NATIONAL ACADEMY OF SCIENCES

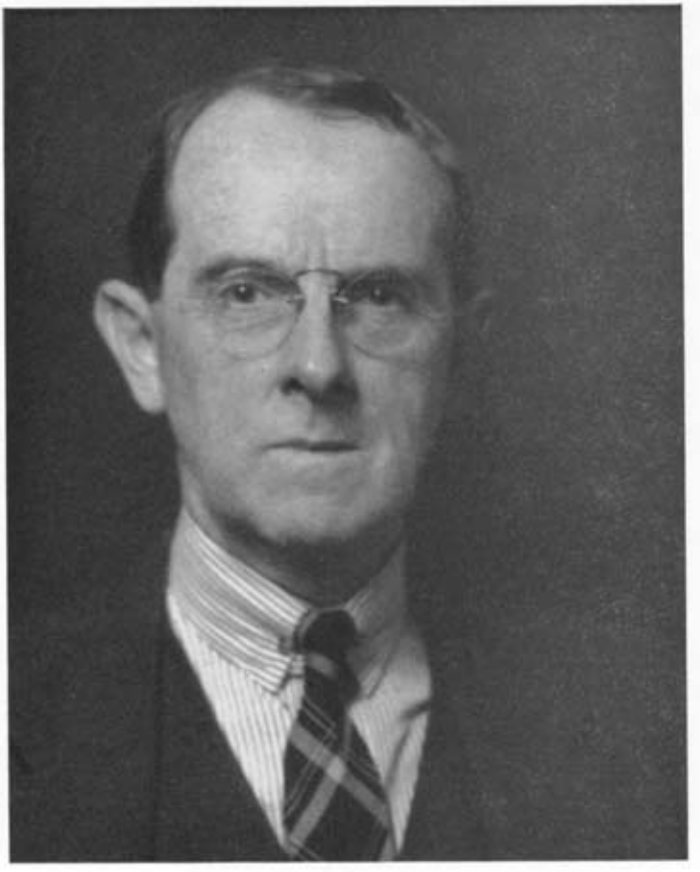
JOHN BOSWELL WHITEHEAD

1872—1954

A Biographical Memoir by

WILLIAM BENNETT KOUWENHOVEN

Biographical Memoir



John B. Whitehead

JOHN BOSWELL WHITEHEAD

August 18, 1872—November 16, 1954

BY WILLIAM BENNETT KOUWENHOVEN

DR. JOHN BOSWELL WHITEHEAD was born in Norfolk, Virginia, on August 18, 1872, the son of Henry Colgate and Margaret Walke Whitehead. The family was of English extraction, having emigrated to this country in 1640. His immediate ancestors had been prominent in southern Virginia, and both his great-grandfather and his grandfather had served as mayors of Norfolk, Virginia. He received his early schooling in Norfolk and in 1889, at the age of seventeen years, he came to Baltimore, Maryland, where one of his uncles resided. He entered The Johns Hopkins University as a candidate for the B.A. degree. His ambition was to become a lawyer. He planned to return to Virginia after obtaining his B.A. from Hopkins and to study law at the University of Virginia.

When he registered at Hopkins, he found that he had certain advanced credits which gave him vacant periods. The only course that was available in his free periods was Professor Rowland's course in Physics I, and he elected this course. Professor Rowland was at that time carrying on his famous researches on the solar spectrum, the mechanical equivalent of heat, the magnetic effect of a moving electric charge, etc. Young Whitehead was fascinated by Professor Rowland and the atmosphere of research and made many excursions, often unauthorized, into remote rooms and laboratories. As a result of this experience Whitehead abandoned the law, and the next year found him enrolled in one of the earliest courses in electrical engineering in this country, which had been started in 1887

by Professors Rowland and Duncan. Professor Duncan was a brilliant young man and his particular interest was in the field of applied electricity. His enthusiasm was so great that he assigned problems in research even to second-year students. In 1893, Whitehead was awarded his degree, Proficient in Applied Electricity (PAE).

After graduation, Whitehead accepted employment with the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pennsylvania. He was with the company for three years; the first year was spent in the shops and the next two years were spent in the Transformer Department in design and development work. There he met Dr. Charles F. Scott, who was at that time head of the Department and who later became Professor of Electrical Engineering at Yale University. They became fast friends.

In 1896 Whitehead left the Westinghouse Company and went to the Niagara Falls Power Company, with the first of the 5,000 KVA generators that were then going into operation. While there he obtained a copy of the first edition of Charles A. Steinmetz's *Alternating Current Phenomena.* He studied this text while on night shift and found many typographical errors. He listed all of these and then wrote to Professor Steinmetz, calling his attention to the errors. Dr. Steinmetz replied, thanking him, and this was the beginning of a lifelong friendship.

Whitehead, on his occasional trips to Norfolk, often stopped off in Baltimore. In 1897, on one of these trips, he learned that a $100 student assistantship was open in the Department of Physics at Hopkins. He applied for this and was accepted, at the same time declining an offer of $125 a month from the Power Company.

Not long after Whitehead's return to Hopkins as a candidate for his doctorate, Professor Duncan left the University for the Spanish-American War. This departure resulted in the development of a close association between Professor Whitehead and Professor Rowland, which continued until the latter's untimely death in 1901. Without doubt Whitehead's association with Professors Duncan and

Rowland influenced his career and instilled in him a passion for experimental research and a realization of its importance. He was awarded his Ph.D. in 1902, having majored in physics.

Dr. Whitehead married Miss Mary Colston, of Baltimore, in 1903, and there were three daughters—Clara (deceased), Margaret Walke, and Joan Boswell. He was an Episcopalian, and a vestryman at St. David's Episcopal Church for twenty-six years.

Dr. Whitehead's doctorate in 1902 was followed by a year as research assistant at the National Bureau of Standards, and three years as research assistant at the Hopkins Laboratory of the Carnegie Institution of Washington. In 1904 he was appointed Associate Professor of Applied Electricity at The Johns Hopkins University, and in 1910 he became full Professor. In 1912 he became the first Professor of Electrical Engineering in the new Department of Engineering. In 1919 he was appointed Dean of the School of Engineering, and in 1938 Director. In 1942 he retired and became Professor Emeritus. Dr. Whitehead died on November 16, 1954.

SCHOOL OF ENGINEERING

In 1912 the State of Maryland appropriated $1,500,000 for the establishment of a School of Applied Science and Advanced Technology by The Johns Hopkins University. It was decided to provide training in civil, electrical, and mechanical engineering. Dr. Whitehead was appointed Professor of Electrical Engineering, and he bore the major part of the burden in planning and organizing the new venture. He visited all the larger schools of engineering in the East, interviewing presidents, deans, and professors, consulting with them as to plans and available personnel. In addition, he talked with the directors of several industrial research organizations. Dr. Whitehead's task was not made any easier by the attitude of some of his colleagues on the Hopkins staff, who felt that engineering training would result in lowering the standard and the reputation of the University.

When the Hopkins Engineering School opened its doors in 1913, it was operated as one of the departments of the University. Dr. Whitehead emphasized that the new venture should provide two disciplines: (1) a high-quality broad undergraduate engineering training, and (2) graduate and research opportunities in engineering leading to the doctorate. He insisted that the head of each of the branches should present the fundamental course in his subject to the undergraduates, and that every undergraduate student should take the basic courses in civil, electrical, and mechanical engineering. He also insisted that, during the first two years of their residence, the undergraduates should spend all of their time in the University Department of Arts and Sciences. Dr. Whitehead developed the graduate program and, in accordance with the traditions of The Johns Hopkins University, he emphasized the importance of research.

He insisted that purely mathematical theory should be substantiated by the results of carefully carried out experiments. An early example of this is to be found in a series of his papers on high voltage corona in air. This study continued through some seven or eight years. Dr. Whitehead was one of the pioneers in this field and he uncovered and verified, by experiment, many of the fundamental laws which are recognized today as governing this important phenomena. A result of his work was to emphasize the value of the corona voltmeter as an instrument for the measurement of high voltage.

It was largely due to Dr. Whitehead's ability as an organizer and a leader, and his insistence on high standards and research, that in 1919 the Department of Engineering became the School of Engineering of The Johns Hopkins University, and Dr. Whitehead its Dean.

That Dr. Whitehead was successful in this endeavor is clearly shown by a report of the American Council on Education, published in 1934. In this report, in which the various universities and colleges throughout the country are rated, the Department of Electrical Engineering of the School of Engineering of The Johns Hopkins University was one of the three schools in the country to be rated as distinguished.

CONSULTING

Dr. Whitehead was active in consulting work. His first venture into this field occurred in 1912, when the University decided to move from its crowded quarters in downtown Baltimore to Homewood. Dr. Whitehead and Mr. Charles Reeder, a mechanical engineer, formed the consulting firm of Whitehead and Reeder. They designed and drew the plans and specifications for the electrical and mechanical equipment that was installed in the powerhouse, Maryland Hall, Gilman Hall, Latrobe Hall, and the tunnels that the University was building at Homewood at that time.

An incident occurred during this construction which illustrates the inherent fairness and honesty of Dr. Whitehead. I came to Hopkins in 1914 as a young instructor in electrical engineering. I offered to go out to Homewood in my spare time and check the electrical and mechanical work being installed. The electrical specifications called for soldered lugs on the terminals of all stranded conductors. One morning, while checking some of the experimental laboratory panels, I found that the contractor was not using lugs. I called the foreman and stopped the work. He was quite irate, and in about half an hour I was called to the telephone by Dr. Whitehead, who said he had inspected a sample panel early that morning and found it quite satisfactory, and had approved it. He told me to notify the foreman to go ahead and omit the lugs. I carried out his instructions. After lunch I received a personal visit from Dr. Whitehead. He said, "First I want to apologize; you were right about the work being unsatisfactory. The sample panel was fine, but not the others. Lugs must be used as called for in the specifications. I am sorry that I called you down."

Dr. Whitehead served as consultant to the Baltimore & Annapolis Short Line Railroad when it was electrified. He also served as consulting engineer for the City of Baltimore during its negotiations with the Pennsylvania Railroad Company, in connection with the electrification of its line through the City. The Railroad wanted to

run a 110,000-volt transmission line through the heart of Baltimore on steel towers. The Railroad claimed that underground cables were very unreliable at that voltage stress. It was largely through Dr. Whitehead's efforts and his knowledge of high voltage insulation that the overhead line was abandoned in favor of underground cables. Several of Dr. Whitehead's students were employed by the Railroad to help in the installation of the 110-KV cables, which are still in service. In his later years, with the development of his chief interest in high voltage insulation, he served as consultant and director of research projects which were supported by the National Electric Light Association, the Utilities Research Commission of Illinois, the Engineering Foundation, and other organizations and companies.

THE FIRST WORLD WAR

During the First World War Dr. Whitehead was a Major in the Corps of Engineers, United States Army, and was assigned to duty with the Naval Consulting Board, in the development of methods for the detection of submarines. He carried on extensive experiments at the Naval Experiment Station in Annapolis and at the laboratories of the School of Engineering at Hopkins. He continued to work on this problem for some months after the war ended and made an extensive report to the Naval authorities.

EXCHANGE PROFESSORSHIP

During 1926–1927 Dr. Whitehead was on leave as The Johns Hopkins University Exchange Professor in France. This assignment illustrates another facet of Dr. Whitehead's thoroughness. When notified of his appointment, he began an intensive course in spoken French, of which he had a reading knowledge. He became proficient in the language and was able to present his lectures in French at the ten institutions that he visited throughout France. During his year abroad he was an official delegate of the American Institute of Electrical Engineers at the International Conference on High Voltage Electrical Systems.

RESEARCH

An early example of the nature of Dr. Whitehead's contributions is to be found in a series of papers on high voltage corona in air that has already been mentioned. Later, Dr. Whitehead began a series of experimental investigations dealing with dielectric theory and the dielectric properties as related to high voltage insulation. He became intensely interested in the influence of internal gaseous ionization on the performance and life of impregnated insulation. He gave particular attention to the fundamental character of dielectric absorption. The knowledge that he and his students obtained resulted in a marked increase in the permissible voltage stresses and in the life of impregnated-paper high voltage cable.

He had the ability to plan and execute systematic programs designed to develop fundamental laws which were essential for improvement and efficient application of dielectrics. He was an indefatigable worker and followed closely the work of others here and abroad, and became the world recognized authority on electrical insulation. Dr. Whitehead organized the annual Conference on Insulation under the auspices of the National Research Council of the National Academy of Sciences, and was its leader for many years.

THE MAN

Dr. Whitehead was courteous, friendly but reserved, and possessed great energy and imagination. He continued his studies after his retirement and until his last illness.

Dr. Whitehead was basically an educator, with a passion for experimental research. The first graduate courses in electrical engineering in the United States were offered at The Johns Hopkins University under his leadership. He insisted that his graduate students carry on experimental research and, at the same time, he set them an example by working in the laboratory himself. He was the leader and was respected by all of his students. Each year he called upon every graduate student and each member of his staff to present a report on the studies that the individual had made.

Some of the students classed him as a tartar. No student ever attended one of his classes in shirt sleeves. Late students were rare. When one entered, Dr. Whitehead would stop talking and eye the boy as he went to his seat. Only after the latecomer was seated was the lecture resumed. Few came late a second time.

Dr. Whitehead was not one to abandon a piece of research if there were still higher peaks to climb. In my old notes I find numerous memoranda written by him, saying, "Tell 'B' to make tests at higher voltages; tell 'S' that measurements should be made at other temperatures; ask 'H' to repeat his experiments at 80°"; and similar directions.

His passion for experimental data created a dilemma for his students. Many of his graduate students, after working two or three years on their experimental dissertations, would bring the data to the Professor. They would go over the results, and then the student would ask permission to apply for his degree. "My boy"—Dr. Whitehead was shocked—"you're not going to stop now! Look what this is leading to. Surely you can't leave now with so many questions unanswered." Back would go the student for more data which, when obtained, would only bring more points to be solved. His students worked out a system of writing up a detailed outline of all that they had been asked to do after an interview with Dr. Whitehead. When this was completed, and further work was suggested, they confronted him with the memorandum. The problems being endless, they could have spent their lives working for a degree.

Dr. Whitehead was so successful in instilling an enthusiasm for research that many of his graduate students have continued to carry on research, develop new theories, and discover new and improved materials throughout their professional careers. It gave him great pleasure to receive a paper written by one of his former students who was in industry or teaching.

He was deeply interested in the lives of his students as well as in their experimental work. If a student made a mistake and got into difficulties he would help him. In a number of instances he made

personal loans to his boys to carry them over unexpected crises. Dr. Whitehead told me one day that he had never lost a penny by this practice. His door was always open and his students were welcome.

He would never discard a piece of apparatus. When an experimental program was completed the equipment was stored. Dr. Whitehead had a pet saying, "Keep a thing nine years and you will find a use for it." I remember well his coming into my laboratory one afternoon and asking, "W. B., where is that big magnet that we wound about six years ago? I have a use for it."

He was a lover of good music, although he did not play an instrument. He served for a number of years as an officer of a group of amateur musicians called the Johns Hopkins Orchestra. He was also well read, which reminds me of an incident told me by Dr. John French, Professor of English at Hopkins. One day Dr. French boarded a trolley and found a vacant seat behind Dr. Whitehead. He noted that Dr. Whitehead was reading a book. So without saying anything he looked over Dr. Whitehead's shoulder. It was a copy of Shakespeare's plays.

Dr. Whitehead was a sincerely honest and patriotic citizen of the United States of America. He would not tolerate shady practices or un-American activities. When such instances arose he became a formidable and vocal advocate of his beliefs.

I met Dr. Whitehead for the first time in December of 1913 and, at his invitation, I came to Hopkins nine months later as an instructor in electrical engineering. It was my good fortune to have the opportunity of serving under and with Dr. Whitehead for forty years. It was a wonderful and stimulating experience.

HONORS

Dr. Whitehead was a member or fellow of many scientific organizations, including the National Academy of Sciences (elected 1932), the American Physical Society, the American Association for the Advancement of Science, and the Engineering Division of the Na-

tional Research Council, and was an Honorary Member of the French Society of Electrical Engineers. He was a member of Phi Beta Kappa and Tau Beta Pi. Dr. Whitehead was deeply interested in the American Institute of Electrical Engineers and served on its Board of Directors and as its President (1933–1934). He organized the Baltimore Section of the American Institute of Electrical Engineers in 1904 and served as its chairman for nineteen years. He was a member of many Institute committees and chairman of a number of them. Almost every year, from 1910 until his death, he presented to the Institute one or more technical papers embodying the results of his research.

Many honors were conferred upon him. Among them were the Edward Longstreth Medal and the Elliott Cresson Gold Medal of the Franklin Institute; the Triennial Prize of the Institut of Elektrotechnique, Montefiore, Liege, Belgium, in 1922, and again in 1925; the Henry Dailme Medaille d'Honneur of the University of Nancy, France, in 1925; the Medal of Meritorious Achievement of the Advertising Club of Baltimore, in 1934; and the Edison Medal of the American Institute of Electrical Engineers, in 1941.

The most signal honor awarded him was the naming of a new engineering building constructed on the Hopkins campus, Whitehead Hall. It is rare for a University building to be named for a living man. This was an honor that both pleased and embarrassed him. He suggested that, owing to a previous engagement, he might be out of town when the building was dedicated.

The day of the dedication was a beautiful, clear day and the exercises were held out of doors. Dr. Whitehead sat quietly enjoying the bright sunshine while the speakers praised him. When it came his turn to speak he said that he was confused. He could find no precedent to follow. Usually the man so honored was dead. Then he thought of Koko, in *The Mikado*. Koko cheerfully admitted that he had reached his high state through luck and politics. Koko, instead of being embarrassed by his eminence, had come to enjoy it, and liked to bask in the admiration of his countrymen. And, concluded Dr.

Whitehead, "Certain of my friends tell me that I am something of a basker."

Dr. Whitehead's real monuments are the Hopkins School of Engineering and the love, respect, and admiration of his students.

KEY TO ABBREVIATIONS

Am. J. Sci. = American Journal of Science
Elec. Eng. = Electrical Engineering
Elec. World = Electrical World
J. Am. Inst. Elec. Engrs. = Journal of the American Institute of Electrical Engineers
J. Appl. Phys. = Journal of Applied Physics
J. Franklin Inst. = Journal of the Franklin Institute
Physik. Z. = Psysikalische Zeitschrift
Proc. Am. Inst. Elec. Engrs. = Proceedings of the American Institute of Electrical Engineers
Proc. Am. Phil. Soc. = Proceedings of the American Philosophical Society
Trans. Am. Electrochem. Soc. = Transactions of the American Electrochemical Society
Trans. Am. Inst. Elec. Engrs. = Transactions of the American Institute of Electrical Engineers

BIBLIOGRAPHY

1900

Inductive E.M.F. in Transformers. Electrical World and Engineer, 35: 660–62; L'Eclairage Electrique, 26(1901):406.

1902

Magnetic Effect of Electric Displacement. Am. J. Sci., 14:109–28; Physik. Z., 4:229.

1904

Effect of Magnetic Field on Electric Displacement Current. Physik. Z., 5:300–2.

1905

Magnetic Effect of Electric Displacement. Physical Review, 21:111–21; Physik. Z., 6:474–80.

With H. D. Hill. Self-inductance Measurements. Am. J. Sci., 19:149–64.

1908

From Steam to Electricity on a Single Track Road. Proc. Am. Inst. Elec. Engrs., 27:627–56.

1909

The Resistance and Reactance of Armored Cables. Proc. Am. Inst. Elec. Engrs., 28:555; London Electrician, 43:801.

With L. O. Grondahl. The Performance of a Synchronous Motor. Elec. World, 53:914–19.

1910

Telegraphic Communication in the South. In: *The South in the Building of the Nation,* Vol. V: *Economic History, 1607–1865,* pp. 372–76. Richmond, Virginia, Southern Historical Publication Society.

The Development of Telegraphic and Telephonic Communication. In: *The South in the Building of the Nation,* Vol. VI: *Economic History, 1865–1910,* pp. 339–44. Richmond, Virginia, Southern Historical Publication Society.

1911

Visual Sensation in the Alternating Magnetic Field. Proc. Am. Inst. Elec. Engrs., 30:80–82.

The Generation and Distribution of Electricity with Special Reference to Lighting. In: *Lectures on Illuminating Engineering,* Vol. I, pp. 237–76. Baltimore, Maryland, The Johns Hopkins University.

The High Voltage Corona in Air. Proc. Am. Phil. Soc., 50:374–96.

The Electric Strength of Air. Proc. Am. Inst. Elec. Engrs., 30:1079–1109.

The Electric Strength of Air. II. Proc. Am. Inst. Elec. Engrs., 30:2333–55.

1912

With C. F. Meyer. The Vibrations of Telephone Diaphragms. Proc. Am. Inst. Elec. Engrs., 31:1023–44.

The Electric Strength of Air. III. Proc. Am. Inst. Elec. Engrs., 31:1023–44.

1913

With T. T. Fitch. The Electric Strength of Air. IV. Proc. Am. Inst. Elec. Engrs., 32:1317–33.

1914

With W. S. Gorton. The Electric Strength of Air. V. Proc. Am. Inst. Elec. Engrs., 33:915–36.

1915

The Electric Strength of Air. VI. Proc. Am. Inst. Elec. Engrs., 34:843–65.

1916

With M. W. Pullen. The Corona Voltmeter. Proc. Am. Inst. Elec. Engrs., 35:791–815.

The Corona as a Standard for Measuring High Voltage. Elec. World, 67:1405–9.

1917

The Electric Strength of Air and Methods of Measuring High Voltage. J. Franklin Inst., 183:433–51.

With W. S. Brown. The Electric Strength of Air. VII. Proc. Am. Inst. Elec. Engrs., 36:159–88.

1920

With T. Isshiki. Notes on the Synchronous Commutator. J. Am. Inst. Elec. Engrs., 39:105–16.

With L. O. Grondahl. Submarine Detection in an Alternating Magnetic Field. J. Am. Inst. Elec. Engrs., 39:223–34, 381–95.

With T. Isshiki. Corona Voltmeter and the Electric Strength of Air. II. J. Am. Inst. Elec. Engrs., 39:441–44, 511–26.

High Voltage Corona in Air. Proc. Am. Phil. Soc., 19:245.

1921

With F. W. Lee. The Electric Strength of Air under Continuous Potentials and as Influenced by Temperature. J. Am. Inst. Elec. Engrs., 40: 373–86.

1922

With N. Inouye. Wave Form and Amplification of the High Voltage Corona. Trans. Am. Inst. Elec. Engrs., 41:138.

Education and Industry. Elec. World, 80:1437–38.

1923

Gaseous Ionization in Built-up Insulation. I. Trans. Am. Inst. Elec. Engrs., 42:921.

Measurement of High Values of Insulation Resistance. Elec. World, 82: 1007–9.

The Problem of Insulation. J. Am. Inst. Elec. Engrs., 42:618–22.

Influence of Gaseous Ionization and Spark Discharge on Fibrous Insulating Materials and on Mica. J. Am. Inst. Elec. Engrs., 42:1297–1304.

1924

The Corona as Lightning Arrester. J. Am. Inst. Elec. Engrs., 43:914–22.

The Four Years' Course and After. Journal of Engineering Education, 15:184–89.

Gaseous Ionization in Built-up Insulation. II. J. Am. Inst. Elec. Engrs., 43:19–25.

1925

Our Annual Waste of Research Material. J. Am. Inst. Elec. Engrs., 44: 140–41.

1926

Dielectric Absorption and Theories of Dielectric Behavior. J. Am. Inst. Elec. Engrs., 45:515–24.

Phase Difference in Dielectrics. J. Am. Inst. Elec. Engrs., 45:1225–28.

1927

Lectures on Dielectric Theory and Insulation (series of nine lectures delivered at leading French universities, as Fifth Exchange Professor to France of Professors of Engineering and Applied Science). French edition, Société Française des Electriciens. English edition, New York, McGraw-Hill Book Company, Inc. vii + 154 pp.

With F. Hamburger, Jr. Influence of Residual Air and Moisture in Impregnated Paper Insulation. J. Am. Inst. Elec. Engrs., 46:939–48.

1928

With W. B. Kouwenhoven and F. Hamburger, Jr. Residual Air and Moisture in Impregnated Paper Insulation. II. J. Am. Inst. Elec. Engrs., 47:565–66.

1929

With R. H. Marvin. Anomalous Conductions as a Cause of Dielectric Absorption. J. Am. Inst. Elec. Engrs., 48:186–89.

Dielectric Absorption and Dielectric Loss. J. Franklin Inst., 208:453–68.

Mechanism of Dielectric Loss and Breakdown. Elec. World, 94:103–5.

1930

With R. H. Marvin. Conductivity of Insulating Oils. Trans. Am. Inst. Elec. Engrs., 49:647–56.

1931

Conductivity of Insulating Oils. II. Trans. Am. Inst. Elec. Engrs., 50: 672–73.

With W. B. Kouwenhoven. Fundamental Properties of Impregnated Paper. Trans. Am. Inst. Elec. Engrs., 50:674.

With F. Hamburger, Jr. Residual Air and Moisture in Impregnated Paper Insulation. III. Elec. Eng., 50:674–75.

With D. M. Davis. On the Importance of Grounding in Cystoscope-Lighting Devices. Journal of Urology, 25:111–16.

1932

With Alfredo Baños. Predetermination of the A.C. Characteristics of Dielectrics. Trans. Am. Inst. Elec. Engrs., 51:392–402.

Dielectric Loss and Relaxation Time in Rosin. Physics, 2:82–92.

1933

Dielectric Losses in Impregnated Paper. Trans. Am. Inst. Elec. Engrs., 52: 667–81.

With E. W. Greenfield. Capillary Action in Impregnated Paper Insulation. Physics, 3:324–30.

1934

The Life of Impregnated Paper. Elec. Eng., 53:244–51.

Liquid Insulators. Trans. Am. Electrochem. Soc., 65:35–46.

With E. W. Greenfield. Dielectric Properties of Cellulose Paper. I. Trans. Am. Inst. Elec. Engrs., 53:1389–96.

With E. W. Greenfield. Dielectric Properties of Cellulose Paper. II. Trans. Am. Inst. Elec. Engrs., 53:1498–1503.

1935

Impregnated Paper Insulation: the Inherent Electrical Properties. New York, John Wiley & Sons, Inc. xiii + 221 pp.

With S. H. Shevki. D. C. Clean-up in Insulating Oils. Trans. Am. Inst. Elec. Engrs., 54:603–9.

With E. E. Minor. Space Charge in Liquid Dielectrics. Physics, 6:380–88.

Recent Progress in Dielectric Research. Trans. Am. Inst. Elec. Engrs., 54: 1288–91.

1936

Lewis Buckley Stillwell. Citation on the Presentation of the Edison Medal. Elec. Eng., March.

Recent Progress in Dielectric Research. Trans. Inst. Elec. Engrs., 55:1180–85.

1937

With F. E. Mauritz. Oxidation in Insulating Oil. Trans. Am. Inst. Elec. Engrs., 56:465–74.

Limitations of High Voltage Insulation. J. Franklin Inst., 224:363–79.

The School of Engineering, 1912–1937. Alumni Magazine, The Johns Hopkins University, June.

With T. B. Jones. Oil Oxidation in Impregnated Paper. Trans. Am. Inst. Elec. Engrs., 56:1492–1501.

Recent Progress in Insulation Research. Trans. Am. Inst. Elec. Engrs., 56:1346–52.

1939

Progress in Insulation Research—1938. Elec. Eng., 58:23–31.

Electricity and Magnetism: an Introduction to the Mathematical Theory. New York and London, McGraw-Hill Book Company, Inc. xi + 221 pp.

1940

The Dielectric Strength and Life of Impregnated-Paper Insulation. I. The Influence of the Density of the Paper. Trans. Am. Inst. Elec. Engrs., 59:715–20.

The Dielectric Strength and Life of Impregnated-Paper Insulation. II. The Influence of the Thickness of the Paper. Trans. Am. Inst. Elec. Engrs., 59:660–63.

With Bun Po Kang. The Conductivity of Insulating Oils under Alternating Stress. J. Appl. Phys., 11:593–603.

1941

With M. R. Shaw, Jr. Detection of Initial Failure in High-Voltage Insulation. Trans. Am. Inst. Elec. Engrs., 60:267–72.

With J. J. Chapman. The Dielectric Properties of Resin-Oil Mixtures. J. Franklin Inst., 231:245–68.

1942

With G. S. Eager, Jr. D.C.-A.C. Correlation in Dielectrics. J. Appl. Phys., 13:43–49.

With W. H. MacWilliams, Jr. Temperature and Electric Stress in Impregnated-Paper Insulation. Trans. Am. Inst. Elec. Engrs., 61:10–13.

The Dielectric Strength and Life of Impregnated-Paper Insulation. III. Trans Am. Inst. Elec. Engrs., 61:618–22.

1945

With J. M. Kopper. The Dielectric Strength and Life of Impregnated-Paper Insulation. IV. Trans. Am. Inst. Elec. Engrs., 64:171–77.

1947

Dielectric Heating—the Measurement of Loss under Rising Temperature. Trans. Am. Inst. Elec. Engrs., 66:947–49.

1949

With W. Rueggeberg. The Measurement of Dielectric Loss at High Frequencies and under Changing Temperature. I. Trans. Am. Inst. Elec. Engrs., 68:520–24.

1951

Radial and Tangential Stresses in Impregnated Paper Insulation. Trans. Am. Inst. Elec. Engrs., 70:56–63.

PATENTS

Number	Title	Issued
1,059,095	High Voltage Measuring Instrument	4–15–13
1,078,711	Improved System of Long Distance Electric Transmission	11–18–13
1,259,696	High Voltage Measuring Instrument; Further Improvements in the Corona Voltmeter	3–19–18