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OF

MICHAEL IDVORSKY PUPIN

1858–1935

BY

BERGEN DAVIS

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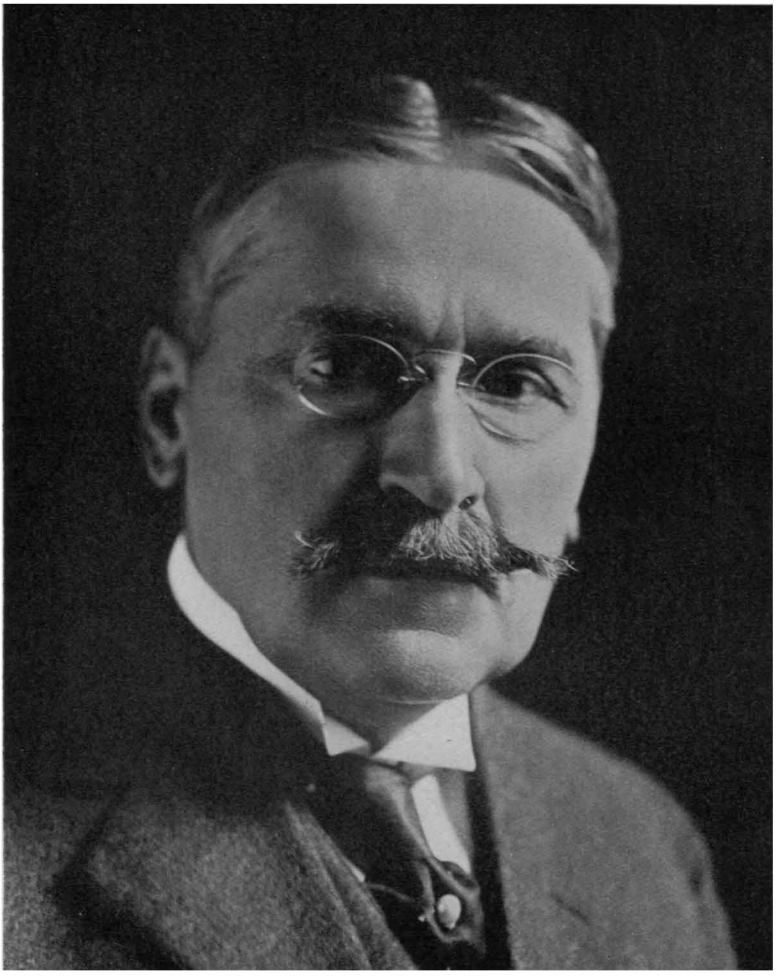

MICHAEL IDVORSKY PUPIN

1858–1935

BY BERGEN DAVIS

The subject of this memoir was born on October 4, 1858, in the small village of Idvor in the Banat of Austria—an Austrian citizen, he was pure Serbian in race. His father, Constantine, and his mother, Olympiada, were sturdy peasants in moderate circumstances. The parents illustrate the very significant difference between intelligence and education. Neither of them could read or write. His father, however, was several times elected "knez" or chief of his village. His mother was a woman of great piety, wisdom and mental vigor. All readers of "From Immigrant to Inventor" will be impressed by the great influence she exerted on the character, early education, and future career of her son Michael.

In 1690, upon the invitation of King Leopold I of Austria, thirty-five thousand picked Serbian families moved from Serbia to the north side of the Danube River into a province known as the Banat. These Serbs were invited there to guard the Austrian frontier against the Turks. A narrow strip of territory was assigned to them. Idvor was one of these settlements. Although technically citizens of Austria, these settlers retained the language and folk-ways of old Serbia.

From this ancestry and from the struggle with the physical characteristics of the land, Pupin acquired great powers of self-discipline, and also derived his poetical temperament, his imagination and his courageous spirit.

His formal education was begun in the village school of Idvor, where he learned reading, writing and arithmetic. As he showed marked mental vigor and capacity, his mother prevailed upon his father to send him to school first in Pechavo, and later to Prague. An incident that occurred on his journey to Prague had an influence on his later emigration to America. He journeyed down the Danube to Budapest, where he took a train bound for Vienna. He was to have changed at Gaenserndorf for Prague. The compartment was warm. He fell asleep and was

carried directly into Vienna. Having no money to pay his return fare, he was hailed before the station master, in the boy's eyes, an awesome official in uniform. He was brow-beaten and insulted by this petty official. An elderly couple who witnessed the affair came forward and offered to pay the young man's fare to Prague, to which place they themselves were bound. They took him with them into a first-class coach. On this journey, he learned that his new-found friends were from America, the country of Benjamin Franklin of whom he had read. During this ride from Vienna to Prague, these generous Americans treated him as an equal and, on arrival in Prague, took him to their hotel as a guest until he could get established in lodgings.

After about a year in Prague, his father died, and, fearing his schooling would be too great a burden on his mother, he decided to emigrate to America. To get the necessary money for his passage to New York in the steerage, he sold his books, his watch, and his great sheepskin coat. He sailed for New York on March 12, 1874, on the steamship "Westphalia." He suffered greatly from cold on this trip (minus his great coat). His experiences form an interesting paragraph in his autobiography. After a painful voyage of fourteen days, he landed in New York on March 26th with five cents in his pocket and a red fez on his head.

His first job was that of driving a team of mules on a farm in Delaware. He also began to learn English under the tutelage of the daughter of the farmer. He also learned much of American thought and customs, which were new and strange to him. After a few months on this farm, he drifted back to New York City and spent the winter of 1874-75 in great hardship. He walked the streets seeking work, performing odd jobs of painting and unloading coal into basements. The evenings were spent in reading in the library of Cooper Union. In the spring of 1875 he again went to work on a farm near Dayton, New Jersey. The persistent efforts of the farmer and family to convert him to their narrow religious views became intolerable. He returned to New York and finally found work in a cracker factory on Cortlandt Street. His experiences there and the accounts of his friends Jim and Bilharz form one of the most

interesting chapters in "From Immigrant to Inventor." The early chapters of this book are of great interest and should be read by all who are interested in the problem of Americanization of immigrants. During the next three years, he attended evening classes at Cooper Union and strenuously trained himself in English by conversation, discussion with Bilharz and Jim, and by attendance at the theater. In the meantime, by industry and thrift he accumulated a modest sum in a savings bank. His friend Bilharz at the cracker factory, who was a classical scholar, helped him to prepare for college.

His career at Columbia College, which he entered in the autumn of 1879, was a successful one, not only academically, but also in a social way. He took a prominent part in athletics, won a number of prizes in Greek and mathematics, and was elected president of his class in his senior year. While in college, he became much interested in the classics, particularly Greek, but his enthusiasm for physical science was aroused by witnessing Faraday's experiment on electro-magnetic induction as performed by Professor Rood in the classroom. He resolved to find out all about this wonderful phenomenon. On graduation in 1883, he was appointed first Tyndall Fellow in Physics from Columbia College. The next six years were spent at the Universities of Cambridge, England, and Berlin.

At Cambridge he was occupied principally with mathematical physics and became especially interested in the electro-magnetic theory of Maxwell. After a year or so at Cambridge, he went to Berlin and, at the suggestion of Helmholtz, began a research in the new science of physical chemistry. He completed a dissertation on the subject of "Osmotic Pressure and Free Energy," receiving the degree of Doctor of Philosophy in 1889.

Before returning to America, Professor Pupin married Sarah Katherine Jackson, the widow of Frederick J. Agate, and the sister of his classmate and future colleague, Professor A. V. Williams Jackson.

Pupin returned to Columbia as instructor in the newly created department of electrical engineering, he and his friend, Francis B. Crocker, constituting the whole staff of that department. Later he was made Adjunct Professor, and in 1901 was ap-

pointed Professor of Electro-Mechanics. The basic theoretical courses in electrical engineering were given by Pupin in the mornings, and in the afternoons he was required to give laboratory instruction. Notwithstanding a heavy teaching load, he found time in the evenings to carry on with experimental research. His earliest work was in the field of electrical phenomena associated with the discharge of electricity through gases.

As a result of his teaching duties, he became interested in electrical engineering problems and occupied himself with the experimental investigation of the peculiarities of wave forms of alternating currents, to which Professor Rowland of Johns Hopkins University had called his attention. His familiarity with the methods of Helmholtz in analyzing complex sound wave forms by means of resonators enabled him to apply a similar method to the analysis of complex current wave forms. This he accomplished by the use in electrical circuits of adjustable condensers and inductances. He was thus led to the discovery of electrical tuning, which is so essential in the art of radio communication.

In December, 1895, Roentgen announced his epoch-making discovery of X-rays. Pupin became interested immediately, and two weeks later, on January 2, 1896, he took the first X-ray photograph made in America. With the aid of a phosphorescent screen, furnished by his friend Thomas A. Edison, superimposed on a photographic plate, he was able to make good X-ray pictures in a few seconds of exposure. In a communication to the New York Academy of Sciences on April 6, 1896, he announced the discovery of secondary X-radiation and is now generally accorded priority for that discovery.

On April 15, 1896, Professor Pupin was stricken suddenly with pneumonia. After a few days of anxious care of him, Mrs. Pupin was also seized with the same disease and died after a short illness. This illness and loss were a great shock, and were followed by great depression of spirit. Upon the advice of his physician, he spent the following summer at Norfolk, a village in the Berkshires, in the northwest corner of Connecticut. Convalescence was slow until his physician, a lover of horses, presented him with a pair of beautiful young cobs only partially

trained from his stud. Boyhood love of horses and his interest in training them brought back health by the end of the summer. Comet and Princess Rose, under his skillful training, became prize winners at the New York and Philadelphia horse shows of 1897-98.

Naturally, he became much attached to Norfolk and the following year purchased a farm near the village. About ten years later, using stones from the fields, he built his picturesque summer home, to which he was accustomed to go not only for rest, but also for opportunity to work, free from the distractions of city life. This home is now the residence of his daughter, Mrs. L. Graham Smith, and her husband.

Upon recovery from his illness, Pupin returned to a problem which eventually led to the invention of the "loaded line." While in Paris, fifteen years previously, he had found at a riverside bookstall a treatise by La Grange containing a paper, "Researches sur la Nature et la Propagation du Son," in which a solution was given of the problem of a vibrating string fixed at each end and loaded at equal intervals with equal masses. Pupin now proposed to generalize the conditions assumed by La Grange, through assuming the string itself to have mass, and the medium surrounding the string to exert a dissipative reaction to its motion. He was able to obtain a solution of this more general problem, but did not at the time realize its tremendous practical importance.

This investigation furnished a solution of the exactly analogous problem of the propagation of electro-magnetic signals over telephone lines having distributed capacity and loaded at equal intervals with inductances. Professor Pupin's investigation showed that the malevolent influences of capacity and resistance in causing distortion and attenuation could be overcome by the introduction of inductances at specified distances along the line.

This invention of the "loaded line" was of the highest importance in telephone transmission. Before this invention, long distance telephoning was impossible. Also, before the year 1900, the streets of large cities such as New York were disfigured by telephone poles carrying hundreds of wires. It was not prac-

tical to transmit, even for short distance, over wires placed underground. The loaded line made transmission possible on underground cables over much longer distances. The unsightly overhead wires completely disappeared from our city streets.

The American rights to this invention were acquired by the American Telephone and Telegraph Company. This "loading" is used universally in the art of telephone transmission throughout the world. The German rights were acquired by the Siemens and Halske Company. This loading of telephone lines is called "pupinization" on the continent of Europe.

The use of loading coils had an enormous growth in the first quarter-century after this invention. By 1911 there were 125,000 loading coils in use on 85,000 miles of open circuit and 170,000 miles of cable circuits. By 1926 there were 1,250,000 coils in use on 1,600,000 miles of cable and 250,000 miles of open wire circuits. The writer is informed by an engineer of the American Telephone and Telegraph Company that at the end of 1936 there were over 8,500,000 loading coils in service in the United States. There are approximately 5,000,000 circuit miles of loaded toll cable and 4,000,000 circuit miles of loaded local cable in use.

A prominent electrical engineer has estimated that in the first twenty-five years this invention saved the American people more than one hundred million dollars.

Not long after the sale of his telephone invention, Pupin disposed also of his wireless inventions, such as electrical tuning and the electrolytic rectifier, to the Marconi Company of America. For many years after the first announcement of the principle of "loading," he was immersed in the many problems that arose in connection with the practical application of loading coils to telephone circuits. These practical problems absorbed much of his attention up to the outbreak of the World War. These problems and this latter event diverted Pupin's attention and prevented his participation in the advancement of pure physics in which he began his career and in which he always remained so much interested.

After the solution of the many problems that arose in connection with the introduction of the "loaded line" into prac-

tice, Pupin carried forward many interesting experiments in alternating current phenomena. As early as 1899 he developed and published a theory of artificial lines called "net works." This theory contained the mathematical foundations used in the construction of electrical filters at the present time. The negative resistance idea was suggested by Pupin and was first produced by running an induction motor beyond synchronism. He showed that if such a negative resistance is introduced in a circuit containing inductance, capacity and resistance, continuous electrical oscillations can be produced. A student, E. H. Armstrong, working in his laboratory, produced this negative resistance by means of the three electrode vacuum tube. This led him (Armstrong) to the invention of the high frequency vacuum tube oscillator, which is the foundation of modern radio broadcasting.

In his later years Pupin withdrew largely from personal scientific research. His time and thought, especially after the World War, were given to semi-public affairs. He made many public addresses before scientific and educational institutions. The underlying theme of many of these addresses was idealism in science and American idealism in life. He was an eloquent speaker, possessed a forceful personality and was endowed with a poetic imagination that gave great pleasure and profit to popular audiences.

One result of this popular activity was the writing and publishing of that remarkable book, "From Immigrant to Inventor." In this he tells of his boyhood life in Idvor, of his journey to America at the age of sixteen, of his hardships and fortitude in these, his struggling years. A book remarkable for its merit as literature, it is filled with the charm of a poetic imagination. Here, too, a major theme is idealism in American science. This book had a great popular appeal and has had a large and continuous sale up to the present time. It has been translated into several foreign languages, and letters of appreciation from all over the world gave the author assurance that his time and labor had not been in vain. On account of persistent demand, an abridged edition was issued suitable for use in the public schools.

In 1927 he issued another book based on the ideas he had put forth in his popular addresses. The title was "The New Reformation." The purpose of this book may be inferred from the concluding words of the prologue: "It is hoped by strengthening our understanding of the physical realities, these narratives will reform our mental attitude and make it better prepared for the recognition of the truth that physical and spiritual realities are the fruit of the same tree of knowledge, which was nurtured by the soil of human experience." In this book, writes his colleague and friend, Professor A. P. Wills, "Pupin has revealed the simple and rational philosophy of life to which he adhered and the spiritual sentiments which were a part of his religious faith."

At the outbreak of the Balkan War in 1912, Pupin was appointed Honorary Consul General and, I believe, was the only diplomatic representative of Serbia in America during the Balkan and the World Wars. He started at this time, at his own expense, a Serbian daily newspaper, mainly for the purpose of keeping Serbian immigrants informed as to the war movements in the Balkans. He also organized a Serbian sisterhood whose members were encouraged to collect contributions to the Serbian Red Cross, and, in the interest of the Serbian National Defense League, to inspire volunteers for the service. In 1914 this work was extended throughout the United States, and highly satisfactory results were obtained.

As the only representative of Serbia in America during the World War, he had charge of that government's purchases, and in at least one instance personally assumed large financial responsibility for the same. He headed the committee formed in this country to help Serbian war sufferers. He was active in the formation of the Serbian Child Welfare Association which did noble work in providing medical supplies, clothing and homes for Serbian war orphans.

At the conclusion of the World War, Premier Paskitch invited Pupin to serve as Serbian representative at the Paris peace conference in April, 1919. Here, in collaboration with his colleague, Professor Douglas Johnson, he was able to advance arguments which resulted in extending materially the proposed

boundaries of the newly created Kingdom of the Serbs, Croats and Slovenes, now known as Yugoslavia.

On the entrance of the United States into the World War in 1917, Professor Pupin organized a group at Columbia University for research into methods of detecting submarines. Together with his colleagues, Professors A. P. Wills and J. H. Morecroft, he carried forward many interesting and valuable experiments on submarine detection at Key West, Florida, and New London, Connecticut, making use of supersonic waves. During the war he served as member of the National Research Council and the National Advisory Committee for Aeronautics. After the war he helped munificently to restore the Serbian churches, schools, museums, etc., for which cause he contributed about one hundred thousand dollars over a period of fourteen years.

In 1911 he had established a memorial fund of $25,000 with the Royal Society in Belgrade in memory of his mother, Olympiada Pupin, the income of the fund to be used for scholarships. In 1928 he established a trust fund of ten million dinars (about $250,000). This fund, which is at the disposal of the Serbian Cultural Society of Belgrade, is to be used for scholarships. Just before his death, he established another fund, the Pupin Memorial Fund of two million dinars (about $50,000). Out of this fund a Pupin memorial home was built in his native village of Idvor. In this there are classrooms for students in agriculture, lecture rooms, and a large hall for moving pictures, concerts, etc. The fund provides several annual scholarships for boys of Idvor for advanced study of agriculture. He also gave other sums for cultural purposes to the National Museum in Belgrade and the Museum of Art in Zagreb.

A few years before his death Professor Pupin transferred the remainder of his property to Columbia University, subject, however, to certain life interests. At the expiration of these life interests, the income is to be applied to the support of research in physics and physical chemistry.

For many years Pupin had been in demand as a speaker on public occasions. This demand increased greatly after the publi-

cation of "From Immigrant to Inventor." He was always an interesting and impressive speaker to the layman in science. He did much service in arousing popular interest in science, and especially in combating that strange notion that prevails in some quarters that over-development of science is a potent cause of our economic ills.

In person, Professor Pupin was a large, vigorous man who gave the impression of great reserve of physical strength. He had a vivid personality that impressed all who came in contact with him. He was fond of social life, was of fine breeding and possessed the social graces to a high degree. He was generous and hospitable in social intercourse, and for the last thirty-five years of his life it was his custom to invite his many friends in succession to enjoy visits during the summer at his home in Norfolk.

Pupin's great physical vigor lasted him up to seventy years of his life, when a decline in health began. A partial paralysis of the legs set in which gradually increased, and finally he was not able to walk, but was confined to chair and bed. He died at the Harkness Pavilion at the Medical Center, New York City, on the twelfth day of March, 1935.

Below this sketch is appended a list of his many honors, awards and degrees. A list is also given of his published papers and of his patents.

Professor Pupin received many honors and awards for his services to engineering, to science, and to public affairs.

Awards:

The Elliot Cresson Medal of the Franklin Institute.
The Edison Medal of the American Institute of Electrical Engineers.
Honor Medal of the Radio Institute of America.
Honor Medal of the Institute of Social Sciences.
The Herbert Prix of the French Academy.
The John Fritz Medal of the Four National Engineering Societies.

Awards and Decorations:

George Washington Award of the Western Society of Engineers. 1928.
White Eagle, First Order of Yugoslavia. 1929.
White Lion, First Order of Czechoslovakia. 1929.

Membership in Societies:

National Academy of Sciences.
American Mathematical Society.
American Philosophical Society.
American Physical Society.
Honorary Member, American Institute of Electrical Engineers.
Honorary Member, German Electrical Society.
Corresponding Member, Royal Serbian Academy, Belgrade.

President of:

New York Academy of Sciences.
Radio Institute of America.
American Institute of Electrical Engineers.
American Association for the Advancement of Science.
University Club of New York,
also, Chairman of the Engineering Foundation.

Honorary Degrees:

Year	*Degree*	*Institution*
1904	Sc.D.	Columbia University
1915	LL.D.	Johns Hopkins University
1924	Sc.D.	Princeton University
1924	LL.D.	New York University
1924	LL.B.	Muhlenberg College
1925	D.Eng.	Case School of Applied Science
1925	L.H.D.	George Washington University
1925	Sc.D.	Union College
1926	LL.D.	Marietta College
1926	LL.D.	University of California
1926	Sc.D.	Rutgers University
1926	LL.D.	Delaware University
1926	LL.D.	Kenyon College
1927	Sc.D.	Brown University
1927	Sc.D.	Rochester University
1928	LL.D.	Middlebury College
1929	Sc.D.	University of Belgrade, Yugoslavia
1929	Sc.D.	University of Prague, Czechoslovakia

BOOKS BY MICHAEL I. PUPIN

Thermodynamics of Reversible Cycles in Gases and Saturated Vapors. John Wiley & Sons. 1894.

Serbian Orthodox Church, edited by Michael I. Pupin. . . . with an introduction by Sir Thomas Graham Jackson, bart. London, J. Murray. 1918. 64 pp., 64 pl.

Yugoslavia. (In Association for International Conciliation Amer. branch —Yugoslavia). American Association for International Conciliation. 1919.

From Immigrant to Inventor. New York, Scribner. 1923. 396 pp.

The New Reformation; from Physical to Spiritual Realities. New York, Scribner. 1927. 273 pp.

Romance of the Machine. New York, Scribner. 1930. 111 pp.

Discussion by M. Pupin and other prominent engineers in "Toward Civilization," edited by C. A. Beard. New York, Longmans, Green & Co. 1930.

SCIENTIFIC PUBLICATIONS OF M. I. PUPIN

1889

Der Osmotische Druch und seine Beziehung zur Freien Energie. Inaugural Dissertation, Berlin, June, 1889.

1890

Practical Aspects of the Alternating Current Theory, May 21, 1890. Trans. Amer. Inst. Elec. Eng., Vol. vii, 204, June and July, 1890.

1891

On Polyphasal Generators, Dec. 16, 1891. Trans. Amer. Inst. Elec. Eng., Vol. viii, Dec., 1891.

The Characteristic Features of the Frankfurt Electrical Exhibition. School of Mines Quarterly, Nov., 1891.

1892

On the Action of Vacuum Discharge Streamers upon Each Other. Amer. Jour. Sci., April, 1892.

On Electrical Discharges through Poor Vacua and on Coronoidal Discharges. Amer. Jour. Sci., June, 1892.

1893

New Method of Measuring the Solar Corona without an Eclipse. Astron. & Astro Phys., April, 1893.

On Electrical Oscillations of Low Frequency and their Resonance. Amer. Jour. Sci., April, May and June, 1893.

Practical Aspects of Low Frequency Electrical Resonance, May 17, 1893. Trans. Amer. Inst. Elec. Eng., Vol. x, 370, June and July, 1893.

1894

Resonance Analysis of Alternating and Polyphase Currents, May 17, 1894. Amer. Jour. Sci., Nov., 1894. Trans. Amer. Inst. Elec. Eng., Vol. xi, Oct., 1894.

Submarine Rapid Telegraphy and Telephony. Elec. World, May 19, 1894.

System of Resonating Conductors for Telegraphy and Telephony. Elec. Eng., May, 1894.

1895

An Automatic Mercury Vapor Pump. Amer. Jour. Sci., January, 1895.

The Most General Relation Between Electric and Magnetic Force and their Respective Displacements. A.A.A.S. Proc., 1895; 55-56.

Electrical Consonance. Elec. World, Feb. 9, 1895.

"Les Oscillations Electriques," by H. Poincare (Review), Science, Jan. and Feb., 1895.

Studies in the Electro-Magnetic Theory. I. The Law of Electro-Magnetic Flux. Amer. Jour. Sci., Series 4, Vol. 1, 1895.

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Roentgen Rays. Science, 1896.

Diffuse Reflection of Roentgen Rays (Science, April, 1896), announcing Pupin's discovery of secondary X-ray radiation.

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Propagation of Long Electrical Waves, Mar. 22, 1899. Trans. Amer. Inst. Elec. Eng., Vol. xv, 144.

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1900

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Wave Propagation over Non-Uniform Electrical Conductors. Trans. Amer. Math. Soc., July, 1900.

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A Faradmeter. Trans. Amer. Inst. Elec. Eng., Vol. xvii, 75-77, 1900.

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1901

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A Note on Loaded Conductors. Elec. World and Eng., Vol. 38, 587-588, Oct. 12, 1901.

1902

The General Problem of Wave Propagation over Non-Uniform Conductors. Elec. World and Eng., Mar. 1, 1902.

1907

Distortion in Telephone Transmission. Elec. World, Vol. 50, 927, Nov. 9, 1907. (Letters to the editors.)

1915

Aerial Transmission Problems. Science, Dec. 10, 1915. n.s. 42, 809.

1926

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1933

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1934

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1923

America's Position in Physical Sciences. Colum. Alum. News, Feb. 9, 1923; Vol. XIV, 235-237.

The Spiritual Influence of a Noted Scientist. (Henry Marion Howe.) Colum. Alum. News, Nov. 2, 1923; Vol. XV, 66-67.

1924

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1926

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1927

Higher Endeavor in Science. Science, n.s. Vol. 65, 509-11. May 27, 1927.

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1929

The Pioneering Professors. Scribner's Magazine, Vol. 85, 123-6. Feb., 1929.

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Romance of the Machine. Scribner's Magazine, Vol. 87, 130-7. Feb., 1930.

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1933

Our Debt to Joseph Henry, Scientist. American Scholar, Vol. 2, 132-8. March, 1933.

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LIST OF PATENTS

1894

519,346 Apparatus for telegraphic or telephonic transmission

519,347 Transformer for telegraphic, telephonic, or other electrical systems

1900

640,515 Distributing electrical energy by alternating currents

640,516 Electrical transmission by resonance-circuits

652,230 Reducing attenuation of electrical waves and apparatus thereof

652,231 Reducing attenuation of electrical waves

1902

697,660 Winding-machine

707,007 Multiple telegraphy

707,008 Multiple telegraphy

713,044 Producing asymmetrical currents from symmetrical alternating electromotive forces

713,045 Apparatus for producing asymmetrical currents from symmetrical alternating electromotive forces

1904

761,995 Apparatus for reducing alternation of electrical waves
768,301 Wireless electrical signalling

1906

821,741 Telegraphy

1920

1,334,165 Electric-wave transmission
1,336,378 Antenna with distributed positive resistance

1921

1,388,441 Multiple antenna for electrical wave transmission
1,399,877 Sound generator

1922

1,415,845 Selectively opposing impedance to received electrical oscillations
1,416,061 Radio-receiving system having high selectivity

1923

1,446,769 Aperiodic pilot conductor
1,456,909 Wave conductor
1,452,833 Selective amplifying apparatus

1924

1,488,514 Selective amplifying apparatus
1,494,803 Electrical tuning
1,502,875 Tone-producing radio receiver

1925

1,541,845 Electrical wave transmission
1,561,278 Wave signalling system
1,561,279 Equalizing vacuum-tube amplifier

1926

1,571,488 Electromagnetic production of direct current without fluctuations

1928

1,657,587 Electrical pulse generator

1931

1,834,735 Inductive artificial line
1,811,368 Telegraph system

1934

1,983,774 Supply system for vacuum tubes