Application of electricity to industry:

General: In hardly any other field have the advances since 1878 been as tremendous as those in the field of electricity and the application of electricity to industries, in the wake of which there naturally followed the development of a new industry, to wit, the manufacture of electrical apparatus and supplies. At the beginning of our period (1878), the only real practical uses of electricity were in the telegraph, stock tickers and burglar alarms of a rather crude and expensive type. In 1898, electric current was used for lighting, heating, cooking, welding, extraction of metals from ores (such as the Hall process for extracting aluminum from bauxite by means of an electric "bath", thereby lowering the price of aluminum from $4.00 to twenty cents per pound), the manufacture of carborundum and graphite, the driving of motors of every description, hydroelectric developments, and others.

Statistics:

a) Electrical apparatus and supplies.

Year	Number of Establishments	Capital	Value of Products
1880	76	1,509,758	2,655,036
1890	189	18,997,337	19,114,714
1900	580	83,130,943	91,348,889

Census 1900 Gen.Tables P.7

b) 168 American manufacturing concerns exhibited their electrical products at the Philadelphia International Electric Exhibition, September 1884, according to the official catalogue of the Exhibition. (Pp.15-73)

In the fall term of 1883, Cornell University for the first time offered courses in electrical engineering, and Harvard and Yale began giving similar courses at just about the same time.

c) Number of central electric power stations beginning operations during each year.

1881--- 8	1887---147	1893---192	
1882--- 30	1888---160	1894---191	
1883--- 27	1889---208	1895---239	
1884--- 47	1890---227	1896---193	
1885--- 55	1891---198	1897---228	
1886---100	1892---243	1898---277	Total---2774

d) Thousands of electrical inventions were patented during these years, the five leading patentees being:

Thomas A.Edison--711 inventions
Elihu Thomson 394 "
Edward Weston 274 "
Charles E.Scribner 248 "
C.G.Van Depoele 244 "

Growth of Westinghouse Electric Company in 1889:
It might be interesting to note the prodigious growth in the electrical industry as reflected in the growth of one of the leading manufacturers of electrical supplies and apparatus.

"At the commencement of the year ~~1888~~ 1889, the company occupied one building on Garrison Alley, Pittsburgh, and employed 700 men in its various departments, viz: machine shop, lamp department, detail department and converter room. Arc lamps the company did not make at all then, and its system of alternating incandescent current was then adopted by 132 central station plants throughout the country.

"However soon a very vigorous increase in all the departments had to be made on account of the enormous demand made upon its capacity by the public. First of all the lamp factory had to be removed to New York to give room to the Waterhouse arc light plant, which had been purchased by the company, and which was then removed from Hartford, Conn., to Pittsburgh. Still the room was too cramped and the company erected a new six-story building adjoining the old shops. In the meantime the Shallenberger alternating current meter had been brought out, and the demand for that appliance soon received such an impetus that the company had to establish a separate department and employ 300 men exclusively on the manufacture of this meter.

"A complete pottery was also added to the works for the manufacture of switches, cut-outs and other safety devices. The laboratory was fitted up with all the necessaries which make a place of that kind perfect, and the Westinghouse laboratory is now considered by those who have visited it the finest and most complete in the country.

"The machine shop has been repeatedly enlarged to meet the increased demand for Westinghouse electric apparatus. Several new engines were put into the buildings and a new battery of boilers consisting of two Babcock and Wilcox boilers, 500 horse-power each.

"With all these improvements the company has more than duplicated its former capacity. To-day (1890) there are about 1400 men employed by the company, the number of central stations is 266, and the total capacity of incandescent lamps operated by the Westinghouse alternating current system amounts to nearly 500,000. "

Electric Power, N.Y., Vol.II P.55 Feb. 1890

As far as price and cost of electric power goes, the following data covering the middle of our period is illustrative:

The Rochester Electric Light Company, using the Genessee Falls as its source, furnished power to the extent of one-eighth horse-power to 108 tailor shops at the rate of $18.00 a year. Fan motors were kept in continual motion from June 1 to October 1 for a total price of $15.00. One h.p. motors were run for twenty-five cents a day. Other rates were $120 per year for two h.p., $250 for five h.p., $300 for six h.p., $400 for eight h.p., and $700 for 15 h.p. (This was in 1890.)

Electric Power, N.Y., Vol.II P.333 Oct. 1890

INDIVIDUAL ELECTRICAL DEVELOPMENTS.

Telephone: The introduction and early history of the telephone is given in somedetail in Mr.Nevins' book. Telephony,however, did not really begin to develop widespread until the decade of the 'eighties.

"The telephone was naturally first used over a single wire connecting two stations; but the possibility of a wider use was immediately perceived wherein a number of such wires, practically unlimited,should be so connected together that a person at any station of such system could hold conversation with persons at any other station,and the 'exchange' arose. The exchange was,naturally,at first confined,or substantially confined,to the municipal limits of single cities or towns. It spread rapidly,until in 1884 there was an exchange in every town or city of 10,000 inhabitants or over in the United States, and of course in many towns of smaller population. The connection of neighboring exchanges with one another by trunk lines, whereby the subscribers in either exchange could talk with the subscribers in any other exchange of the group,naturally followed,and this in an ever-widening circle,until in 1892 it had become possible for the subscribers to the exchanges in New York to talk with the subscribers to the exchanges in Chicago,and a little later the system of exchanges in New England was connected with New York,and thence to Chicago.

"The line from New York to Chicago was formally opened to the public on the 18th of October,1892. The connecting of these cities,and the furnishing of aparatus for personal conversation between them was such an addition to the facilitie of business as,by a sort of common consent,to be recognized as a matter of public concern,and the formal opening was made by a conversation between the mayors of the respective cities."

John E.Hudson, President American Bell Tel.Co.,in
Depew's One Hundred Years of Amer.Commerce
Volume I Pp. 134-135

Bell Statistics.

ON Jan.1,1881	there	were	29,714	miles	of	wire	for	telephone purposes
On Jan.1,1891	"	"	331,642	"	"	"	"	"
On Jan.1,1895	"	"	577,231	"	"	"	"	"

On Jan.1,1881	there	were	47,880	exchange	subscribers
On Jan.1,1891	"	"	202,931	"	"
On Jan.1,1895	"	"	242,432	"	"

Statistics for conversations held,date back only to 1884,in which year there were 215,280,000. In 1895 the average was 2,088,152 conversations per day or 670,000,000 per year. In 1885 the average number of calls per subscriber per day was five and a half. In 1895 it was eight and a half. In the same year the rate from New York to Chicago was $9.00 for five minutes and $4.50 at night.

In 1880 there were 148 telephone companies with 54,319 receiving phones,3,338 employees,and 34,305 miles of wire. In 1900, the Bell system alone had 1500 exchanges,1,080,000 subscribers, 33,000 employees,1,254,203 miles of wire, two billion conversations per year,and a capital of $300,000,000. In addition there were other companies with 2,750 exchanges,700,000 subscribers, and an investment of $150,000,000.*

*L. Koch

TELEPHONE (CONT.)

Casson, in his "History of the Telephone" gives some interesting side-lights on telephone history, from which I have selected the following:

"Garfield was first among the American Presidents to possess a telephone. An exhibition instrument was placed in his home, without cost, in 1878, while he was still a member of Congress. Neither Cleveland nor Harrison, from temperamental reasons, used the magic wire very often. Under their regime, there was one lonely idle telephone in the White House, used by the servants several times a week. But with McKinley came a new order of things. To him a telephone was more than a necessity. It was a pastime, an exhilarating sport. He was the one President who really revelled in the comforts of telephony. In 1895 he sat in his Canton home and heard the cheers of the Chicago Convention. Later he sat there and ran the first presidential telephone campaign; talked to his managers in thirty-eight States. Thus he came to regard the telephone with a higher degree of appreciation than any of his predecessors had done, and eulogized it on many public occasions. 'It is bringing us all closer together,' was his favorite phrase." (P.202)

"The first steamship line to take notice of the telephone was the Clyde which had a wire from dock to office in 1877; and the first railway was the Pennsylvania which two years later was persuaded by Professor Bell himself to give it a trial in Altoona." (P.208)

"By 1892 Boston and New York were talking to Chicago, Milwaukee, Pittsburgh, and Washington. One-half of the people of the United States were within talking distance of each other. The thousand-mile talk had ceased to be a fairy tale. Several years later the western end of the line was pushed over the plains to Nebraska, enabling the spoken word in Boston to be heard in Omaha. Slowly and with much effort the public were taught to substitute the telephone for travel. A special long-distance salon was fitted up in New York City to entice people into the habit of talking to other cities. Cabs were sent for customers; and when one arrived he was escorted over Oriental rugs to a gilded booth, draped with siken curtains. This was the famous 'Room Nine.' By such and many other allurements a larger idea of telephone service was given to the public mind; until in 1909 as many as 18000 New York-Chicago conversations were held, and the revenue for strictly long-distance messages was $22,000 a day." (P.183)

"The Bell telephone secured its first million of capital in 1879; its first million of earnings in 1882; its first million of dividends in 1884; its first million of surplus in 1885. It had paid out its first million for legal expenses by 1886; began first to send a million messages a day in 1888; had strung its first million miles of wire in 1900, and had installed its first million telephones in 1898. By 1897 it had spun as many cobwebs of wire as the mighty Western Union itself; by 1900 it had twice as many miles of wire as the Western Union." (P.182)

INDIVIDUAL ELECTRICAL DEVELOPMENTS (CONT.)

Transformers: While Brush was working on his arc-lighting system, while Edison was perfecting his incandescent-lighting system, and while Lieutenant Sprague was working out his "multiple-unit" control for electric street railways, the need became apparent for some means of supplying larger and wider areas with electric current from the same source of supply, that is, the same central station. Experiments with this end in view led to the discovery of the so-called "transformers" and of alternating current.

The transformer is essentially the application on a large scale of the discovery made in 1831 by Faraday in which he observed that by sending a current of electricity through one of two coils of wire wound around a soft iron ring, a current would also be "induced" in the other coil. About 1884 a Frenchman, Gaulard, and an Englishman, Gibbs, showed by means of a crude transformer that current could be sent a distance of many miles. Then William Stanley, Jr.,* a young engineer of Great Barrington, Mass., became interested in the idea and soon succeeded in working out a type of transformer that has become the model for all the later ones in use in America.

Briefly, the transformer consists of an iron core around which are wound two coils of copper wire, one coil being of fine wire and the other of coarse wire. When a current from the generator is sent through the primary coil, the alternations set up equivalent magnetic alternations in the iron core, thereby inducing a secondary current in the other or secondary coil. If it is desired to get the current at a higher pressure (voltage) at the receiving end of the line, the coarse wire coils are connected to the generator and the current is "stepped up." Conversely, if it is desired to lower the pressure, the current is "stepped down" by connecting the fine wire coils to the generator. The coils are enclosed in large iron casings. A collection of pamphlets issued by the Pittsburgh Transformer Company, the largest makers of transformers, contains interesting illustrations.

Great Barrington had the honor of being the first "to illustrate the momentous new departure in electric light and power." In 1886 the first large alternating current station was installed, in Buffalo, by the Westinghouse Electric Company, using Stanley transformers. The enormous progress in the use of transformers can be seen by the fact that the first one was made in 1886, and in 1900 there were 36,513 in use. A later improvement of the transformer was the use of polyphase alternating current rather than the single-phase current which Stanley had to use. It remained for Nikola Tesla, a Serb by birth, to invent the polyphase system now generally in use.

* Stanley was a U. S. Naval Academy man-Prof. ?

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INDIVIDUAL ELECTRICAL DEVELOPMENTS (CONT.)

ELECTRIC STREET RAILWAYS: It did not take long before engineers and electricians began to consider electricity as a means for drawing heavy loads, in other words, for use on railway lines. The story of electric railways is thus told by Herbert H. Vreeland, a President of the Metropolitan Traction Company:

"Edison built the first electric road in America at Menlo Park, New Jersey, in 1880, and three years later on the same great inventor, co-operating with Stephen B. Field, built a similar road for temporary use at the Chicago Exposition in 1883. Leo Daft at the same time was making similar experiments in Baltimore, Pittsburgh, and other places, and Charles J. Van Depoele was doing likewise in Toronto. None of these, however, had reached such a point that its practical value was demonstrated beyond a doubt---. But, in 1888, Frank J. Sprague, first among the younger electricians of America, obtained sufficient capital to make an actual test upon a street in the city of Richmond, Va. He brought together the best features of all the systems which had then been devised, applied to motive-power the fundamental principles which he had learned in building electric light plants and establishing stationary motors, added new and simple, but effective, motor-control and suspension methods, and in general worked out a well-defined system, the essential features of which have not been changed (since.)

"His work in Richmond naturally attracted the attention of men engaged in the street-railway business, and scores visited [Richmond] to behold its actual operation. Among them were Mr. Whitney [who had contemplated building and consolidating the cable lines in Boston] and Messrs. Widener and Elkins of Philadelphia. They appreciated at a glance the possibilities of the new invention, and after making most thorough examinations personally, as well as through expert engineers and electricians, did not hesitate to adopt, expand, and improve it in every possible direction. Mr. Whitney at once abandoned the idea of laying a cable under the streets of Boston, and began forthwith to lay the foundations of the great West End system, which (in 1895) was the largest in the world in point of carrying capacity and revenue. Mr. Widener and Col. Elkins proceeded with no less vigor to consolidate and electrify the principal lines of Philadelphia, and within three years after the Richmond road was inaugurated, there were hundreds of miles of overhead trolley-lines in successful operation in the streets of nearly every large city in the Union.

"Since that time the work of changing old horse-car lines into modern electric railways by the overhead system has progressed so rapidly that there were [in 1895] in actual operation in New England, 1592 miles; in the Eastern States, 3189 miles; in the Central States, 3578 miles; in the Southern States, 743 miles; and in the Western States, 1461 miles, making a total of over 10,000 miles of overhead trolley lines in operation as against less than 2000 miles operated by horses."

(Depew I , 143-144)

MISCELLANEOUS.

FIXTURES FOR ELECTRIC LIGHTS: "When the incandescent light was first introduced there were no fixtures for it, and the first 'electrolier' was nothing more than a gas chandelier, around which the wires to the lamp were twined, the sockets to the lamp being fastened just below the gas burner outlets. It was thus demonstrated that the incadescent lamp could be burned upside down as well as in any other position, and special fixtures were soon brought out, many of them of a high standard of artistic merit. Improvements, due to Mr. Luther Stieringer and others, next allowed the wires to be carried with safety within the stem of the gasolier or chandelier, and the combination fixture, burning both gas and electricity, thus became a permanent feature.

"In 1881 the residence of J. Hood Wright in New York City was lighted with Edison electric incandescent lamps, and most of the lamps, with the exception of those in fixtures, were protected by individual fuses, the object of which was to cut off the flow of current by fusing, should the proper amount be exceeded."

Census Bureau Special Report 1902 P.101

The extent to which electric current was used for lamps, arcs and motors in the prinicpal cities of the United States in 1898, is shown by the following table, in sixteen candle-power equivalents:

New York	1,718,000	San Francisco	231,000
Chicago	1,278,000	Baltimore	224,000
Boston	616,000	Cincinnati	201,000
Philadelphia	488,000	Rochester	184,000
Brooklyn	322,000	Buffalo	125,000
St. Louis	303,000	New Orleans	81,000

The capitalization in electrical appliances in 1898 was estimated at $1,900,000,000.

(Ed. W. Byrn Progress of Invention in 19th Century P.60-61)

The growth of the business of the General Electric Company as set forth in the Company's eighth annual report was as follows:

In 1893	there was an increase of	36%	over 1892
In 1894	" " " "	126%	" 1893
In 1895	" " " "	10%	" 1894
In 1896	" " " "	60%	" 1895
In 1897	" " " "	60%	" 1896
In 1898	" " " "	21%	" 1897
In 1899	" " " "	51%	" 1898

In the same year the Third Avenue Railroad Company and the Union Railway Company of New York entered into a $5,000,000 contract with the Westinghouse Company for electrical equipment for their lines. (This was the largest electrical contract entered into up to that time.)