NATIONAL ACADEMY OF SCIENCES

ROBERT ERASTUS WILSON

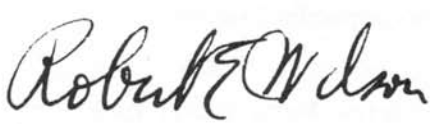
1893—1964

A Biographical Memoir by

L. WILLIAM MOORE AND DONALD L. CAMPBELL

Biographical Memoir

Photograph courtesy of Jean Raeburn



ROBERT ERASTUS WILSON

March 19, 1893–September 1, 1964

BY L. WILLIAM MOORE
AND
DONALD L. CAMPBELL

ROBERT ERASTUS WILSON was inspired by a competitive fervor for excellence, which he applied to such disparate fields as science, education, business, and public affairs. He was the son of a mathematics professor, and his interest in science was awakened early. He developed a high regard for analytical reasoning, which served him well in all of his undertakings. As his college chemistry professor noted, "Bob would make a good research man—he's quite sure there's a better way to do everything than the way now used."[1] This was indeed to become his guiding principle.

In 1954 he said about himself: "I have made few outstanding scientific discoveries. My principal contributions to science were probably in the field of generalizing scattered facts, theories, and observations and in applying scientific principles to the solution of practical problems."[2] In the exercise of this philosophy, he obtained eighty-nine U.S. and

NOTE: The Academy would like to express its thanks to Manson Benedict for his invaluable contributions to this memoir. Dr. Benedict generously contributed the comprehensive section concerning Dr. Wilson's government service, as well as a good deal of information in the section entitled "Honors and Distinctions."

[1] "Dr. Robert E. Wilson Retires," *Standard Torch,* March 1958, p. 5.

[2] Robert E. Wilson, "Autobiographical Statement" (1954), p. 2, Archives of the National Academy of Sciences, Washington, D.C.

fourteen foreign patents and published more than 100 technical papers. He was recognized with three important scientific medals and other awards and with eighteen honorary college and university degrees.

His serious pursuits were accompanied by an unfailing sense of humor. He was asked once what his middle initial stood for. "I've been trying to keep that a secret," he grinned. "In accordance with family custom, I was named Robert after one grandfather and Erastus after the other. I once checked to see if I could not have been given the middle name of the other grandfather, but found out that it would have been Ebenezer."[3] He also was fond of telling friends the story of "four significant facts" about his life, which he duly related to the Academy in 1954: "1. I married a secretary in 1916. 2. I hired my first secretary in 1919 (Catherine V. Ogilvie). 3. Both of them are still with me. 4. They are good friends!"[4]

THE EARLY YEARS

Robert Erastus Wilson was born March 19, 1893 in Beaver Falls, Pennsylvania. He was reared as the eldest of four children of William H. Wilson, who was a mathematics professor first at Geneva College, Beaver Falls, Pennsylvania, and then at The College of Wooster (Ohio), from 1900 until his death in 1907. At that time, Bob Wilson was fourteen years old. Since the family had little money, his mother, Madge (Cunningham) Wilson, formed a college boarding club in their home near the campus. The children all helped by waiting tables, washing dishes, and performing other chores. All four graduated from college, and Bob and his brother were able to finance their graduate work almost entirely through scholarships and their own efforts.

[3] "Robert E. Wilson Retires," p. 2.
[4] Wilson, "Autobiographical Statement," p. 4.

Bob attended public school through the eighth grade (skipping the first, second, and fifth), then preparatory school and The College of Wooster. He said, "I liked all forms of science, mathematics, and mechanical drawing; I disliked history or anything else which seemed to rely primarily on memory as against reasoning. My professor of chemistry was more responsible than any other individual for awakening my interest in science in general and chemistry in particular."[5]

Wilson was graduated magna cum laude from The College of Wooster in 1914 with the degree Ph.B. He took pride in knowing that his father, in 1889, and one of his daughters, in 1943, were also graduated from Wooster with top honors.

In 1916 he married Pearl M. Rockfellow. They were the parents of three daughters: Doris Mildred (Mrs. Louis O. Blanchard, Jr.), Lois Marian (Mrs. James A. Scott), and Janice Marjorie (Mrs. William E. George). In a contemporary account of the parent Wilsons in 1958, an article says, "Their evenings alone are usually spent sitting across from each other at a big, thirty-one-year-old, two-sided mahogany desk in their apartment overlooking Lake Michigan. While Bob, with his bulging briefcase on the windowsill, reads reports or works on a speech, Pearl works with her household accounts, on one of her scrapbooks, or writes to one of her two hundred correspondents."[6]

After graduation from Wooster, Wilson went to the Massachusetts Institute of Technology, where he received his B.S. in chemical engineering in 1916. He describes his early work as follows:

> My first scientific contributions were with regard to methods of measuring the vapor pressures of hydrated salts, which were described in my

[5] *Ibid.*, p. 1.
[6] "Robert E. Wilson Retires," p. 3.

undergraduate thesis at MIT but were not published in the *Journal of the American Chemical Society* until 1921—"Some New Methods of Determination of Vapor Pressure of Salt-Hydrates." This work led to what was probably my first substantial scientific contribution, though it took the form of posing a question, not giving the answer. The question was: How could one reconcile the kinetic theory of vapor pressure with the phase rule? For example, in a mixture of hydrated and a dehydrated salt, under the kinetic theory one would expect the number of the water molecules escaping to be proportional to the number of "vacant spaces" present on the surface. Under this theory, the vapor pressure should vary roughly in proportion to the degree of hydration of the salt. However, both the phase rule and experimental evidence state that if you have a mixture of hydrated and unhydrated salt, the vapor pressure is the same whether it is 1 per cent or 99 per cent hydrated (assuming the salt has only one crystalline hydrate).

I put this question up to several of my professors at the Massachusetts Institute of Technology, including such outstanding men as Arthur A. Noyes and Warren K. Lewis, neither of whom was able to give the answer. I was then fortunate enough to be assigned to the General Electric Laboratory at Schenectady, New York, for a summer job after I was graduated from Massachusetts Institute of Technology, and I put the question to Irving Langmuir. He, too, was unable to answer it but thought the question was quite intriguing and important in connection with a paper he was then writing. The next morning he called me up to ask if I had the answer, which, of course, I did not. He then said that he had the answer and that it would constitute an important part of his forthcoming paper on the characteristics of the solid state. He pointed out that the only way to reconcile the two theories was to assume that, in the case of the hydrated salt, molecules left or entered the crystal surface only *at the boundary* between the two phases—in other words, the water molecules on an undisturbed surface of hydrate were relatively stable, and likewise water molecules which struck a completely dehydrated surface were not able to stay, but at the boundary between the two phases, the forces were closely in balance, and the vapor pressure was that required to substantially equalize the number of molecules entering and leaving the boundary; at slightly higher vapor pressures, the water molecules would leave until it was all dehydrated and vice versa.[7]

[7] Wilson, "Autobiographical Statement," p. 1.

Wilson remained at MIT in 1916, serving as research associate in the Research Laboratory of Applied Chemistry under William H. Walker. In 1917 he became consulting chemical engineer for the Bureau of Mines in Washington, DC. In World War I, he served as captain and then major, at age twenty-five, of the Chemical Warfare Service. He and Dr. James B. Conant were the youngest majors in the service. Wilson directed the CWS research division. He made a number of important contributions to the creation of more efficient gas absorbents of various types, including soda limes, impregnated charcoals, and the like, for gas masks. In 1919 Wilson returned to MIT as director of the Research Laboratory of Applied Chemistry and associate professor of chemical engineering. From 1919 to 1922 he was also associated with Arthur D. Little, Incorporated.

During his early years at MIT Wilson published outstanding papers on the mechanism of corrosion of iron, the mechanism of lubrication, and the flow of fluids through pipelines, "all of which tended to bring order out of rather chaotic subjects," as he put it. He also developed accurate methods of measuring the effective volatility of motor fuels.

THE TRANSITION TO INDUSTRY

Wilson moved from the MIT campus to industry in 1922. He brought with him the insight into the problems of business he had developed as he helped MIT set the pattern of cooperation with industry, working with such university clients as Vacuum Oil Company, US Steel, Standard Oil (New Jersey), General Motors, Goodyear, Pittsburgh Plate Glass, and others. To leave a job he liked, with an income of $10,000 a year, he set his price high, at $14,000, when he was invited to join Standard Oil Company (Indiana) in the position of assistant director of research in the company's laboratory near Chicago. That seemed too high a salary for a young man of twenty-nine, in the estimation of Standard's chairman, Robert W. Stewart. Stewart balked at the figure—until he talked with the young man. That convinced him, and Wilson was hired at his own figure. He remained with the company for thirty-six years.

In the field of oil refining, Wilson developed many new methods of reducing evaporation losses in storage, improvements in cracking, and the coking of residual fuels by what is known as the "delayed coking process." He also contributed substantially to the assembly of fundamental data concerning the properties of petroleum hydrocarbons, the solvent extraction of lubricating oils, and the use of propane as a refining agent for the separation of wax or, under other conditions, the separation of asphalt from the heavier fractions of petroleum.

Dr. Wilson, as he was commonly addressed both within and outside the company, continuously showed his mettle as he progressed in the corporation. From his beginning position in Standard Oil, he advanced to director of research and head of the Development and Patent Department and then to membership on the Board of Directors. He moved into broad management responsibilities in 1934 when he became vice chairman and later president of a principal subsidiary, Pan American Petroleum and Transport Company, with headquarters in New York City. PAPTCO functions were later transferred to Standard Oil's American Oil Company (now Amoco Oil Company).

When the time came for Standard to replace its top management in 1945, it looked to Dr. Wilson and A. W. Peake, whose company experience had been in crude oil and natural gas exploration and production. Under a relatively new team-management concept, Dr. Wilson was elected chairman of the Board of Directors and chief executive officer, with direct responsibility for all staff departments, and Mr. Peake was elected president in charge of operations. When Dr. Wilson retired from company service thirteen years later, the company, one of the ten largest corporations in the United States, had doubled its net worth.

GOVERNMENT SERVICE

In 1940, while president of Pan American, Wilson was placed in charge of the Natural Gas and Petroleum Section of the National Defense Advisory Commission. Working three days a week as a dollar-a-year man, he served as technical adviser to the government on oil-industry matters and stimulated manufacture of 100-octane gasoline and synthetic rubber. In 1940 and 1941 he served as consultant to the Petroleum Unit of the Office of Production Management, where he fostered close relationships between the Army and Navy and the petroleum industry and helped establish petroleum product specifications. In 1942 he served on four committees of the Petroleum Industry War Council, composed of seventy-eight oil company executives. In 1945, at the request of the U.S. Treasury, he served as one of the four managing directors of the General Aniline and Film Corporation, a German company seized at the end of the war.

Before his retirement from the petroleum industry, Wilson prepared for his second career by accepting an appointment from President Eisenhower in 1956 as a member of the nine-man General Advisory Committee of the U.S. Atomic Energy Commission.

Wilson served so effectively on this advisory committee that in 1960 President Eisenhower named him one of the five commissioners of the U.S. Atomic Energy Commission. As a commissioner, he led the successful effort to amend the Atomic Energy Act to permit private ownership of special (fissile) nuclear material, and he stimulated expansion of U.S.

nuclear generating capacity. He was interested in the use of nuclear power as an instrument of national policy and as an economic benefit to the United States in foreign trade. He formulated U.S. policy in cooperating with friendly nations to develop nuclear power and to provide an assured source of enriched uranium with safeguards to prevent its diversion for military uses. Wilson strongly supported development of the centrifuge method for enriching uranium, because of its reduced power consumption compared with gaseous diffusion. He differed with the Commission's decision to delay development of the centrifuge because of its capability to produce weapon-grade uranium-235. He stated very strongly that one could not legislate against technical progress; he believed that one should utilize new developments and solve the political problems associated with them. If Wilson's advice had been followed, the United States might not have lost its world leadership in supplying enriched uranium.

Wilson resigned from the Commission on February 1, 1964 because of failing health. He received a personal letter from President Johnson that read, in part:

> Your outstanding performance as a commissioner and the high esteem and respect with which you are regarded by your fellow commissioners as a scientist, a businessman, and a public servant must be a source of great satisfaction to you as your years of public service come to an end.
>
> As a result of your foresight and determination, we have a stronger and more self-reliant private atomic energy industry today.
>
> I join all of your friends and a grateful nation in thanking you for your years of fruitful and beneficial service.

Chairman Glenn T. Seaborg of the Atomic Energy Commission stated: "The entire atomic energy program will miss Dr. Wilson's services. He brought to the Commission not only an extensive technical background, but a broad experience in business and finance."

Later in 1964 Dr. Wilson contributed further to the national atomic energy program by serving as an official adviser to the U.S. delegation to the Third United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland. There his career as a scientist, engineer, and public servant was cut short by a stroke. He died in the Geneva Cantonal Hospital on September 1, 1964. At that time Glenn Seaborg said: "Dr. Wilson's wide experience and wisdom, imparted with vigor and generous spirit, greatly enriched the development of atomic energy in the United States and in the world."

THE PUBLIC AND PRIVATE MAN

Although for many years he held senior industrial executive positions, Wilson was recognized as one of the eminent chemical engineers in the United States. He was awarded the Chemical Industry Medal in 1939, the Perkin Medal in 1943, the Lord Cadman Memorial Medal in 1951, the Northwestern University Centennial Award in 1951, and the Washington Award in 1956.

Dr. Wilson maintained his participation in professional organizations through the years. He was chairman of both the Division of Physical Chemistry and the Division of Industrial and Engineering Chemistry of the American Chemical Society, certainly an unusual combination. He also served as a director of the American Chemical Society and of the Society of Automotive Engineers.

All his life he was never far from the concerns of formal education. He was a life member of the Corporation of Massachusetts Institute of Technology, a trustee of the University of Chicago, and chairman of the board of The College of Wooster (Ohio). Moreover, his deep interest in the future of education led him to establish, in 1952, a philanthropic foundation financially supported by Standard Oil (Indiana) and dedicated to the aid of educational and other public institutions. It is now named Amoco Foundation.

Both as a scientist and as a businessman, Dr. Wilson felt a strong need to communicate his views. In addition to his technical writings, he wrote scores of articles for a wide range of publications, including the *Saturday Evening Post* (1953), appeared on radio and television programs, and delivered more than five hundred public addresses; he had to turn away requests for fully a thousand more. His subjects ranged from atomic energy to religion, and his convictions were strong. He used to joke, "Among businessmen I pose as a scientist; among scientists, as a businessman."[8] Among churchmen he spoke for both business and science: "Most scientists, as they learn more about the wonders of nature, grow in respect for the Creator, many of whose wonders they are barely beginning to understand, let alone duplicate."[9] In his speeches, Dr. Wilson often compressed man's five hundred thousand years of development into fifty years, in order to illustrate recent progress. In this time scale, man had his first printing press only two weeks ago—and only within the last day did he have radio, television, rayon, nylon, sulfa drugs, and 100-octane gasoline. In 1956 the Illinois Society of Certified Public Accountants bestowed its first annual Public Information Award on Dr. Wilson.

Dr. Wilson was a teetotaler and also refrained from the use of tobacco, but he enjoyed candy and desserts. Once at a dinner with business associates, he was teasingly asked whether he was aware that there was some alcohol in the cherries jubilee he was relishing at the end of the repast. He instantly responded, the story goes, that it was quite all right if one took it with a spoon.

[8] "Robert E. Wilson Retires," p. 6.
[9] *Ibid.*

His competitive nature was demonstrated in his fondness for golf (he played in the low 80s for years) and his dedication to playing bridge. His concentration in golf was so intense that at times when he had the honor he would drive and then immediately stride off in pursuit of the ball, momentarily forgetting that three others remained to tee off. During the years that he donated a silver cup as a prize for low gross in American Chemical Society golf tournaments, he was always one of the strong contenders; he won it once.

Dr. Wilson's name is memorialized in the Robert E. Wilson Award, which is presented for outstanding chemical engineering contributions and achievements in the nuclear industry. The award has been sponsored annually, beginning in 1967, by the Nuclear Engineering Division of the American Institute of Chemical Engineers.

HONORS AND DISTINCTIONS

HONORARY DEGREES

1931	Sc.D., The College of Wooster (Ohio)
1940	Eng.D., Polytechnic Institute of Brooklyn
1941	LL.D., Colby College
1947	LL.D., Northwestern University
1948	L.H.D., University of Tulsa
1952	LL.D., Lake Forest College
1953	LL.D., William Jewel College
1953	LL.D., Hamline University
1954	H.H.D., Bradley University
1955	LL.D., University of Akron
1955	L.H.D., Shurtleff College
1955	H.H.D., Parsons College
1955	Sc.D., Drexel Institute of Technology
1957	LL.D., Washington University
1957	LL.D., Huron College
1958	LL.D., Colorado College
1961	LL.D., American University
1963	Sc.D., Geneva College (Beaver Falls, Pennsylvania)

ACADEMIC POSITIONS

1916–1917	Research Associate, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology
1919–1922	Director, Research Laboratory of Applied Chemistry, and Associate Professor of Chemical Engineering, MIT

MILITARY SERVICE

1918–1919	Captain and Major, Directing Research Division, Chemical Warfare Service

GOVERNMENTAL POSITIONS

1917–1918	Consulting Chemical Engineer, Bureau of Mines
1940	Natural Gas and Petroleum Section, National Defense Advisory Commission
1940–1941	Consultant, Petroleum Unit, Office of Production Management

1942	Support committees, Petroleum Industry War Council
1956	Member, General Advisory Committee, U.S. Atomic Energy Commission
1960–1964	Commissioner, Atomic Energy Commission
1964	Official Advisor, U.S. Delegation, Third U.N. Conference on Peaceful Uses of Atomic Energy

AWARDS AND HONORS

1939	Chemical Industry Medal
1943	Perkin Medal, Society of Chemical Industry
1951	Lord Cadman Memorial Medal, British Institute of Petroleum
1951	Northwestern University Centennial Award
1951	Pennsylvania Ambassador Award, Pennsylvania State Chamber of Commerce
1956	Washington Award, Western Society of Engineers
1956	Public Information Award, Illinois Society of Certified Public Accountants
1964	Award to Executives, American Society for Testing and Materials

MEMBERSHIPS IN LEARNED SOCIETIES

Alpha Chi Sigma
American Chemical Society
American Institute of Chemical Engineers
American Nuclear Society
American Philosophical Society
American Society for Testing and Materials
Delta Sigma Rho
The Indiana Society of Chicago
National Academy of Sciences
Newcomen Society in North America
Phi Beta Kappa
Royal Society of Arts, London
25-Year Club of the Petroleum Industry

BIBLIOGRAPHY

1919

With A. B. Lamb and G. L. Wendt. Portable electric filter for smokes and bacteria. Trans. Am. Electrochem. Soc., 35:357.

With H. G. Horsch. Electrolytic process for the production of sodium permanganate from ferro manganese. Trans. Am. Electrochem. Soc., 35:371.

With A. B. Lamb and N. K. Channey. Gas mask absorbents. J. Ind. Eng. Chem., 11:420–38.

1920

Note on the absorption of nitrogen and oxygen by charcoal. Phys. Rev., 16:8–16.

Soda lime as an absorbent for industrial purposes. J. Ind. Eng. Chem., 12:1000–1007.

1921

Humidity control by means of sulfuric acid solutions with critical compilation of vapor pressure data. J. Ind. Eng. Chem., 13:326.

Determination of the dew point of gasoline. J. Soc. Automot. Eng., 9:265–68.

Some new methods of determination of vapor pressure of salt-hydrates. J. Am. Chem. Soc., 43:704–25.

With D. P. Barnard. The total sensible heats of motor fuels and their mixtures with air. J. Ind. Eng. Chem., 13:912–15.

With D. P. Barnard. Condensation temperature of gasoline- and kerosene-air mixtures. J. Ind. Eng. Chem., 13:906–12. Also in: Mass. Inst. Technol. Bull. 36.

1922

With D. P. Barnard. The mechanism of lubrication—New methods of measuring the property of oiliness. J. Soc. Automot. Eng., 11:49. Also in: J. Ind. Eng. Chem., 14:682; Mass. Inst. Technol. Bull. 47.

Moisture absorbing efficiency of carbon dioxide absorbents for metabolism apparatus. Boston Med. Surg. J., 187:133–35.

Measuring the true volatility of motor fuel. J. Soc. Automot. Eng., 10:6, 17–20.

With E. W. Fuller and M. O. Schur. Acceleration of the hydrolysis of mustard gas by alkaline colloidal solutions. J. Am. Chem. Soc., 44:2762–82.

With Tyler Fuwa. Humidity equilibria of various common substances. J. Ind. Eng. Chem., 14:913.

With L. W. Parsons. A new method of color measurement for oils. J. Ind. Eng. Chem., 14:269–78. Also in: Mass. Inst. Technol. Bull. 43.

With E. W. Fuller and M. O. Schur. Solubility and specific rates of hydrolysis of mustard gas in water. J. Am. Chem. Soc., 44: 2867–78.

With E. W. Fuller. Reactions of phosgene with benzene and m-xylene in the presence of aluminum chloride. J. Ind. Eng. Chem., 14:406–9.

With W. H. McAdams and M. Soltzer. The flow of liquids through commercial pipelines. J. Ind. Eng. Chem. 14:105 (correction: J. Ind. Eng. Chem., 14:462).

With D. P. Barnard. Lubrication. Eng. News, 3:105.

With W. H. McAdams. Flow of liquids through commercial pipelines. Eng. News-Rec., 89:690. Also in: Mass. Inst. Technol. Bull. 19.

With F. P. Hall. Measurement of the plasticity of clay slips. Ind. Eng. Chem., 14:1120–25. Also in: Am. Ceram. Soc. J., 5:916.

1923

With W. G. Horsch and M. A. Youtz. Electrolytic production of sodium and potassium permanganate from ferro manganese. J. Ind. Eng. Chem., 13:763–69.

With others. Report on grease. Am. Soc. Test. Mater. Proc., 23: 349–51.

With F. R. Baxter. The measurement of consistency with particular application to greases and petrolatum. Am. Soc. Test. Mater. Proc., 23:453–55.

The marketing of tetraethyl lead as an antiknock compound in gasoline. Chem. Bull., 10:283–84.

With W. B. Ross. Control of the gelling point of glue. Ind. Eng. Chem., 15:367–70.

With D. P. Barnard. Further data on effective volatility of motor fuels. J. Soc. Automot. Eng., 12:287–92.

With D. P. Barnard. Lubrication. Mass. Inst. Technol. Tech. Eng. (January):204–20.

Mechanism of corrosion of iron. Ind. Eng. Chem., 15:427.

The mechanism of the corrosion of iron and steel in natural waters and the calculation of specific rates of corrosion. Ind. Eng. Chem., 15:127–33. Also in: Mass. Inst. Technol. Bull. 64.

With M. A. Youtz. The importance of diffusion in organic electrochemistry. J. Ind. Chem., 15:603. Also in: Mass. Inst. Technol. Bull. 62.

With Edward P. Wylde. The vapor pressure of volatile solvents. Ind. Eng. Chem., 15:801–9.

With E. D. Ries. Surface films as plastic solids. Colloid Symp. Monogr., 1923:145–73.

With C. A. Hasslacher and E. Masterson. The removal of small amounts of carbon monoxide from gases by passage through heated granular soda lime. Ind. Eng. Chem., 15:698–701. Also in: Mass. Inst. Technol. Chem. Eng. Bull. 65.

With H. S. Davis. Measurement of the relative absorption efficiencies of gas-absorbent oils. Ind. Eng. Chem., 15:947–50. Also in: Mass. Inst. Technol. Bull. 71.

1924

With W. H. Bahlke. Physical properties of paraffin hydrocarbons. Ind. Eng. Chem., 16:115–22.

With R. E. Wilkin. Use of koehler safety lamp in testing tanks for combustible gases or vapors. Ind. Eng. Chem., 16:1154.

With R. E. Wilkin. The solvent-index of refraction method of determining oil in wax. Ind. Eng. Chem., 16:9–12.

With A. R. Fortsch. The viscosity of oils at high temperatures. Ind. Eng. Chem., 16:789–92.

With W. H. Bahlke. A boiling point correction chart for normal liquids. Ind. Eng. Chem., 16:1131–32.

1925

With W. H. Bahlke. Temperature of vapor above boiling salt solutions. Chem. Metall. Eng., 32:327–29.

With D. P. Barnard. Dew points of gasoline-air mixtures. Ind. Eng. Chem., 17:428–29.

With M. V. Atwell, E. P. Brown, and G. W. Chenicek. Prevention of evaporation losses from gasoline storage tanks. Ind. Eng. Chem., 17:1030.

With W. H. Bahlke. Special corrosion problems in oil refining. Ind. Eng. Chem., 17:355–58.

With A. R. Fortsch. Measurement of absolute viscosity of light distillates with the Saybolt thermo-viscometer. Ind. Eng. Chem., 17:291–94.

1926

With R. E. Wilkin. A suggested remedy for crankcase-oil dilution. J. Soc. Automot. Eng., 18:163.

"Introduction" (speech before joint meeting, divisions of industrial and engineering chemistry and petroleum chemistry, seventy-first meeting of the American Chemical Society, Tulsa, Oklahoma). Ind. Eng. Chem., 18(5):452.

With R. E. Wilkin. Principles underlying the use of equilibrium oils for automotive engines. Ind. Eng. Chem., 18:486–90.

With H. G. Schnetzler. Effect of pressure and temperature on total volume of partially vaporized mid-continent crude. Ind. Eng. Chem., 18:523.

1927

With others. Measurement of antiknock value of gasoline, discussion. Am. Pet. Inst., 8(6):187–202. Also in: Chem. Abstr. 1542.

With others. Paint as a protective coating (in the oil industry), discussion. Am. Pet. Inst., 8(6):367–70. Also in: Chem. Abstr. 1543.

With others. Corrosion, an economical refinery problem, discussion. Am. Pet. Inst., 8(6):370–83.

1928

With D. P. Barnard. The significance of various tests applied to motor oils. Am. Soc. Test. Mat. Proc., 28(2):674–85.

Fifteen years of the Burton process. Ind. Eng. Chem., 20:1099–1101.

1929

Dew point of gasoline-air mixture is defined. Natl. Pet. News, 21(31):70.

Corrosion of underground steel structures and its prevention. J. West. Soc. Eng., 34:578–95.

1930

Significance of tests for motor fuels. J. Soc. Automot. Eng., 27(1): 33–42. Also in: Oil Gas. J., 29(9):40, 98, 100; (10):38, 127–28.

1931

Possibilities of low grade motor fuels overestimated. J. Soc. Automot. Eng., 28:1, 93.

What is octane number? Pet. Age, 25:10, 32.

1933

The science of motor oil. Radio Talk, November 8, 1933, sponsored by Science Service.

1934

With P. C. Keith, Jr. Recent developments in propane technique. Proc. 15th Ann. Meeting Am. Petroleum Inst., III:15, 106–19.

With D. P. Barnard. Chemical hay for mechanical horses (presented at SAE Tractor and Industrial Power Equipment Meeting, Milwaukee, April 18-19). J. Soc. Automot. Eng., 35:4, 359.

With P. C. Keith, Jr. Economic aspects of solvent refining of lubricating oils. Refiner Nat. Gas. Manuf., 13:252–58. Also in: Oil Gas J. (July 19):14; Proc. A.P.I. 4th Mid-Year Meeting 38 (May 22–24).

With P. C. Keith, Jr. Solvent extraction costs lower on midcontinent lubes than conventional processes. Natl. Pet. News, 26:20D.

1936

With P. C. Keith, Jr., and R. E. Haylett. The use of liquid propane in dewaxing, deasphalting and refining heavy oils. Ind. Eng. Chem., 28:9, 1065. Also in: Trans. Am. Inst. Chem. Eng., 32: 364–406; Chem. Eng. Congr. World Power Conf. (Advance Proof), No. F8, 3:348–90.

1939

Refinery gas: A raw material of growing importance (Society of Chemical Industry 1939 Medal Address). Chem. Ind. (London), 58:51, 1095.

1943

Research and patents. Ind. Eng. Chem. News, 35:177–85.

1944

Liquid fuel from nonpetroleum sources. Ind. Eng. Chem. News, 22:1244–50.

1945

The challenge of the future to the Chicago Section. Chem. Bull., 32(10):434–36.

1946

The petroleum industry's real reserve, technology. Min. Mag., 36: 187–91, 200. Also in: Chem. Abstr. 55497.

The CFR—A twenty-five-year bond between two great industries. N.Y. Coord. Res. Council. (Sept. 18).

1947

Incentives for research. Tech. Rev., 49:217–19, 232, 234, 236, 238.

1948

With J. K. Roberts. Petroleum and natural gas; uses and possible replacements. Seventy-five years of progress in the mineral industry 1871–1946. Am. Inst. Min. Metall. Engrs.: 722–44. Also in: Chem. Abstr. 6708–9.

Early recollections of Tom (Midgley) and Ethyl (anti-knock gasoline.) Ethyl News (anniversary issue):11–14. Also in: Chem. Abstr. 21461.

Supplying the Midwest with petroleum products. J. Soc. Automot. Eng., 56(7):18–20.

1949

The attitude of management toward research. Chem. Eng. News, 27:274–77. Also in: Chem. Abstr. 3117e.

API wildcatting in some interesting areas. Proc. Am. Pet. Inst., 29(1): 15–23.

1951

Liquid fuels for the future. World Popul. Future Res., 212–28. Also in: Chem. Abstr. 7253h.

Process in petroleum technology. Adv. Chem., ser. 5:1–2.

1952

The petroleum industry. In: *Industrial Science, Present and Future,* pp. 13–26. Washington, D.C.: American Association for the Advancement of Science. Also in: Chem. Abstr. 11509b.

Competitive and cooperative research in the American petroleum industry (Third Cadman Memorial Lecture). J. Inst. Pet., 37: 407–24. Also in: Chem. Abstr. 713.

1953

We, the accused. Sat. Eve. Post, 24 Jan.

1955

Maintaining the pace of scientific development. Chem. Eng. News, 33:1664–69. Also in: Chem. Abstr. 7302.

PATENTS

1918

1,330,032. Manufacture of permanganate. (Filed 2/27/18; issued 2/3/20.)

1,453,562. With L. W. Parsons and S. L. Chisholm. Manufacture of permanganate. (Filed 9/27/18; issued 5/1/23.)

1,335,949. With C. P. McNeil. Soda-lime–slow setting cement composition for use an an absorbent. (Filed 10/2/18; issued 4/6/20.)

1,360,700. With W. G. Horsch. Electrolytic production of permanganate. (Filed 11/28/18; issued 11/30/20.)

1919

1,393,474. Lead arsenate powder protected by colloids. (Filed 3/1/19; issued 10/11/21.)

1920

1,540,445. Ferric hydroxide gel absorbent. (Filed 1/28/20; issued 6/2/25.)

1,496,757. With W. K. Lewis and C. S. Venable. Separation of gases by diffusion—use of sweet gas—multistage. (Filed 7/26/20; issued 6/3/24.)

1,433,732. With W. K. Lewis. Production of "Smoke Screens" by interaction of two or more dilute streams. (Filed 11/10/20; issued 10/31/22.)

1921

1,519,470. With J. C. Whetzel. Carbon impregnation (gas masks) with metallic copper, etc. (Filed 1/22/21; issued 12/15/24.)

1,494,090. Countercurrent extraction of solids and pastes. (Filed 10/8/21; issued 5/23/24.)

1922

1,540,448. Highly porous metal (iron) by reduction of porous metallic oxide gels. (Filed 3/10/22; issued 6/2/25.)

1,791,020. True temperature measuring device for use on gases in presence of much radiant heat. (Filed 5/5/22; issued 2/3/31.)

1,603,568. Continuous process removing volatile fluids from solids —using solid absorbents. (Filed 6/1/22; issued 10/19/26.)

1,544,115. With L. W. Parsons and S. L. Chisholm. Permanganate manufacture. (Filed 7/17/22; issued 6/30/25.)

1,592,480. With L. W. Parsons and S. L. Chisholm. Alkali earth permanganate manufacture. (Filed 7/17/22; issued 7/13/26.)

1,471,765. Evaporation to recover solids from solutions and dispersions—spray—internal heat. (Filed 7/18/22; issued 10/23/23.)

1,719,350. Antisolvent dewaxing. Aliphatic alcohols. (Filed 7/18/22; issued 7/2/29.)

1,533,053. Removing volatile fluids from solids by absorption in solids in absence of air. (Filed 7/22/22; issued 4/7/25.)

1923

1,596,385. Balloon assembly construction used to prevent evaporation loss. (Filed 5/4/23; issued 8/17/26.)

1,597,399. Floating roof storage tank construction—folding fabric seal. (Filed 5/4/23; issued 8/24/26.)

1,489,725. Conservation of volatile liquids—solid absorption of condensables. (Filed 6/22/23; issued 4/8/24.)

1,566,943. With E. P. Brown. Fabric impervious to hydrocarbon vapors for conservation balloons. (Filed 6/27/23; issued 12/22/25.)

1,603,888. "Even Money" gasoline dispensing pump. (Filed 7/19/23; issued 10/19/26.)

1,589,025. "Even Money" gasoline dispensing pump. (Filed 11/12/23; issued 6/15/26.)

1,592,587. "Even Money" gasoline dispensing pump. (Filed 12/31/23; issued 7/13/26.)

1924

1,566,944. Single vent tank through solid absorbent bed to reduce evaporation losses. (Filed 1/30/24; issued 12/22/25.)

1,630,044. Rotary kiln for regenerating fuller's earth. Internal heat. Special distributing system for air. (Filed 2/23/24; issued 5/24/27.)

1,589,026. Mechanical-liquid seal for gasoline storage tanks. (Filed 3/24/24; issued 6/15/26.)

1,669,183. Apparatus for preventing evaporation loss. Breather balloon construction. (Filed 3/26/24; issued 5/8/28.)

1,520,493. Regeneration of fuller's earths containing combustible matter. (Filed 5/19/24; issued 12/23/24.)

1,767,196. Vapor outlet for stills—deentrainment. (Filed 5/22/24; issued 6/24/30.)

1,540,446. Aluminum hydroxide gel absorbent. (Filed 7/9/24; issued 6/2/25.)

1,540,447. Gel like copper oxide absorbent. (Filed 7/9/24; issued 6/2/25.)

1,647,424. Evaporation loss prevention—interconnected vapor spaces with collapsible container (balloon). (Filed 10/8/24; issued 11/1/27.)

1,615,407. With F. M. Rogers. Continuous distillation of petroleum-vacuum-pipe still. (Filed 10/11/24; issued 1/25/27.)

1,815,753. Antiknock fluid compositions. Additional component to reduce freezing point. (Filed 11/8/24; issued 7/21/31.)

1,599,108. Bromine manufacture from brines. (Filed 11/24/24; issued 9/7/26.)

1,654,200. With H. V. Atwell. Continuous coking method. Deposit and removal on nickeliferrous metal. (Filed 11/26/24; issued 12/27/27.)

1,676,610. Distillation of oils—stripping residue and recycling stripper vapors through furnace coil. (Filed 12/22/24; issued 7/10/28.)

1925

1,632,259. With W. H. Bahlke. Continuously indicating hydrometer which compensates for variation in temperature. (Filed 1/5/25; issued 6/14/27.)

1,547,141. Prediluted motor oil. (Filed 1/15/25; issued 7/21/25.)

1,731,479. Fractioning column construction—pancake reflux coils, etc. (filed 1/15/25; issued 10/15/29.)

1,716,939. With R. D. Hunneman, W. H. Bahlke, and F. M. Rogers. Bubble tower construction. (Filed 1/31/25; issued 6/11/29.)

1,898,414. Pressure shell pipe still cracking. Segregation of shell into zones. (Filed 3/13/25; issued 2/21/33.)

1,791,209. With R. D. Hunneman. Vacuum-steam distillation. Temp. 675-760°F. Pressure 75 mm. (Filed 4/1/25; issued 2/3/31.)

1,751,182. Vacuum pipe still steam distillation with centrifugal separator. (Filed 4/3/25; issued 3/18/30.)

1,758,590. Superheated steam—vacuum distillation. Nozzle and target. (Filed 4/4/25; issued 5/13/30.)

1,700,392. Automobile radiator cooling fluid. Specific hydrocarbon fraction. (Filed 4/21/25; issued 1/29/29.)

1,712,187. Pressure shell cracking of oils followed by lower pressure tube cracking of residue. (Filed 6/29/25; issued 5/7/29.)

1926

1,924,520. With E. J. Shaeffer, G. W. Watts, and E. P. Brown. Flash distillation of hot pressure tar. (Filed 4/10/26; issued 8/29/33.)

1,825,378. Control valve for use on hot cracked streams. (Filed 5/27/26; issued 9/29/31.)

2,021,471. Cracking—stripping tar with light vapors from cracking. (Filed 10/18/26; issued 11/19/35.)

1,996,091. Cracking—methods of heating oil in furnaces. (Filed 11/1/26; issued 4/2/35.)

1927

1,654,201. With H. V. Atwell. Continuous coking apparatus of U.S. 1,654,200. (Filed 1/21/27; issued 12/27/27.)

1,737,347. "Solid Billet" heat exchanger. (Filed 1/22/27; issued 11/26/29.)

19,701 (Reissue). "Billet" heat exchanger. (Filed 1/22/27; issued 9/10/35.)

1,726,281. With J. E. Moore and C. W. Chenicek. Breather bag construction—method of weighting. (Filed 4/1/27; issued 8/27/29.)

1,778,475. With W. H. Bahlke. Bubble tower—dam construction and location. (Filed 8/6/27; issued 10/14/30.)

1928

1,966,746. Distillation equipment—multicoil pipe still—multiple columns. (Filed 5/16/28; issued 7/17/34.)

1,831,053. Prediluted oil—diluted prior to dewaxing and dewaxed. (Filed 7/2/28; issued 11/10/31.)

1,859,322. Underwater storage of volatile hydrocarbons—submerged open bottom hemispherical tank. (Filed 7/5/28; issued 5/24/32.)

2,090,245. Coking—"Delayed." (Filed 12/31/28; issued 8/17/37.)

1929

1,899,918. Bubble tower construction. (Filed 10/14/29; issued 2/28/33.)

1,841,691. Aeroplane fuel tank breather. Absorbs water and vapors. (Filed 11/29/29; issued 1/19/32.)

1930

1,950,201. Molecular (vacuum) distillation apparatus. (Filed 1/2/30; issued 4/25/33.)

1,906,033. "Molecular" or vacuum surface distillation apparatus. (Filed 1/2/30; issued 4/25/33.)

1,871,937. Furnace construction vertical cylindrical radiant section, refractory target protects superimposed convection section. (Filed 3/28/30; issued 8/16/32.)

1,960,885. Destructive hydrogenation of pressure tar—two coil common reactor chamber. (Filed 5/21/30; issued 5/29/34.)

1,883,211. Method of concentrating caustic soda. Pipe stilling. (Filed 10/20/30; issued 10/18/32.)

1,958,528. Destructive hydrogenation—liquid followed by vapor phase. (Filed 11/28/30; issued 5/15/34.)

1,991,971. Coking. Coking zone superimposed by a fractionating column. (Filed 12/31/30; issued 2/19/35.)

1931

2,123,457. Tree spray—white oil and antioxidant. (Filed 1/16/31; issued 7/12/38.)

2,009,367. Cracking oils—fractionation of products in a series of fractionating towers at successively lower pressure. (Filed 6/1/31; issued 7/23/35.)

2,077,656. Dewaxing—propane and light diluent. (Filed 8/31/31; issued 4/20/37.)

2,004,560. Antioxidant R-amino hydroxy benzene stabilized leaded motor fuel. (Filed 9/18/31; issued 6/11/35.)

2,029,687. Countercurrent liquid—liquid extractor. (Filed 12/18/31; issued 2/4/36.)

1932

1,992,014. With T. H. Rogers. Gasoline plus color-unstable antioxidant plus color stabilizer. Ex alpha naphthol plus tributyl amine. (Filed 1/26/32; issued 2/19/35.)

2,023,110. Color unstable antioxidant in motor fuel stabilized by addition of polyhydroxy benzene compound. (Filed 5/2/32; issued 12/3/35.)

2,026,336. Propane dewaxing—chilling method. (Filed 6/20/32; issued 12/31/35.)

1,907,924. Process for carbureting air with normally gaseous hydrocarbons. (Filed 6/30/32; issued 5/9/33.)

2,096,949. Liquid fractionation propane (deasphalting) pressure tar—increasing bitumen content. (Filed 7/5/32; issued 10/26/37.)

2,096,950. Solvent extraction and dewaxing of lubricating oils—solvent recovery. (Filed 10/6/32; issued 10/26/37.)

2,029,688. Countercurrent liquid—liquid extractor. (Filed 12/3/32; issued 2/4/36.)

1933

2,029,690. Countercurrent liquid–liquid extractor. (Filed 7/10/33; issued 2/4/36.)

1934

2,064,708. Cracking—back flushing pressure relief lines. (Filed 6/30/34; issued 6/30/34.)

2,086,487. With W. H. Bahlke and F. W. Sullivan, Jr. Solvent extraction—deasphalting multiple solvents. (Filed 5/29/34; issued 7/6/37.)

1935

2,090,907. Furnace construction multiple radiant sections with wall tubes, single roof section, single convection section. (Filed 1/26/35; issued 8/24/37.)

2,143,882. With P. C. Keith, Jr., and M. J. Livingston. Propane deresinating of oils. (Filed 8/15/35; issued 1/17/39.)

1937

2,221,708. Heater construction (furnace with several vertical banks of tubes fired from both sides). (Filed 6/16/37; issued 8/13/40.)