Early History of the A-C System in America

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President A.I.E.E. 1926–27

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As part of the Institute's celebration of the fiftieth anniversary of the establishment of the alternating-current system in America, which is being carried out under the auspices of a special committee,* this brief story of the inception and early history of the alternating current system has been prepared by 2 past-presidents of the Institute, both of whom were actively identified with the early development of the system, and both of whom have made many important contributions to the development and application of alternating current power. It is a story of achievement against the strenuous opposition of many prominent electrical engineers of that time. The present almost universal use of alternating current in the great electric power systems of today is in itself a fitting tribute to the genius and vision of George Westinghouse and William Stanley who, through their long and persistent efforts under extraordinary difficulties established the first alternating current system in America on March 20, 1886.

Significance of Alternating Current

THE outstanding place which electric power occupies in our modern life has been attained through the use of alternating current. Hence the celebration of the fiftieth anniversary of its introduction in America recounts more than an episode in engineering development—it points to the beginning of a utilization of electric service which marks a new era in our industrial, economic, and social life.

In larger perspective, steam power direct from Watt's engine created nineteenth century transportation and an industrial revolution, but in the twentieth century it becomes many times more effective through electric transmission and conversion into light and heat and motor power.

The pioneer ideas and apparatus of a half century ago are significant because of what evolved from them. A review of the state of the art when alternating current began, and its subsequent progress, reveals a marvelous story of engineering achievement; while a recital of electric service today brings into clear focus the supreme function of electricity in amplifying the usefulness of power.

For the development of electrical service in which it has led the world, the United States is fundamentally indebted to 2 men: George Westinghouse through his vision and commercial enterprise, and William Stanley through his genius and persistent effort under conditions of extraordinary difficulty. Each received the Edison medal awarded by the American Institute of Electrical Engineers, for his contribution to the alternating current development. Others both here and abroad contributed, but through the association of these 2 men there were provided the impetus and the facilities that produced the result.

It is a story of romance and of wonder: how crude apparatus in a simple demonstration in 1886 by William Stanley in Great Barrington, Mass., through its commercial exploitation by George Westinghouse, soon led to extending electric light as a luxury; then—within a generation—to providing a universal necessity.

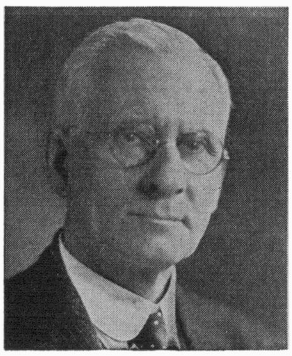
However, the early advocates of the alternating current system had much opposition. Technical problems were many and obscure. Opposition from the scientific and engineering world ranged from incredulity to the most vicious and vigorous condemnation by the exponents of the direct current system then in use.

The 2 most distinguished electrical engineers of Europe and America at that time, Sir William Thomson and Thomas A. Edison, were outspoken in condemnation of the alternating current system.

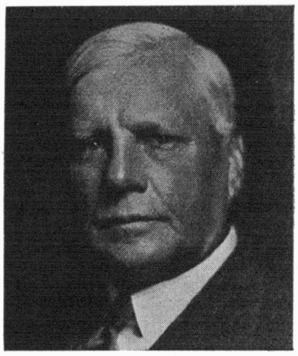
In the November 1889 issue of the *North American Review*, Thomas A. Edison, in voicing his disapproval, stated: "There is no plea which will justify the use of high tension and alternating current, in either a scientific or commercial sense—my personal desire would be to prohibit entirely the use of alternating currents. They are unnecessary, as they are dangerous." Sir William Thomson (Lord Kelvin), president of the International Niagara Commission, outstanding advocate of direct current among those

*Committee on celebration of fiftieth anniversary of establishment of alternating current system in America, A. W. Berresford (A'94, M'06, F'14, member for life and past-president) chairman.

Chas. F. Scott



C. C. Chesney



associated as technical advisors in the Niagara enterprise, cabled on May 1, 1883, as final decisions were about to be made: "Trust you avoid gigantic mistake of adoption of alternating current."

But in spite of every possible legal and engineering opposition, the alternating current system made rapid progress. It was a case of the survival of the fittest, and the alternating current system as developed by William Stanley and George Westinghouse in their complementary relations triumphed.

These facts are related here only to emphasize the undeveloped state of the art of that early period, and to indicate how limited and provincial was its outlook compared with present accomplishments.

Historic Periods of Electric Service

Direct Current Only

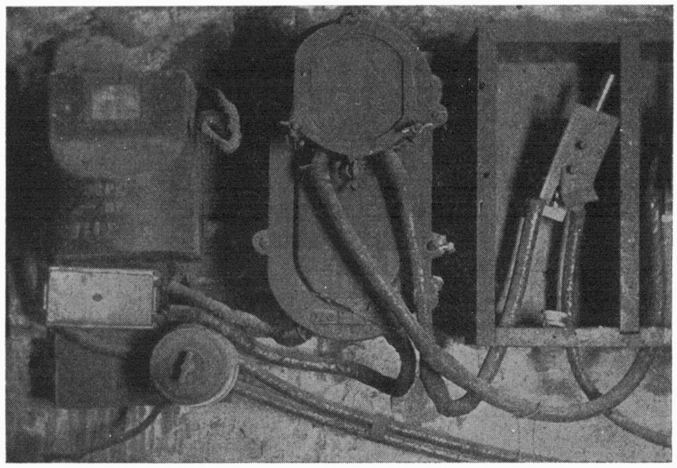
Electroplating was the first important industrial use of electric current. Public service began with street lighting by arc lamps, which in the early eighties were becoming common in most cities and towns. Each direct current arc machine supplied a constant current to from 15 to 50 or more lamps connected in series. Incandescent lamps of nominally 100 volts were operated by direct current from isolated plants in hotels and stores; the pioneer central station was Edison's Pearl Street Station in New York City (September 4, 1882). The serious limitation was distance. The 3-wire direct-current system was not commercially practical beyond a radius of $^1/_2$ to $^3/_4$-mile, because of the excessive cost of the copper conductors. Service therefore was limited to the centers of cities. Outlying residential districts were not served, nor was central station power for motors available in quantities to make it a factor in industrial operations.

Alternating Current

Single Phase Alternating Current—Many Systems. In 1886 the alternating current transformer system extended the radius for incandescent lighting at first to a few miles, and then to much greater distances. Small wires carried a small current to the customer's premises, where it was "transformed" to a large current (coincident with change from high voltage to low voltage) for operating lamps. The significant feature was the transformer.

In this period there were many "systems." A typical central station might include many engine-driven arc-light machines, each with its own independent circuit; direct current generators supplying nearby incandescent lamps; 500-volt generators for street railways; and alternators for remote lighting. Large cities had a dozen or more stations, each supplying one or more kinds of service.

Polyphase Alternating Current. Inaugurated commercially in 1893 at the World's Fair, and on a large scale at Niagara in 1895, the polyphase system came into extended use during the nineties of the past century. Not only did it provide for operation of induction motors, but it led to a radical revision of electrical methods. Polyphase generators could be made of greater capacity; they were better suited to operation in parallel in the same or in remote stations; they were adapted to turbogenerator speeds and outputs; the polyphase system was adapted to high voltage, to long distance transmission, and to supplying through substations direct current as well as alternating current. All types of electric service were then available from a single power generating unit which could operate with others in "superpower" systems or networks. Thus equipped, electric power extended in use some thirtyfold in the 30 years beginning in 1900.

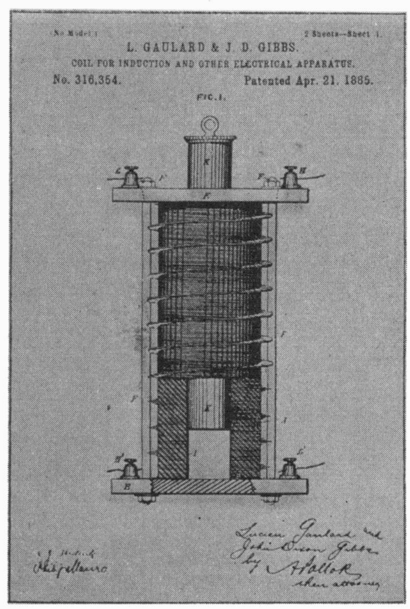


40-light 1,000-volt transformer with an early Shallenberger meter; an old installation found still in service just a few years ago in the basement of a Sixth Avenue store in New York City

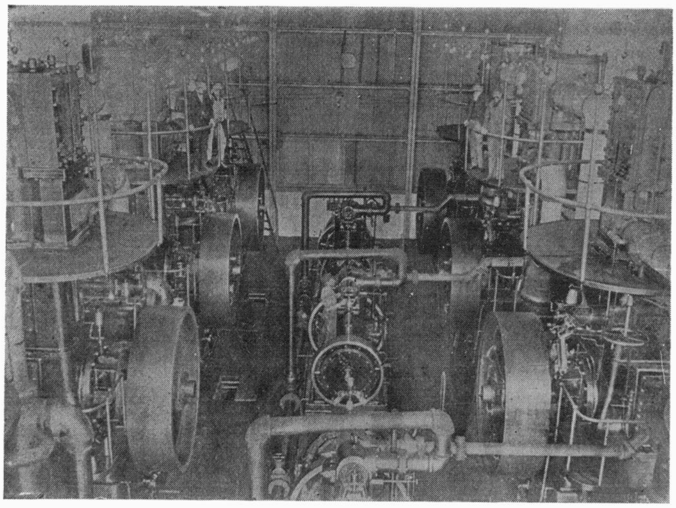
Commercial Beginning of Alternating Current in 1886

Commercial alternating current distribution in America in all probability was derived by evolution from the English Gaulard and Gibbs system with transformers connected in series.

An installation of this type was exhibited at the



Reproduction of a patent drawing of the original Gaulard and Gibbs transformer that was registered in the United States, and to which George Westinghouse had secured all rights



Interior view of the main engine room of the United Electric Light and Power Company's 29th Street and First Avenue generating station

The engines were double-acting steeple-compound units, 2 of which were used originally at the 1893 World's Fair in Chicago, Ill.; at the close of the fair they were rebuilt and installed in this station, where they were direct-connected to 60 cycle polyphase generators

Turin Exhibition in 1884, and there were other installations in Italy and England. This system, however, did not prove to be practical as a general system, since owing to the units being connected in series, the regulation was not satisfactory, and the voltage distribution was disturbed seriously whenever a customer was switched on or off, the more so as the transformers employed were of very imperfect design and construction.

Knowledge of the Gaulard and Gibbs system reached George Westinghouse in the spring of 1885. He was interested in developing new enterprises, so he secured options on Gaulard and Gibbs patents; and in January or February 1886, Franklin Pope negotiated for Westinghouse the purchase of the patent rights for the United States.

George Westinghouse secured apparatus for test, several of the "secondary generators" (transformers) and a Siemens alternator, which arrived at Pittsburgh about September 1, 1885.

Westinghouse had in his employ at the time a young inventor of a self-regulating dynamo and of incandescent lamps, William Stanley. O. B. Shallenberger, the inventor of the integrating meter, was on the staff. Stanley took keen interest in the Gaulard and Gibbs project.

In September 1883, at Englewood, N. J., prior to his association with Westinghouse, Stanley noted and discovered the counter electromotive force set up in an induction coil during its excitation by an alternating current. He says: "I believe that I first coined the word 'counter' electromotive force."

In February 1884, Stanley became associated with Westinghouse, as previously stated, directing his activities toward the development of direct current machinery and systems, as well as incandescent lamps, which Westinghouse was putting on the market.

In the spring of 1885, Stanley took up actively again the alternating current problems which he more or less had studied in 1883. In September 1885, when some of the Gaulard and Gibbs apparatus and the Siemens alternator had reached Pittsburgh, his theories quickly developed into concrete form. He now had apparatus and alternating current for use in tests. His alert and fertile mind soon focused on 2 fundamental features, the system and the device. He rejected the Gaulard and Gibbs plan of operating the primaries in series by a constant current (after the method of operating arc lamps) and chose the method of parallel connection to a constant potential primary circuit. He was not alarmed at the idea of connecting a coil of a few ohms resistance to an alternating current circuit of several hundred volts, as his study of the subject convinced him that by proper design the counter electromotive force would sufficiently limit the current, and furthermore that current in the secondary winding would reduce the counter electromotive force so that the primary current would vary with the secondary load.

To meet these ideal conditions he altered the construction of the "transformer." In the Gaulard and Gibbs device the primary coil had but few turns (usually the same as the secondary), and the core of iron wires was slim and long and in some constructions was a straight core and not a complete ring. Stanley made transformers with many primary turns, some "with iron wire cores in the form of a ring," while others he says "had continuous and laminated cores." He recounts satisfactory laboratory tests of his experimental transformers embodying these features during the latter part of September 1885.

Two months later Stanley prepared a "Specification for Induction Patent," claiming a system in which parallel connected transformers exert a counter electromotive force sufficient practically to obstruct the flow of current, and which "shall vary with secondary load," and embodying a closed magnetic core. He later wrote that the features of low magnetic resistance producing a high counter electromotive force so that "no current flows" and acting as "a frictionless vehicle to transfer all the lines of force from the primary to the secondary circuit without loss in transmission" were 2 points which "have never to my knowledge been demonstrated outside of my work." Thus, according to Stanley's own testimony he developed a transformer and a transformer system which he tested in the Westinghouse shops in Pittsburgh, Pa., in its entirety prior to September 29, 1885.

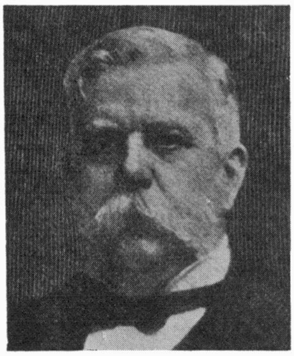
This system of Stanley's subsequently was tested in Pittsburgh by Reginald Belfield, an engineer of the Gaulard and Gibbs Company who arrived at Pittsburgh from England about November 23, 1885. Belfield testified later that he rated the Stanley converters of high value, cheaper to build, smaller in size, and more generally useful for electric lighting (than the Gaulard and Gibbs apparatus).

At the National Exhibition in Budapest, opened May 1, 1885, the firm of Ganz and Company presented a new system designed by Zippernowski, Deri, and Blathy, in which transformers operated in parallel from a constant potential circuit. This system was also exhibited at an exposition in London in the summer of 1885, and had been seen by Belfield. Stanley testified in 1888 that he had no information in regard to this system prior to September 29, 1885.

The December 1885 conferences on, and the tests of, the new transformers and system of Stanley's at Pittsburgh were constructive and convincing. Westinghouse quickly grasped the salient points of the apparatus and suggested improved methods of construction, such as the H shaped punching (which replaced 3 strips); the coils surrounded the middle section of the punching after which the coils were completely enclosed by 2 supplementary strips. This subsequently was improved by Stanley's E plate with one detached strip laid alongside, and this was improved further by Schmid, another Westinghouse employee, who made a complete plate in one piece, slotted so that by bending the extensions the central tongue could be slipped through the opening in the coils. In modern transformer building, however, all formed plates have been superseded by the simpler straight strip and L shaped punching.

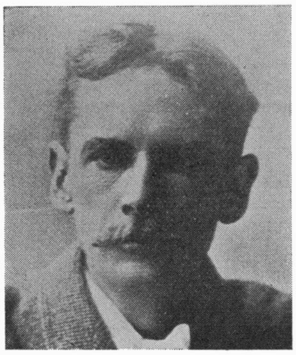
Following the tests and discussions in Pittsburgh after Belfield's arrival, Stanley said that the system should have intensive experimental development, and that he would like to undertake it at his old home in Great Barrington. His health was frail, and he preferred living among the Berkshire hills instead of among the Pittsburgh mills. Belfield joined Stanley in Great Barrington on January 5, 1886.

Westinghouse organized the Westinghouse Electric Company the charter for which was granted January 8, 1886, and the practical organization was completed March 8, 1886. The capital stock was $1,000,000.



George Westinghouse

A 16-pole a-c generator installed in a plant of the Brush Electric Light Company, Buffalo, N. Y., on November 30, 1886. The design was the work of Stanley, Shallenberger, and Schmid



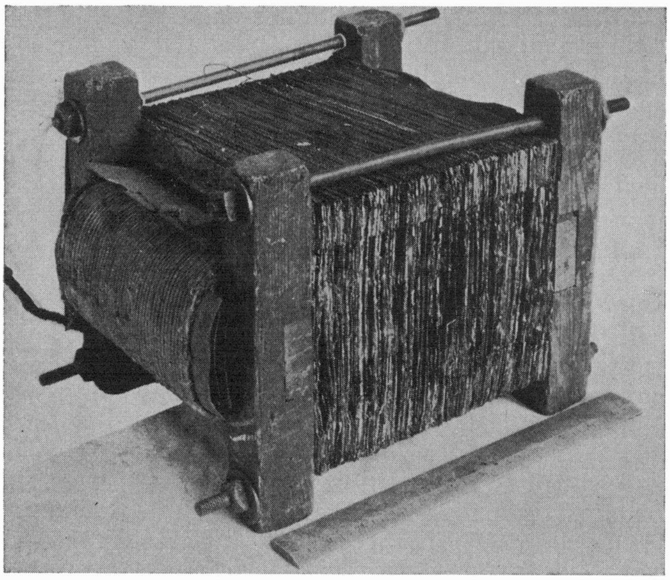
William Stanley

In the early fall of 1885, Stanley had opened a laboratory in an old rubber mill at Great Barrington, in which later he installed the Siemens alternator sent him by Westinghouse. A half dozen transformers made in Pittsburgh in December and January were supplemented by a score of others manufactured in the rubber mill laboratory. These were made by hand, with several improvements introduced in the course of manufacture, and there were no exact duplicates.

Stanley stated a few years later: "The object of my investigations in Great Barrington on converters (transformers) was to acquire accurate data respecting the length of wire, weight of iron, and structural shape of converters, limited by consideration of cost on one hand and commercial efficiency on the other"—in short, to find the most economical proportions to build converters.

At first, iron plates of about $^1/_8$ inch in thickness were tried. The thin iron used by photographers for making tintypes was found to work well, and the local supply was about exhausted in transformer construction. The plates were insulated with thin paper.

On March 17, 1886, Stanley reported to Westinghouse that "the lamps in my cousin's store were running last night." A week later the local newspaper reported the supplying of lights to several stores on Main Street on March 20. Operation continued in this demonstration plant, which lighted a score of houses and stores with the equivalent of 200 16-candlepower lamps, until the sudden demise of the 500 volt generator on June 17, which considerately was attributed to a misplaced screw driver. Westinghouse, with others, had visited the plant in April, and was convinced of its importance. Stanley had



The "induction coil" or transformer designed by William Stanley in the fall of 1885. It was wound for 500 volts primary, 100 volts secondary

much to contend with in demonstrating the merit of his alternating current system of distribution, as indicated in the following extracts from a letter of H. M. Byllesby, later a very prominent figure in the public utility field, written to T. C. Martin, former editor of *Electrical World*, on November 25, 1922. We quote:

"Dear Mr. Martin:

"In those days Stanley had taken up his residence at Great Barrington, Mass., where he was equipped with a laboratory, and where he installed the first real alternating current plant in the United States and put in operation, which was about February or March 1886.

"It had been found prior to my taking charge of the Westinghouse Electric that Stanley's best work was done away from contact with the every day, never ending mental work, discipline, and industry of either the main office of the shops, or the working laboratory at Pittsburgh, and so in the earlier days of the alternating current, Stanley was established with a residence at Great Barrington, Mass.

"When I joined the ranks of the Westinghouse Electric Company there was substantially no one in the organization, excepting Mr. Westinghouse himself and dear old Frank Pope, who had any real expectation of anything commercial coming out of the alternating current system.

"I had known Stanley for several years prior to joining Mr. Westinghouse's interests. There was a mutual liking between us, and sometime in February or March 1886, when I was busy developing the direct current apparatus for the then Westinghouse Electric, and making sales which for those days were of rather unusual importance, Stanley came down to see me at New York on a Friday and impressed me with the fact that he actually did have a small alternating current station running at Great Barrington, that he could receive no audience from any of his associates in the company and that he pathetically implored me to go back to Great Barrington with him and look at it.

"This I did, and spent the following Saturday there. I found he had a complete system, barring of course the meter and the motor, that it was actually performing, and performing well, and with relatively slight modification could be put upon the market.

"I returned to Pittsburgh and reported to Mr. Westinghouse and my associates. I was enthusiastic to the last degree. All of them, even Mr. Westinghouse, were somewhat skeptical, but we immediately had a thorough examination made, which resulting in proving that the alternating current system had arrived successfully.

"******and to my surprise Mr. Westinghouse placed me in full charge as vice president and general manager of the company, this was on July 1, 1886.

"From that time forward we progressed with amazing speed and on about the 6th of September 1886, we had completed and had running 2 alternating current machines of the joint design of Stanley, Shallenberger, Albert Schmid, and myself.

"Each of these machines had a capacity of 750 lights, as then rated. They were driven by Westinghouse engines, located in the erecting shop in Duquesne Alley, and their output was transmitted over a transmission line borrowed from the Allegheny County Electric Light Company, to 2 residences which we rented for that purpose in what was called Lawrenceville, Pittsburgh, a distance from the generating units of about $2^1/_2$ to 3 miles.

"In each of the residences we installed banks of . . . lamps, and we kept this plant running continuously for a period of several weeks; and immediately thereafter started selling plants throughout the country.

"Incidentally, one of these residences—and the lights were kept running night and day—was in charge of L. B. Stillwell, who had come into the organization through an acquaintanceship with myself, about 3 weeks prior to that time.

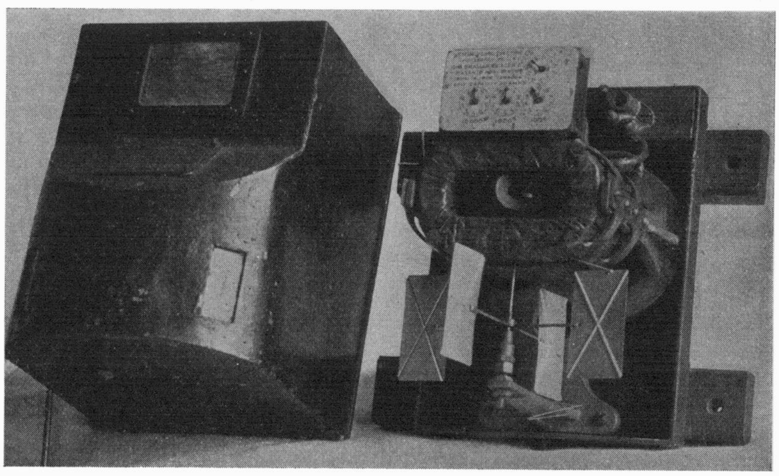
"Mr. Westinghouse had been absent practically from the time that I was installed as vice president and general manager of the electric company on July 1, 1886, until we had run successfully on this Lawrenceville plant for about 10 days.

"I had wired him at Quebec where he was staying with his family, of the success, and he immediately returned home.

(Signed) H. M. Byllesby"

Commercial Service Inaugurated Nov. 1886

As indicated in the foregoing letter, activities were transferred from Great Barrington to Pittsburgh. The single phase alternator for which Stanley furnished the drawing had a smooth cylindrical armature with wires laid on the surface and held by band wires—the armature rotated in a multipolar field. Transformers according to the Stanley pattern also were designed for manufacture; the electrical features by Shallenberger, who had participated in tests and discussions with Stanley; and the mechanical features by Albert Schmid.



Induction type ampere-hour meter, the first a-c integrating meter and the parent of all a-c watt-hour meters now in use, invented by Shallenberger in 1888

The supplemental tests with the new apparatus, employing the circuit several miles from the Westinghouse factory to Lawrenceville, were followed by commercial installations. The first plant began operation November 30, 1886 at Buffalo, New York, only a year and 4 days after Stanley completed his "Specification for Induction Patent." The plant at Greensburg, Pa., began operation soon afterward, although its apparatus had been shipped first. In the following October Shallenberger stated that between 30 and 40 plants were in operation. These were all of the 133-cycle 1000-volt type. No other fact so aptly illustrates the importance of the development—its completeness, and the existing need—than this exceeding rapidity in development.

NOTE: The foregoing story of the transformer in 1885–1886 is the understanding of the authors after recourse to various statements and records, most of which dealt with particular incidents or phases of the development. The statements made are based largely upon testimony given in 1888–1889 in a patent interference between Slattery and Stanley, in which Stanley was successful.

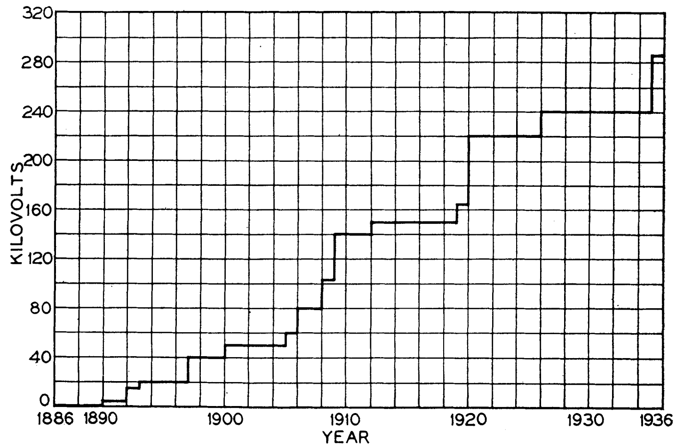
Appendix

SUPPLEMENTARY STATEMENT—BY CHAS. F. SCOTT

I owe much to Stanley for his lucid paper on alternating current phenomena ("Phenomena of Retardation in the Induction Coil," A.I.E.E. TRANSACTIONS, January 1888, pages 3–14). My acquaintance with him, followed by lifelong friendship, began in October 1888 when I assisted in tests on an experimental machine which he brought to Pittsburgh. A short time prior to his death, Stanley wrote me that he felt that his part in the early drama was not understood. Upon invitation, I spent 2 days in Great Barrington, during which time Stanley showed me the old rubber mill and the location of the houses that were lighted. He told of his proposal to Westinghouse in December 1885 that he take up the problem of intensive development in Great Barrington. He wanted to embody in actual apparatus his theory of transformer action, and to demonstrate an operating system. There were difficulties aplenty. Shop facilities were meagre; materials were hard to get; his health was erratic; speed regulation of engines and voltage regulation of alternators were atrocious. It was a pioneer adventure, with little of theory or precedent to guide, and he took pride and satisfaction in having brought forth a successful result. He hoped that occasion might come to tell his story to the American Institute of Electrical Engineers. This is the opportunity.

SUPPLEMENTARY PIONEER DEVELOPMENTS —BY C. C. CHESNEY

The Niagara Falls-Buffalo 23-mile transmission was established in November 1896, at 11,000 volts between conductors, which some 4 years later was increased to 22,000. It had followed quickly on the heels of the great Frankfort-on-Mein electrical exposition, held in Germany in 1891, with its progressive demonstration of a 100-mile 3-phase power transmission from a waterfall at Lauffen to the exposition. The brief years that intervened between the Frankfort Exposition and the World's Fair witnessed the great economic-technical battles of the phases, 3-phase versus 2-phase, and of the frequencies. The controversy invaded the counsels of the Niagara



50 years' trend of approximate transmission potentials in America, 1886–1936

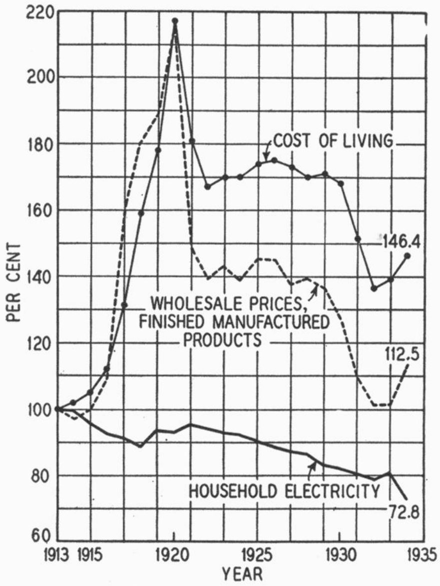
Falls-Buffalo power transmission development, when suddenly the contest was stopped, so far as Niagara Falls development was concerned, by Scott's invention of the T connection for transformers to convert 2-phase to 3-phase circuit in balanced power relation.

With the growth of the electrical industry came the development of transformers for higher and higher voltages. On the knowledge of this development, the transmission voltages of the then projected great power companies of California, the Standard Electric and the Bay Counties Companies, were fixed at 50,000 and 60,000 volts, respectively.

These latter voltages enabled these companies to deliver power so successfully to regions widely separated from its source that the extension of the possible territorial limits coverable by the alternating current system was purely a function of the apparatus made available by further engineering developments.

The value of the tremendous power stored in the mountain streams of California, and for that matter of the world, was passively realized, but it was the work of these 2 utilities that first demonstrated the technical feasibility of the conversion and transmission by means of alternating current, of any amount of such water power any distance, controlled only by the usual commercial and financial limitations.

It is well known, and has been stated many times, that a discovery in science is not an isolated event. The laws of nature have ordained that progress or change is never by leaps or revolutions. This, of course, is true of electrical engineering, and that branch of it, the long distance transmission of power by means of alternating current. It has grown, as does the snowball, by the process of almost infini-



Comparison of the price of electricity with the cost of living and with the prices of manufactured products, 1913–34

The figures on which these curves are based were computed by the United States Bureau of Labor Statistics and furnished by the National Industrial Conference Board

tesimal additions. Practically every experiment or new development in the generation, transmission, and conversion of electric power is a modification of an experiment that has gone before. Almost every new theory is built through the contributions of many workers, of many different elements—one adding a little here and another a little there—so that to the observer in retrospect the progress seems to have been continuous and uniform.

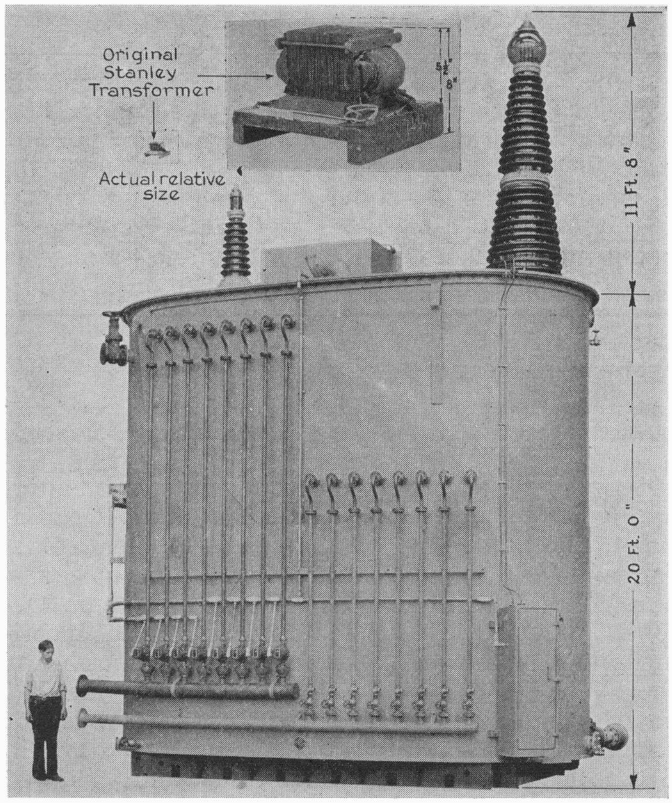
The changes introduced into the art during the past century by the engineers of that period have placed the whole structure of the electrical art of today, as applied to light and power, firmly on the use of alternating current. It has made economically possible the generation of large amounts of power in suitably located central stations, and its conversion and transmission to those points where it can be used most advantageously by industry to operate and to increase the capacity and the economy of mills and factories; to provide electric transportation for the town and country; to extend and to improve the processes of mining and metallurgy; and now to place in the homes of the great agricultural class, through the use of electric power, the comforts and conveniences of the city, and to place in the hands of the farmer the opportunity to extend broadly the economy of the farm to a point at which it may compare favorably in efficiency and productiveness with the factory and workshop.

The effect of the introduction of the alternating current system on the economic conditions within the nation is shown by the fact that of all elements entering into the living cost of the average man, the cost of electricity is the one factor that has shown a substantially continuous decline. It now approximates but $^3/_4$ of its cost in 1913–14, while general living cost has *increased* nearly $^1/_2$ in the same period.

These contributions by practical engineering to the world's affairs have been progressive in character, and have been directed toward the one ultimate purpose of all science and engineering—the improvement of human conditions, and an endeavor to bring into the world an era of more gracious living.

The invention of the integrating meter by Oliver Shallenberger was vital and immediately important in the growth of the electrical industry. Until the invention of this instrument and much needed device, there was no instrument to measure the quantity of alternating current supplied to the consumer. While the meter operated on the same fundamental principles as the Tesla motor, Shallenberger invented the meter independently of Tesla.

The super-voltage transformer was practically impossible without oil. Professor Elihu Thomson introduced its use commercially, but the idea was not new, as the use of oil for insulating induction apparatus was patented by David Brooks of Philadelphia in 1878.



Comparison of original transformer built in 1886 by William Stanley and one of the transformers built in 1935 for use on the Boulder Dam-Los Angeles transmission line

Stanley's Great Barrington plant demonstrated for the first time in America how electric power could be generated at a low voltage, transformed to a higher voltage, retransformed to a lower voltage, and used at this voltage as might be required. This feature of adapting the voltage to varying requirements and of maintaining it substantially constant, irrespective of the load, rendered possible the enormous development and progress in the distribution and transmission of electric energy that have taken place.

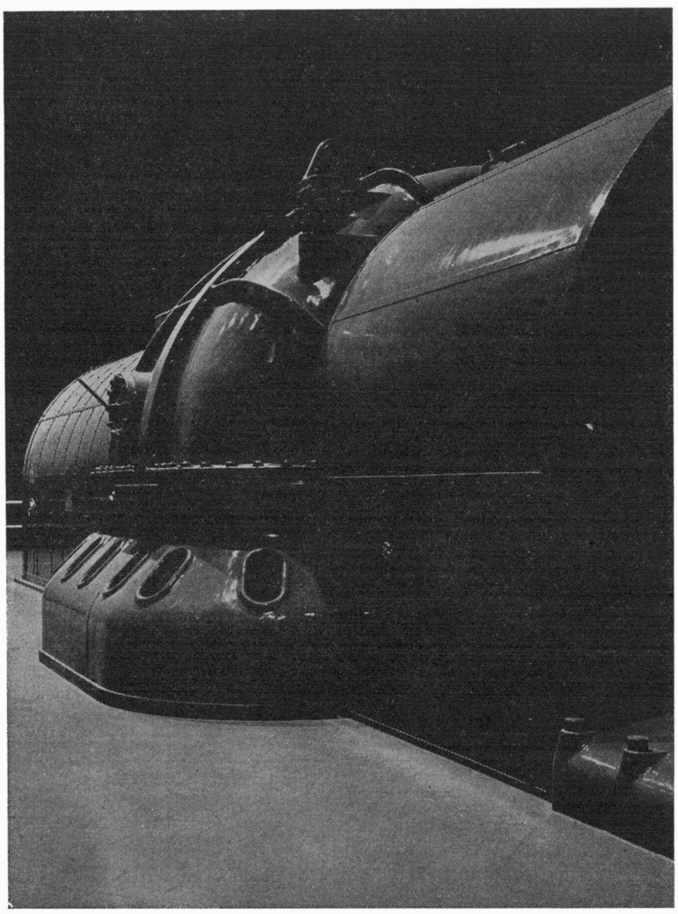
This capability of voltage transformation lies in the transformer itself, insignificant though it always has appeared. Stanley always spoke of the transformer as the "heart of the alternating current system." Naturally, the great development of the art has been accompanied by a similar development of the transformer.

Very early, Stanley had visualized properly the fundamentals of the transformer design, and correctly solved many of the problems in the Great Barrington installation. This revealed a thorough understanding on his part, of electromagnetic induction—surprising for 50 years ago.

The same ability in handling these laws as applied to transformers was shown by Stanley in the construction of the inductor alternator, which had no windings on the rotor, a feature considered of much value at the time. The inductor alternator, as well as the Stanley induction meter, did not survive; but the transformer did, and is substantially the same as the one originally built by Stanley.

At 30 years of age, Stanley had a full conception of the alternating current station idea of manufacturing power, that is, the manufacture of power in some suitable location, transmitting and distributing it to points of consumption by the use of alternating current. With this idea fixed in his mind, and fully determined to find at Pittsfield, Mass., whether there were any limits in sight barring the use of potentials higher than 2,000 volts, then generally employed, he instructed his associate to design and build transformers and line for 15,000 volt operation. To this end a pole line was erected in 1892, and a transformer house built and set up with transformers. These increased the potential of the town circuit from 1,000 volts to 15,000 volts. The line was connected to this potential supply, the current sent around a farm and back to the same transformer house, then the line potential retransformed to 1,000 volts, and the distribution transformers of the local company operated. This little plant was operated during the New England winter with entire success, and the engineering data obtained were the reason for subsequent recommendation by the Stanley Electric Manufacturing Company for use of potentials of higher than 15,000 volts.

The Stanley Electric Manufacturing Company, organized in 1891, later became the Pittsfield Works of the General Electric Company.



Editor's Note: In addition to the wealth of historical information given in the foregoing Scott-Chesney article, there is additional information of a similar nature contained in the texts of the Edison Medal addresses delivered during the recent winter convention upon the occasion of the award of the 1935 Edison Medal to Dr. Lewis B. Stillwell. These addresses are published in the news section of this issue of ELECTRICAL ENGINEERING.

For the convenience of those wishing to pursue further this subject of electrical history, the following list of selected references is offered:

1. ELECTRICAL ENGINEERING, v. 53, May 1934. In this 50th anniversary issue appear many data collected first hand from many authoritative sources and pertaining to the early history and continued development of the alternating current system.

2. *Electrical Review*, v. 40, Feb. 15, 1902. Beginning on page 223 of this, the 20th anniversary issue of the publication, is William Stanley's own account of some of his pioneering work on the alternating current system, appearing under the heading "The Beginning of Alternating Current Engineering." Also in this issue is a series of articles contrasting the status of the electrical development of that time to the status at the time of the establishment of the publication 20 years before. Several portraits of men then prominent in the development of electrical arts and trades also are shown.

3. THE WESTINGHOUSE CONVERTERS AND OVERHEAD SYSTEM. *Electrical World*, v. 10, 1887, p. 65. A brief illustrated description of the Westinghouse converters (transformers) and alternating current system of distribution.

4. REPORT OF N.E.L.A. COMMITTEE ON ELECTRICAL DISTRIBUTION BY ALTERNATING CURRENTS. *Elec. World*, v. 10, 1887, p. 92–3. A report on the status of alternating current distribution at that time, and an account of some of the difficulties encountered. (Report read by Slattery who had a patent interference with Stanley.)

5. *Electrical Review*, v. 38, Jan. 12, 1901. This issue contains a group of illustrated articles outlining the history of electricity and its applications up to that time, and includes a series of portraits of men who had contributed to the progress of the art in the 19th century.

6. PITTSFIELD SECTION, A.I.E.E. ANNIVERSARY DINNER. *Electrical Review and Western Electrician*, v. 58, 1911, p. 926. This is an account of the fourth annual dinner of the A.I.E.E. Pittsfield Section, commemorating the 25th anniversary of the first commercial application of the transformer and alternating current generator in America. William Stanley was the guest of honor, and the meeting was featured by addresses by several well known Institute members. A brief account of the meeting was published in the A.I.E.E. PROC., v. 30, 1911, p. 191.

7. SPEECHES AT THE A.I.E.E. ANNUAL BANQUET. A.I.E.E. PROC., v. 31, 1912, p. 321–37. A complete account of the 1912 annual banquet of the A.I.E.E. held during the convention at Boston, Mass., and at which the 1911 Edison Medal was presented to George Westinghouse.

8. A.I.E.E. PROC., v. 32, 1913, p. 304–05. A brief account of the ceremony of presentation of the 1912 Edison Medal to William Stanley.