| Total . . . . .                                 | <u>1,113,160</u> |

The mechanical construction of the telegraphs of this country was designed by our late distinguished Member Edwin Clark and his brother, Latimer Clark, also a Member. Their affairs were originally directed by our Past-Presidents, Robert Stephenson, Bidder, and Locke. We in this country have always been in advance of other countries in telegraphic progress, and this was greatly due to the inventive genius of Cromwell Varley, a Member of the Institution. These are men under whom I served and learnt, and whose engineering traditions I have done my best to maintain and to better. Progress has never been checked. The speed of signalling and the capacity of working have been increased sixfold, and wires can now be worked faster than messages can be handled by the clerical staff.

The form of submarine cable and the nature of the materials used in its construction have varied but very little since the first cable was laid in 1851. The recent invasion of our channels and seas by the *Limnoria terebrans*, a mischievous little crustacean which bores through the gutta percha insulating covering, and exposes the copper conductor to the sea-water, leading to its certain destruction, has led to the use of a serving of brass tape as a defence. It has proved most effective.

No one has done more than Lord Kelvin (Honorary Member) to improve the working of submarine cables. His recording apparatus is almost universally employed on long cables. By the duplex method of transmission the capacity of cables has been practically doubled, and this has been still further improved by applying to cables the system of automatic working, which is such a distinguishing feature of our Post-Office system. The number of electrical impulses which can be sent through any cable per minute is dependent upon its form, and is subject to simple and exact laws, but it varies with the quality and purity of the materials used. There is no difficulty in maintaining the purity of copper. Indeed copper is frequently supplied purer than the standard of purity adopted in this country—known as Matthiessen's standard. The purity of gutta percha is, however questionable. The supply of this dielectric has dwindled; it has failed to meet the demand; its cultivation has been neglected. The result is a dearth of the commodity, a great increase in price, and its adulteration by spurious gums. India-rubber, its sole competitor for cables, is being absorbed for waterproof garments and pneumatic tyres, but for underground purposes paper is being used to an enormous extent. Paper has the merit, when kept dry, not only of being an admirable insulator, but of being very durable. There is

paper in existence in our libraries over 1,000 years old. The difficulty is to keep it dry. This is one of the problems the engineer delights to consider. He has been most successful in obtaining a solution. The lead-covered paper cables, which are being laid in the streets of all our great cities, are admirable. I am laying one of seventy-six wires for the Post-Office telegraphs between London and Birmingham, and the Cable Companies are contemplating leading their long cables from Cornwall up to London, so as to be free from the weather troubles of this wet and stormy island.

It is impossible to forecast the future of telegraphy. New instruments and new processes are constantly being patented, but few of them secure adoption, for they rarely meet a pressing need or improve our existing practice. The writing telegraph originating with our late Member of Council, E. A. Cowper, which reproduced actual handwriting, much improved by Elisha Gray, and called the "Telautograph," is steadily working its way into practical form, and electrical type-writing machines of simple and economical form are gradually replacing the A B C visual indicator. The introduction of the telephone is revolutionising the mode of transacting business. There seems to be a distinct want of some instrument to record the fleeting words and figures of bargains and orders transmitted by telephone. Hence a supplement to that marvellous machine is needed. The telautograph and electrical type-writer will fill this want. Visions of dispensing with wires altogether have been fostered by the popularity of Marconi's "wireless telegraphy"; but wireless telegraphy is as old as telegraphy itself, and a practical system of my own is now in actual use by the Post Office and the War Department. Sensational experiments for booming a new financial enterprise are not processes that commend themselves to the Institution. We want practical work and engineering progress.

#### TELEPHONY.

I was sent, in 1877, together with Sir Henry Fischer, to investigate the telegraph system of the American Continent, and especially to inquire into the accuracy of the incredible report that a young Scotchman named Bell had succeeded in transmitting the human voice along wires to great distances by electricity. I returned from the States with the first pair of practical instruments that reached this country. They differed but little from the instrument that is used to-day to receive the sounds.

The receiver, the part of the telephone that converts the energy of electric currents into sounds that reproduce speech, sprang nearly perfect in all its beauty and startling effect, from the hands of Graham Bell. But the transmitting portion, that part which transforms the energy of the human voice into electric currents, has constantly been improved since Edison and Hughes showed us how to use the varying resistance of carbon in a loose condition, subject to change of pressure and of motion under the influence of sonorous vibrations. The third portion, the circuit, is that to the improvement of which I have devoted my special attention. Speech is now practically possible between any two post-offices in the United Kingdom. We can also speak between many important towns in England and in France. It is theoretically possible to talk with every capital in Europe, and we are now considering the submersion of special telephone cables to Belgium, Holland, and Germany. The progress of the use of the telephone in Great Britain has been checked by financial complications. It fell into the hands of the company promoter. It has remained the shuttlecock of the Stock Exchange. It is the function of the Postmaster-General to work for the public every system of intercommunication of thought which affects the interests of the whole nation. Telephony is an Imperial business, like the Post and the Telegraph. It ought to be in the hands of the State. The public and the press have frequently kicked violently against the present régime. Committees of Parliament have sat and deliberated upon the question. The report of the last committee is now under consideration.

*"Quidquid delirant reges, plectuntur Achivi."*

Two causes exist to impede this desirable absorption, the fear of being "done" by watered and inflated capital, and the assumed bad bargain made in absorbing the telegraphs in 1869. The former is a mere bugbear. The public does not want to purchase stock. It wants to acquire a plant and business, which can be easily and fairly valued. The latter is a gross fallacy. The business of the Telegraph Companies—practically an unlimited monopoly—was purchased on absolutely fair terms, viz., 20 years' purchase of the net profits. The sum paid was £4,989,048. The number of messages then sent in one year was about 5,000,000, and the gross income about £500,000. The income has now grown to £3,071,723, the number of messages has reached 83,029,999, and the capital account which was closed in 1891, viz., £10,131,129, including the cost of the Post Office extensions,

remained the same. If a syndicate desired now to re-purchase the business and acquire the plant, they would have to find a capital of over £30,000,000. In what respect, then, was the transfer of the telegraphs to the State a failure? Our magnificent system has been built virtually out of revenue, our tariff is very cheap, scarcely a village of any consequence is without its telegraph, our press is virtually subsidized by having its news supplied at much less than cost price; we can rely upon safe and accurate delivery, and upon speedy despatch of messages. We lead the world. There has been no failure, and there was no bad bargain.

The present condition of the Telephone business in this country is shown by the following return :—

#### TELEPHONES IN USE.

|  |     |                |
|--|-----|----------------|
| National Telephone Company (30th June, 1898) | . . | 133,498        |
| Railway Companies ( " " )                    | . . | 15,911         |
| General Post Office ( " " )                  | . . | 9,588          |
| Total . . . . .                              |     | <u>158,997</u> |

#### RAILWAYS.

The regulation of the traffic on a railway, and the general business of the line, could not possibly be conducted without the telegraph. The safety of the passenger and the freedom from collision are due to the introduction of the block system, which is worked entirely by electric signals, and which has been made compulsory by Parliament on all British railways. It was my good fortune to have taken a very active part in the introduction of the block system, especially in the assimilation of the working of the indoor (electric) and the outdoor (mechanical) systems of signalling and in their interlocking. More recently, the control of the traffic and the secure working of single lines by the Tablet and electrical train-staff have been carried to a very high state of perfection. Distant signals can now be fixed anywhere out of sight of the signalman who works them, for the position of the semaphore by day, or the character of the light by night, are repeated back by electricity upon miniature signals, fixed in the signal box. The state of the signals can even be indicated on the engine to the driver in foggy weather or by night, and the state of distant points shown to the signalman in all seasons.

The regulations of the Board of Trade, regarded often as unnecessary interference by railway men, together with the careful engineering inspection before the opening of a line, and a judicial inquiry in case of accident, have tended more than anything else to add to the security of railway travelling.

In 1897, 24 persons, including 6 railway servants when travelling, were killed from accidents beyond their own control. This was above the average. It has been said that a first-class compartment on one of our great railways is the safest place in the world. It is safer than bed, for, in 1896, 1,809 persons were suffocated in bed. It is safer than a dining-room, for, in the same year, 148 people were choked by food. 925 were killed by falling down stairs. Bicycles are far more destructive to life. Accidents in the streets of London are so frequent, and therefore so uneventful, that they are not even recorded in the press. Accidents on railways are so rare and eventful that columns of large type are devoted to a description of their minutest details.

The safety of railway travelling as effected by modern improvements in working is shown by the following facts :—

|            |             |             |                      |
|------------|-------------|-------------|----------------------|
| 1874 . . . | 1 person in | 5,556,284   | journies was killed. |
| 1884 . . . | "           | 22,419,092  | " "                  |
| 1894 . . . | "           | 56,963,307  | " "                  |
| 1896 . . . | "           | 196,067,887 | " "                  |

The train accidents in—

|                |      |     |
|----------------|------|-----|
| 1878 . . . . . | were | 108 |
| 1888 . . . . . | "    | 61  |
| 1897 . . . . . | "    | 48  |

More than 50 per cent. of the causes of these accidents were due to the negligence, want of care, or mistake, of those conducting the traffic, which emphasizes my previous statement that carelessness is the direst disease we suffer from.

The employment of electricity in the working of railways has not only been highly beneficent in the security of human life, but it has vastly increased the capacity of a road to carry trains. The underground traffic of the metropolis is conducted with marvellous regularity and security, though the trains are burrowing about in darkness and following each other with such short intervals of time that the limit of the line for the number of trains has been reached. Electric traction is going to extend this limit by increasing the acceleration at starting and improving the speed of running. It will also reduce the cost of working per train-mile, so that the advent of electricity as a moving agency is

certain to prove highly economical. What it will do as a remover of bad smells and foul air and for personal comfort cannot be estimated. Time alone will enable us to assess the intrinsic value of public satisfaction acquired by the change.

The extent to which electrical appliances are used on the railways of this country is shown by the following Tables:—

Table I gives the number and description of the various classes of electrical apparatus in use on railways in the United Kingdom in the year 1898:—

| Description.  | Total.  |
|---|---------|
| Single needle instruments . . . . .   | 20,800  |
| Morse sounders . . . . .  | 435     |
| „ recorders . . . . .   | 12      |
| Telephones . . . . .  | 15,911  |
| Duplex apparatus (complete) . . . . .   | 33      |
| Bell instruments (for message work, complete, }<br>with keys, relay and galvanometers, &c.) . } | 615     |
| Phonopores (complete) . . . . .   | 207     |
| Block instruments . . . . .   | 35,689  |
| Train staff instruments . . . . .   | 1,621   |
| Tyer's tablet instruments . . . . .   | 1,499   |
| Interlocking „ . . . . .  | 5,640   |
| Repeater „ . . . . .  | 25,569  |
| Treadles . . . . .  | 2,668   |
| Fouling bars . . . . .  | 856     |
| „ bar indicators . . . . .  | 361     |
| Replacers . . . . .   | 180     |
| Slot selectors . . . . .  | 408     |
| Single-stroke and relay bells . . . . .   | 25,095  |
| Galvanometers . . . . .   | 736     |
| Large trembler bells (platform, &c.) . . . . .  | 2,674   |
| Small „ „ . . . . .   | 8,080   |
| Night and day switches . . . . .  | 6,585   |
| Fire-alarm commutators . . . . .  | 149     |
| Train describers . . . . .  | 479     |
| Light indicators . . . . .  | 2,846   |
| Signal repeater disks . . . . .   | 924     |
| Test-boxes . . . . .  | 114     |
| Water-tank apparatus . . . . .  | 13      |
| Telephone switch-boards . . . . .   | 17      |
| Bell-indicators . . . . .   | 87      |
| Point detectors and indicators (various) . . . . .  | 19      |
| Signal lever-lock . . . . .   | 345     |
| Extra contact-makers and switches . . . . .   | 210     |
| Magneto electric bells . . . . .  | 4       |
| Relays . . . . .  | 361     |
| Special appliances (various) . . . . .  | 2,771   |
| Total . . . . .   | 164,013 |

Table II gives the length of double and single line in the United

Kingdom open for passenger traffic on the 31st December, 1895, the latest period for which returns have been published, and the length of such lines worked upon the various systems:—

|                       | Line Open for Passenger Traffic. |             | Worked on Absolute-Block System. |                                   |                             |   | Worked on other Telegraph Systems. |              | Single Lines worked under— |                     |                     |
|-----------------------|----------------------------------|-------------|----------------------------------|-----------------------------------|-----------------------------|---|------------------------------------|--------------|----------------------------|---------------------|---------------------|
|                       | Double.                          | Single.     | Double Line.                     | Single Line.                      |                             |   | Double Line.                       | Single Line. | Single-Engine System.      | Train-Porte System. | Train-Staff System. |
|                       |                                  |             |                                  | Combined with Train-Staff System. | Without Train-Staff System. | By Electrically-controlled Train-Staff or Tablet. |                                    |              |                            |                     |                     |
| England and Wales . . | Miles 9,325                      | Miles 4,472 | Miles 9,310                      | Miles 2,200                       | Miles 20                    | Miles 1,847                                       | Miles 15                           | Miles 29     | Miles 228                  | Miles 1             | Miles 147           |
| Scotland . .          | 1,314                            | 1,768       | 1,312                            | 210                               | 32                          | 1,066   | 1                                  | ..           | 427                        | 1                   | 31                  |
| Ireland . .           | 613                              | 2,534       | 613                              | 494                               | 1                           | 1,824   | ..                                 | ..           | 118                        | ..                  | 98                  |
| United Kingdom . .    | 11,252                           | 8,774       | 11,235                           | 2,904                             | 53                          | 4,737   | 16                                 | 29           | 773                        | 2                   | 276                 |

### DOMESTIC APPLIANCES.

The introduction of electricity into our houses has added materially to the comfort and luxury of home. If we were living in the days of ancient Greece, the presiding domestic deity would have been *Electra*. The old bellhanger has been rung out by the new goddess. *Electra* has entered our hall-door, and attracts the attention of our domestics, not by a gamut of ill-toned and irregularly excited bells, but by neat indicators and one uniform sound. The timid visitor fears no more that he has expressed rage or impatience by his inexperience of the mechanical pull required at the front door. The domestic telephone is coming in as an adjunct to the bell. Its use saves two journeys. The bell attracts attention, the telephone transmits the order. Hot water is obtained in half the time and with half the labour. Fire and burglar alarms are fixed to our doors and windows; clocks are propelled, regulated and controlled. Even lifts are hoisted for the infirm and aged. Ventilation, and in warmer countries coolness, are assisted by fans. Heating appliances are becoming very general where powerful currents are available. Radiators assist



the coal fire by maintaining the temperature of a room uniform throughout its length and breadth. Ovens are heated, water is boiled, flat-irons become and are maintained at a useful temperature, breakfast dishes and tea-cakes are kept hot, even curling-tongs have imparted to them the requisite temperature to perform their peculiar function.

### ELECTRIC LIGHT.

But it is in supplying us with light, without defiling the air we breathe in our dwellings with noxious vapour, that electricity has proved to be a true benefactor to the human race. The Legislature has facilitated the acquisition by municipalities of those local industries that affect the welfare of the whole community, such as road-making, sewerage, the supply of water, tramways, and, above all, electric light. No one doubts that new industries of a speculative character are best pioneered by private enterprise. The company promoter has, however, so abused the power placed in his hands by the Limited Liability Act that, not only has the development of electric lighting been retarded in this country, but the prospect of private enterprise in furthering other industries has been checked. Fortunately the success, the comfort, the intrinsic value, the economy and the sanitary properties of electric light have commended it to our municipal magnates, and its introduction has become the fashion. The following Table shows the position of the industry in this country and in the United States at the present time:—

ELECTRIC LIGHT UNDERTAKINGS.

|                            | United Kingdom. |            | United States.  |            |
|----------------------------|-----------------|------------|-----------------|------------|
|                            | Municipalities. | Companies. | Municipalities. | Companies. |
| Number of central stations | 72              | 63         | 338             | 2,251      |
| Capital stock . . . £      | 4,599,154       | 3,258,343  | 3,419,019       | 48,207,527 |
| Number of arcs . . .       | 5,753           | 1,259      | 26,087          | 265,064    |
| Number of glows . . .      | 1,393,514       | 1,936,893  | 693,984         | 14,278,358 |
| Kilowatt capacity . .      | 44,219          | 24,344     | 41,193          | 578,051    |

In spite of our financial troubles, of the inertia of municipal bodies, of the active competition of vested interests, our progress compares not unfavourably with other European countries, but

the progress of the industry in the United States has been phenomenal. The return for the United Kingdom is, however, by no means complete. It omits all private installations. We in the Post Office alone have 50,000 lamps which are not enumerated; and if we consider all our great railway companies, banks, warehouses, manufactories, and shops which have their own installations, the statistics will be very considerably extended. Lamps are being improved and cheapened, wiring is being reduced in cost, and the economic distribution of energy is being furthered. But the most promising field for economy is the combination of all classes of electrical industry in one centre, especially that of light and tramway working where fuel is cheap, water abundant for condensing, and nuisances of no account. The cost of the production of electrical energy depends principally upon the continuity of its output. If it can be generated continuously during the 24 hours of the day its cost is only a fraction of a penny per unit. If it is used solely for light, a unit may cost threepence. Hence local authorities, who are undertakers of electric energy, neglect their duty to those who have elected them as the custodians of their interests if they fail to secure the tramways in their district, either as their own property or as customers for their current. For the tramways, by taking energy during the day, reduce the cost of working during the night by removing the incubus of running continuously imposed on undertakers by Act of Parliament. This may enable the ratepayers to be supplied at a price for electric light certainly one penny per unit less than if there were no tramways. The cheaper the supply of energy per unit the more certain and speedy the advent of the electric light as the poor man's lamp, and the more beneficial its introduction into the confined, ill-ventilated and overcrowded homes of the working classes. By improving locomotion to the suburbs and enabling them to live in pure air, and by clearing the air they breathe of the impurities due to the combustion of tallow, oil and gas, the more readily should the public fall down and worship the golden image which Parliament and science have set up.

It is on board ship that electric light has been pre-eminently successful, and where it filled such a crying want that its introduction met with no check. It was almost immediately and universally adopted. Search lights, prompted by the great development of the torpedo, were introduced into our Navy as early as 1875 by Mr. Henry Wilde. The first ship to be fitted with internal electric lighting was the "Inflexible" in 1882. In 1884 the Admiralty ordered it to be applied to all H.M. warships.

The first application of electrical power was in the case of H.M.S. "Barfleur," where motors were used for working guns and for the supply of ammunition. It has subsequently been partially extended to the working of gun-turrets, ventilating fans, capstans, and boat-hoisting gear; but hydraulics, the child of our venerable Past-President, Lord Armstrong, is the form still more generally preferred and used for power in our Navy, though other nations make a much more extended use of electricity. The technical reports received by the United States Navy Department indicate that the electrical appliances on their warships worked very successfully during the recent war. Electrical conductors are readily stowed away in safe quarters, and easily repaired when severed by shot. The electrical energy used in a first-class battleship is expended thus:—

|                                |           |
|--------------------------------|-----------|
| Internal lighting . . . . .    | 60 E.H.P. |
| Search-lights . . . . .        | 65 "      |
| Ventilation . . . . .          | 30 "      |
| Capstans, hoists, &c. . . . .  | 60 "      |
| Reserve . . . . .              | 45 "      |
| Total . . . . .                | 260 "     |
| Number of glow-lamps . . . . . | 1,000     |
| " " search-lamps . . . . .     | 6         |
| " " ventilating fans . . . . . | 16        |
| " " motors . . . . .           | 2 to 8    |

The following Table illustrates the progress of electric work done by that branch of the service which is so eminently presided over by our Vice-President, Sir W. H. White:—

| Year.              | Ships fitted with Electricity. |                    | Total Number fitted. |                    | Electric Machinery.    |              |
|--------------------|--------------------------------|--------------------|----------------------|--------------------|------------------------|--------------|
|                    | Search-Lights.                 | Internal Lighting. | Search-Lights.       | Internal Lighting. | Number of Sets fitted. | Total E.H.P. |
| 1876 . . . . .     | Nil                            | Nil                | Nil                  | Nil                | Nil                    | Nil          |
| 1876 to 1880 . . . | 19                             | Nil                | 38                   | Nil                | 19                     | 33           |
| 1880 „ 1884 . . .  | 30                             | 1                  | 50                   | ..                 | 30                     | 120          |
| 1884 „ 1888 . . .  | 150                            | 30                 | 220                  | 8,000              | 180                    | 3,700        |
| 1888 „ 1894 . . .  | 265                            | 126                | 750                  | 50,000             | 450                    | 15,000       |
| 1894 „ 1898 . . .  | 500                            | 240                | 1,100                | 95,000             | 800                    | 25,000       |

### LIGHTHOUSES.

The introduction of electricity into our lighthouses has not been such an unqualified success as into our ships. No new electric light has been installed on the coast of Great Britain since St. Catherine's (Isle of Wight) was fitted up in 1888. Other electric lamps are to be found at the South Foreland, at the Lizard, and at Soutar Point, only four lighthouses in all upon our coasts.

This is due chiefly to the great prime cost of its installation and to the annual expense of its maintenance. But the sailor himself is not enamoured of it. It does not assist him in judging distances. It is too brilliant in clear weather, while in bad weather it penetrates a fog no further than an ordinary oil lamp. Moreover, great modern improvements have rapidly followed each other in other apparatus, lenses and lamps. A third-order light of to-day can be made superior to a first-order light of ten years ago. Oils have improved and gas has been introduced. Lord Kelvin proposed that lighthouses should signal their individuality to passing ships by flashing their number in the Morse alphabet. But the Morse alphabet, in 1875, was as unknown as Egyptian hieroglyphics to our nautical authorities. The same end was obtained with less mental exertion by occulting and group-flashing systems.

A new and very promising plan has recently been introduced in France, called the "Feux-éclairs" or "lightning flash" system. It has been installed in many places, but especially at the two Capes dominating the Bay of Biscay. Nothing more brilliant or more effective is to be seen anywhere than the lights that rapidly sweep across the horizon, like well-directed flashes of summer lightning, with a motion that conveys the idea of a wave of some illuminated spirit-arm warning the navigator away from the rocky dangers of Ushant.

Our Trinity House has not yet introduced this plan. Any change of our well-considered and deeply-important coast-lighting system is not to be hastily effected. We are very proud of our well-guarded shores. Every headland and landfall, every isolated rock, all dangerous shoals and banks and narrow channels in lines of trade are so illuminated that navigation by night is as safe and easy as by day. Lighthouses and lightships stud our channels. Most of them are placed in direct communication with our Post Office telegraph system, so that the speediest help can be secured in moments of difficulty and danger.

We, however, want improvement during fogs and storms. Here electricity steps in. I wrote, in 1893, of wireless telegraphy:—

"These waves are transmitted by the ether ; they are independent of day or night, of fog or snow or rain, and, therefore, if by any means a lighthouse can flash its indicating signals by electromagnetic disturbances through space, ships could find out their position in spite of darkness and of weather. Fog would lose one of its terrors, and electricity become a great life-saving agency." We are nearing that goal.

### TRACTION.

Electrically worked railways originated in Europe. The first experimental line was constructed by Dr. Werner Siemens in Berlin in 1879. When I visited America in 1884 there was only one experimental line at work in Cleveland, Ohio. Now there are more miles of line so worked in Cleveland alone than in the whole of the United Kingdom. The reason for this is not difficult to comprehend. The climatic influences of the States, the habits of the people, the cost of horseflesh, the necessity for more rapid transit, soon proved the vast superiority of electric over every other form of traction. Horses and cables will soon disappear. In England the Tramways Act of 1870 has been restrictive. It deferred the real solution of the question for 21 years. Its avowed tendency has been to throw the industry into the hands of the municipalities. Private enterprise has therefore not been encouraged, and municipalities have not taken it up. Local authorities have now been educated. The successful progress in the States and on the Continent has proved contagious, and everywhere our great cities are rising to the occasion. Indeed, to neglect to supply tramways where they would be useful, healthful, and valuable, is to a certain extent an abuse of the trust confided to the municipality by the Legislature. Rapid and convenient suburban transit is a social factor of great importance to the working classes, who can be readily transported from close quarters to pure air and healthy dwellings. Hamburg is one of the best trammed cities on the Continent. The trams were constructed by private enterprise under lease from the municipality. The latter supplies the electric energy. The tramway company is bound to take the current at a fair and reasonable price, but they have also to pay a tax on the gross receipts, which is set aside by the local authority as a sinking fund, so that on the expiry of the agreement the town will have the capital to purchase the tramways. Corporations in this

country who have secured a provisional order for the installation of electric light have secured also legal powers to supply electric energy for all purposes. It is therefore their right, and it may become a very valuable property. The duplication and multiplication of central electrical stations is likely to become a serious evil. It is absurd to see two buildings erected where one only is needed, and two causes of nuisance perpetuated where none need exist. I have already pointed out the economy of combining electric lighting and tramway working. The relative merits of overhead and underground conductors, and the use of storage batteries, are practically the only important engineering questions under discussion. The underground conduit system has been materially helped by the practical object lesson to be seen in New York, where the tramways are being very successfully worked on this plan. The trolley system is much more economical. Its erection does not interfere with the traffic of the streets. The principal objection to it is its anti-æsthetic appearance, but it is wonderful how ideas of utility and the influence of custom make us submit to disfigurement. What is more inartistic than a lamp-post, or more hideous than the barn-like appearance of many a railway terminus?

The corrosion of water- and gas-pipes, the disturbances of telegraphs and magnetic observatories, are serious questions arising from the introduction of powerful currents into the earth, but fortunately the remedies are simple, easily attainable, and very effective.

I have alluded to the proposed working of our underground railways. The success of the Mersey Dock line and of the South London and Waterloo lines, has placed the question beyond controversy. The problem to be solved is how is the conversion from steam to electricity to be effected without interfering in any way with the existing traffic or with the existing permanent way? This is not to be solved on paper. It must be determined by actual trial, and this is about to be done on the short line connecting Earls Court and High Street, Kensington. Electric traction as an economical measure in all cases of dense traffic is so certain that every great railway company must consider, sooner or later, the working of its suburban traffic by electricity. This experiment on the Metropolitan Underground Railways, therefore, should interest them all. It is a question deeply affecting the interests and comfort of the public and the condition of the congested traffic of our streets.

The storage battery fulfils a very important function in the

economical working of an electric railway. It equalises the pressure on the circuits. It meets the fluctuations of the load. It takes in current when the load is light; it lets out current when the load is heavy. It thus secures the continuous working of the engines at their full constant and most economical conditions, and it enables the engines to be shut down altogether when the load is very light as it is at night, in the early morning, and on Sundays.

In Buffalo the battery is charged by energy from Niagara, 21 miles away, and the local engines are shut down for 12 hours every day, and for 10 hours on Sunday.

Electric traction is invading even our streets. The number of unstable and weak-kneed cab-horses seems destined to be reduced by their electric competitor; while the pride of London—the fleet hansom—will be freed from an obstructive and not always sweet-smelling *avant courier*. When the real storage battery is produced the auto-mobile problem will be solved. At present steam and oil are active competitors.

#### ELECTRO-CHEMISTRY.

The transference of electricity through liquids is accompanied by the disintegration of the molecules of the liquids into their constituent elements. The act of conduction is of the nature of work done. Energy is expended upon the electrolyte to break it up, and the quantity thus chemically decomposed is an exact measure of the work done. Every electrolyte requires a certain voltage to overcome the affinity between its atoms, and then the mass decomposed per minute or per hour depends solely upon the current passing. The process is a cheap one and has become general. Three electrical HP. continuously applied deposit 10 lbs. of pure copper every hour from copper sulphates at the cost of one penny. All the copper used for telegraphy is thus obtained. Zinc in a very pure form is extracted electrolytically from chloride of zinc, produced from zinc blende, in large quantities. Caustic soda and chlorine are produced by similar means from common salt. The electroplating of gold, silver and nickel is a lucrative and extensive business, especially in Birmingham and Sheffield. Gold and silver are refined by this electrolysis in Russia, and nickel in the United States. Sea-water is decomposed in this way for disinfecting purposes by the Hermite process.

The passage of electricity through certain gases is accompanied by their dissociation and by the generation of intense heat. Hence the arc furnace. Aluminium is thus obtained from cryolite

and bauxite at Foyers by utilizing the energy of the Falls. Phosphorus is also separated from apatite, and other mineral phosphates. Calcium carbide, obtained in the same way, is becoming an important industry.

It is remarkable that our coalfields have not been utilized in this direction. Electrical energy can be generated on a coalfield, where coal of good calorific value is raised at a cost of 3s. per ton, cheaper than by a waterfall, even at Niagara.

Electro-metallurgy is now a very large business, but it is destined to increase still more, for the generation of electrical energy is becoming better understood and more cheaply effected.

### THE TRANSMISSION OF POWER.

The energy wasted in waterfalls is enough to maintain in operation the industries of the whole world. Great cities as a rule are not located near great falls; nor has a beneficent Providence provided great cities with waterfalls as, according to the American humorist, He has with broad rivers. There is but one Niagara, and we are seeing how industries are rather going to the falls than the energy of the falls is being transmitted to the industrial centres. The arbitrament of money is limiting the distance to which energy can be profitably transmitted. The Cataracts of the Nile can be utilized in irrigating the waste lands of the upper regions of the river, but their energy cannot compete, at Alexandria, with that of coal transported in mass from England.

At Tivoli, 15 miles across the Campagna, the energy of the falls is economically utilized to light Rome and to drive the tramways of that city. The electric railways at Portrush and Bessbrook, in Ireland, are worked by water-power, and Worcester, Keswick and Lynton use it in this country, but on a very small scale. It is not used more, for the simple reason that there are no more falls to use. Water-power is used very extensively in Switzerland, because it is so abundant there, and in our Colonies, especially in South Africa; but it is in the United States, especially in Utah and California, where the greatest works have been installed, especially for the transmission of energy to mines.

In mines electricity is invaluable. It is used for moving trams and for working hoists. It lights up and ventilates the galleries, and by pumping keeps them free of water. It operates the drills, picks, stamps, crushers, compressors, and all kinds of machinery. The modern type of induction motor, having neither brushes nor sliding contacts, is free from sparks and safe from



dust. Electrical energy is clean, safe, convenient, cheap, and it produces neither refuse nor side products. It is transmitted to considerable distances. In mountainous countries the economical distance is limited by the voltage which insulation can resist; 40,000 volts are being practically used between Provo Canyon and Mercur, in Utah, in transmitting 2,000 HP. 32 miles.

The following Table records some interesting installations:—

| Place.  | Electric Power Generated. | Pressure on Line.          | Distance Transmitted. | Remarks.  |
|---|---------------------------|----------------------------|-----------------------|---|
|   | Kilowatts                 | Volts.                     | Miles.                |   |
| Eschdorf - Grünberg, Schleswig }                                      | 225                       | {10,000<br>(three phase)}  | 15                    | {One 80-HP. Siemens and Halske dynamo, driven from water-wheel; one 220-HP. S. and H. dynamo, driven from turbines (above driven through counter-shafting); one 220-HP. S. and H. dynamo, direct-coupled to engine. |
| Ogden, Salt Lake City, Utah . . }                                     | 3,750                     | {15,000<br>(three phase)}  | 36                    | {Plant consists of five 1,000-HP. twenty-four-pole three-phase generators, driven by Knight water-wheels running at 300 revolutions per minute.   |
| Big Cottonwood, Utah . . . . }  | 1,800                     | {10,000<br>(three phase)}  | 14                    | {Plant consists of four 450-kilowatt three-phase general electric generators, each one directly coupled to a Pelton wheel.  |
| Folsom - Sacramento, California }                                     | 3,000                     | {11,000<br>(three phase)}  | 22½                   | {Plant consists of four 1,000-HP. three-phase generators built by the General Electric Company, coupled direct to the turbine shafts.   |
| San Antonio Creek to Pomona . . }                                     | 480                       | {10,000<br>(single phase)} | 13¾                   | {Plant consists of four 120-kilowatt twelve-pole Westinghouse alternators, driven by a Pelton water-power plant.  |
| To San Bernardino, California . . }                                   |                           |                            | 28¾                   |   |
| Rand Central Electric Works, Brakpan to Johannesburg, Transvaal . . } | 3,200                     | {10,000<br>(three phase)}  | 18                    | {Plant consists of four S. and H. rotary-phase machines, coupled direct to 1,000 HP. to 1,200 HP. engines.  |

It is effecting a great economy in coal consumption in our workshops and factories. The efficiency of steam-driven shafting is known to be very poor. Scattered steam-engines and long steam-piping run away with money by their continuous waste of energy. The motor is used only when and where it is wanted, its efficiency is very high and it costs nothing when it is idle. It can be used either for the small power required by machines and

tools at present worked by hand, or for a goods locomotive of 2,000 HP., such as is now being used at Baltimore.

This utilization of energy at a distance is reinstating many home industries, to the great advantage of the working classes, whose time is wasted in long excursions to the factory, and whose health, morals and well-being are not improved by herding in great numbers and by incessant association with the grievance-monger and the professional agitator.

# CONCLUSION.

I have touched lightly—I fear too lightly—upon some of the applications of electricity. I have confined myself, in a very general sense, to those with which I have been personally associated. I have shown how electricity began its beneficent career by protecting our lives and property from the disastrous effects of Nature's dread artillery, how it facilitates intercommunication between mind and mind by economizing time and annihilating space. It

*“Speeds the soft intercourse from soul to soul,  
And wafts a sigh from Indus to the Pole.”*

By its metallic nerves it brings into one fold not only the scattered families of one nation, but all countries and all languages, to the manifest promotion of peace and general goodwill. Not only does it show us how to utilize the waste energies of Nature, but it enables us to direct them to the place where they are most wanted and to use them with the greatest economy. It opens to our view Nature's secret storehouses, presenting us with new elements, new facts and new treasures. It economizes labour and purifies material. It lightens our darkness in more senses than one, and by enabling us to see the unseen, it tends to aid the gentle healing art and to alleviate both suffering and pain. It aids us in the pursuit of truth, and it has exploded the doctrine that the pursuit of truth means the destruction of faith.

I have occupied your time sufficiently I hope to impress upon you the universality of electricity. Its flood-gates were opened when our good Queen ascended the throne, and during her glorious reign it has overflowed all the fields cultivated by the engineer. Though its followers are now regarded as specialists, the period is not distant when it must cease to be a speciality. Its facts and tenets, its science and practice, must form the framework of the

profession of the engineer. Every engineer must ultimately become an electrician; and electricity will be the most general, the most useful, and the most interesting form in which he applies the fundamental principles of energy to the wants, the comforts and the happiness of mankind.

On the motion of Sir Frederick Bramwell, Bart. (Past-President), seconded by Mr. Edward Woods (Past-President), it was

*Resolved*—That the best thanks of the Institution be accorded to the President for his Address, and that he be asked to permit it to be printed in the Minutes of Proceedings.

The President then presented the Telford, Watt, George Stephenson and James Forrest Medals, and announced the other awards made by the Council in respect of Session 1896-97.

A reception was subsequently held in the Library.