The functional activities we pick out for attempted intellectual understanding are those related to the immediate hitch we face. This means, then, that although an infinite number of conditional relationships exist, in any concrete scientific pursuit the range of conditional relationships an investigator might pick out as important will be limited, and will be bounded by the nature of the hitch he has encountered. Scientific progress results from the ability to pick out the most relevant conditional relationships for empirical investigation, not by further analysis of established variables alone.

(This is the second of a series of three articles.)

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Frederick Gardner Cottrell: 1877–1948

Farrington Daniels

University of Wisconsin, Madison

FREDERICK GARDNER COTTRELL, who died at the age of 71, was among those fortunate pioneers who live to see many of their dreams for the betterment of mankind come true. As a scientist, engineer, and humanist, he loved to explore new fields of applied science, to uncover new ideas which his associates might explore and test in detail, to encourage experiments, and to foster projects of promising industrial and social value.

Specifically, he made several important contributions which will be long remembered by scientists and engineers. Among them is the Cottrell electrostatic precipitator, known simply as a "Cottrell," for the precipitation of dust and mist. Also of note are his boiling-point apparatus, the Research Corporation which he established, and the chemical applications of pebble-bed furnaces.

He was a vigorous, unselfish, imaginative physical chemist and industrial engineer who acted something the part of a catalyst in bringing together inventors, engineers, scientists, and industrialists to develop new processes. In these repeated endeavors, Dr. Cottrell had no thought of personal gain or prestige, but was intent upon seeing the wheels of progress turn. He lived modestly, indeed frugally, and cared little about his own comfort. Clothes or traveling accommodations were less important to him than a visit with a productive scientist, or a good book. He read widely and was an indefatigable conversationalist. His abiding interest in people revealed itself in his spoken thoughts. His approach to a group of related ideas or to a new industrial application of science emphasized individual scientists even more than the work they had done. One idea led rapidly to another and in turn to still others, usually by association with names and faces that came to his mind. It was this intense interest in men, coupled with a keen knowledge of the facts and implications of his field of work, that enabled him to accomplish so much.

The broad scope of his interests brought him into early contact with the problem of financing research and development work. With income from patents on the Cottrell precipitator he set up the Research

Corporation, which has since given millions of dollars to support scientific research in universities and private institutions. In 1948 alone, over $750,000 was granted by the corporation for this purpose. Dr. Cottrell was instrumental also in establishing the corporation's policy of helping to put into production commercially important inventions "left on the doorstep" of educational institutions. He worked closely with the Wisconsin Alumni Research Foundation and was a director of the research foundations established at Purdue and Stanford Universities to carry out similar services.

Dr. Cottrell's publications and patents date back to 1906 and relate to many subjects, including the electrical separation of suspensions, cryogenic separation of gases, laboratory apparatus, recovery of wastes, and pebble-bed furnaces.

He was the recipient of many honors: the Perkin Medal, the Willard Gibbs Medal of the Chicago Section of the American Chemical Society, the Medal of the Mining and Metallurgical Society, the Washington Award of the Washington Chemical Society, the Holly Medal of the American Society of Mechanical Engineers, and the Medal of the American Institute of Chemists.

Many different societies claimed him as a member: the National Academy of Sciences, the American Philosophical Society, the American Chemical Society, the American Institute of Mining and Metallurgical Engineers, the American Electrochemical Society, the National Institute of Mining Engineers, the Société de Chimie Industrielle, Phi Beta Kappa, Sigma Xi, and Alpha Chi Sigma.

Frederick Gardner Cottrell, the son of Henry and Cynthia L. (Durfee) Cottrell, was born in Oakland, California, on January 10, 1877. He took his bachelor's degree in chemistry 19 years later at the University of California, spent the following year as Le Conte Fellow at the same university, and taught high school in Oakland for three years before departing for Germany for further study. He obtained his Ph.D. at Leipzig in 1902.

Returning to the University of California, he was instructor there from 1902 to 1906 and assistant professor from 1906 to 1911. In 1911 he joined the United States Bureau of Mines, where he was successively chief physical chemist on field duty (1911–14), chief chemist (1914–15), chief metallurgist (1916–19), assistant director (1919–20), and finally director. Half a year later he relinquished his position as director of the Bureau of Mines to accept the chairmanship of the Division of Chemistry and Chemical Technology of the National Research Council. Within another year, however, in 1922, he was called to head the vigorous and comparatively new U. S. Fixed Nitrogen Research Laboratory, where he felt he could better direct research programs without being restricted so much by administrative detail.

He was director of the Nitrogen Research Laboratory until 1927 and after its reorganization in that year remained as chief of the Division of Fertilizer and Fixed Nitrogen Investigation of the Bureau of Soils in the U. S. Department of Agriculture. Leaving this post in 1930, he continued as consultant to the bureau until 1940. Previously, he had received an LL.D. from the University of California in 1927 and had served as consultant to the Smithsonian Institution in 1928–29.

Perhaps Dr. Cottrell's most exciting period of activity occurred between 1935 and 1938, when he was president of Research Associates, Inc., an organization established to carry inventors' ideas into quick development and application.

In 1939 he persuaded the University of Wisconsin to undertake experiments which might lead to the fixation of nitrogen on an industrial scale. The principle employed involved the application of his pebble-bed method to the heating and quick chilling of air.

During World War II Dr. Cottrell's advice was sought on such projects as industrial use of domestic manganese resources, magnesium production, the manufacture of high temperature ceramics, and many others. By frequent trips around the country he kept in touch with the many researches in which he was concerned. Nominally residing in Washington, D. C., during much of his later life, he spent his final years at Palo Alto, California.

On November 15th Dr. Cottrell was enjoying the company of old friends at the meeting of the National Academy of Sciences in Berkeley on the campus of the University of California, for which he had genuine affection. Among the technical papers he heard was a review of the development of the cyclotron, in which he had been particularly interested and which had been started years before with the help of a grant from the Research Corporation. The next morning, on November 16, 1948, his heart stopped while he was attending a scientific meeting. This is the way he probably would have chosen for the ending of his vigorous, unselfish life.