If we may look for one moment at the future, I think we may safely say that in the days to come the progress of chemistry will enter into more intimate relations with the useful arts and industries, and chemical science become a still greater blessing to mankind.

ELECTRICAL SECTION.

THE SEVENTY-FIFTH ANNIVERSARY OF THE
FRANKLIN INSTITUTE FROM AN ELECTRICAL
STANDPOINT.

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[An address delivered in Convention Hall, National Export Exposition, Tuesday, October 3, 1899, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.]

The seventy-five years that mark the life of the Franklin Institute have been fraught with much for the world's weal. During this time great discoveries have been made, and great inventions born, in nearly all departments of physical science, but in none of the sciences have these discoveries or inventions excelled, indeed, I may say, none have equalled, those of electric science and its allied useful arts. Both of these have taken their place in the front rank of progress, and bid fair to continue to outstrip all competitors in their useful gifts to mankind. It is eminently fitting, therefore, that the Electrical Section of the Franklin Institute, representing as it does the electric arts and sciences, shall join with others in celebrating the seventy-fifth anniversary of the Mother Institute, in the Convention Hall of the National Export Exposition of 1899.

The wonderful progress of electric science and its allied useful arts, and the marvellous gifts they have bestowed on the world have not, as in the case of many other physical sciences, been spread equally over an extended period of

time. The last century and a half will take in very nearly all the discoveries and inventions made in electricity; the last century will include by far the most important of these discoveries and inventions; the last half a century, the most valuable and useful, and the last decade and a half, the period of their most extended commercial applications.

Our Institute, founded as it was in 1824, began its existence about the time when electrical activity was markedly increasing, existed during the time of its greatest growth, and still exists at the close of that decade and a half when the commercial applications of electricity have assumed such grand proportions. It is fitting, therefore, that we should inquire both as to how well our Institute, devoted as it is to science and the mechanic or useful arts, has availed itself of the advantages of living in an age of such marked mental activity; and as to what share it has had in the development and application of electrical science.

There is, in every age, a mental horizon which forms the limits of man's actual knowledge. Within this horizon all physical phenomena are readily assignable to their proper causes. Beyond it, other phenomena, discoverable only by the prophetic glance, are too dimly seen to be ascribed to known causes.

In the electrical field this mental horizon was for a long time extremely circumscribed, and even when some progress was made and the horizon extended, obstacles to further progress would loom up, offering apparently insurmountable barriers to further extension. Fortunately, one by one these have been swept away, and the horizon of possible conquest, by unwearying research, has been so greatly extended that, in the public estimation at least, there is little that electric science cannot accomplish.

For thousands of years after his creation man was absolutely blind to the existence of any electric force. Although this mighty power was in operation all around him, in the lightning flash, the Northern light and other physical phenomena, yet he remained practically ignorant of its presence, until Thales, some 600 B.C., discovered the curious properties acquired by a bit of rubbed amber. Even

then the electric horizon long remained relatively limited ; for, with the exception of an unimportant observation by Theophrastus, about 321 B.C., it was practically more than 2,000 years before any further advance was made into the great unknown land whose shores were thus first dimly discerned. Not until 1600 A.D. had Gilbert and others discovered that many other substances than amber acquired similar properties when subjected to friction. It is true the Chinese were reputed to have been acquainted with the directive power of the lodestone, and to have applied it to practical ends, as early as 2600 B.C.; it is true that some little extension of magnetic knowledge had occurred during the next thousand years or so, and that some little advance had been made in magnetic science by Hartmann, in 1544, and Norman, in 1576, in the discovery of the dip of the magnetic needle. But the intimate relations existing between electricity and magnetism had not yet been discovered, and, consequently, this knowledge failed to influence the limits of the electric horizon.

Before discussing the part played by our Institute in the world's progress in electric science, let us inquire briefly as to what general principles had been discovered at the time of the birth of the Franklin Institute, in 1824. The extent of this knowledge was very limited. Although from the standpoint of that time—1824—this progress appeared to be wonderfully great, yet, compared with what is now known, it was exceedingly small. Reviewing it with necessary brevity, we find that, in addition to the work of Thales, Theophrastus and Gilbert, already recited, Guericke and Hawksbee had produced, in 1675 and 1700, respectively, fairly good frictional electric machines, and that Newton, in 1675, had discovered that electrification imparted to one side of a glass plate produced electrification on the opposite side. No great discovery had been made, however, until Von Kleist, in 1745, invented the Leyden jar, the early type of electric condenser.

This memorable discovery gave an impetus to the study of electricity, which resulted in a fairly considerable advance. In 1752, Franklin, outrivalling Prometheus, had

robbed Jove of his thunderbolts, and with that national characteristic of turning all knowledge to every-day use, had shortly afterwards constructed the first lightning rod. Then, excepting the discovery made by *Æpinus*, in 1759, and *Canton*, in 1760, of the phenomena of pyro-electricity or electrification produced in certain crystalline bodies by unequal heating, a period of comparative rest followed, until *Galvani* and *Volta* made their famous discoveries in 1786 and 1796, respectively, the former, in connection with the frog's legs, and the latter with the voltaic cell or battery.

Volta's invention of the voltaic cell gave a marked impetus to electric investigations, by reason of the means thus afforded for readily producing electricity, and the nineteenth century opened auspiciously for electric science. In 1800, *Nicholson* and *Carlisle* effected the decomposition of water by a current from a voltaic pile, and, during the same year, *Henry* of Manchester similarly effected the decomposition of sulphuric and nitric acids. Nor did the advance stop here. In 1807, *Davy* made his immortal discovery of the compound nature of the alkalis, and produced metallic potassium by electrolysis, and shortly afterwards extended his discovery by demonstrating that all the earths and alkalis also compound substances. In 1807, he publicly demonstrated the illuminating power of the carbon voltaic arc. Finally, in 1820, just four years prior to the birth of our Franklin Institute, *Oersted* demonstrated the long-suspected relation between electricity and magnetism, and thus swept away another great barrier to advance.

In considering the part played by the Franklin Institute in the world's progress in electricity during the seventy-five years of its existence, it will be impossible, in the brief time allotted to this address, to make any attempt to trace, or even to call attention to, the individual work undertaken by its members, in the domain of either pure or applied electric science. Such work has been both varied and valuable, and will be found in the *Journal of the Franklin Institute*, in the reports of its various committees, in the transactions of learned societies, or in periodical literature. It will, I be-

lieve, be more profitable to employ our time in pointing out the aid our Institute, as a whole, has given, and the contributions she has made, to the general advance in electric science that has taken place during this term. And this, indeed, will be the preferable course, since it is the work of the Institute as a whole, and not of its individual members, in which the public is interested in this, the seventy-fifth year of its existence.

Little did those fourteen men, who, in 1824, organized the Franklin Institute, appreciate the importance of the work they then inaugurated. But, fortunately for its progress, none of the essential requisites for success were absent ; the originators were eminently capable men ; a great public need existed for the kind of work inaugurated, and its growth was intelligently directed ; naturally, therefore, the Institute continued to expand until it assumed the fair proportions it possesses to-day.

There is an enthusiasm begotten of comradeship. When men of similar interests associate themselves together for carrying out any work, that work is not only better carried out as a whole, but the individual workers labor more earnestly and intelligently. But, besides this enthusiasm bred of numbers, each worker, strong in some particular direction, complements or fills out weak points in his fellow-workers. The germs of ideas that might, perchance, have slumbered and died, if selfishly guarded by their originators, blossom out into valuable inventions and discoveries in the enlivening environment of mutual work. It is for the same reason that class study is less fatiguing than individual study, and is, moreover, generally more remunerative, since the errors of others often prevent the continuance of errors in ourselves, and the removal of their difficulties aids in the removal of our own. And even when one has reached the necessity to specialize and pursue his studies alone, it is an advantage to come every now and then into mental contact with others of similar, if not identical, pursuits, not only to have enthusiasm enkindled, but also to readily exchange ideas, solve doubts, suggest lines of research, and encourage each other to further advance in the line of his special studies.

The solitary recluse student, who limits his companionship strictly to his own thoughts, may have the good fortune to avoid errors and make fair advance in his special studies, but that advance will be both surer and more rapid if he will but admit into his mental world either the thoughts of others as expressed in books, or, still better, thoughts fresh from the living lips of those who will afterwards publish them in printed characters. But no matter from whence the student gathers knowledge, its value to mankind may be gauged by the extent to which it is freely given to his fellow-student.

Unfortunately for the world's progress, the characteristics of the miser are not limited to the selfish hoarding of money or other forms of material wealth. The mentally rich are often more reprehensible in hoarding for their exclusive use the little store of knowledge they are foolish enough to believe can be kept exclusively their own; or, if they share such knowledge at all, it is only with little exclusive coteries of their own, for self-glorification. These pigmy mutual admiration societies, whose members are occupied mainly in sounding each his own praises and magnifying his own achievements, aid but little in the general progress of the world. Their mental world, in their belief, is so far uplifted beyond that of the rest of mankind that they are unwilling to have it enter into their lives, and when they have anything worth publishing they too often phrase their discoveries in language unintelligible save to those belonging to their exclusive set.

Associations formed of such men never have and never will develop phenomenal growth. What discoveries are made by any of their members will practically remain a dead letter. It is no excuse to plead that certain lines of study are so abstruse that it is impossible to describe them so as to permit any but those especially skilled even to faintly comprehend, much less to thoroughly grasp them. This is not true. An idea, no matter how complex, if thoroughly understood, is capable of analysis into its component ideas, and these, necessarily elementary, are readily susceptible of being so phrased as to be thor-

oughly grasped by others. He who assumes that his ideas are so far removed from the range of the average intellect that it is useless for him to attempt to appeal to it, and who adopts a mysticism in giving them to the public, not only renders such publications comparatively worthless, but even renders himself liable to the suspicion of but vaguely comprehending the ideas himself.

Some apologists for exclusiveness in scientific research have endeavored to erect a barrier between pure and applied science. While, of course, a distinction necessarily exists between the two, yet the lines of demarcation are by no means sharp, and it is worse than foolish to attempt to keep them apart. Ideas, evolved by the so-called pure scientists, that are incapable of being put to practical use, are shadowy and unsubstantial, and unworthy of being ranked as great ideas.

Another unsound contention of these scientific exclusionists is that the investigator is degraded by actually putting his discoveries into operation for the benefit of his fellow-man. Fortunately for the world, these ideas were not shared by such grand investigators as Morse, Henry or others of their type. Indeed, it is impossible for one to become a great physical investigator who does not continually subject his theoretical deductions to proof by actual trial. It is folly to maintain that he who aims at discovering the laws of nature can make any marked advance without constantly interrogating her by actual experiment. When certain deductions have been made and a generalization reached, if the investigator fails to test the correctness of such investigation by trial, he will, most probably, fail to achieve further advance into the unknown. Conclusions based on laboratory experiments carried on by minute quantities of material and comparatively feeble forces, and those conducted on a commercial scale, are perhaps equally reliable. But no one can deny that the most conclusive test of the correctness of any general physical law is obtained by commercial results rather than those of the laboratory. When a machine embodying the principles of a great invention has been reduced to a drawing, much has been done. But

such a machine cannot be regarded as actually completed until it has been put into gross material and employed in doing actual work.

The magnificent exhibits of the National Export Exposition that are to-day offered for our inspection have been rendered possible only by the carrying out of such lines of action. They are the natural fruits of great ideas embodied in practical working machines or processes.

The Franklin Institute has achieved the marked growth it possesses to-day because its work has possessed the following characteristics, viz.:

(1) Co-operation of work undertaken jointly by men learned in books and men learned in things, a great working brotherhood of theory and practice.

(2) The widest possible publication, in language intelligible to all, of ideas born in its midst, or presented to it for consideration.

(3) Reduction to practice, by subjecting all discoveries and inventions to the test of actual, every-day use, thus carrying out the purpose for which it was incorporated; viz., "The Promotion and Encouragement of Manufacture and the Mechanic and Useful Arts."

For the proper carrying out of these characteristic types of work the Institute has its Regular Monthly Meetings, its valuable Library of Reference, its Memorial Electric Library, its Historical Collections, its various Sections, its Popular Lectures, its Committee on Science and the Arts, its Drawing School, its *Journal of the Franklin Institute*, and last, but by no means least, its Exhibitions or Expositions. It is far from my purpose to refer to these in detail. They are enumerated merely to permit you to readily see how ample are the means the Institute possesses for carrying on its work along the directions already outlined.

The Franklin Institute has carried on important work of the above-named characteristic types in all the physical sciences. But, as representing the Electrical Section, we are to-night mainly interested in electric science, and in this direction the work of the Institute has been of a character of which we may justly be proud. Through all its

characteristic types of work it has contributed freely to advance in electric science, and we might profitably examine in detail contributions of each of these agencies did time permit. Without any desire to belittle the work of the other agencies, I will ask you to examine briefly with me one only of the most conspicuous of these; namely, that of the International Electric Exhibition of 1884, and this, I think, we are justified in doing, since this particular class of work was strictly limited to electrical devices and applications. I might, indeed, well expend the time in considering the work of our Electrical Section, but, since the Exhibition was held at its suggestion, I think a consideration of the work of this exhibition will suffice.

The Electrical Exhibition of 1884 assumed its international character by virtue of an Act of Congress approved February 26, 1883. Like the present National Export Exposition, it was located in West Philadelphia. The conditions were especially favorable for the holding in this country of an exclusively electrical exhibition. The movement favorably attracted the attention of electric scientists and of manufacturers of electrical apparatus in all parts of the world, so that the exhibition contained electrical devices, apparatus and machinery from all parts of the world. Every branch of electric science contributed some exhibits of the most interesting type; namely, working exhibits, interesting as showing the mastery that had been achieved in those branches of electric science that had produced such exhibits, thus putting the electric forces to every-day work. Besides, there were interesting historical exhibits.

The extent and variety of the different exhibits excited wonderment in the minds of the many visitors. To those unacquainted with electric science, a wonderment that it covered so extended a field; to those fairly acquainted with the achievements of electricity, a wonderment that these achievements so far exceeded in number and variety what they had heretofore credited it with; to those from distant countries, or distant parts of this country, a wonderment that other countries, or other parts of this country, had so far ad-

vanced in their products ; to capitalists, a wonderment that so promising and varied a field was offered for profitable investment ; to those of an inventive mind, a wonderment that so much room still existed for improvements in existing methods of application, or for work in new directions. The environment of the exhibition favored unusual electrical growth, and subsequent facts amply show that the expectations for such growth were fully realized.

True to its general policy of educating the masses, the authorities of the Franklin Institute proceeded to utilize the occasion to increase the knowledge of its members and visitors. Besides the numerous working exhibits, it collected an admirable historical exhibit, showing the gradual growth of electric apparatus and appliances ; it began the collection of a valuable Memorial Electrical Library, it gave to the visitors the names of the different apparatus exhibited, by suitably placed cards, and for further information referred the visitors to printed placards describing the apparatus in detail—placards that were afterwards amplified and issued in the shape of Primers of Electricity ; it had courses of public lectures on electrical topics delivered by eminent scientific men, as well as special lectures prepared for the children of the public schools. The exhibition thus became a great school for all sorts, conditions and ages.

During the progress of the exhibition, and called together by reason of its existence, there was assembled a United States Electrical Commission, appointed by the President of the United States under authority of an Act passed by Congress, May, 1884. Under this authority the Commission conducted a National Conference of Electricians, wisely including in its invitations to such conference both men eminent in electrical science and men eminent in the electric arts in this and in other countries.

It was practically in the International Electric Exhibition of the Franklin Institute that the great American Institute of Electrical Engineers had its birth. This great body of eminent electricians that has done so much to create and direct electrical science, both in this country and abroad, may, strictly speaking, be claimed as the child of the Frank-

lin Institute, and, although it is to-day an independent and separate body, yet the friendly relations still existing between the two Institutes may be inferred from the fact that out of the twelve presidents of the American Institute of Electrical Engineers, five have been selected from members of the Franklin Institute, and that during the nearly fifteen years of the existence of the American Institute of Electrical Engineers, eight of these years it has been presided over by a member of the Franklin Institute.

It is difficult to properly estimate the beneficial effects produced on the progress of electric science and its allied useful arts by the mere coming together of such bodies of men in an environment so essentially electric. The wonderful possibilities of electricity, though generally appreciated before the time of the exhibition, were then more clearly seen, and the foundation was laid, certainly in this country, and, most probably, in other countries as well, for that marvellous growth in the commercial applications of electricity which has taken place since the time of the exhibition.

It is far from my desire to claim for this special work of the Franklin Institute that it was the sole influence that determined this subsequent phenomenal growth. It is sufficient if I have shown that it was a directing cause. I certainly feel justified in claiming that never before in the history of this country, and, perhaps, never since, has so much been done to further and foster the electric arts than has been accomplished, both directly and indirectly, by the International Electric Exhibition of 1884, undertaken under the auspices of the Franklin Institute of the State of Pennsylvania.

In inquiring as to the part our Institute has taken in the advances that have been made in electric science during the past seventy-five years, let us briefly consider some of the more important that have been made during this period. We are to-day practically at the beginning of the twentieth century. The seventy-five years we are about considering practically constitute the second, third and last quarters of the nineteenth century. While we can conveniently consider the advances made during this time as the

second, third and last quarters of the nineteenth century, yet it will be advantageous to consider the last quarter, especially with reference to its last decade and a half. In other words, we will divide the three-quarters of a century into two parts, viz., the sixty years prior to 1884, and the fifteen years subsequent to this time. I do this designedly to call your attention to the marked influence the Electrical Exhibition appears to have had on the electrical activity of the entire world; for, we will find that by far the greater bulk of era-making applications reached their most extended commercial extension after 1884.

Of the discoveries made prior to 1884, let us first briefly consider those of the second quarter of the nineteenth century. Oersted's great discovery was almost immediately followed by Ampère's valuable researches, so that, quite naturally, the beginning of this period was noted for the production of the electro-magnet, in substantially its present form, by Sturgeon, in 1825, and by Henry, in 1828. The wonderful extent to which electro-magnets enter into the structure of nearly all modern electric appliances will give some idea of the value of this invention.

But another discovery was made in this quarter of the nineteenth century that was even more important than that of the electro-magnet. I refer to Faraday's immortal discovery, in 1831, of magneto-electric induction. This was the reverse of Oersted's discovery of the production of magnetism from electricity, since it showed how electricity could be produced from magnetism. Faraday demonstrated that when a coiled keeper was suddenly separated from a permanent magnet a spark was produced; that when a permanent bar magnet was suddenly thrust into or withdrawn from a coil of wire, an electric current was set up in the coil, flowing in one direction on the insertion of the magnet, and in the opposite direction on its withdrawal. He also laid the basis for the subsequent invention of a practical dynamo-electric machine by demonstrating that an electric current was produced in a copper disc by rotating it between a pair of magnet poles. All these in 1831.

Faraday's discoveries soon led to the production of fairly

efficient magneto-electric machines, the forerunner of the modern dynamo. Such machines were produced by Dal Negro and Pixii in 1832, by Saxton in 1833, and, subsequently, by Clarke, Ritchie, Jacobi, Sturgeon, Wheatstone, Cooke, Nollet, Von Malderen, and many others. In 1854, Hjorth had discovered, and practically applied, the reaction principle, whereby the currents generated in the armature coils were utilized to strengthen the magnetism of the field, the armature and the field, thus mutually aiding each other until the machine "built up," or became capable of producing its full working current. This principle was independently discovered, either partially or completely by others, especially by Varley, in 1867, and independently by Werner Siemens and by Wheatstone in the same year. Numerous inventions followed, the dynamo of the third quarter of the nineteenth century, reaching its practical culmination in 1870, in the then famous generator of Gramme.

Naturally, the invention of the electric motor also followed Faraday's discovery, so that this important application of electricity also belongs to the second quarter of the nineteenth century. As early as 1831, Henry had suggested and described methods for utilizing electro-magnetism as a motive power. Dal Negro made similar suggestions in 1833, and Jacobi in 1834, and Page in 1850, had produced operative electric motors.

During this period the electrolytic power of the current had been practically applied by Jacobi, who, in 1838, had invented the art of galvanoplasty or electrotyping, whereby the cold casting of the metals might be effected by electrolytic deposition. Elkington and Wright, at a somewhat later date, had made important applications in the same direction. It was also during this period that Ohm, in 1827, made his great generalization concerning the flow of current in the electric circuit.

Another exceedingly important invention of this second quarter of the nineteenth century was that of electro magnetic telegraphy, rendered possible by the production, in 1836, by Daniell of his constant voltaic cell. Consequently, the next year, 1837, was memorable in the annals of tele-

graphy, since during it Morse in America, Steinheil in Munich, and Wheatstone and Cooke in England, produced electro-magnetic telegraphic systems that are substantially similar to those employed to-day. Ever since this date telegraphy flourished, and in 1858, near the beginning of the third quarter of the nineteenth century, Field had accomplished the laying of the first Atlantic cable.

The early part of the third quarter of the nineteenth century was largely occupied in telegraphic matters. The suitability of gutta-percha for the insulation of submarine cables was recognized, the phenomena of electric charge in telegraphic wire carefully studied, the existence of earth currents demonstrated, and various improvements made in telegraphic apparatus. This part of the period culminated in the laying of the Atlantic cable in 1858.

It is interesting to note that this laying of the Atlantic cable, requiring, as it did, the investment of considerable capital, necessitated a more accurate knowledge of electric laws, and so laid the foundations of electric engineering, which may properly date its origin from this time. It is true that frequent efforts had been made before 1858, to introduce the electric light on an extended commercial scale, and that Staite, Petrie, Foucault and many others had produced fairly operative lamps, but the electric current, as furnished by voltaic batteries, was too costly, and these efforts signally failed.

The last quarter of the nineteenth century, as you are all aware, has been a period of marvellous activity in electric science. The excellent dynamos of Gramme, Siemens, Halske, Hopkinson and others in Europe, and of Brush, Weston, Thomson-Houston, Edison, Crocker-Wheeler and others in America, assuring, as they do, the production of cheap current, have rendered possible many extended commercial applications of electricity. For example, another attempt, and this time a successful one, had been made for the extended commercial introduction of electric lighting. Improvements have been made, by the above and others, in generators and lamps for arc and incandescent systems, both by direct and alternating currents; and the

commercial applications of electric lighting that exist to-day, at the close of the last quarter of the nineteenth century, have assumed enormous proportions.

As we have seen, improvements in arc lighting were extended over a comparatively long period of time. The same is true of improvements in incandescent lighting. As early as 1845, King had invented a lamp whose light was due to the electric incandescence of a small pencil or thin plate of carbon in a Torricellian vacuum. Roberts, in 1852, had produced a light by incandescing conductors in a high vacuum. More recently these have been followed, among numerous others, by Lane-Fox, Swan, Maxim, Sawyer-Mann and Edison, especially the latter, who have produced the efficient incandescent lamps of to-day.

Near the beginning of the last quarter of the nineteenth century, in 1876, another era-making application of electricity was accomplished by Bell in the speaking telephone. Bell's invention was an improvement of Reis' prior telephone of 1861. The telephone has, during the latter part of this period, attained a marvellous growth, and is to-day a formidable rival of the ordinary telegraph.

The application of the direct electric current to systems of street-car propulsion is another direction in which enormous progress has been made during the last decade and a half. But probably in no direction has progress been so great as it has in the field of alternating electric currents. Though known long prior to 1875, yet their marked extension commenced at a comparatively recent date. Short as this time has been, it has sufficed to almost create a new science within a science. Electric power transmission on an extensive scale has also been rendered possible by means of alternating-current apparatus.

As to electrical progress since 1884, the time is so recent, a mere decade and a half, that the prominent developments are still fresh in your minds, and might, therefore, be left to what has already been mentioned in connection with the last quarter of the nineteenth century. But so much has been accomplished during this time, and the part our Institute has played, especially in its International Electrical

Exhibition, in determining and shaping this progress has been so important, that we can well devote some time to a consideration of the most important of these developments. If the nineteenth century may be referred to as the Age of Electricity, its last decade and a half may pre-eminently be regarded as the Age of Commercial Electricity, the time during which electric arts have reached their highest development. Indeed, this trait may possibly be the characteristic feature of the twentieth century, so far as electricity is concerned.

Taking up the commercial applications of electricity which have attained phenomenal growth during this time, without strict reference to their chronological order, we will first consider street railways. The replacement of the lumbering stage and omnibus by the horse car, on the tramway or car track, and the partial replacement of the latter by the cable car had already occurred. It was about 1884, that the peculiar fitness of electric traction for the work led to its extensive introduction, and, so rapid has been its adoption since that time, that to-day there is scarcely a horse car to be found in any of our large progressive cities or towns.

Electric traction is pre-eminently one of the commercial applications of electricity that have offered an attractive field for the remunerative investment of a vast amount of capital. Some idea of the extent of this investment may be obtained from the fact that, in the United States alone, the gross receipts of some 222 street railways reached, in a single year (1898), the vast sum of about \$128,000,000. Of these 222 roads, some 26 had annual gross receipts of \$1,000,000 or over; some 20, annual gross receipts of between \$500,000 and \$1,000,000; some 58, between \$100,000 and \$500,000; some 62, between \$50,000 and \$100,000, and the remainder between \$25,000 and \$50,000.

Although alternating electric currents, transformers and polyphase motors have been known long prior to 1884, yet their extensive commercial application has been subsequent to that date. The comparative simplicity of the armatures of polyphase motors, their long life under continual use,

and their powerful starting torque give them advantages over continuous-current motors that the commercial world has been prompt to recognize. Moreover, the readiness with which alternating electric currents, in connection with the modern transformer and polyphase motors, lend themselves to the economical transmission of energy over considerable distances, has caused the system to be almost exclusively employed for electric power transmission. In addition to this, we may add the extensive practical application of alternating currents to electric lighting, both arc and incandescent, and to heating, welding and some forms of electric furnaces.

The following estimate as to the total production of alternating-current apparatus in the United States in 1898, will give some idea of the extended use of this type of electric apparatus, viz., total estimated production of alternating-current generators and motors, 120,000 horse-power; of transformers, 750,000 lights capacity, and of meters, 750,000 lights capacity.

Although, as we have seen, the storage battery had its origin in Planté's secondary battery of 1859, it was not until 1884, that it was capable of extended commercial application. As it exists to-day, its efficiency and length of life under the requirements of actual use have permitted it to come into very extended every-day use, not only for general purposes, but also in electric light and power stations for the purpose of adding to the total output at the time of maximum load. Another use for the storage battery, that promises great developments, is its use for the propulsion of automobiles. The growth of this comparatively new branch of electric science bids fair to assume enormous proportions in the almost immediate future.

Extended commercial applications of the telegraph and the telephone, especially the latter, have been especially marked since 1884. The fundamental apparatus of both the electro-magnetic telegraph and the speaking telephone were invented long prior to this date; the telegraph in 1837, and the telephone in 1861; but while the extended commercial application of the telegraph was made long prior to 1884,

Field having laid the first Atlantic cable in 1854, the extended commercial application of the telephone has been since that time. I will permit you to infer its marvellous growth from the case of a single city, say New York, where, in 1895, there were about 10,000 telephone stations. In August, 1899, there were in the neighborhood of 33,000 stations, thus rather more than trebling the number in less than half a decade. New York City to-day, that is, the old city together with the boroughs of Manhattan and the Bronx, is said to have more telephones than London and Paris together.

The practical commercial application of electro-magnetic waves has been accomplished since 1884. The existence of electro-magnetic waves had been recognized long before this time. As early as 1842, Henry of Princeton observed that steel needles placed in the cellar of his house, were magnetized by a condenser discharge in an upper room. Maxwell, in 1864, had announced his hypothesis as to the practical identity between electro-magnetic radiation and ordinary light, and in 1888, Herz, by employing the principle of resonance, had corroborated Maxwell's hypothesis, showing that electro-magnetic waves possess practically the same velocity as light. Finally, Marconi and others have applied these principles to the transmission of intelligence, and wireless telegraphy is being put to actual use; and although the probabilities of its ever becoming a formidable rival of existing telegraphic systems are somewhat remote, yet it possesses great future possibilities.

The so-called X-rays form, most probably, another variety of electro-magnetic waves that has come into extended commercial use since 1884. Their peculiar behavior as regards many substances opaque to ordinary light (itself a form of electro-magnetic radiation) has rendered them of great practical value in connection with photography, for accurately locating the position of certain foreign substances in the human body, as well as indicating abnormal conditions of its tissues, organs, etc. The Wehnelt interrupter, which has been of so great service in connection with the induction apparatus used in X-ray work, has also been introduced since 1884.

Electric lighting, both arc and incandescent, has shown an enormous increase in actual use since 1884. The number of electric lighting stations now existing in the United States is by no means limited to the number of cities and towns in this country. In nearly all large cities there are separate stations provided for different localities. Moreover, the number of isolated plants in all our large cities and towns is considerable, some of which, in the case of tall office buildings, are almost sufficiently large to equal in their output that of moderately large central stations. For example, in the city of Boston there are, according to a recent report, no less than twenty-nine generating stations and 195 isolated plants. The dynamos in operation have a total capacity of 424,443 incandescent lamps and 10,094 arc lamps, which, including some 7,070 electric motors, require some 90,382 horse-power of boilers and 66,774 horse-power of engines.

The part which electricity, mainly since 1884, has come to play in our lives in great cities is manifold. We light our streets, our public buildings and our houses with it, drive our street cars; transmit messages by telegraph and telephone, operate annunciators, protect our buildings by fire and burglar alarms, drive motors, rotate fans, bring cheap power from distant waterfalls to our doors, install electricity for varied purposes on our war vessels, and employ it in many other ways, which will doubtless suggest themselves to you.

This extended commercial use of current calls for the manufacture of much apparatus. Looking over the annual report of a single large company in this country, we find that for the year ending January 31, 1899, the total sales, as billed to customers, amounted to more than \$17,260,000, and this, good, profitable business, the calculated direct profits amounting to more than \$2,500,000. Some idea of the business done by the company in electric lighting may be inferred from the fact that during this term the orders for incandescent electric lamps reached 8,400,000 lamps!

The manifold uses of electricity to-day in our modern cities mean the employment of a vast number of electric

wires and conduits, both overhead and underground. Take, for example, the city of Boston. There are, in this city, according to a recent report, of underground wires alone, 726,997 feet of conduit; 3,469,011 feet of duct; 5,427,482 feet of cable; 167,751,793 feet of single conductor in cables.

The enormous demand for electric apparatus has not been without its effect on the price of copper, which has advanced materially during the past five years, rivalling even the increase in the price of zinc, lead and iron.

Such is the record of the seventy-five years during which the Franklin Institute has existed. That it has exerted a marked influence on the extension and application of electricity, not only, as I have endeavored to point out, by its great International Electrical Exhibition of 1884, but also through the many other kinds of work by which it endeavors to extend electric science and ensure practical applications of the same, I believe none will question. Regarding to-night the growth attained by electric science during the nineteenth century, we may well exclaim with Morse, "What hath God wrought?"

THE INFLUENCE OF TECHNICAL SOCIETIES IN PROMOTING THE PROGRESS OF THE ARTS.

BY RALPH W. POPE,

Secretary of the American Institute of Electrical Engineers.

[An address delivered in Convention Hall, National Export Exposition, Tuesday, October 3d, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.]

When we consider the vast strides made during the century in practically every branch of applied science, or even the advances made within the memory of the youngest among us, it is not now difficult to realize that seventy-five years ago there existed a field for the Franklin Institute.

That it survived, and is now active along the lines projected by its founders, proves, beyond question, the wisdom