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EGER VAUGHAN MURPHREE

1898—1962

A Biographical Memoir by

EDWIN R. GILLILAND

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EGER V. MURPHREE was a pioneer in the introduction of the newly developing chemical engineering science into industry and he was an intellectual and administrative leader in changing petroleum processing from a mechanical to a chemical industry.

Eger Vaughan Murphree was born November 3, 1898, in Bayonne, New Jersey. When he was eight years old his parents moved to Louisville, Kentucky, where he attended Louisville Mayo High School preparatory to enrolling at Kentucky University. At Kentucky he majored in chemistry and mathematics. In addition to his scholastic activities he was active in athletics. He was captain of the football team in 1920, and was rated All-Southern tackle. Following his graduation from Kentucky in 1920 he remained another year for graduate work in chemistry and obtained an M.S. degree in 1921. Combining his interest in science and football, he next accepted a position as physics and mathematics instructor and football coach at Paris High School, Paris, Illinois.

The following year he went to the Massachusetts Institute of Technology and was a Staff Assistant and Research Associate in the Chemical Engineering Department.

This was an exciting time in chemical engineering at M.I.T.

Dr. W. H. Walker had outlined the modern type of chemical engineering education and he had found in Dr. W. K. Lewis a man to develop this program. At the time Murphree arrived in Cambridge, the Chemical Engineering Department was brimming with enthusiasm in the study of the mechanism of the physical and chemical interreactions occurring at the interface separating solids, liquids, and gases. It did not take Lewis long to recognize that Murphree was a man of unusual technical ability and promise. He was thoroughly grounded in physics and chemistry. He had a mastery of mathematics that went far beyond the qualifications of his contemporaries in the field of applied chemistry. He had a well-developed scientific imagination. He combined with all this an unusual sense of the relevant and the practical. Very soon he became an important member of the Department team. At M.I.T. Murphree started to use the rate of solution as a technique in studying the effect of various methods of agitation on interreactions between solids and liquids. Soon, however, his interest was directed to the problems of distillation and recitification, and his work in this field throws a flood of light on the character of his mind.

The quantitative approach to engineering is rarely purely empirical. However, ultimate relationships are almost always extremely complicated. In the field of distillation the methods of the past had assumed that the vapor rising through the liquid on the plate of a rectifying column would come to complete equilibrium. Failure to obtain equilibrium in the column was allowed for by insertion of a correction coefficient, a so-called plate efficiency. In many situations this approximation was satisfactory but in important cases it led to gross confusion. Murphree had this impressed upon him when faced with the engineering problems of the complex reaction in ammonia recovery towers of the Solvay process, involving the three important volatile components, ammonia, carbon dioxide, and water. He recognized that in these multicomponent systems the old approach was worse than sterile, it was misleading. He started new thinking by focusing attention upon what happens progressively to the bubble of vapor as it rises through the liquid on the plate, endeavoring thus to develop a better understanding of factors governing plate efficiency. This approach immediately threw helpful light on what was going on in the column. It is true that it involved more complicated methods of computation but Murphree showed how to handle these. He was the first to study constructively the mechanisms of interractions between vapor and liquid in the process of distillation.

Murphree was a master at hitting a sound balance between the completeness of analysis and the limitations inherit in the computation. In the use of mathematics he combined imagination with practicality. He put his analysis of the distillation system into useful form for other engineers, and the Murphree plate efficiency is the most widely used today in distillation calculations.

Murphree also studied the fundamental problems of turbulence at the interface between a liquid and a solid. This problem had been attacked by Prandtl through the assumption of the existence of a lamilar film at the interface, separating the interface itself from the main body of the fluid moving past it. The Prandtl approach was equivalent to assuming a discontinuity between the surface film and the main liquid body in that it neglected mixing, other than molecular diffusion in the film. Murphree, recognizing the improbability of any such discontinuity, developed a theory of progressive increase in turbulent motion as one moves out into the fluid and proceeded to apply the analysis to a study of the interrelationships of fluid friction and heat transfer. This work was interrupted when he left the Institute for an industrial career. The approach proposed by Murphree is receiving more and more attention because it clearly comes closer to reality than the picture of discrete layers.

Murphree accomplished these major contributions in two years at M.I.T. In 1924 he left to accept a position as Chemical Engineer with the Solvay Process Company, but his major industrial career began in 1930 when he left Solvay to accept a position as Director of a new group being formed by the Standard Oil Company (New Jersey) to develop chemical processes utilizing petroleum material. He progressed rapidly and in 1947 he was elected President of the Standard Oil Development Company.

Murphree's leadership of the research and development work of the Standard Oil Company (New Jersey) led to many important developments, a number of which were of great significance to the country during World War II. Four examples will illustrate the ability of this group under his leadership to take chemical reactions developed in the laboratory to commercial-plant operation in a minimum of time.

When World War II broke out the only American source of toluene was from coal tar, and its availability was seriously limited. Murphree's organization had studied the synthesis of toluene from petroleum constituents, and fortunately a group of plants of associated and affiliated companies had the facilities and the organization to test out the individual steps in commercial equipment. The dramatic story of this pilot plant test, in operations extending from Texas to New Jersey to Louisiana, is matched by that of the construction in a little over a year by a Texas affiliate, the Humble Oil and Refining Company, of a commercial plant which in the first year of American participation in the war supplied two thirds of the toluene used in explosives.

The initiation of the synthetic rubber program required large supplies of butadiene. Its initial production from alcohol saved the day in the early stages of the program, but it was clear from the start that this monomer must ultimately come from petroleum. Murphree's organization had developed in the laboratory a new catalyst and a new technique of operating control for butadiene synthesis by the dehydrogenation of butenes. From the data available he reached the conclusion that in view of the crisis it was justifiable to bypass the usual pilot plant stages of development. He convinced not only his organization but the Rubber Director's Office and the staff of other companies as well. The successful completion and operation of fourteen plants proved his technical judgment right.

A similar situation arose in the development of butyl rubber, so promising for inner tubes because of its low permeability to air. The process had been developed in the laboratories of the Standard Oil Company (New Jersey) and Murphree decided that the process was technically sound and that a short circuiting of the development stages was justified. The plants were built and successfully operated.

The development by the Standard Oil Company of the fluid catalyst technique for the cracking of oil made a major contribution to the war effort. To obtain high performance from the reciprocating engines used in the airplanes during the war it was necessary to have high octane gasoline that could be made satisfactorily only with catalytic cracking. Murphree's organization developed a continuous process for the reaction by the fluidized solid technique. There were many problems to be solved in going to the tremendous-sized reactors needed. These were chemical reactors much larger than had ever been built for any reaction and they used a catalyst that had to be regenerated every few minutes. There were many engineering obstacles which had to be overcome and Murphree's guidance and judgment were crucial in many stages. The demand for gasoline was so great that the construction of thirty-two fluid catalytic cracking plants was underway before the first commercial plant was in operation, but Murphree had concluded that the process was sound on the basis of small-scale tests and was bold enough to proceed. The successful operation of these plants demonstrated the soundness of his judgment.

In addition to the work he did for the war effort through his organization, he also served as a member of the Office of Scientific Research and Development, S-1 Executive Committee headed by Dr. J. B. Conant. The committee was instrumental in the establishment of the Manhattan project, which developed the atomic bomb. Prior to the organization of that committee, Murphree was chairman of the Planning Board, which was responsible for the technical and engineering aspects of the procurement of materials for the construction of the pilot and full-size production plants. In addition, Murphree was in charge of the design of the heavy water plant in British Columbia and supervised much of the work on the centrifugal method of separating uranium isotopes.

Murphree will be long remembered for the many contributions he made to the development of the process industries, both for specific technical contributions and for his organization of the principles and the methods of attacking the industrial application of laboratory results.

HONORS AND DISTINCTIONS

MEMBERSHIPS

Academy of Political Sciences
American Chemical Society
American Nuclear Society (Charter Member)
American Institute of Chemical Engineers
American Institute of Mining and Metallurgical Engineers
American Institute of Physics
American Petroleum Institute
American Physical Society
Armed Forces Chemical Association
Directors of Industrial Research
Industrial Research Institute
Institute of Petroleum
National Academy of Sciences (1950)
New York Academy of Sciences (Fellow, 1955)
Society of Chemical Industry

SPECIAL SERVICES

Office of Scientific Research & Development, S-1 Section, 1941-1942; S-1 Executive Committee, 1941-1945
Chairman, Planning Board (D.S.M.) Project, 1941-1942
Manhattan District Project, 1942-1945
General Advisory Committee of the Atomic Energy Commission
Atomic Energy Commission Ad Hoc Advisory Committee on Reactor Policies and Programs, 1958-1961
Advisory Panel on Atomic Energy, Office of Assistant Secretary of Defense, 1958
U.S. Chamber of Commerce Committee on Commercial Uses of Atomic Energy, 1960-1961
Army Scientific Advisory Panel on Atomic Energy, Department of the Army
Special Assistant to Secretary of Defense for Guided Missiles, 1956-1957
Finance & Budget Committee, Atomic Industrial Forum
Permanent Council of the World Petroleum Congress, 1949-1962; Chairman, 1951-1959

President of Fifth World Petroleum Congress, 1956-1960

Chairman of U.S. National Committee for Sixth World Petroleum Congress, Inc.

Visiting Committee, Department of Chemistry, Harvard University, 1955-1956

Visiting Committee, Department of Chemistry, Massachusetts Institute of Technology

Kentucky Research Foundation

HONORS

Perkins Medal for work in applied chemistry, American Section of the Society of Chemical Industry, 1950

Industrial Research Institute Award for outstanding accomplishments in the organization and direction of research, 1953

BIBLIOGRAPHY

KEY TO ABBREVIATIONS

Am. Inst. Chem. Engrs. = American Institute of Chemical Engineers
J. Ind. Eng. Chem. = Journal of Industrial and Engineering Chemistry
Oil & Gas J. = Oil and Gas Journal, the Oil Investors' Journal

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1924

With W. K. Lewis. Relation between vapor pressure and vapor composition in binary mixtures of volatile liquids. Journal of the American Chemical Society, 46:1-7.

1925

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1932

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1939

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1940

With E. J. Gohr and C. L. Brown. Hydrogenation of petroleum. J. Ind. Eng. Chem., 32:1203-12.

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1946

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The Standard Oil Development Company. The Register of Phi Lambda Upsilon, 31(3):64-73.

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1947

With E. J. Gohr and A. F. Kaulakis. The fluid-solids technique: applications in the petroleum industry. Journal of the Petroleum Institute, 33:608-20.

Research and development in the oil industry. Chemical Institute of Canada, January 14, 1947.

1948

With A. J. Blackwood and A. C. Patterson. Advances in motor fuel manufacturing processes leading to better fuel economy.

Transactions of the Fuel Economy Conference of the World Power Conference, The Hague, September 2-9, 1947. Paper No. 4, Section C-2.

Natural gas, coal, oil shale as sources of liquid fuels. Oil & Gas J., 46:66, 68-70, 95-96; The Mines Magazine, 38:89-92, 110-11, 114.

Application of the fluid solids technique to producing synthetic liquids fuels. Petroleum Processing, 3:355.

Synthetic fuels. Mining and Metallurgical Society of America, 41: 30.

1949

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UNITED STATES PATENTS

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2,104,401	Solvent Treating Oils and Recovering Solvent
2,113,160	Centrifuge Unloader
2,144,077	Grease and Method of Preparation
2,156,266	Obtaining Oxidation Products from Hydrocarbons
2,165,807	Separation of Mixtures of Liquid and Solid Constituents
2,183,148	Purifying Acetylene Gas and Manufacturing Acetaldehyde Therewith
2,191,675	Solid Lubricant Composition
2,199,837	Catalyst Regeneration
2,227,149	Lubricating Oil for Diesel Engine
2,256,621	Refining Process
2,256,622	Manufacture of Hydrocarbon Products by Hydrogenation of Carbon Oxides
2,311,318	Process for Cracking Oils
2,436,870	Preparation of Chlorine
2,438,456	Hydrocarbon Conversion
2,438,467	Treating Hydrocarbon Fluids
2,446,076	Separation and Purification of Gases
2,451,040	Process and Apparatus for Production of Olefins and Diolefins
2,451,041	Improvements in Aviation Gasoline
2,451,804	Method and Apparatus for Contacting Solids and Gases
2,459,836	Controlling Reaction Temperatures