work following with painstaking detail, step by step, the testing and development of ideas—always aiming first at a full understanding of materials and their behavior and with faith that, once these things are really understood, they can be used more advantageously. But let me close with a more general comment.

More significant than the specific discoveries on the programs of research in this laboratory has been the fundamental philosophy of its operation, and this is the great pioneering achievement of the man who directed and guided it from its beginning, Dr. Willis R. Whitney. He had supreme faith in science and in men. He conceived of a great industrial research laboratory, not as a place where mediocre men would carry on routine tests to help production men with their week-to-week problems or as a place to make inventions whose financial value to the company would show in black ink on the cost accountant's books at the end of the year or as a storehouse of industrial secrets. He thought of it as a center for the advancement of knowledge and art in all things pertainng to electricity and for the stimulation of such knowledge and art everywhere for the benefit of mankind. He realized that, in the long run, his company would benefit more from a general advance in knowledge and use of electricity than from the selfish accumulation of a lot of trade secrets. He furthermore had great faith in men; having selected men of brilliant ability and high character and loyalty to the enterprise, he gave them every possible encouragement and support, and protected their freedom to explore the unknown. At the same time, Dr. Whitney saw to it that the laboratory was alert, as opportunity arose, to the possibilities for reducing to practical applications the scientific discoveries which ensued. In all this he was ably aided and abetted by that prince of executive engineers, Larry Hawkins.

These basic policies are now being continued by Dr. Whitney's successor, Dr. Coolidge. They have stood the test of time and have been an inspiration to scientific men everywhere. I can express no greater hope, on this happy occasion, than that they will continue to receive the farsighted support of the officers of this great company.

Some one has remarked that, in every era of history, the stage of civilization has been limited by the tools at man's disposal. Tools and men with ideas—these have been the great contributions to our era from the Research Laboratory of the General Electric Company.

THE RESEARCH LABORATORY OF THE GENERAL ELECTRIC COMPANY

By L. A. HAWKINS

EXECUTIVE ENGINEER, RESEARCH LABORATORY, GENERAL ELECTRIC COMPANY

THE fortieth anniversary of the founding of the Research Laboratory of the General Electric Company was celebrated on December 17, 1940.

Research in General Electric had its beginnings long before 1900. It may be said to have started with the scientific investigations by Professor Elihu Thomson in the 70's of the last century, while he was a teacher in a Philadelphia high school, for those investigations and the developments consequent upon them laid the foundations on which the beginnings of General Electric were built. Thomson continued his scientific studies throughout his long and fruitful life. He was the first great industrial scientist in America. That fact was fittingly recognized at the Research Laboratory's birthday party by the unveiling of a plaque in his memory.

But it was in 1900 that the present Research Laboratory had its small beginnings.

In December of that year a young professor of chemistry from M. I. T., Dr. Willis R. Whitney, came to Schenectady to give half his time to research in the electrical field. The half-time arrangement had been made because Whitney doubted if enough worth-while problems could be found to occupy him fully. He began his work in a barn then used by Dr. C. P. Steinmetz as a laboratory, sharing the services of Steinmetz's single laboratory assistant. Two or three weeks later the barn burned down, and a small building was made available in the Schenectady Works, into which Whitney and his assistant moved. In June, 1901, five M. I. T. graduates were brought to Schenectady, and the growth of the laboratory was begun.

The purpose of the Research Laboratory was made clear in the following extract from the annual report of E. W. Rice, Jr., third vice-president, to President Coffin:

> Although our engineers have always been liberally supplied with every facility for the development of new and original designs and improvement of existing standards, it has been deemed wise during the past year to establish a laboratory to be devoted exclusively to research. It is hoped by this means that many profitable fields may be discovered.

It did not take long for Whitney to perceive that there were more than enough worth-while problems in the company's field to occupy the full time of himself and a growing staff of assistants for a life-time and more, so he severed his connection with M. I. T. and thereafter devoted himself entirely to building up the laboratory which stands to-day as a monument to his life's work.

In 1905, Whitney induced a former colleague of his at M. I. T., Dr. William D. Coolidge, to join him in Schenectady. Coolidge became almost at once Whitney's right-hand man, and in 1908 was made assistant director of the laboratory. When, in 1932, Whitney retired from the directorship to devote himself to his first and dearest love, experiment, Coolidge succeeded him as director, and in 1940 was made vice-president of General Electric Company, as Whitney had been in 1928.

1909 is another milestone in the laboratory's progress. In that year a young instructor at Stevens Institute of Technology, Dr. Irving Langmuir, went to Schenectady to spend his summer vacation in the laboratory. He found so much to interest him there that he stayed on to become later its assistant, and still later its associate director.

The year 1912 brought to the laboratory Dr. Saul Dushman, whose work on high vacuum and on fundamental physical theory is well known, and 1913 brought Dr. Albert W. Hull, the creator of more new types of electron tubes than any other man. Both later became assistant directors of the laboratory.

In its second decade the laboratory was growing rapidly. Its researches were bearing valuable fruit, especially in the lighting field. Whitney's metalized carbon filament, Coolidge's drawn tungsten filament and Langmuir's gas-filled lamp had, step by step, quadrupled the efficiency of the incandescent lamp of 1900. The magnetite arc, another product of the laboratory, alone survived for a time the competition of the new illuminant in street lighting. Improvements in silicon steel were reducing the core loss in distribution transformers. The graphitized brush was eliminating costly delays due to brush failures in heavy duty electrical transportation. Tungsten contacts for automobile ignition were replacing expensive platinum and simultaneously reducing ignition troubles almost to the vanishing point. The first sheathed-wire (later, "Calrod") heating units for electric ranges had been produced. New alloys and new insulations were improving the company's products.

Soon came the Coolidge x-ray tube, transforming x-ray technique from a tricky art to an exact science and greatly extending the scope and utility of x-rays; the radio power tube, the most essential element in radio broadcasting; the Tungar rectifier for battery charging; the screened grid tube for efficient radio frequency amplification, together with the "tron" family—kenotron, pliotron, magnetron, dynatron and thyratron, with their diverse and valuable uses; the atomic hydrogen welding torch, extending the field of electric welding; the copper brazing process in hydrogen, useful in a variety of fabrications; the calorizing process for protecting metals against oxidation at high temperature; the electro-dynamic loud speaker, giving high-fidelity reproduction; glyptal resins in their various forms; the oil-immersed x-ray unit, which made dental radiography safe and much more convenient; carboloy for heavy duty machine tools, the cascade principle of tube design which made possible x-ray tubes for operation on a million volts or more; special alloys, such as fernico for glass metal seals and alnico for permanent magnets; the inductotherm for producing artificial fever in therapy; novel forms of automatic balancing machines; highly sensitive mercury vapor detectors; new insulations such as flamenol for cables and formex for enameled wire; and, most recently, the hermetically sealed, gas-insulated, million-volt x-ray tube and resonance transformer for high-speed industrial radiography.

The foregoing list could be considerably extended, but it is more than long enough to show the variety and importance of the Research Laboratory's contributions to the products of the company and to the development of the electrical art.

To produce such results, naturally much applied research and development work were required, but the primary function of the Research Laboratory—fundamental research—has never been forgotten. Although developmental work and services to other departments on special problems have always demanded a large share of the laboratory's activities, fundamental researches in the physical, chemical and metallurgical phenomena underlying the company's work have been continuously carried on. It is from such researches, broadening and deepening knowledge, that the radically new things come. Some of the most important of the developments listed above had their origin in such researches. The belief that fundamental research is likely to prove, in the long run, most effective in promoting the interests of the company and of the electrical industry has resulted in the encouragement of such research throughout the laboratory's history. That encouragement, and the freedom permitted in the prosecution and publication of fundamental investigations, have often been strongly influential in attracting good men to the laboratory's staff. They have also resulted in enabling the laboratory to make important contributions to the advancement of science. An address by Dr. Karl T. Compton, delivered at the laboratory's recent birthday party and published in this week's issue of SCIENCE, is a gracious acknowledgement of the significance of that aspect of the laboratory's work.

Many medals and other honors have been awarded by scientific societies and other institutions to members of the laboratory's staff. Langmuir, its associate director, was the first industrial scientist in America to receive the greatest prize in the field of science—a Nobel award.

The Research Laboratory, with its 305 employees, of whom 130 constitute its technical staff, is only one of sixteen laboratories maintained by the General Electric Company, but the company's policy is to concentrate in it researches of a fundamental nature. The growth of the other laboratories, particularly the Works Laboratories, of which there is one at each of the larger factories, has facilitated the expansion of fundamental research in the Research Laboratory by relieving it in large measure of much of the developmental and service work it was formerly obliged to do. There is therefore reason to hope that its contributions to science will increase, rather than diminish, in the years to come.

OBITUARY

DAVID HILT TENNENT

QUIET, reserved, modest and intent, D. H. Tennent pursued his consistent life of study and teaching through thirty-six years in the congenial surroundings of Bryn Mawr. Successor there to the position held by such distinguished men as Loeb, Wilson and Morgan, he leaves a profound impression upon the institution which he so long served and upon the many students he taught and inspired. For one year he varied this routine in 1930 by occupying the position of visiting professor at Keio University, and again, at intervals, by going on collecting expeditions to such widely remote places as Australia, Japan and Jamaica. The same interests made him a frequent visitor to the Tortugas Marine Station, of which he was the executive officer from 1937 to 1940, and to Cold Spring Harbor, Beaufort, Pacific Grove, Naples and Woods Hole. Always these trips were made to secure Echinoderm material for his cytological and embryological studies.

Beloved by his friends, honored and respected by his college, he inspired universal esteem among biologists for his extensive, consistent and suggestive work upon fundamental problems of the cell, which continued up to the day of his death. These deal largely with the history of specific chromosomes in cross-fertilized eggs and with the effects of foreign agents upon developing ova, including the photodynamic effects of dyes. Through the years he continued these studies while busy all the time with large teaching and administrative duties. In recognition of his successful combined activities he was honored in 1938 by appointment to the position of research professor, the first instance of this at Bryn Mawr.

Honors came to him also from organizations of scientists, such as election to the National Academy of Sciences, the American Philosophical Society and to the presidency of the American Naturalists and the American Society of Zoologists. He was also a member of Phi Beta Kappa and Sigma Xi. For many years he served on the Board of Trustees of the Marine Biological Laboratory at Woods Hole, where in 1920 to 1922, he had charge of the course in embryology. In all the fields where he labored he will be greatly missed, both for his sound, constructive work and for the inspiration and pleasure of his companionship.

Dr. Tennent was born in Janesville, Wisconsin, on May 28, 1873, and died at Bryn Mawr on January 15, 1941. He married Esther Margaret Maddux on May 8, 1909. In 1900 he received his B.S. degree from Olivet College and in 1904 his Ph.D. degree from Johns Hopkins. For the year 1903 he was acting professor of biology and physics at Randolph-Macon College. Finally, in 1904 he became attached to Bryn Mawr, where he reached the rank of professor in 1912.

C. E. MCCLUNG

RECENT DEATHS

DR. CH. WARDELL STILES, formerly medical zoologist of the Bureau of Animal Industry of the U. S. Department of Agriculture and later of the U. S. Public Health Service, died on January 24. He was seventy-three years old.

DR. LOUIS JOHN GILLESPIE, professor of physicochemical research at the Massachusetts Institute of Technology, died on January 24. He was fifty-four years old.

DR. D. W. MOREHOUSE, from 1900 to 1922 professor of physics and astronomy at Drake University and since that date president of the university, died on January 21 in his sixty-fifth year.

LEWIS BUCKLEY STILLWELL, consulting electrical engineer of Princeton, N. J., died on January 19 in his seventy-eighth year.

WALTER LORING WEBB, consulting engineer of Philadelphia, died on January 24 at the age of seventy-seven years.

DR. FRANK WEISS TRAPHAGEN, consulting chemist and metallurgist, died on January 21. He was seventy-nine years old.

CHARLES WILLIAM LENG, director of the Public Museum of Staten Island, N. Y., died on January 25. He was eighty-one years old.