

## APPENDIX VI

## CHARLES FRANCIS BRUSH\*

CHARLES FRANCIS BRUSH was born March 17, 1849, in Euclid Township, Cuyahoga County, Ohio.

He received his early education in the public schools of Cleveland, Ohio, and graduated from Central High School of that city. He then entering the University of Michigan and was graduated therefrom in 1869 with the degree of mining engineer. From the same University he received the honorary degrees of M.S., in 1899, and Sc.D., in 1912. The honorary degree of Ph.D. was conferred upon him in 1880 by Western Reserve University; and that of LL.D., in 1900, by the same institution, and also, in 1903, by Kenyon College. In 1928 he received the degree of Doctor of Engineering from the Case School of Applied Science.

He was the first successful pioneer in practical electric arc lighting. The electric arc had been discovered two generations earlier, but was a mere scientific curiosity. In 1876 Mr. Brush designed a dynamo in which the armature no longer consisted of a single long coil, but a series of disconnected coils. His new dynamo, the first of the open-coil type, was found to produce a high-tension current eminently adapted to commercial purposes and essential for series arc lighting. It was the opening note of the age of electricity.

Mr. Brush then discovered that excellent carbons could be made from cheap petroleum coke, and that waste heat caused by the electrical resistance of the carbons could be prevented by electroplating with a thin conducting shell of copper. A few weeks later he invented a magnetic control lamp which kept the carbons always the same distance apart. In 1877 he devised the differential regulating winding, making it possible to operate two

\* The following has been compiled mainly from the National Cyclopaedia of American Biography.

or more lamps in series. The latter invention marked the birth, not only of the electric lighting industry, but also of central station distribution, the foundation of modern electrical engineering.

April 18, 1878, his dynamo and arc lamp carried off all honors at the Franklin Institute, of Philadelphia, in competition with existing American and foreign machines.

In 1880 the Brush Electric Company was founded. By 1882 Brush lights, as they were popularly called, had spread throughout America and Europe, and were appearing in Shanghai and Tokio. The civilized world rapidly became familiar with the electric light, and the name of Charles Francis Brush was soon known in every classroom in the world.

He made two other contributions of incalculable importance to the electrical industry. The first was the compound-field dynamo, to produce current of constant voltage, which was the parent of the modern constant potential generator; the second was the fundamental storage-battery. Up to the time of its invention, batteries could not be made effective until they had "built themselves up" by the very slow formation of a thick oxide coating upon the lead plates. Dr. Brush conceived the idea of supplying oxide in the first place, and pressing it into a suitable support. In his famous patent, No. 337,299 of March 2, 1886, was the broad and fundamental claim, "the mechanical application to the electrodes of active material, or material adapted to become active."

His application was filed in 1881, and years of litigation followed before the patent was granted; but its exceedingly broad claim was repeatedly sustained by the courts, and controlled all practical forms of storage battery during the life of the patent.

In 1884 he became interested in the electric furnace, and designed the dynamo and electrodes with which Cowles Brothers produced the first electrolytic aluminum.

In 1891 the Brush Electric Company consolidated with the Thomson-Houston and Edison companies to form the General Electric Company.

Later Dr. Brush became interested in the invention of Dr. Carl Linde for the production of oxygen from liquid air, and in 1905 founded the Linde Air Products Company, of which he was first president. It grew rapidly into a great industry. To avoid the occasional explosion in the rectifiers, he invented a means of filtering the air before it entered the compressors, which excluded not only dust, but most important, the vapor of gasoline and other hydrocarbons. It was not patented and became universally employed.

He discovered in 1895, the presence of the element helium in the earth's atmosphere.

Dr. Brush conducted extensive experiments in the behavior of gases under varying pressures. He found serious errors in the standards previously established.

In 1915 he published his first paper on "Spontaneous Generation of Heat in Recently Hardened Steel," which was followed by others upon the same subject. Further research resulted, in 1918, in the publication of "The Development of Magnetic Susceptibility in Manganese Steel by Prolonged Heat Treatment." In recognition of these contributions to the science of metallurgy he was made an honorary member of the American Society for Steel Treating.

Meanwhile he had carried on painstaking experiments which may cause his name to be linked with gravitation as it is now linked with electric lighting. In December, 1910, he read before the American Association for the Advancement of Science a paper entitled, "A Kinetic Theory of Gravitation," which presented the new postulate that some, and perhaps all, of the vast intrinsic energy of the ether of space exists in the form of isotropic ether waves of excessively short wave-lengths. In 1922 and 1923, with extremely refined apparatus of his own design, he demonstrated that certain kinds of matter, when allowed to fall freely under the influence of gravitation, fell measurably faster than certain other kinds of matter under identical conditions, thus showing that the ratio of mass to weight is not the same for all kinds of matter, as had been supposed hitherto.

In the two following years he demonstrated that some metals and alloys, after being given a certain crystalline structure by carefully applied heat treatment, lost measurably in weight when subjected to great mechanical stress. Repetition of his work, undertaken at Union College, has confirmed, qualitatively, his results.

In 1925, Dr. Brush discovered that certain complex silicates among the basalts, lavas, and clays were generating an appreciable amount of heat not due to radioactivity nor to the adjustment of internal strains. He believed that this hitherto unsuspected phenomenon is due to the absorption, by matter, of the isotropic ether waves postulated in his earlier paper as the cause of gravitation, and that it is sufficient to account for the internal heat of the earth and other planets, and partly that of the sun and stars.

In April, 1929, Dr. Brush presented before the Franklin Institute his last paper on the "Kinetic Theory of Gravitation," further strengthened by independent experiments made by the Bureau of Standards on the spontaneous generation of heat in certain substances. Since his death additional experiments by the Bureau have further confirmed these results qualitatively.

His achievements have received notable marks of recognition from time to time, both in this country and abroad. In 1881 he was decorated by the government of France, a Chevalier of the Legion of Honor, in recognition of his discoveries in electricity. In 1899 the American Academy of Arts and Sciences awarded him the Rumford Medal for "the practical development of electric arc lighting." In 1913 the American Institute of Electrical Engineers awarded him the Edison Medal. In 1928 he was awarded the Franklin Medal by the Franklin Institute, for the pioneer development of the electric arc light, and the invention of the practical storage-battery. In the same year he received the Cleveland Medal for distinguished public service from the Cleveland Chamber of Commerce. In 1929 he was appointed Director of the American Society of the French Legion of Honor.

A GENEALOGY OF

He was a trustee of Western Reserve University, Adelbert College, University School, the Cleveland School of Art; a incorporator of the Case School of Applied Science, and a warden of Trinity Cathedral. He was a life member and former president of the Cleveland Chamber of Commerce.

Dr. Brush was a fellow of the American Association for the Advancement of Science, the American Physical Society, the American Geographical Society, and the North British Academy of Arts; honorary member of the American Society for Steel Treating, life member of the American Association of Mechanical Engineers, and of the British Association; member of the Royal Society of Arts (London), the American Institute of Electrical Engineers, the American Institute of Mining and Metallurgical Engineers, the National Electric Light Association, the Archaeological Institute of America, the American Historical Association, the Franklin Institute of Philadelphia, the American Chemical Society, the American Philosophical Society, the Illuminating Engineering Society and the Delta Kappa Epsilon fraternity.

Early in 1928 he created and endowed The Brush Foundation. (See Appendix VII, page 28.)

He died June 15, 1929.

Married October 6, 1875, Mary E. Morris, born May 20, 1854, died June 25, 1902.

ISSUE

1 Edna Brush, born March 25, 1880, died October 11, 1930. Married, November 14, 1905, to Roger Griswold Perkins.

ISSUE

A Charles Brush Perkins, born March 29, 1907. Married July 18, 1930, Maria Elizabeth Bush.

B Roger Griswold Perkins, born March 17, 1910. Married June 19, 1931, to Georgette Josephine Yerby. Died June 2, 1932.

C Maurice Perkins, born May 21, 1912.

D John Morris Perkins, born October 28, 1914, died March 14, 1927.

2 Helene Brush, born April 27, 1884.

THE BRUSH FAMILY

3 CHARLES FRANCIS BRUSH, JR., born September 20, 1893. Graduated from the University School, Cleveland, June, 1911; from Harvard University, June, 1915; from Massachusetts Institute of Technology, June, 1917. Commissioned as First Lieutenant, Ordnance Officers Reserve Corps, June, 1917; called to service, September, 1917; discharged, January, 1919. He died May 29, 1927.

Married, July 28, 1917, Dorothy Adams Hamilton, born March 14, 1894.

ISSUE

A Jane Hamilton Brush, born July 24, 1920, died May 23, 1927.

B Charles Francis Brush, III, born April 3, 1923.