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FREDERICK ALBERT SAUNDERS

1875—1963

A Biographical Memoir by

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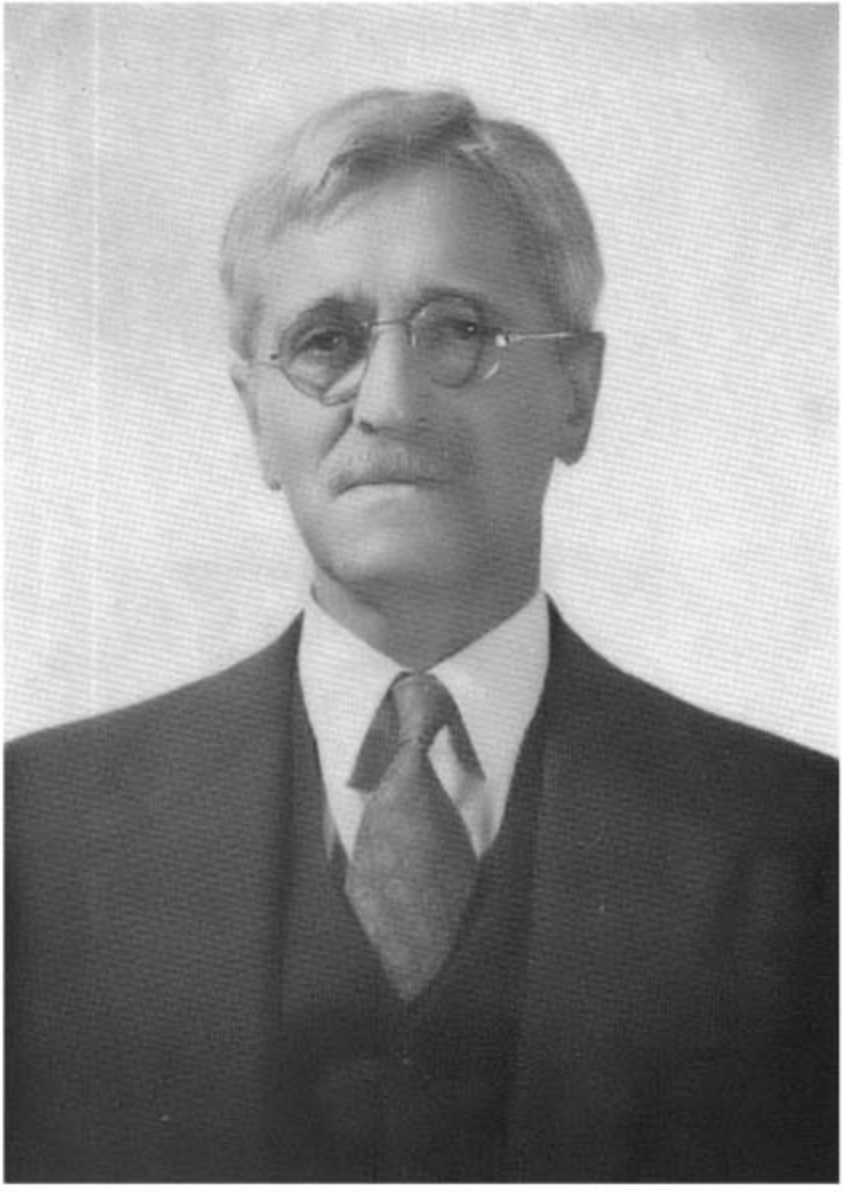

Frederick A. Saunders

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August 18, 1875–June 9, 1963

BY HARRY F. OLSON

FREDERICK ALBERT SAUNDERS was born in London, Ontario, on August 18, 1875. He was educated in London and Ottawa, Canada. He received a Bachelor of Arts degree from Toronto University in 1895 and a Doctor of Philosophy degree from The Johns Hopkins University in 1899.

In 1900 he married Grace A. Elder. Two children were born to this union, namely, Anthony E., who died in 1943, and Margery, now Mrs. John B. Middleton. He married Margaret Tucker in 1925.

His mother, Sarah Agnes Robinson, was born in Macclesfield, England, in 1836 and emigrated to Canada at an early age. His father, William Saunders, was born in Crediton, Devonshire, England, in 1836 and emigrated to Canada when he was thirteen years old. The parents were married at the age of twenty-one and one daughter and five sons[1] were born to this union. Both parents were intensely interested in several branches of science; their enthusiasm was caught by all of their five sons.

William Saunders was apprenticed to a doctor druggist when he was fifteen years old. A few years later he was placed in charge of a drug company and remained in this position until

[1] Elsie Pomeroy, *William Saunders and His Five Sons* (Toronto, Ryerson Press, 1956).

1886. He prospered in this business by application of hard work and an active mind which led him to expand into new fields. In 1886 he left the drug company and became a public analyst. He also lectured on materia medica at the local medical college. On being advised to spend more time out-of-doors on account of his health he bought an apple orchard. As a result of this experience he became interested in plants and insects and made an extensive collection of both. He was instrumental in founding the Entomological Society of Ontario, for which he served as the editor of its journal for several years as well as its president. His book *Insects Injurious to Fruits* was published by Lippincott in 1883. Somewhat later he gave up the orchard but made use of a smaller piece of land where he embarked with his usual vigor into the crossbreeding of small fruits.

As a result of these widening interests and the high reputation won in connection with all of them, he was chosen in 1885 to plan a system of Experimental Farms for Canada and the following year was made Director of the system. The Central Farm was started in 1886 near Ottawa. This was followed by others which were scattered from the Atlantic to the Pacific. In 1887 the family moved to Ottawa on a site upon which now is located the William Saunders Memorial Building. He retired from a specific position in 1911 at the age of seventy-five years. He received many honors including a Doctor of Laws degree and the award of a Companion of the Bath from King Edward VII.

The daughter, Anne Saunders, was the first child born to William and Sarah Saunders. The eldest son, William Edwin, was trained as a druggist and continued in his father's business and interests. He became a well-known ornithologist, botanist, and conservationist. Through him, his younger brothers acquired a lifelong interest in birds.

The second son, Henry S., was also trained as a druggist

but later became an amateur entomologist and botanist. Later still he was a professional musician. He was a lover of the works of Walt Whitman, of which he made a valuable collection. These books were donated to the Brown University Library.

The third son, Charles E., received a Doctor of Philosophy degree in Chemistry from The Johns Hopkins University. He had a short career as a teacher and musician. However, owing to poor health he became a Cerealist for the Experimental Farms of Canada where he could be outdoors a great deal. His habits of careful observation and his scientific training made him most useful to his father in carrying on his program of wheat crosses with the aim of producing good early wheat which could be grown in the Canadian Northwest. One such cross was carefully followed in all its progeny, and in the twelfth generation produced one extra early ear which proved to be stable and was named Marquis wheat. This strain of wheat had a spectacular success, and as a result opened a vast area to wheat cultivation. For this and other important work he was knighted, after his retirement, by King George VI.

The fourth son, Arthur Percy, followed his brother in The Johns Hopkins University and then became Professor of Chemistry and later Dean in Hamilton College, where he remained for over forty years. He was well known as an amateur musician, an artist, and a literary critic. In extracurricular activities he was prominent as a breeder of peonies. He was an active member and served as President of the American Peony Society.

The fifth son, Frederick Albert Saunders, was reared in the preceding interesting scientific and artistic atmosphere. He shared in the music with which the home was filled from his earliest recollection. He took violin lessons as a boy and retained his love of chamber music to his latest years. Other

family pleasures were connected with the use of a 4-inch telescope and a good microscope. As a consequence, the entire family was interested in astronomy and in minute water organisms. In the University of Toronto he left the chemical path trod by his brothers and embarked on the study of physics. He received the Doctor of Philosophy degree from The Johns Hopkins University in 1899, where he worked under Henry A. Rowland, whose interest in gratings and spectra permeated the Physics Laboratory and infected many of his students.

Following his graduate work, Saunders served as instructor in Physics at Haverford College from 1899 to 1901. In the latter year he moved to the University of Syracuse, where he advanced from instructor to Professor in the next thirteen years.

Following some work in the ultrared which resulted in his first paper, he set up a spectrum grating at the University of Syracuse with assistance from the Rumford Committee of the American Academy of Arts and Sciences. With this apparatus he began finding new lines mostly outside of the visible spectra. He studied the differences in the spectra produced by various sources and parts thereof. In this connection, he found it very interesting to extend known series of lines and discover new ones, particularly in the case of elements which were not known to possess any regularities at all. In these investigations he enjoyed the cooperation of A. Fowler, of the Imperial College, England. Fowler's publication, "Report on Series in Line Spectra" (1922), includes the observations of Saunders in great detail up to that date.

In the sabbatical year 1913-1914 he had the privilege of visiting the Cavendish Laboratory, University of Cambridge, England, for a few weeks. During that time, at the request of J. J. Thomson, he tested the spectrum of the gas residue in a tube which had suffered a very long cathode-ray bombardment. The general hope was that something new would appear but

only the familiar elements were found, to the disappointment of everybody connected with the project.

During the winter semester of that same sabbatical year he became the guest of F. Paschen at the University of Tubingen, Germany. At that time Professor Paschen was the most skillful experimenter in the field of spectra. It was during this time that Saunders made a brief excursion into the field of vacuum-grating spectroscopy. One interesting feature was that Paschen himself fabricated the apparatus by blowing the quartz lamps for the project. This example of friendly, skillful, and enthusiastic cooperation and leadership with a group of men from many nations served Saunders for the rest of his life as a model of what a laboratory should be.

He returned from his sabbatical year in the middle of 1914 to begin five years at Vassar College, where adequate resources for new apparatus were made available for research and teaching. The extra work required in establishing new courses occupied most of his time. However, the problems connected with the new courses and the necessary and complementary lecture experiments became increasingly interesting.

The work at Vassar College was interrupted by World War I. He spent the summer of 1917 in Princeton, New Jersey, as a member of a group including Augustus Trowbridge, Karl Compton, and Henry Norris Russell, developing methods of sound ranging.

In 1918 he joined a group in Washington, D.C., under R. A. Millikan in the National Research Council, where he had the title of Spectroscopist to the Bureau of Aircraft Production. Here the task was to measure several interesting optical devices which had been submitted for military use.

After the close of World War I he spent three interesting weeks in the General Electric Research Laboratory in Schenectady, New York, as the guest of Willis Whitney. Here he

attempted to produce metallic barium. The net result was the production of an alloy of barium and tin. Useful spectra of this alloy were photographed.

Following another semester at Vassar he was invited by Theodore Lyman to Harvard University to continue the spectroscopic work of their mutual interest. In addition, he was given the responsibility of a large elementary course left as an orphan by the untimely death of Wallace C. Sabine. Saunders carried the responsibility of the course for twenty-two years. With assistance from many of his colleagues the laboratory experiments were improved and expanded and the laboratory manual was revised twice. Of greater significance is his textbook, *A Survey of Physics for College Students,* which was written in 1930. The textbook was revised several times and is still in use. He also gave courses in optics and acoustics. Saunders was Chairman of the Department of Physics for twelve years. His administration as chairman was smooth-running and efficient. He was characteristically gracious, generous, considerate, and outgoing. He had a way of bolstering the self-confidence of the people with whom he dealt by assuming their competence from the start.

In his early years at Harvard University he used many light sources to produce variations in certain spectra, in particular, of the calcium group. This work was of help in classifying the lines into series and in sorting out the lines due to the normal atom and its once-ionized state. Some puzzling groups resisted classification until he found that they belonged to a series, with limits beyond the normal spectrum. H. N. Russell was intrigued by this problem and as a result the Russell-Saunders team was formed. One of the first results contributed by Russell was the electron coupling scheme. Two joint papers were published in 1925, which led to the solution of more complex spectra. A large number of physicists rushed into this

intriguing field and it was not long before most of the common spectra had been solved. The solution to the more complex ones required more sophisticated equipment. A large part of this latter work was done by G. R. Harrison at the Massachusetts Institute of Technology and many others.

Research work in collaboration with T. Lyman and his students was carried out in the very short waves. The fundamental series of helium investigated by Lyman was the most interesting piece of work during that period. In some cases, spectra, in the visible and the whole range of the ultraviolet, were photographed simultaneously from opposite ends of the same discharge tube, thereby providing the same conditions among the luminous atoms in both ends. This experimental technique assisted in the identification of lines and their classification.

To summarize, the period of Saunders's activity in spectroscopy was the heyday of that subject. The task of organizing a welter of wavelength data into systematic converging series was a challenge to skill and patience which Saunders could not resist. His name became most widely known through a paper written in 1925, in collaboration with Henry Norris Russell, on the interpretation of certain energy levels revealed for the first time by the spectra of the alkaline-earth elements. These levels were shown to give evidence of the interaction of two different excited electrons. Russell and Saunders correctly interpreted this interaction as one in which the primary coupling joins the orbital angular momenta of the individual electrons into a quantized resultant that interacts with the residual spin angular momentum to form a quantized over-all resultant. The step was an important one. Shortly after the publication of this paper, Saunders was elected to the National Academy of Sciences.

Saunders attended the founding of the Acoustical Society

of America in New York in 1929. He had for many years before that acted as a consultant in architectural acoustics. In addition, a middle-grade course in sound was given by him. In the early 1930s Henry S. Shaw, of Boston, Massachusetts, who was equally interested in scientific research and music, asked Saunders if he would be willing to undertake experimental study of the violin family.

As a result of his interest and excellent work in acoustics, he was elected to serve on the Executive Council of the Acoustical Society of America from 1931 to 1935. He was the fifth president of the Society and served during the period 1937 to 1939.

He was made Professor Emeritus at Harvard in 1941. He served as Visiting Lecturer at Mt. Holyoke in 1942 and for several years thereafter. Following World War II he also served as a teacher at Mt. Holyoke so that a younger teacher could be released for defense research. In addition to serving as lecturer and teacher he continued his research in acoustics at Mt. Holyoke. His office and laboratory were located there until his death. He played in the Mt. Holyoke College Orchestra until two years before his death. Recognition of his musical activities took the form of a memorial recital presented by two local musicians on October 11, 1963.

In view of the fact that the solution of atomic spectra had become too complex and time-consuming for him to pursue, he was glad to shift over to more intensive work in the acoustical field, particularly in view of the support by Henry S. Shaw. This new field of research for Saunders proved to be extremely interesting and quite challenging in that it combined acoustics with psychology, chemistry, and botany. In addition, his long experience with stringed instruments was of great value in this work.

Electronics methods were used to measure all the aspects of the mechanical action of violins, which had till then been

almost always estimated by the human ear. A harmonic analyzer was built for this work by H. H. Hall, and over sixty tones of each of some fifty violins were measured, involving some 125 analyses for each violin. The results of this mass of work disclosed the fact that the distribution of strength among the overtones, which is generally considered as determining the quality of the tone, varies greatly all over the range of any violin. The best violins seem to have a characteristic arrangement of the average strength in tonal regions, but the differences in this respect among the best old violins and the best new ones are very slight. Later on, the distribution of tonal loudness was found to be important. The most expensive violins were found to vary greatly among themselves, and experts do not agree as to the merits of any one of them. The mechanical action of the instrument was found to have less to do with its price than the name of its maker and its state of preservation.

Other qualities which were studied included the intensity of each tone, the speed of growth and of decay of tones, and the amount of power required to sustain a continuous tone. Several celebrated violinists (including J. Heifetz) helped in this work by submitting their violins for test or by playing on them before some of his special apparatus.

Most of his research during the period 1937 to 1946 was concerned with measurements on instruments in the violin family except for one brief excursion into the field of wind instruments. Unfortunately, there was very little that could be deduced from the research that would provide the violin maker with data for improving the performance characteristics of the instrument.

However, in 1948 the research took a new turn. Mrs. Morton Hutchins of Montclair, New Jersey, had been interested in the research on violins. As a result, she indicated an interest in the

construction of experimental violins under the guidance of Saunders. She was a skilled worker in metal and wood, a former physics teacher, and an accomplished player of the viola. Prior to the association with Saunders she had constructed two violas. Thus it will be seen that she was admirably equipped to carry on this type of investigation.

Mrs. Hutchins constructed two dozen instruments in the period from 1948 to 1954. Nothing about the viola making was taken for granted without adequate tests to guide the work. Some new ideas of practical importance were developed. In particular, the loudness of the tone was found to depend greatly on the thickness of the top near its outer edge. Also, it was determined that the peaks of loudness in the range of the instrument should be regularly spaced for the best results. Methods of shifting these peaks have been worked out, though the amounts of the shifts are small. The larger ones can be managed but would produce instruments which would not be acceptable to the rather conservative public.

In 1954 the work on Saunders's violins attracted the attention of A. S. Hopping, a retired electronics engineer, and he joined the small dedicated group working on improvements in the violin family. He developed sophisticated electronic apparatus for testing violins during the construction. He also tested the physical properties of woods to determine those most suitable for violin construction. As a result, the latest complete violins and violas are excellent in all respects and have attained a favorable acceptance on a wide scale.

Saunders enjoyed high standing among ornithologists as an expert on bird identification and behavior. He belonged to the Nuttall Ornithological Club of Cambridge, was an enthusiastic member of the Northeastern Bird Banding Association, and for many years was a director of the Massachusetts Audubon Society.

In summary, Frederick Albert Saunders made many fundamental contributions in spectroscopy over a long term of years and during the period of greatest interest in the subject. This was followed by research in various fields of acoustics. He started the research on musical instruments which is now being carried on by others. He was also an inspiring teacher and lecturer, continuing as both through five decades. Besides his teaching and research in physics Saunders had many interests. He was an accomplished musician. He also devoted much time to ornithology, particularly in connection with bird migration.

Saunders was a Fellow of the American Physical Society, the American Association for the Advancement of Science, and the Acoustical Society of America. He was elected a member of the National Academy of Sciences in 1925.

BIBLIOGRAPHY

KEY TO ABBREVIATIONS

Astrophys. J. = Astrophysical Journal
J. Acoust. Soc. Am. = Journal of the Acoustical Society of America
J. Franklin Inst. = Journal of the Franklin Institute
Proc. Nat. Acad. Sci. = Proceedings of the National Academy of Sciences

1901

With C. E. Mendenhall. Spectrum of a black body. Astrophys. J., 13:25.
A new form of radiometer. Astrophys. J., 14:136.

1905

Narrow triplets in the spectra of alkali metals. Astrophys. J., 21:195.

1908

Series in alkali metal spectra. Astrophys. J., 28:71.
Series in the spectrum of barium. Astrophys. J., 28:223.

1910

Series in the spectra of Ca. Sr. and Ba. Astrophys. J., 32:153.

1914

Calcium and magnesium vapor lamps. Astrophys. J., 40:377.

1916

Ultra-violet metallic spectra. Astrophys. J., 43:234.

1920

Series in the spectrum of barium. Astrophys. J., 51:23.
Revision of the series in the spectrum of calcium. Astrophys. J., 52:265.

1922

Revision of the series in the spectrum of strontium. Astrophys. J., 56:73.

1924

Some aspects of modern spectroscopy. Science, 59:47.

1925

With H. N. Russell. Regularities in the spectra of the alkaline earths. Astrophys. J., 61:38.

With H. N. Russell. The spectrum of ionized calcium. Astrophys. J., 62:1.

1926

With T. Lyman. Extreme ultra-violet spectrum of neon. Proc. Nat. Acad. Sci., 12:92.

The spectrum of argon. Proc. Nat. Acad. Sci., 12:556.

1930

A Survey of Physics for College Students (textbook). New York, Henry Holt and Company. x + 635 pp.; revised ed., viii + 679 pp., 1936; 3d ed., 724 pp., 1943.

1934

With E. G. Schneider and Emily Buckingham. The second spectra of strontium and barium. Proc. Nat. Acad. Sci., 20:291.

1937

The mechanical action of violins. J. Acoust. Soc. Am., 9:81.

1940

A scientific search for the secret of Stradivarius. J. Franklin Inst., 229:1.

Studies of the instruments of the Curtis String Quartet. Overtones (Curtis Institute of Music), 10(2):39.

1941

With R. B. Watson and W. J. Cunningham. Improved techniques in the study of violins. J. Acoust. Soc. Am., 12:399.

1946

The mechanical action of instruments of the violin family. J. Acoust. Soc. Am., 17:169.

Analyses of the tones of a few wind instruments. J. Acoust. Soc. Am., 18:395.

1952

With C. M. Hutchins. On improving violins. Violins and Violinists (Chicago), November.

1953

Recent work on violins. J. Acoust. Soc. Am., 25:491.

1956

Comments on the article by R. B. Chatwin on American work on violins. The Strad (London), 67(794):48.

1957

A study of two famous violins. The Strad (London), 68(806):54; 68(807):102.

1958

With C. M. Hutchins and A. S. Hopping. A study of tap-tones The Strad (London), 69(820):120; 69(821):158.

1959

With Frederick V. Hunt. George Washington Pierce, January 11, 1872–August 25, 1956. National Academy of Sciences, *Biographical Memoirs,* 33:351.

1960

Remarks to recent correspondents. The Strad (London), 70(838): 361.

With C. M. Hutchins and A. S. Hopping. Subharmonics and plate tap tones in violin acoustics. J. Acoust. Soc. Am., 32:1943.

1962

Violins old and new—an experimental study. Sound, 1:7.