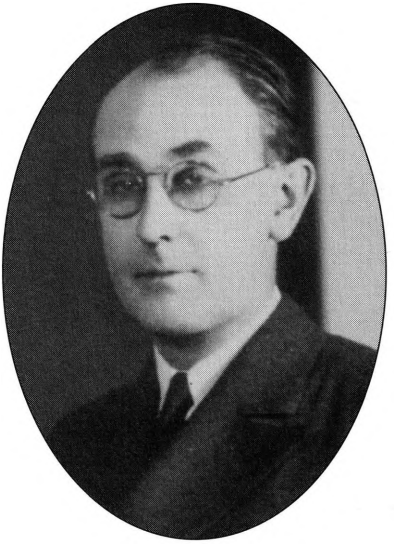
The Sabines at Riverbank



The Sabines at Riverbank

Their Role in the Science of Architectural Acoustics

John W. Kopec

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Contents

This book is dedicated to Don Williams; Riverbank;
the IIT Research Institute; the Sabine family;
the Acoustical Society of America;
and all the past, present, and future individuals
involved in the challenging art and science of
architectural acoustics.

Acknowledgments

Besides the large contingent of Acoustical Society of America members encouraging this book, there were so many contributors that it would require another chapter to acknowledge them all properly. Nonetheless, I must acknowledge a few noteworthy individuals who provided assistance, guidance, advice, and hard work; without their efforts, above and beyond the call, this book would never have come in to being.

From my parent organization, the IIT Research Institute (IITRI), owner of the Riverbank Acoustical Laboratory, I am indebted to Renny Norman, Keith McKee, Owen Viergutz, David Morrison, Arthur Vogt, John English, James Stangel, and Anthony Valentino.

Thanks to IITRI for administrative authorization and support. Riverbank staff members Arline Mundy, Diane (Haase) Perrone, and Karin Dorring contributed untold time and effort. It was Diane who volunteered to translate my Chicagoese and shorten the page-long fragments of my original notes into readable pages of one- or two-line sentences. Later, Karin Dorring came to my rescue to satisfy the many diverse publisher and printer needs.

Special thanks goes to Patrick Parks of St. Charles, Illinois. Besides being a Fox Valley history buff himself, Patrick teaches writing at Elgin Community College. He not only reviewed but also edited the second draft into book-like form, contributing to the literary acceptability of the book.

This book is a tribute to the noble efforts of Pat Parks, Karin Dorring, and Diane Perrone who have been selfless in fulfilling my dream of documenting the Sabine family's contributions in acoustics.

Key book, chapter, and segment reviewers and their respective areas of interest are as follows:

- Leo Beranek (architectural acoustics and Wallace Sabine historian)
- William Cavanaugh (Acoustical Society of America and Sabine Centennial Committee)
- Karin T. Dorring (Riverbank Acoustical Laboratories)
- Marie Frasz (Fabyan Museum curator)
- David M. Hamilton (Publisher's Editor)
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- David L. Lubman (consultants)

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- Cornelia E. Sabine (Paul, Hale, and Richard Sabine family representative)
- Hale Johnson Sabine (Sabine family/Acoustical Society of America historian)
- Richard Schlindwein (Manager, Riverbank Inc.)
- John Vanthournout (Riverbank trustee)
- Alma Vogt (legal secretary)
- Arthur Vogt (Illinois Institute of Technology Research Institute manager)
- Donald L. Williams (Riverbank Acoustical Laboratories resident, employee, and historian)
- Charles Wiseman (final editor and publisher)

Preface

Wallace Clement Sabine (1868-1919) is the father of the science of architectural acoustics. During his investigations of the acoustical conditions in several Harvard University buildings, Wallace Sabine gained the confidence he needed to consult on the acoustics of the new Boston Symphony Hall being designed by the legendary New York City architectural firm of McKim, Mead, and White. This firm was formed in 1878 when Charles Follen McKim formed a partnership with William Rutherford Mead and William B. Bigelow. Bigelow retired the following year when Stanford White joined the firm and the firm's name was established. Largely on the basis of his success at Boston Symphony Hall, Sabine's counsel was sought on a wide range of buildings — the New England Conservatory of Music's new building in Boston; the Pulitzer House and Century Theater in New York City; churches and cathedrals in Los Angeles, Detroit and Boston; and the Rhode Island State capitol building. By 1916, Sabine's list of consulting projects had grown to include the chamber of the U.S. House of Representatives in Washington, D.C.; the U.S. Military Academy chapel at West Point; the Halifax Cathedral in Nova Scotia; the Remington Typewriter Company, where he advised on quieting typing clatter; and the Gustavino Company, for which he developed and patented a ceramic acoustical tile that found wide application in churches. His consulting files reveal that many of his projects after 1913 also involved noise and noise telescoping of heating and ventilating equipment sound and vibration. Clearly, Sabine was the foremost authority on architectural acoustics through most of the first quarter of the twentieth century.

One of Wallace Sabine's consultations around 1913 was with the wealthy industrialist, financier Colonel George Fabyan. Sabine met him at his estate in Geneva, Illinois, where the Colonel dabbled in various scientific enterprises. Fabyan had heard of Sabine's reputation in physics and acoustics through his brother Marshall, who served as a visiting adviser for the Fabyan Chair at Harvard Medical School. Marshall had retained Sabine to advise him on an acoustic levitation machine that was not working. During this consultation, Fabyan learned of Sabine's frustration with his inadequate acoustic isolation laboratory at Harvard and offered to build him a suitable one in the quiet prairie country of Illinois at his Riverbank estate. Sabine accepted the offer

and designed what was to become the internationally recognized Riverbank Acoustical Laboratory. He supervised its construction, which was completed just a few months before his untimely death in 1919 at the age of fifty.

Sabine's death left a great void at Riverbank, a void that was to be filled by two other Harvard physicists named Sabine: Paul Earls Sabine (1879-1958) and Hale Johnson Sabine (1909-1981). In 1919, Colonel Fabyan again turned to Harvard University to find someone to direct the new Riverbank Laboratory and was referred to Paul Sabine, a distant cousin of Wallace. Paul Sabine was working on a World War I research project in spectroscopy at the time and had had little contact with, or knowledge of, Wallace Sabine's work. Fabyan apparently charmed Paul Sabine into coming to Riverbank to direct what was then the only laboratory devoted to acoustical research and testing of acoustical materials and systems. Paul directed Riverbank during the critical, formative years and for nearly three decades thereafter until his death in 1958. During this period, Paul Sabine was also involved in founding the Acoustical Society of America and establishing acoustics as a respected and essential subdiscipline of physics. Paul's son, Hale, whose physics training at Harvard ultimately led him to the profession of acoustics, also became involved at Riverbank during the 1950s and 1960s to round out the leadership of the Sabines at Riverbank.

No one other than John Kopec with the historical perspective, patience, persistence, and inside knowledge of the Riverbank Acoustical Laboratory could have documented this extraordinary history. John's undamped fascination and enthusiasm for the Riverbank history began with his employment as a laboratory assistant there in 1974 and continues today in his current position as manager of the laboratory. He also serves as curator of the Riverbank Museum and of the Architectural Acoustics Archives of the Acoustical Society of America, located at Riverbank since 1984. About two years after the 1976 discovery of the Wallace Sabine research notebooks, John found Sabine's missing consulting files in a little-used storage room at Riverbank. He coauthored with Leo Beranek the article entitled "Wallace C. Sabine, Acoustical Consultant" (*Journal of the Acoustical Society of America* 69: 1-16, 1981). Without doubt, John Kopec has become the leading scholar on the Sabines at Riverbank.

In this volume, John Kopec masterfully weaves a fascinating story with many intricate details. It includes the involvement of an often controversial philanthropist and lover of science and scientific things, Colonel George Fabyan; the germination and execution of an idea for a state-of-the-art laboratory specializing in acoustical research and measurements; and the successive leaderships of three Harvard University-trained physics graduates named Sabine and their contributions spanning nearly three quarters of the twentieth century, toward the advancement of the profession and discipline of acoustics. Wallace Sabine's life and work has already been documented

thoroughly in William Dana Orcutt's affectionate biography, *Wallace Clement Sabine: A Study in Achievement* (Plimpton Press, Norwood, Massachusetts, 1933) and in Sabine's *Collected Papers on Acoustics* (Peninsula Publishing, Los Altos, California, 1994). However, the substantial contributions of the two other Sabines to acoustics have, until now, been less well documented.

It is clear from Kopec's history of the Sabines at Riverbank that architectural acoustics and, indeed, the wider field of applied acoustics itself involve a great deal more than merely the acoustics of auditoriums and churches. Even on his first important consulting project, Boston Symphony Hall, Wallace Sabine insisted on more than just the application of his new reverberation equation. He required adequate isolation of the hall's listening chamber from exterior sounds, hence the hall's interior surrounding buffer corridors and other features that protected the hall from exterior traffic and streetcar noise of the early 1900s and still do today. He also ensured shallow balcony and concert-stage depths to guarantee evenly distributed sound over all the seats and wall niches and deep ceiling coffers to enhance diffusion of the sound field throughout the concert hall. Wallace Sabine's later research focused more and more on unanswered questions of sound distribution and transmission and other unquantified problems in acoustics and noise control, and Paul and Hale Sabine continued his pioneering work. They, too, were deeply involved in the growing public awareness about noise pollution. Indeed, the need for methods and materials for environmental noise control became even greater after World War II, especially with the introduction of new and noisy transportation modes such as jet aircraft. The Sabines' and Riverbank's technical and research staff members were all part and parcel of this expanding acoustical activity. We are in John Kopec's debt for his dedication in telling the story of solid achievement of the Sabines at Riverbank.

William J. Cavanaugh
Fellow, Acoustical Society of America
Sudbury, Massachusetts
June 1994

Introduction

Many disciplines in the academic and professional world contribute to the science of architectural acoustics. Perhaps more than any other science, architectural acoustics illustrates the need for the integration of disciplines in order to fully understand physical behavior.

For example, medical people involved in hearing, speech, physiology, and psychology relate to architectural acoustics through the interaction between people and their home and work environments. Mechanical engineers relate to architectural acoustics through the analysis of the causes and effects of structural vibration. Physicists develop and explore the basic laws involving sound fields in rooms and auditoria. Electrical engineers develop instruments to detect, record, and measure sound in various architectural environments. Architects design buildings with the overall sound and vibration environment as a consideration. Musicians and performing artists are concerned about the environment in which they perform or practice. It was one specialized scientist, however, who ended my search for the discipline that architectural acoustics really belongs to. A space scientist thought architectural acoustics belonged to his profession, saying, "Is it not indeed true that the most popular scientific belief today on how everything started is based on the concept of the Big *Bang* Theory and that BANG as discovered by space scientists, was the original noise that effected the greatest feat of architecture ever accomplished — the formation of our universe?"

While researching the careers of Wallace Clement Sabine, Paul Earls Sabine and Hale Johnson Sabine, I found that each career unfolded slowly. As each Riverbank archive file was searched, I extracted bits and pieces. Eventually, not one but three outstanding careers emerged. When compiled, I found that each career exhibited a special aura of scientific magnificence.

Wallace and Paul Sabine were distant cousins, both having the same great-grandfather; Hale was Paul's son. One Sabine career was not necessarily that much greater technically than the others, especially when you relate the professional significance with the respective time and generation for each. It is most apparent, however, that the professional careers of Paul and Hale Sabine were often placed in the comparative shadows of the extraordinary pioneering career of Wallace Sabine. By sharing the common denominator of the Sabine name, the many individual accomplishments achieved by Paul and Hale Sabine were professionally Sabine weighted. All three demonstrat-

ed dedication, individuality, and tenacity of purpose. When all three professional careers are combined and the total spectrum of scientific accomplishments listed, you become aware of the magnitude of the professional contributions made by this one family. That one family could have accomplished so much in one particular science is overwhelming. That all their achievements have passed almost virtually unnoticed through American scientific history is extraordinary.

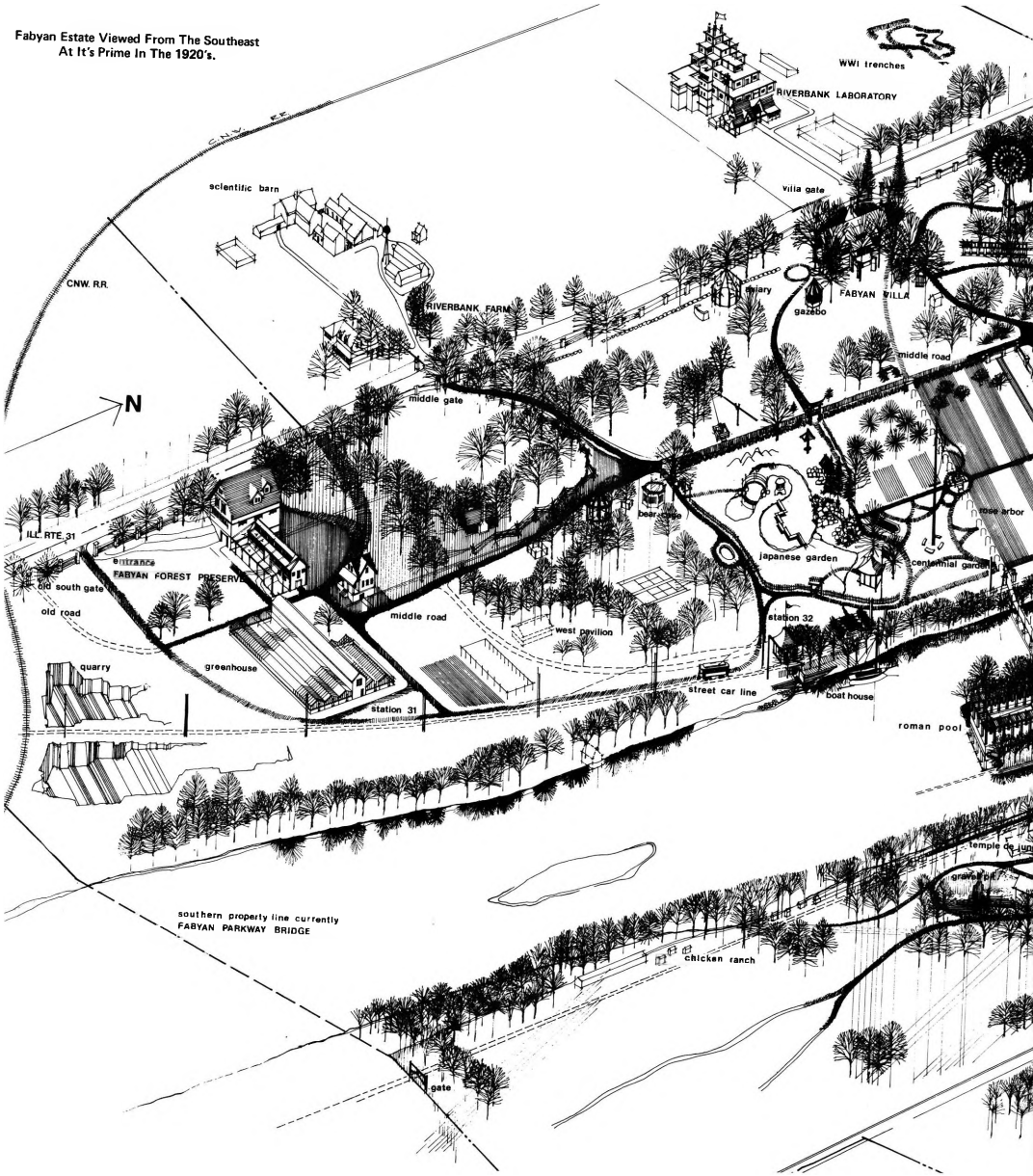
Much diverse material other than acoustics surfaced during my years of research. To reduce the interruption in the flow of reading, these diversions are indented throughout the book; the more lengthy diversions are consolidated in the postscript.

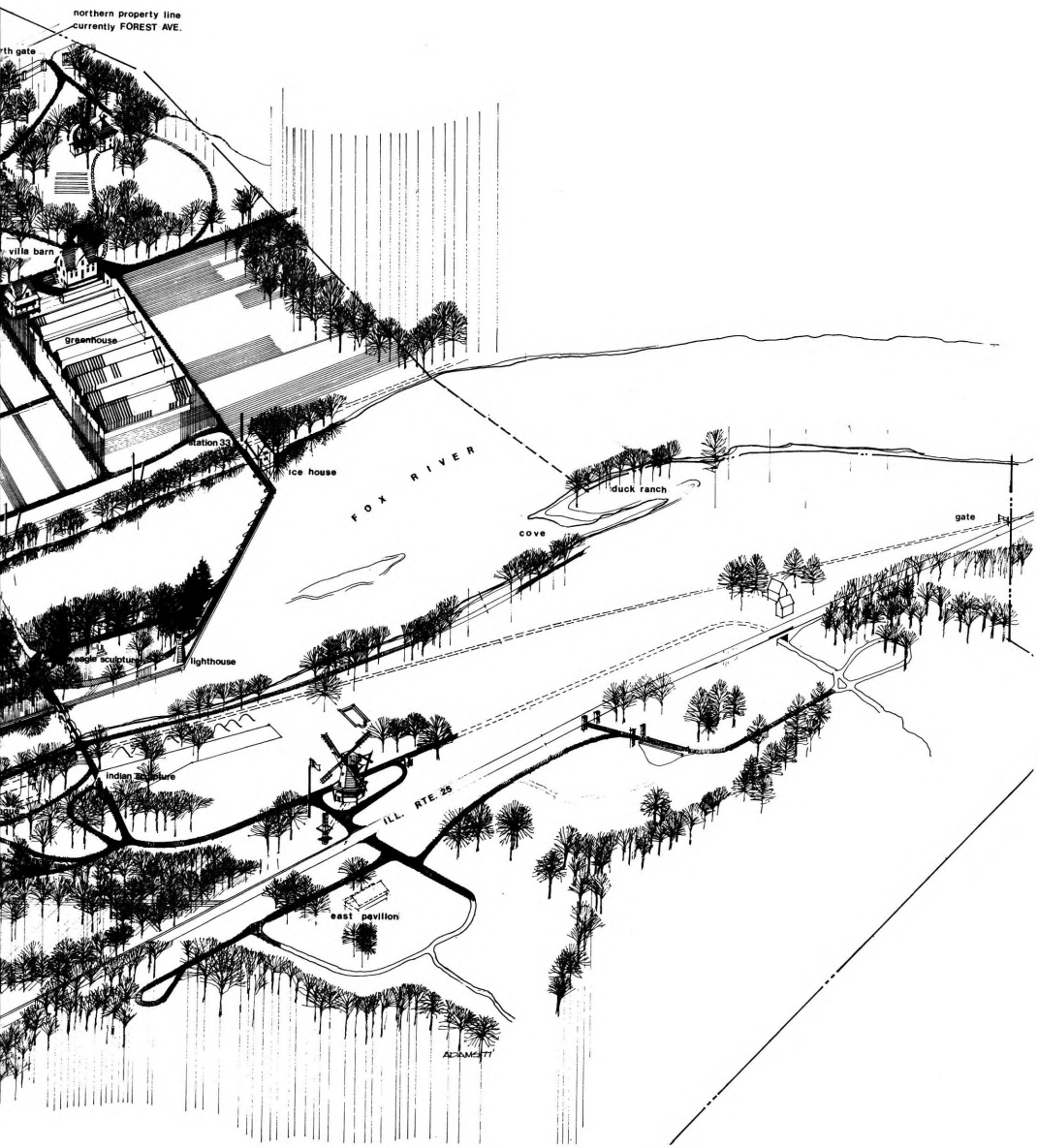
I hope that this book will help others to realize more fully the Sabines' contribution to the science of architectural acoustics and to understand what the Sabines meant to architectural acoustics, the Riverbank Acoustical Laboratory, Harvard University, the Acoustical Society of America, and me.

J.W.K.

The Sabines at Riverbank

Fabyan Estate Viewed From The Southeast
At It's Prime In The 1920's.

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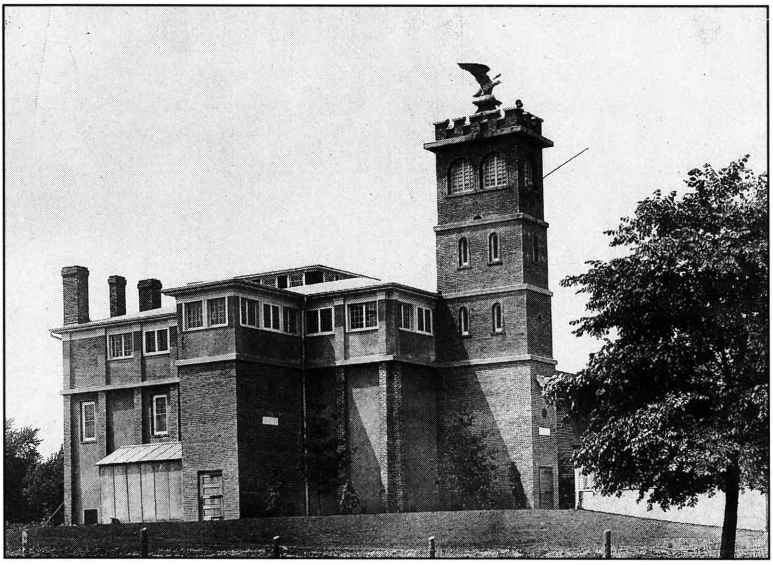


Riverbank Acoustical Laboratories, ca. 1918.

CHAPTER

1

Replacing a Scientific Legend

Winters in Geneva, Illinois, can be bitter and ruthless. Raw, icy winds howl across the snow-covered plains to the north and west, pushing blizzards across the barren farmland as they go, and slam into the wet, heavy air above the Fox River Valley. The cold is bone chilling, paralyzing.

In February 1919, however, the winter was undoubtedly of less concern for Paul Earls Sabine than the opportunity to observe for his first time the Riverbank Acoustical Laboratory, a scientific laboratory that recently became his responsibility.

The only convenient way to reach the laboratory was by automobile. Sabine would have parked in the laboratory parking lot located on the western edge of this privately owned 600-acre estate. When stepping from his car, he would have been standing at the highest point in Kane County. Immediately southward was the acoustical laboratory, a large structure that defied definition. The building seemed to be a composite of architectural styles, owing nothing to anyone.

The main section of this unique structure was (and still is) a four-story conglomerate of masonry topped by — depending on one's aesthetic viewpoint — either a blockhouse, a lookout tower, or a cupola. On the east end of the building stood a ten-foot-square, six-story-tall bell tower. Although the tower was more reminiscent of a college or university, it mysteriously managed to entwine with the academic image auras of medieval nobility, spiritual ecclesiastical order, and American patriotism.

On the roof of the cathedral-windowed belfry perched a full-winged, concrete replica of an American bald eagle. From afar, this powerful-looking portrayal of our national emblem appeared to be soaring above the Riverbank tree tops, the Fox Valley, and all Kane County, ever peering, searching, and protecting — an allegory that Riverbank estate owner, Colonel George

Fabyan, surely intended his personal sculptor, Silvio Silvestri, to convey.

As Paul Sabine approached the laboratory entrance driveway, he passed two Silvestri-sculpted sentry lions bearing shields, each mounted atop an eight-foot brick column that completed a wrought iron fence. When he reached the main entrance, he saw, carved into the cornerstone, the date 1918 and the initials "W. C. S." These same initials and the inscription "The Wallace Clement Sabine Laboratory of Acoustics" were etched in the frosted glass window of the door, reminders that this new acoustical laboratory, the first independent laboratory dedicated to the science of architectural acoustical testing, was specifically designed by, and built for, Wallace Sabine. The unexpected death of Wallace Sabine a month earlier was the immediate reason that his cousin Paul was standing at the door of this strange building on a frigid day in 1919. The other, less clear-cut reasons for Paul's arrival at Riverbank have their roots in the plays of Shakespeare, the pursuit of levitation, and the secrets of the Rosicrucians.

In 1913, Colonel George Fabyan was in dire need of an acoustical consultant to assist with a scientific project being conducted on his estate. This particular Riverbank project dealt with the building and testing of an acoustical levitating device constructed from a seventeenth-century description of a similar machine written in code by Sir Francis Bacon and deciphered by Elizabeth Wells Gallup. Mrs. Gallup had come to Riverbank just after the turn of the century to continue her life-long search for proof that it was actually Bacon who had written the Shakespearean plays. During her research, she discovered that Bacon was a member of the Rosicrucian Society of England, a clandestine organization whose activities included conducting scientific experiments. Because this type of activity was interpreted by some to be witchcraft, the Rosicrucians had to carry out the experiments and divulge their findings in secret.

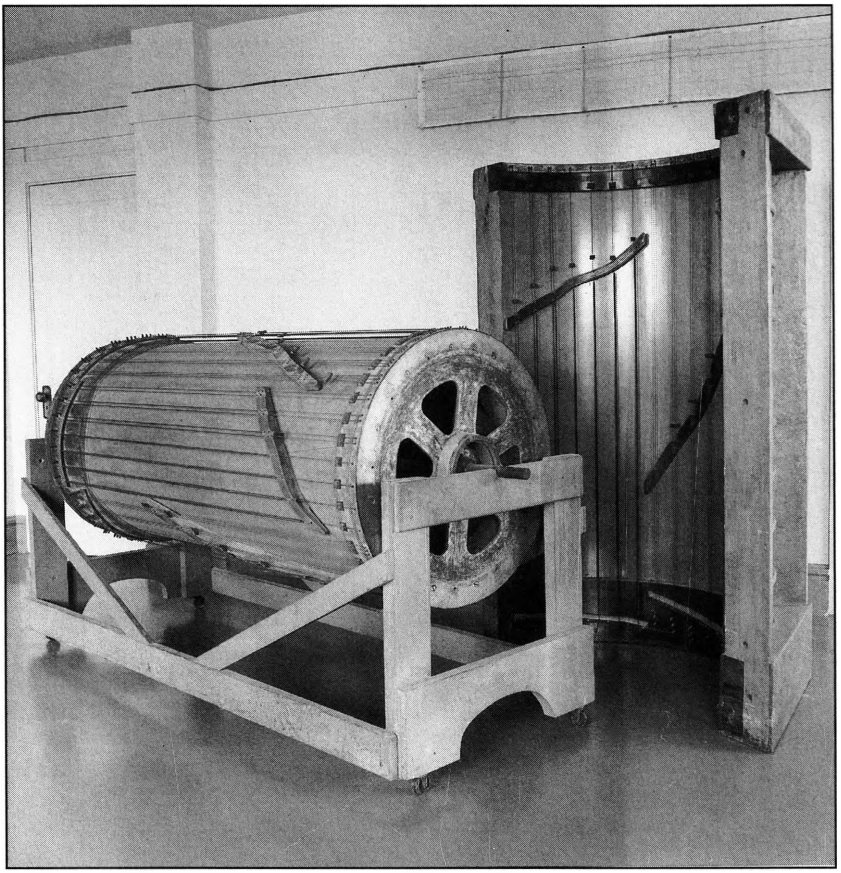
Fortunately for the society, Sir Francis Bacon was in charge of the Queen's royal printing and was able, by virtue of the position, to provide the medium through which other members were informed of experiment results. A biliteral cipher (not unlike the binary code used in computers today), using two different-sized alphabets, allowed Bacon to encode information about recent experiments; this encoded text appeared in printed pamphlets or proclamations. Members of the Rosicrucian Society, who knew how to decipher the code, were thus able to read about the research of others.

According to Mrs. Gallup, Bacon applied the same coding technique in many of his personal writings. This is referenced in the galley proofs of "The Fundamental Principles of the Baconian Ciphers," dated 1916, a document the colonel dedicated to his mother. In this work Mrs. Gallup included various poems, short stories, and nursery rhymes, along with explanations of a variety of the society's experiments — one of which was an experiment with an acoustic levitation device. Immediately after she deciphered the descrip-

Laboratory Entrance and Cornerstone.

tion of this so-called antigravity machine, Mrs. Gallup informed Colonel Fabyan. The colonel responded by hiring Bert Eisenhour, a civil engineer from a woodworking firm in Chicago, to construct the device.

In essence, the Bacon cipher described the principle behind the levitation device in this fashion: If (1) musical strings are incorporated in the proper sequence on a vertically mounted cylinder, (2) the cylinder is rotated inside a peripheral outer shell assembly that contains similarly mounted musical strings, (3) the cylinder is rotated at a high rate of speed, its strings struck and set into vibration, and (4) the strings are in perfect tune with the strings



The Acoustical Levitating Device.

mounted on the shell, then, through sympathetic vibration, the strings on the shell will also vibrate, creating a combined force field within the cavity between the cylinder and the outer shell that results in a lift force strong enough for the outer shell to levitate. Such was the theory, but the device built at Riverbank could not be made to work.

Eisenhour felt certain that the device did not perform as hoped because of improper tuning. He believed that when the cylinder was in rotation, the strings stretched and, therefore, were out of tune with their counterparts mounted on the shell. To resolve the problem, Eisenhour reasoned he needed to find an individual knowledgeable enough in acoustics to calculate the frequency at which the strings should be pretuned to become in tune with the strings on the outer shell when the cylinder rotates at the proper speed.[1] The expert they contacted was Wallace Clement Sabine of the Physics Depart-

ment at Harvard University. Sabine made his first visit to Riverbank in the same year, 1913, a visit that resulted in the end of the levitation device project but the beginning of a long-term friendship with Colonel George Fabyan.

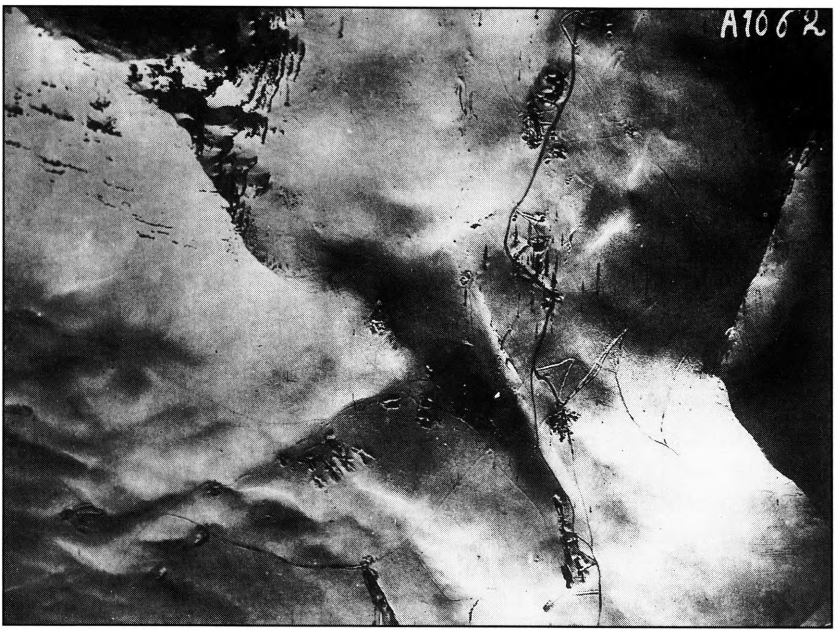
In 1915, during one of his many stays at the estate, Sabine told his host about the technical problems he had encountered in trying to perform experiments in architectural acoustics at Harvard's Jefferson Laboratory. Most of the problems, the professor explained, centered on the unwanted noise and vibrations from the street outside the laboratory that created difficulties in obtaining meaningful data; most of the testing had to be conducted late at night. The colonel proposed that if Wallace Sabine would consider coming to Riverbank, he would pay for the construction of an acoustical laboratory of the professor's design. Naturally, Sabine agreed.

In 1916, before he began preparations for his scheduled lecture tour at the Sorbonne in Paris, Sabine submitted his drawings for an acoustical laboratory to the Colonel. Because both the colonel and the professor became immersed in various war projects shortly thereafter, the laboratory was not completed until 1918. Colonel Fabyan conformed strictly to the professor's design of the test chamber but deviated considerably from Sabine's more conservative design for the outer office building, resulting in the majestic structure that greeted Paul Sabine less than a year later.

Also because of the war, Professor Wallace Sabine was unable to present his Sorbonne lectures on architectural acoustics as a Harvard exchange professor until 1917. These presentations were followed by lectures at the Ecole des Beaux Arts (School of Fine Arts) and before the French Society of Architects in Paris. During this same period, he was a scientific advisor for the United States Navy Department of Information and the French Bureau of Inventions on submarines and airplanes. He later became a staff member of the Bureau of Research for the Air Service of the American Expeditionary Forces and provided services for the British Munitions Inventions Bureau in England, the French fleet at Toulon in the Mediterranean, and Italy on the Italian front.

One of the professor's developments, that involved Riverbank, was the use of cameras in airplanes for aerial reconnaissance. Because of this work, the French awarded him the French Legion of Merit Medal for locating some hidden German airfields. Glass negatives (the photographs were apparently taken by Sabine himself) discovered in one of Riverbank's laboratories in 1980 showed aerial views of sections of actual World War I trenches at the front. The trenches were later duplicated at Riverbank for training purposes. The Riverbank project focused on the effectiveness of new explosives and weapons, including a special type of trench mortar, in and around the artificial ditches.

Professor Sabine participated in various Allied experiments and was at the



Austrian Cannon in the Alps with Path
An Aerial Reconnaissance Photograph of the Italian Front.

English, French, Italian, and American fronts. Although he earned the rank of colonel in the four Allied armies, there are no records or pictures indicating he ever wore a military uniform. If this were the case, had he ever been captured, he would have been regarded as a spy. Reportedly, the Germans tried to capture him three times, and on their third attempt, they missed by only five minutes.

After leaving the western front in the fall of 1917, Wallace Sabine returned to Washington and became director of Technical Information for Bureau of Aircraft Production in the U.S. War Department. In 1918, he was appointed by President Wilson to serve as a member of the National Advisory Committee on Aeronautics. It was during the fall of 1918 that the professor was able to see his new laboratory in Geneva, Illinois, for the first time and take a set of absorption measurements.

On November 11, 1918, the day the armistice was signed, Professor Sabine was finally able to relinquish some of his military obligations and return to Harvard University, where he proceeded with his work in architectural acoustics. These efforts included preparations for experiments at his new laboratory in Geneva. The government, however, continually required his services, and he virtually commuted back and forth between Harvard

and Washington. One such project was to set up a plan for study and research in aeronautics. The plan he created was so futuristic in scope that the guidelines, written in 1918, were incorporated into the guidelines established for National Aeronautics and Space Administration decades later.

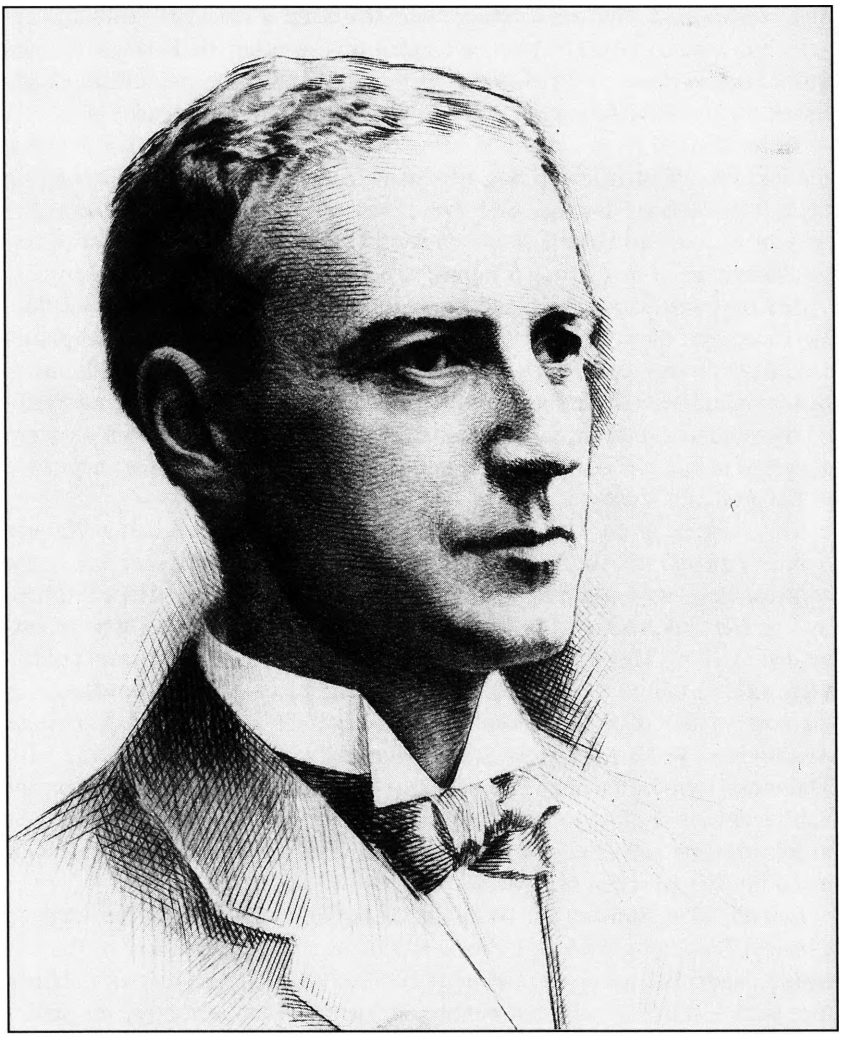
As evidenced by his many contributions to science, Professor Wallace Sabine was adept in compiling pertinent facts and theories, incorporating them into his own findings, and then developing solutions to problems not only of the present but the future as well. One Harvard alumnus, for example, remembered that during a lecture to a physics class, Sabine suddenly deviated from the class subject and began to expound on the future of aviation. He stated that there would most assuredly be another war and that airplanes would play a significant part. He went on to suggest that the students consider aeronautics as a career because the demand would be great. Because many of the students only knew about airplanes of 1918, most of which were scrapped at war's end, it is no wonder that these students became suspicious of the professor's wits.

This lecture, in conjunction with another raised questions about Wallace Sabine's mental health. As the story goes, the professor was seen out in the courtyard one day, dumping and burning his files. The story was confirmed by Leo Beranek, author of several articles about Wallace Sabine, who reported that in 1939, Theodore Lyman, then emeritus professor of physics at Harvard, said to him that he found Sabine burning his papers and notebooks in the courtyard outside the laboratory. In the preface to *Collected Papers on Acoustics — Wallace Clement Sabine* (Harvard University Press, 1922, vii), Theodore Lyman wrote, "The severity of the criticism which Professor Sabine always applied to his own productions increased with time, and it is to this extreme self-criticism and repression that we must ascribe the loss of much invaluable scientific material."

Lyman, Mrs. Sabine, and William Dana Orcutt (author of the Wallace Clement Biography, Plimpton Press, 1933) did not know that any of the scientific papers had survived, and until 1979, it was believed that all Sabine's files were lost in the courtyard burning incident. In that year, however, several Wallace Sabine files were found at Riverbank. How they actually got to Geneva is uncertain, but in any case, valuable and irreplaceable information was found. A copy of their contents is now housed in the Harvard archives.

As it turned out, the files that were burned contained data from his one-, two-, and four-organ pipe configurations, which he used for determining the sound-barrier qualities of a wall. These data had been cited in other file documents as inaccurate.

The retrieved files disclosed a personality and a brilliance so unique that most acousticians read in awe from beginning to end. Today, Professor Sabine's *Collected Papers on Acoustics* (Peninsula Publishing, Los Altos, California, 1994) is regarded as a must for those involved in the science be-



Wallace Sabine.

cause much of what he states remains the state of the art. His formula for sound absorption is still used in many standard acoustical tests, and the unit of absorption now bears his name, minus the *e:* sabin.

Late in the winter of 1918, during the Christmas break, Professor Sabine set about the lengthy process of calibrating organ pipes that were to be used as sound generators for the reverberation test chamber at his newly constructed laboratory. Although already in poor health, the professor insisted on

performing this task himself–a decision, it turned out, that proved fatal.

During World War I, Wallace Sabine had been diagnosed with a kidney disorder (later diagnosed as cancer) and was told repeatedly that surgery was necessary. He would reply, "Not while my country is in danger." Sabine believed that because he had survived various illnesses in the past, he surely could brave off any disease to respond to his nation's needs. Not that he was foolhardy, weak of mind, or careless; he was, instead, motivated by a sense of purpose, loyalty, and patriotism.

Many individual recollections of Wallace Sabine describe him as soft spoken, mild mannered, courteous, and even tempered. Those who knew him well considered him extremely alert, astute, caring, and deeply devoted — all in all, an individual not likely to be careless or to seek out dangerous or risky situations. Wallace Sabine demonstrated courage, resolution, and perseverance. Throughout his life — and especially during World War I — Sabine often disregarded problems relating to his own health to complete a myriad of scientific and humanitarian tasks.

In December 1918, however, his health could no longer be disregarded. As the holidays approached, Professor Sabine informed his long-time assistant, John Connors, that because of his lingering illness, it might be best if he took full advantage of the Christmas vacation to allow himself some time "to get patched up." He hoped to be in much better condition by the time the next school session began.

He entered the Peter Bent Bringham Hospital in Boston for a preliminary operation that provided temporary relief. He then returned home to recuperate. During this interim, however, he contracted influenza. Although it was still Christmas break, the fact that Wallace Sabine wasn't able to make his periodic visits to the laboratory created growing concern among the faculty, including his close friend and colleague, Professor Edwin Hall.

In the March 1919 issue of *The Harvard Graduate,* Professor Hall recalled that after reading about the possible seriousness of Sabine's illness, he telephoned his friend. According to Hall, Wallace answered in a voice so cheerful and strong that Professor Hall might have put aside any fears regarding Sabine's health; however, he was well aware of his colleague's penchant for feigning wellness to "censor health bulletins relating to himself." Attuned to this diplomatic subterfuge, Professor Hall called on Wallace Sabine at his home the following day. Although Sabine put up a remarkable front, it was not too difficult for Professor Hall to ascertain that his old friend's illness was serious and that Wallace, too, was aware of his condition. Nevertheless, Sabine ignored the rules of the sick chamber and refused to listen to any advice to the contrary. He was then, as he had been during their entire acquaintance, a defier of precept, a law unto himself. This part of his character is even more evident in Professor Hall's account:

> Any time for the past year or two, looking upon his spiritual, still youthful, face, and noting the smiling obstinacy with which he followed a course of toil that must end his life too soon, one might be tempted to think of him as some elfin being that had taken human form in benevolent caprice, but was now planning departure and adventures new. Not that he ever, save in the very ecstasy of pain and weakness, showed any symptom of world-weariness. He was full of affection, full of the zest of life, full of plans for future years. He has told me that he never enjoyed his work of teaching more than during this past fall, so trying to most of those who remained in academic life, and he had been looking forward joyfully to the prospect of resuming his work of research, especially that part of it which was to be carried on in the special laboratory built for him by his friend Colonel Fabyan at Geneva, Illinois.

On January 5, 1919, Wallace Clement Sabine returned to the Peter Bent Bringham Hospital. Despite desperate efforts to save his life, he died, peacefully, on January 10, at the age of fifty. His whole life a private man who shunned publicity and accolades, Wallace Sabine's death was marked by scientists and academicians the world over. Although never well known beyond those small circles in which he operated, Wallace Sabine's contributions were, without question, appreciated and recognized by his peers, and in years to come, Wallace Sabine would be honored posthumously with two deserving titles: The Father of the Science of Architectural Acoustics and The First Modern Day Acoustical Consultant.

The bestowing of the title Father of the Science of Architectural Acoustics caused some controversy among scientists in the field because acoustical research had been conducted many years before Sabine began his work. Indeed, the early Greeks and the ancient Egyptians accounted for sound in their performance facilities. The names of Lord Rayleigh, Joseph Henry and Floyd R. Watson were mentioned to Beranek as more likely candidates to the title. Leo Beranek concluded, however, these earlier scientists dealt primarily with theories and principles of sound propagation and not with architectural acoustics. Joseph Henry authored *Limit of Perceptibility* circa 1860, Lord Rayleigh authored *Theory of Sound* in 1877, and Professor Floyd R. Watson of the University of Illinois wrote various papers from 1890 to the 1950s. Professor Watson, however, supported Sabine for the title. Although Watson's sound work predated Sabine's by twenty years, in a paper at the World Engineering Congress in Tokyo in 1929 Watson stated:

> It appears appropriate to present a paper on Acoustics of Buildings before the World Engineering Congress because, while the scientific basis of the subject may be said to have been laid in the United States in the brilliant, pioneer work of Wallace C. Sabine, the interest in the subject has extended all over the world.[2]

Also, in "Hearing in Auditoriums Effects of Noise and Reverberation," a reprint from *The Architect and Engineer* September 1926-January 1927, Part 1, Page 2, Vern Knudsen, an acoustician of note, had this to say:

> It is an affront to the monumental contributions of Professor W. C. Sabine of Harvard, whose life's work is not only the real foundation but also largely the superstructure of the science of architectural acoustics. Architects and builders all over the United States know of hundreds of instances in which the application of the "absorption" theory of W. C. Sabine has led to complete acoustic success, both in the correction of existing auditoriums and in the design of new ones.

The death of Wallace Sabine was probably felt no more acutely than by his friend and benefactor, Colonel George Fabyan, who now had on his estate a new and virtually unused acoustics laboratory, with no one to provide direction, scope, or purpose. In addition he could not advertise for a qualified expert in the field because in 1919, except for the late Wallace Sabine, there were extremely few.

Finally, the colonel decided that he would contact his brother Marshall at Harvard because it was he who had arranged the first meeting between the colonel and Wallace in 1913. Marshall was well aware of the tremendous loss to the world of science, and in anticipation of George's obvious need, he already had taken action. When contacted, Marshall explained that he had located a more-than-suitable replacement, a cousin of the recently departed professor — Paul Earls Sabine — who had a Ph.D. in spectroscopy from Harvard. Marshall Fabyan mentioned that given current circumstances, chances were excellent that the younger Sabine would be able to step in for his cousin.

Paul Sabine had just completed his part in a project for the U. S. Navy and was returning to a previously held position at the Case School of Applied Science in Cleveland, Ohio. Colonel Fabyan instructed Marshall to do whatever possible to convince Paul not to go back to Ohio but to consider coming to Riverbank. Marshall contacted Sabine, and they arranged a meeting.

The only written account regarding that meeting in 1919 appears in a short note, apparently addressed to a relative, found in Paul Sabine's files:

> I am in preparation for departure to meet my new employer in Geneva, Illinois. According to his brother, it appears that this Colonel Fabyan is very wealthy, patriotic, and quite involved in various scientific endeavors, and it is I that shall heed the beckoned call to continue our dearly departed cousin's work in a new laboratory constructed for him at Riverbank.

"Beckoned" to carry out the work Wallace Sabine had begun, Paul Sabine arrived at Riverbank Laboratories on that bitterly cold day in February 1919 and saw for the first time the unique surroundings that would be his place of work and his home. From letters and notes found in his files, it is clear that Sabine knew the magnitude of the challenges his cousin had left for him and how much there was to be done. It is clear, too, judging from the article that follows ("The Life Work of the late Wallace C. Sabine, An appreciation", *The American Architect,* Vol CXVI, Number 2271, Wednesday July 2, 1919, Page 1) that he knew when accepting the position with Colonel Fabyan, it meant his whole life was about to change. He was, after all, replacing a scientific legend.

THE LIFE WORK OF THE LATE WALLACE C. SABINE
An Appreciation
by Paul E. Sabine

The name and work of Professor Wallace C. Sabine are familiar to all readers of *The American Architect* who have ever had to deal with the troublesome problems of auditorium acoustics. His death, at the age of fifty, which occurred on January 10, cut short a life of extraordinary activity and usefulness. A recital of the facts of his life and the outline of his work in the field in which he was pre-eminent will be of interest to that large circle of architects in Europe and America with whom his commanding knowledge of acoustical problems brought him into contact.

He was born in Richwood, Ohio, in 1868. He first went to the Public School at the age of eight. At twelve, he entered the preparatory course of the Ohio State University, graduating at the age of eighteen. After two years of graduate study at Harvard, in Physics and Mathematics, he was made an assistant, and shortly after an instructor in Physics. In 1895, he became Assistant Professor of Physics, and ten years later received the full Professorship. Less than another decade later, he succeeded Professor B. O. Peirce as Hollis Professor of Mathematics and Natural Philosophy, a chair which had been filled by a long line of distinguished scholars. In 1916-17, he went as Exchange Professor to France, lecturing on the subject of Architectural Acoustics at the Sorbonne and the Ecole des Beaux Arts, and before the French Society of Architects.

Brown University conferred on him the honorary Doctorate of Science. He was a member of the National Academy of Sciences, a former Vice-President of the American Association for the Advancement of Science, and at the time of his death, Vice-President of the American Physical Society.

This record of scholarly achievement is matched by one of equal worth as an administrator. That masterly director of men and affairs, President Eliot, early marked him as "able and clear headed." In 1906, President Eliot confirmed this judgment by asking Professor Sabine to become Dean of the New Graduate School of Applied Science, a post demanding not only administrative skill and tact, but also unusual capacity for constructive work. That the foundations for a new and vastly important departure in scientific education were well laid is conceded by all who know the brief history of this department of Harvard University. It was equally this same capacity for broad-minded and far-seeing constructiveness that made him a strong advocate of the movement that ended the existence of the Graduate School of Applied Science in the attempted merger with the Massachusetts Institute of Technology.

The value of his services during the war was recognized by the governments of England, France and America. While in France, he was on the staff of the Bureau of Research of the Air Service of the American Expeditionary Force, a consultant of the French Bureau des Inventions and the British Munition Inventions Bureau. Because of his close acquaintance with the airplane activities of the Allies, after his return to this country in the fall of 1917, his time and services were in constant demand for America's airplane program. After the reor-

ganization of this work in 1918, he became Director of Technical Information of the Board of Aircraft Production. A prominent member of that service remarked regarding him, "he is the one man in the service who claims to know least and who actually knows most about all phases of the aircraft problem."

Writing of his work during these days of the war, Professor T. C. Mendenhall of Ohio State University, his first teacher of physics, says:

"His services proved to be of incalculable value and he was constantly traveling back and forth between Cambridge and the Capital."

During all this time he was suffering from a serious malady which came near ending his life in Paris in 1916, and he knew that it could be remedied only by an operation to which his friends had urged him to submit. With a complete forgetfulness of self which was characteristic, he invariably answered, "Not while the war is on and other lives are in danger."

Only after his country's crisis was past, did he turn to save himself. He never rallied from the operation performed on January 6, 1919, which, had it been performed earlier, might have saved his life.

Viewed both by the scientist, and the practical man, there are certain outstanding features of Professor Sabine's work in Architectural Acoustics that mark it as of a high order. To the scientist it appeals as being constructive in the highest degree. Definiteness of purpose, directness of attack, simplicity of method, and thoroughness and complete reliability of results distinguish it throughout. To the architect, it appeals strongly, because his results were always presented in a form immediately applicable to concrete and very troublesome problems. He never undertook research simply for the fun of finding out something new, but always to find the answer to a problem that people wanted and needed to have solved. Having done this, he was at pains to state his results in terms that the man who needed them would understand.

To appreciate the value of his contribution to knowledge, we may, for a moment, consider the situation confronting him, when the Corporation of Harvard University asked him in 1895 to undertake the correction of the acoustics of the recently completed lecture room of the Fogg Art Museum. None of the standard text books on sound even mentioned the question of why some rooms are acoustically good and others acoustically bad. At that time no investigations had been published on the subject.

Out of the careful study made for the purpose of solving the particular problem, grew several important results. First of all, the acoustically bad auditorium was made fairly good. At the same time a large amount of valuable data was collected, and, more important, there was evolved a theoretical basis upon which any similar problem could be attacked with some hopes of successful solution. When a year or two later, Messrs. McKim, Mead and White, architects of the new Boston Music Hall, chose to stake their chances of an acoustically successful concert hall on something more substantial than mere luck, Professor Sabine's experience and knowledge were called upon and the acoustical design of the building followed his recommendations. So confident was he of the correctness of his method, that in an article in *The American Architect,* published in 1900, before the completion of the hall, he predicted the

period of reverberation of sound in it of standard intensity to within one-hundredth of a second.

This confidence was justified in the altogether satisfactory acoustical properties of the finished hall. The publication in 1900 of *Architectural Acoustics, Part I,* was the product of five years of painstaking labor and formed the first real contribution to the subject.

In the introduction to this paper is given a complete outline of the elements of the acoustical problem. One needs to consider Loudness, Interference and Resonance, Reverberation, Echo and Extraneous Noises, to know completely the acoustic properties of a room. Of acoustical defects, the most common is excessive reverberation, and in this first paper the writer outlines the method of experimental study and the elimination of this defect. He goes on to develop an adequate mathematical theory, and gives sufficient generalized data to make his method of remedying the difficulty applicable in any particular case, and finally as an example of the use of the method, he gives the computation for the new Boston Music Hall and a comparison with the acoustical properties of two similar halls, the Leipsic Gewandthaus, and the old Boston Music Hall. The publication of this paper definitely removed the whole subject of auditorium acoustics from the half-world of chance and guess work. It demonstrated that the architect may plan for the acoustics of a structure with the same degree of certainty that he provides for lighting and ventilation. It gave a solution both theoretical and practical of a problem as old as architecture itself.

It is to be said that in the eighteen years since the publication of his first paper, Professor Sabine followed consistently the program of investigations there outlined. The order in which they were taken up was determined by the demands of the subject itself, and by the actual needs of architects who consulted him.

A word as to the conditions under which all these investigations were performed may be of interest. In its early stage, the method was largely observational. That is to say, it called for the determination of the acoustical properties of rooms already constructed. In certain experiments these properties were altered by the introduction of large quantities of absorbing material, for example, seat cushions in great numbers. Observations had to be taken when complete silence was possible. To appreciate how rare this condition is, one needs only to undertake to secure it. Necessarily the work was done at night and most of it between the hours of one and five in the morning. Buildings presenting the properties desired for study seldom had the additional advantage of being isolated and free from noise. The notes of this first five years contain data taken in some forty different rooms, ranging in size from small vestibules to large auditoriums and in locations from Bangor to Minneapolis.

In the years immediately following the work on reverberation, the research was extended to include the whole range of musical tones. This, of course, increased many fold the amount of data to be collected. The results of the work of this period were published in part by The American Academy of Arts and Sciences in 1906. In these papers, is described a series of experiments conducted with the aid of some of the faculty of the New England Conservatory, which es-

tablished the fact that there is a very sharp optimum value of the period of reverberation in a room used for piano music.

The experiments to determine the absorbing power of an audience, and of various wall surfaces, and materials for tones of pitches covering the entire musical range are also described, thus completing the experimental study of Reverberation.

Following the year 1906, the new duties of Dean of the Graduate School of Applied Science would have effectively stopped the research activities of most men. However, Professor Sabine found time, while others slept, to determine the sound-absorbing properties of a great number of materials, for the whole musical range. He also developed a tile whose sound-absorbing properties compare very favorably with those of felt. He gave much time to consultation in this country and in England, both as to buildings in construction and as to methods of improving faulty acoustics. During this period he began the experimental study of the phenomenon of sound interference as applied to interior acoustics. The variation in intensity of sound at points in a room containing a constant source of sound was carefully studied and photographically recorded by means of a telephone receiver and string galvanometer. Thus study afforded much information on the so-called "deaf spots" in auditoriums and demonstrated fully the inadequacy of the "sound ray" method of studying acoustical problems. There was also developed in this period the modification of the Toeppler-Boys-Foley method of sound photography, which was applied so successfully to the study of the problems of echo and loudness in large auditoriums. An account of the application of the method appeared in an article on "Theater Acoustics," in *The American Architect* for December, 1913, with photographs showing the progress of an actual sound wave, in a small model of the auditorium being studied.

In 1914, Professor Sabine began the last of the problems outlined in his first paper, namely, that of elimination of extraneous noise. This, of course, is the difficult problem of sound insulation which had been brought to his attention by inquiries from many architects. The results of a preliminary study were published in February, 1915. The method there outlined is an adaptation of that developed for the study of reverberation and sound absorption, to the study of sound transmission. The results, though admittedly incomplete, serve to indicate the limitation upon the efficiency of so-called "sound-deadening" material as ordinarily applied. It is shown that for complete insulation the thickness of deadening material is prohibitive, although relatively thin layers produce an appreciable reduction in the intensity of sound transmitted. It is further shown that for complex walls, let us say alternate layers of iron and felt, the simple law that succeeding layers absorb the same proportion of the sound transmitted to them, does not hold and that the transmission of such a complex wall bears no simple relation to that of its separate constituents.

Finally, as in a number of other instances, the preliminary study of the problem revealed that the complete solution demanded a great deal more than its original scope had anticipated. At the end of the paper, the author characteristically says, "At this point, the apparatus was improved, the method recast and the investigation begun anew."

The war prevented the immediate accomplishment of this purpose and not until the autumn of 1918 was it possible to attempt again its realization. In the interval, the new laboratory, to be fully described in a succeeding article, had been built at Riverbank, Geneva, Illinois. Within a month of the signing of the armistice, which freed him in a measure from the press of duty to his country, although mortally ill, he had begun the heavy task of calibrating instruments for the new laboratory.

Without this latest work, done within a month of the time of his death, the continuation of his work by others would have been almost impossible.

This sketch of his scientific work can not be closed more fittingly than by quoting from the records of the Faculty of Harvard University:

"He attacked a problem as old as the institution of public buildings. It had never been solved before in any thorough going manner. He did solve it, and he did this not by virtue of any extraordinary resources of modern science. He did it in such a way as to show that it might have been done by a man like him centuries before.

Was it then so easy and simple a thing to do? Did he merely happen to find the solution of a difficulty thousands of years old? No, he succeeded by reason of a combination of qualities among which were unending patience and untiring energy."[3]

CHAPTER

2

The Colonel's Estate

A Community of Thinkers

The man who had hired both Wallace and Paul Sabine, Colonel George Fabyan, was, in himself, as much of a challenge to the two men as the research they undertook. By some accounts a tyrant, by others a generous benefactor, Colonel Fabyan was a man of ideas, a man with whom to be reckoned. When Paul Sabine arrived at Riverbank in 1919, the colonel's far-flung interests and his drive for achievement had already made the Fox River estate, in his own words, "a community of thinkers." Perhaps more accurately, it should have been called a community of *doers*.

At one end of the sprawling property, prize cattle were being bred, and hybrid strains of various crops were being grown. On one floor of the laboratory building, Elizabeth Wells Gallup and her team of researchers looked for an answer to the Shakespeare-Bacon mystery, and on another, William and Elizebeth Friedman and their team of cryptologists tried to solve coded mysteries of a more immediate nature. In the field behind the acoustical laboratories, trenches and battlements still stood, reminders of Fabyan's contributions to the war effort only a couple of years earlier. Everywhere, above everything could be heard the screeches, howls, and sounds of Fabyan's exotic animal and bird menagerie.

There are many stories about the colonel and his estate: including tales of romance and war, pretty girls, international politics, adventure and intrigue, science, and the supernatural. Although a few stories were based on actual events that occurred at Riverbank, a greater share seem to have been conjured up solely for the sake of storytelling. What is even more interesting is that some of these tall tales might, in fact, have been dreamed up by Colonel Fabyan himself.

As architect and mastermind of all this chaos, Colonel Fabyan ruled like a

Riverbank Laboratories Tuning Fork Facilities.

feudal lord, walking the grounds; giving orders; and overseeing every project, no matter how small. A tall, handsome, athletic-looking individual — according to some an Ernest Hemingway look-alike — with compelling charm, Colonel Fabyan spoke in a low, gruff voice, in part the result of his chain smoking, and carried himself in an appropriately lordly manner. His attire at home, although perhaps not so lordly, was, at least, singular; either he wore a white turtleneck sweater, white shoes, white flannel trousers, and a blue blazer — yachting garb — or he dressed as an equestrian in jodhpurs and knee-high riding boots, even though no one at Riverbank ever remembered him climbing on a horse. It was not true that he drove a team of zebras pulling a buggy to the Geneva railroad station or the Arcada Movie Theater in St. Charles, Illinois. It has been verified that he did have a private box in the loge portion of the balcony at the Arcada, and he rarely, if ever, missed a movie; his favorites were Westerns. In business, as well as in his scientific pursuits, Colonel Fabyan was known to use his inherited, as well as his earned and established, wealth both frivolously and wisely. Whims and hunches, chance and intuition were as much a part of his decisions as calculated, precise planning.

Colonel Fabyan was a transplanted easterner. He was born on March 15, 1867, in Boston, Massachusetts. His parents, George Francis and Isabella Frances (Littlefield) Fabyan, were Brahmins, part of the city's upper class who belonged to all the right clubs and organizations and gave to all the right

charities. A senior partner in the Bliss Fabyan Company, a textile firm, the senior Fabyan also had business affiliations with Cordis Mills, the Thorndike Company, Metropolitan Storage Warehouse Company, the Old Colony Trust Company, and the Merchants National Bank of Boston. He was a trustee of the Massachusetts Horticultural Society and had memberships in the Union Club of Boston, the Country Club of Brookline, the Eastern Yacht Club of Marblehead, the Metropolitan Club of New York, and the Jekyl Island Club of Georgia.

George Frances Fabyan was also a primary benefactor of the Harvard University medical school. With an original endowment of $250,000, along with many additional contributions of thousands of dollars, he was able to establish the George Fabyan Chair of Comparative Pathology in memory of his father, the colonel's grandfather. Later, because of the Fabyan Chair position at Harvard, the colonel had Marshall Fabyan arrange for Wallace Clement Sabine to come to Riverbank in 1913.

Young George was a nonconformist, forever rebelling against family protocol and tradition. In 1883, at the age of 16, George dropped out of Williston Seminary in East Hampton, Massachusetts, and headed westward. First, he acquired a position with the Kirby-Carpenter Company, lumber merchants in Menominee, Michigan. Soon after, he became a tie and timber agent for the Union Pacific Railroad. During this period, George met and married Nelle Wright of Walker, Minnesota. Shortly after his marriage in 1890, he became an assistant to a cotton broker in Tennessee.

In 1893, George made a significant career change. He decided to move to Chicago and signed on under an assumed name as a warehouse assistant for the branch office of the Bliss Fabyan Company. If the legend is accurate, what occurred next was both the stuff of novels as well as a monumental stroke of luck: George did so well in his new job that when the firm's senior partner, George's own father, paid a visit to the Chicago branch, he was introduced by the plant foreman to the ambitious young man who had been doing such wonders for the company. The next day, George was promoted to resident partner of the Chicago branch.

Once established as regional head of the Bliss Fabyan Company, George Fabyan began purchasing land. Eventually acquiring 600 acres in Geneva township he founded Riverbank. He became an aide-de-camp to then Governor of Illinois Richard Yates, serving him in various capacities, including as a member of the governor's military staff. Thus Riverbank became involved in a number of military projects.

The military projects included a project that led to the construction of military trenches similiar to the trenches on the western front. Various studies were conducted on trench warfare leading to the development of a trench mortar similiar to what is used today and a triton hand grenade. Another project involved studies of fougasse explosives and how to blow up various

George Fayban.

types of bridges. Then there were the projects that involved military code classes, the diciphering of military codes, and the analysis of air reconnascence photos. There was direct liasion between Riverbank and General John Pershing's staff including their scientific adviser Wallace Sabine. The colonel utilized both regular army, Illinois National Guard and his own employees to conduct the projects.

It was because of Fabyan's efforts with the Illinois National Guard and the

United States Army that Governor Yates officially bestowed on him the title of colonel, a title that George Fabyan cherished above all. In recognition of his contributions to the military, the governor designated a troop of cavalry scouts assigned to the 123rd Field Artillery Battalion as The Fabyan Scouts.

The colonel trained some of his field hands and men from the Geneva area and called them the Fox Valley Guards. He was in the process of seeing what was involved in having his Fox Valley Guards become part of the Illinois National Guard stationed at Riverbank when one of his recruiting demonstrations changed everything. As the story goes, the colonel's recruiting demonstration had such an effect on his own guards that most enlisted right on the spot, into the regular army or the Illinois National Guard that was headquartered elsewhere. The colonel was so overwhelmned by the patriotism of his "boys" that he threw them one of the biggest Riverbank parties ever.

In 1905 Fabyan was selected by President Teddy Roosevelt to serve on the peace team that negotiated the signing of the Portsmouth Treaty, ending the Russo-Japanese War. During the negotiations the colonel played a principal role as adviser to Baron Jutaro Komura of Japan. The baron was the Japanese minister of foreign affairs and head of the Japanese delegation to the Portsmouth, New Hampshire, conference. For his part, Fabyan received the Order of the Rising Sun from a representative of the emperor and much admiration from President Roosevelt. Shortly afterward, Riverbank became host to many Japanese dignitaries, including General Kuroki, who was the commander of the land forces in Manchuria during the Russo-Japanese War and Kan In No Miya, the youngest son of Emperor Mutsuhito, brother of Emperor Yoshihito and uncle to Emperor Hirohito. A source stated "that it is thought that the Colonel acted as a temporary Consul for Japan in the Chicago area until a permanent Japanese Consulate was established."

Because the colonel was an official member of the state of Illinois Welcoming Committee, his home also served as a haven for visiting dignitaries. Among those who visited Riverbank were President Teddy Roosevelt, Admiral Byrd, Albert Einstein, Lilly Langtry, Mary Pickford, Billie Burke, Flo Ziegfield, Billie Dove, P.T. Barnum, Ernest Lawrence, Arthur Compton, Marshall Field, Colonel McCormack, Colonel Baker, and the Morton family.

The colonel's house, the villa, was originally a wood-framed farmhouse. Although somewhat typical of the frame homes of the period, it is reported that the original house contained features relating to an arts and crafts motif, where much of what existed inside was handmade. In 1907 the Fabyans commissioned the famous architect Frank Lloyd Wright to do extensive remodeling. Wright transformed the dwelling so that it was in harmony with the natural Riverbank environment. A cruciform design emerged, sporting wide eaves, rich decorative detailing, and multipaned casement windows that echoed the gabled roof lines. Outrigger-type verandas reached out horizontally from the north, south and east sides. These modifications, coupled with

many interior changes, provided the qualities of a longer and lower profile with more available space and light typical of other Frank Lloyd Wright constructions in the Chicago area.

Inside, Wright's idea of furniture — built to fit — was used in a few rooms, and in accordance with one of the avant garde ideas of the day, Nelle had a few pieces suspended by chains from the ceiling. The design exemplified the vision of both Frank Lloyd Wright and the Fabyans.

When Riverbank was at its peak, if one stepped out on the east veranda of the villa, which sat high on the hill of the west bank of the Fox River, one could see a vast portion of the Riverbank estate as it extended far to the horizon. Beyond the distant hillside, opposite the east bank of the Fox River, were the east woods, standing ever so majestic, touching the sky with its many colored fingers. It was the Fox River, however, meandering southward through the middle of the colonel's well-groomed estate that immediately drew one's attention. Somehow, the river was always transformed from its more common murky image as it majestically rolled through the estate, as if ordered to do so by the colonel himself. The sunlight and the magnificent beauty of the manicured grounds combined to turn the typical brown tint of the river into a glittering, silverblue liquid ribbon. Once beyond the boundaries of the estate, the river returned to its original muddy color and continued toward a rendezvous with the Illinois River in Ottawa.

Once the spell manifested by the river was broken, the next intriguing sight was a full-scale, authentic nineteenth-century Dutch windmill perched atop the east bank. In 1914, the colonel purchased the structure from Fritz Runge, who owned and operated the mill in York Center, a township about twenty-five miles from Geneva. The colonel had it dismantled, each piece labeled, and then reconstructed at its current Riverbank location. The colonel bought the mill so that he could have fresh bread made from his own Riverbank-grown grain.

East of the large grain windmill was Route 25 and east of that a large natural forest. On the southern end of the forest, there was a farm. North of the forest stood a girls' detention center, which was demolished in 1984.

Also located on the east shore was a large Indian statue dedicated in honor of Chief Black Hawk. The colonel showed deep respect for the Native American by providing presentations on the Native American way of life on various occasions. He constructed replicas of Native American villages on the east bank and the island highlighting different tribes and their respective customs. Some contend that this reverence was for his wife, whose father was an Indian agent in Walker, Minnesota, her hometown.

North of the statue and below the windmill was the workmen's swimming pool, one of two main pools plus three reflecting pools located on the estate. The largest was a huge Roman-style pool located on the south edge of the island. This lighted pool was a magnificent work of art, with large steps and a

The Large Grain Windmill and Lighthouse.

peripheral colonnade supported by a double row of trellis-supported columns. The columns were actually crafted out of wood but were painted with a special sand mix that resembled early-Roman masonry. In the deck were embedded decorative glass disks, and an elaborate sculpted bench was set to one side.

Then, as now, the island could be reached from either shore via bridges. Originally, the bridges were made of wood and, on occasion, were lost or destroyed because of flooding. The girders and main span of one of the now existing bridges are metal with wood planking and concrete pilings; the other bridge is constructed entirely of metal and concrete. The latter bridge is also protected upstream by a roadbed built over a series of culverts. The area of water between the roadbed and the bridge was known as the cove and, in winter, was used by many for ice skating.

On the island was a large copper-domed lighthouse that flashed its beam in a sequence of two, then three, then two, then three, and so on. For years, this sequence didn't mean much to anyone until a newspaper article disclosed that it actually meant twenty-three from the old expression, "Twenty-three skiddoo," the colonel's way of saying keep off. Because the Fox River was considered a navigable waterway by the government, special legislation in the United States Congress was required before the colonel could construct

the second bridge, leading from the island to the east shore. This legislation prompted the colonel to construct the lighthouse in the first place. One theory is that because of the river's designation as a navigable waterway, the lighthouse was the colonel's way of mocking the government for its having refused him permission to officially declare the portion of the river passing through his estate as private property.

A short distance from the lighthouse is a high pedestal supporting a large sculpted eagle with outstretched wings. This eagle was identical to the tower eagle described earlier. Apparently, Silvestri used the same mold. Through the years, the island eagle deteriorated, and after the laboratory tower eagle was damaged by lightning, both eagles were duplicated (resculpted) and replaced. Not far from the island eagle was a fresh running "spring" that flowed from a multitiered masonry pedestal bedecked with flowers. Many were unaware that the spring was actually fresh cold water from an artesian well pumped from the boat house on the west shore which also supplied the water for the Roman-style pool. The combination of elements enhanced the beauty of an island that was appropriately called Isle of View, a name that spoken rapidly, doubles as a pronouncement of affection.

Another island farther upstream was called Pirates Island. Many of the Riverbank families would camp, fish, and swim off this island because of a natural sandbar and shade trees close to shore. Realizing that Pirates Island was washing away the colonel made a valiant attempt to save it by having a retaining wall built to its north, but, in time, the island was lost to the river.

During the winter of 1916, an early thaw caused one of the most damaging Fox River floods ever reported. Besides the high water, massive sheets of ice appeared as gargantuan monsters that gouged, dug, and ravished the surrounding land as they traveled downstream. The colonel's wooden bridges were swept off their moorings like toothpicks. A swimming pool was completely buried, and a boathouse was flattened. So much damage was done that, eventually, everything of aesthetic importance to Riverbank was either rebuilt, repaired, or replanted.

On the west shore, heading north from the main island road, was an icehouse. Farther down by the bridge was the boathouse that pumped water to the spring and the Roman pool on the island. Beyond this boathouse were two others. The first was the main boathouse. It was set back from the river and was reached by going through a thirtyfoot tunnel. Once inside the boathouse itself, the docking area expanded, revealing an area large enough to accommodate six boats. The ceiling was built to open, and various hoisting gears were used to raise the boats for storage on the second floor. A cement staircase led up and out from the docks to the main grounds.

The other boathouse was smaller and was located right on shore with its dock pilings in the river. The colonel had a motorized launch, a round-bottomed racing scull named *The Lady Nelle,* an eighteen-foot sailboat (eventual-

ly donated to the Boy Scouts of America), two Indian birch-bark canoes, and a handful of fishing boats and rafts. The rafts were used to haul supplies and cattle across the river in the farming areas primarily south of the main grounds.

The individual in charge of boating activities was Jack "The Sailor" Wilhemson, a tall, strong man who once sailed the high seas on Norwegian sailing vessels and had the seamanship credentials to prove it. A character straight out of folklore, Jack the Sailor could dance the jig and tie every sailor's knot known. Quite often, he would intrigue the workers, children, and guests with his tales and demonstrations of knot tying and rope splicing. He was responsible for weaving and erecting an enormous rope spider web that hung between two large elm trees on the estate, an eerie sight to the ladies but a delight to the birds and squirrels, including some imported European black squirrels, who ran and perched there.

Many of Riverbank's guests were treated to a boat ride on the Fox with Jack at the helm singing, spinning yarns, and acting as tour guide. In addition to his talents as an entertainer, he was most adept at handling and caring for the colonel's boats, cattle rafts, pumps, and pools.

Besides the river, perhaps the most breathtaking source of beauty throughout the entire estate were the countless flowers, many of them grown in the colonel's greenhouses and then displayed in arrangements suggested by Nelle Fabyan to Riverbank's gardeners — as many as twenty-five of them working there at one time. Of all the horticultural wonders at Riverbank, the Japanese garden attracted the most attention. Poetic in this peaceful and tranquil setting, it was designed in authentic Japanese style by Taro Otsuka. One published account stated that the services rendered by this professional Japanese gardener were arranged by the Imperial family as a gift of gratitude to the colonel for his efforts regarding the Portsmouth treaty, but this story has never been confirmed. Sumiko Kobayashi, the daughter of the colonel's Japanese gardener, Susumu Kobayashi, had reservations about the authenticity of the story, stating that her mother disputed the story when told about it. Sumiko stated that her father first met Taro Otsuka at the Chicago YMCA in 1917, where Otsuka was employed on a part-time basis, and that Otsuka designed many other gardens in the Chicago area before and after he designed the garden at Riverbank. If Taro Otsuka had any connection to the Japanese Imperial family, the Kobayashis surely would have known and would have discussed the subject during family gatherings. Indeed, such an honorable connection would not have gone unvoiced.

The Riverbank Japanese garden was intricate in detail, both in the physical sense and in the spirit of Japanese tradition. Completely enclosed, the garden allowed the individual spirit to communicate with its ancestral past and harmonize with nature. It was a place that allowed one to reflect on and separate the spiritual being from the physical and material things of life and assess one's inner virtues of honesty, dignity, wisdom, and humility.

When entering the garden through the Torii, a gateway commonly used to approach a Shinto shrine, visitors saw a miniature panaroma of hills leading to a replica of Mount Fujiyama. South of Mount Fujiyama were two goldfish ponds that linked under a half-moon bridge. Lanterns, plants, and other authentic Japanese elements, including a waiting bench chamber, three authentic gateways, and various pathways were spaced throughout.[4]

For fourteen years (1925-1939), the Japanese garden, as well as many of the other floral displays located throughout the estate, were the responsibility of Susumo Kobayashi. Much of what was grown in the greenhouses was cared for by Kobayashi. The Kobayashi family lived in a house located north of the villa and were highly regarded throughout the community.

In addition to the Japanese garden, sculptures and ornamental grottoes were located in the area immediately east of the villa. A few feet across from the largest rock grotto was a 200-foot long, two-section rose arbor that ran eastward from the middle north-south road. The arbor concealed a pathway under its canopy of roses and at the midpoint was a small, open area in which a pedestal-mounted sundial stood. At the far end of the arbor were two large ornamental gates; some say celestial-swinging metal gates. The gates opened to the bridge leading to the island.

Another grotto to the south featured a water-spewing lion's head, lilacs, and rock formations as well as floral plantings. East of the grotto was a trolley line, its rails extending north and south through the estate, part of the Aurora-Elgin Railroad commuter line that had three stops — stations 31, 32, and 33 — on the colonel's estate. It was reported that on occasion, the colonel would treat the passengers to refreshments, usually tea and cookies or, when it was extremely hot outside, fresh cold water or lemonade.

At the top of the west hill, just north of the villa, was an Egyptian-style sculpted armchair, bench, table, and pedestal emblazoned with various hieroglyphics and symbols. These structures most likely resulted from the discovery of the tomb of King Tutankhamen in 1922, when Egyptian mania swept the country. The armchair, as grand as any pharaoh's throne, was created entirely of concrete by Fabyan's sculptor Silvestri. This chair, along with two others that were on the estate during Fabyan's life, were given consideration as *hell chairs,* seats reserved for those times when the colonel wanted or needed to sit and raise hell with the people who worked for him.

Besides the Egyptian throne, a wicker chair swing was on the veranda that was said to have been the colonel's primary roost when he needed to let off steam. Elizebeth Friedman, who spent a number of years at Riverbank, gives an account of how the chair got its name:

> There was a large wicker or reed armed chair held by chains which swung twenty or thirty feet from an enormous tree. This chair I soon came to know as "the hell chair." In it, the Colonel sat and swung back and forth, chain smoking and poking an enormous fire which burned even on summer evenings. Evening after

evening he sat there with anyone he could gather around, and if anyone in the conversation would displease him he would stand the offending person, guest or employee up before the hell chair and literally give them hell. Thus the name.

Perhaps all three chairs — the Egyptian throne and the two wicker swings — served the colonel. The throne does provide the better location for looking out over the entire estate, but it is stone and stationary and surely not as comfortable as a swing. No definitive answer to the location of the so-called hell chair has ever been given, so speculation about it, as is the case with so much of Riverbank, continues.

Some other points of interest on the estate were a gazebo, a sunken pond, a tiered fountain, stone steps with ornate railings, a vineyard north of the villa, a perimeter multilayered limestone wall, yellow clay tennis courts, and Aunt Nelle's doll house. The ground also held various homes and quarters for the staff, a crew that numbered between 125 and 175 and was supervised by the colonel's secretary, Adele (Belle) Cumming, a perfectionist and ardent task master.

Then there were the animals. There were kennels full of dogs, some of them show-ring champions. There was an aviary with tropical birds and peacocks and a large cage where Louie, the Wolf, dutifully served as Riverbank's watchdog, howling whenever anyone approached. Deer romped in a fenced compound, and three bears, one named Mary and all lovers of pumpernickel bread, prowled about their large, barred cage. There was also an intricate circle of cages, known as the pie-shaped zoo, and a pit that served as a summer home to the colonel's alligators; in the winter, they were kept in the conservatory of the south greenhouse.

In addition to the alligators, bears, and birds, the colonel and Mrs. Fabyan also had monkeys, which they had leashed at different locations on the grounds and decked out in little red suits and small hats — or some other outfits — to perform their antics. One monkey was a kleptomaniac. Another had a special eye for picking out the pretty ladies and giving them a well-placed pinch. Another monkey would raise and lower a bucket from a shadoof well and provide water for those desiring a drink; however, if he didn't like you, chances are you would be doused rather than refreshed. The other animals loose on the grounds were on constant alert because the marauding monkeys enjoyed chasing them all over the place.

The youngsters of Riverbank had a paradise to play in. One such youngster was Riverbank Acoustical Laboratories' retiree Lionel (Don) Williams, who was born on the Riverbank estate on May 22, 1920. Don's father, Bert, was the Fabyans' chauffeur. He was also credited with being a person who could repair anything. The same accolade would be said about Don years later. Except for a four-year stint in the army during World War II, Don Williams and Riverbank have shared a life. At the end of 1985, he officially retired as a permanent Riverbank employee (thirty-five years with the IIT

Research Institute), yet by agreeing to stay on as a part-time consultant, in essence, his Riverbank career continues. His recollections of Riverbank are the source for much of the recounting in this book, including this story:

> On a winter day when he was still a boy, Don got angry at one of the colonel's alligators and decided to give the scaly beast a good thrashing. Without any thought of the consequences of his actions, young Don climbed over the retainer wall of the reptiles' greenhouse pit and was about to deliver a blow when he suddenly found himself flying backwards out of the pit and held dangling in the air. When he turned his head to see who would have dared do such a thing, he looked into the face of Jack the Sailor, whose quick actions more than likely saved the boy from losing a limb or his life.

Although the alligators and the rest of the Fabyan's menagerie attracted the most attention, the Fabyans owned an impressive amount of domestic livestock. Nelle Fabyan was a member of the National Livestock Breeders Association and had a box seat at the livestock show held annually at the Chicago amphitheater. Nelle developed many prize-winning animals in the scientific barn located south of the other laboratories. As for the other livestock, although some were sold, many ended up on the colonel's dinner table. A robust eater, Fabyan made sure his supply of hogs, cattle, sheep, ducks, chickens, turkeys, and geese was abundant. He also owned dairy cows and laying hens. The chickens were kept in a 500-foot-long chicken coop located just north of the laboratories. Most of the livestock were located on the perimeter of the farming areas, where wheat, oats, corn, barley, beans, rye, and hay were grown. Besides these crop fields, vegetable research plots were located throughout the estate and in the greenhouses.

During the colonel's life at Riverbank, the estate was not only a scientific community but a sort of public retreat as well, a place for local residents to get away from it all for a while. The scene depicted in Seurat's *A Sunday Afternoon on the Island of La Grande Jatte,* an idyllic, leisurely place for play and companionship, is probably an accurate representation of a traditional weekend on Colonel Fabyan's Fox River island. With so many area residents enjoying the peace and tranquility of the island as welcomed guests, it is no wonder that a great deal of attention was brought to the place and the man who owned it. Both the colonel and his estate became the subject of numerous newspaper articles.

A comparison of two of these articles indicates not only the awe Riverbank inspired in these journalists but also the way in which Colonel Fabyan was able to create different images of himself, playing different roles depending on his mood or purpose.

The first article, from the *Chicago Herald* dated July 12, 1915, was entitled "Col. Geo. Fabyan Soon to be a Miller De Luxe. Buys a Dutch Windmill and Will Turn it to Grinding Out Whole Wheat Flour. Music Trails Visitor, Breaks out in Spots All Over Estate from a Pergola to the Greenhouses":

Colonel George Fabyan, millionaire country gentleman, about to change identity and become the jolly miller deluxe of Geneva.

The deluxe end of his venture is best explained by the fact that the flour will be ground in the old primitive way — between stones — and will be worth about nine times the price of that which now goes to make up a considerable portion of the "high cost of living."

The colonel led the way to a knoll back of Fabyan Villa and pointed to a hill far across a wide expanse which took in dozens of greenhouses filled with growing roses, a big dog kennel filled with scores of animals, over the Fox River which sail and power boats were bobbing, to a hill a half mile away at one end of Riverbank. "That's where my flour mill is going to stand," he said.

The colonel continued walking, heading for a Japanese garden, a veritable wonder place of flowers, bubbling fountains and oriental skill, still discoursing on the wonders of the deluxe flour which he intends to mill.

Suddenly from a Japanese pagoda the Trinity chimes pealed forth. The music seemed to come from nowhere. As suddenly did it cease, only to break out on a porch of the villa, then over by the greenhouses, shifting from place to place and changing from classical to quickening ragtime at intervals. "Little hobby of mine," the colonel explained, half apologetically. "Both my wife and I like good music and like it all the time, so I had it arranged so it would follow us around if we wanted it to. It's produced by vibration on wood and is controlled from the villa. Listen to that. Isn't it pretty?"

"As I was saying about the mill of mine, ..." The colonel's dissertation on flour was broken off by a wild yelp directly back of the visitor, which caused his hair to stand. "Only a coyote. Nothing to be afraid of. He's locked up behind you in that animal house," the colonel explained laughing. "That coyote doesn't make much noise. You ought to hear that tiger cat in the cage next to him scream once in awhile." The visitor looked toward the tiger and took in not only the "cat" but a couple of black bears, a bunch of chattering monkeys, a couple of wolves and a score of other denizens of the wilds.

"Just got in a case of ten foot snakes, ..." Suddenly, the visitor broke off the colonel's remarks with a shout. "Gee, there is a swarm of bees flying right in through the window of your house," he yelled excitedly. "Not so fast, not so fast," the colonel cut in and then broke into a hardy laugh. "Those bees are just going into the music room to deposit their honey. You see I didn't trust that particular bunch of bees," he continued in a jocular way, "so I had their hive placed inside the place (villa) and had it glassed in so we could watch them and see that they didn't cheat. They go in through a hole in the wall. It's made honest bees out of them — this constant supervision."

Besides the bees the colonel has other lodgers in his house, a baboon in a cage and a small dog that is the baboon's companion. The baboon grins at arrivals and the dog barks at them cheerfully just as they enter. The house is unique in having exterior screened compartments with large open fireplaces capable of holding sizable logs. They make delightful spots in the evening when the fire lights up the entrancing landscape and provides both warmth and illumination. Also, if a vagrant mosquito would get by the barrier, the wood smoke would drive him away.

The light house served as a warning to intruders with its twenty three skiddoo connotation, ... "seems to me a burglar wouldn't need much warning after he got inside the stone wall and found all these bears, wolves, tiger cats, about ninety men who knew how to handle pitch forks, not to say anything about the squad of bull dogs and other canines I saw over in the dog kennels," the reporter ventured. "Well speaking of those dogs reminds me that I want to get a couple of bloodhounds," cut in the miller, "once in awhile we have a thief or a highwayman in the neighborhood and they might come in handy."

"But as I was saying about the whole wheat flour," the colonel started again only to be interrupted by the mooing of cattle in an adjoining pasture. "All belong to my wife," he said, "that's her hobby — blooded cattle — that bull over there the herdsman is leading is Ocean Blue, the grand champion Jersey and the other one next to him is Grey Portia, a grand champion Jersey cow. Those over there are all blue ribbon winners" ... . The walk and talk "whole wheat flour" continued back to the villa, again on the way music began creeping up here and there, ...

Here is another portrait of Fabyan, published six years later, April 22, 1921, in the Chicago *Daily News:* "Building Supermen at Fabyan's Colony. Scientists and Thinkers, 150 of them, Work on Many Things at Riverbank."

The colonel whisked out a cigarette case, drew forth a gold-tipped cigarette, broke it in halves and fed them to two monkeys in his private zoo. The monkeys shucked the paper off and complacently chewed the tobacco shreds. It was "Riverbank," one of the strangest and, at the same time, most beautiful country estates in America.

On both sides of the Fox River the estate spread. There was an old Dutch windmill, a mysterious $100,000 laboratory of acoustics, a barn made into an art studio, great hothouses, dog kennels, bear dens, lighthouse, zoo, farms, row after row of plows, Japanese garden, sailboats, champion hogs and cattle, open-air swimming pool and a great country house ...

"Yes," resumed the colonel, "a community of thinkers. There's 150 folks on this place, as I said, and every man, woman and child's doing original remarkable and humanitarian research work. Over there in that hothouse they're trying genetics on roses and tulips. What for? Why look at the average human being, a plighty pitiful contraption of flesh and bones. If we the Riverbank community can improve the human race by experimenting first with flowers and plants ... say, won't that be a wonderful thing? ... ."

"Community is right," he said, "we're all working together; no bosses, no time clocks, no cast iron regulations. I too am just a worker. Well, as I was saying, the best story here is our research work to find out what is wrong with the human body. Man started as a wiggling snake, became a tadpole, acquired shoulders somehow, grew into an antropodal [sic] ape, and then he decided to stand up, walk on his hind legs and become a man. But our stomachs were made to be carried horizontally; not vertically. Look at all the sickness that's come from defying nature! We want to see how nature's made revisions to meet this. The army training was all wrong, by the way. Everybody can live to be 100 years old. Just wait awhile. We're working it out."

Col. Fabyan's words were lost in the yammerings, cooings, growlings and screechings that rushed out through the doorway of the zoo-clinic. Cub lions, wolves, baboons, monkeys, bears, resplendent birds of the Amazon jungles — they all welcomed the colonel. He beamed and tweaked the ear of the black bear ... .

"How do you like my banana crop, young man?" There were clusters of green bananas hanging from trees. While the colonel told of the acoustics laboratory containing mausoleum-like buildings within buildings; of machines invented by scientists of the community for seeing and photographing sound; of organs that play by magnetic keys; of a brilliant girl who sat studying one single problem for eight months ... .

"Something new in sculpture," chuckled the Col. Fabyan! He nodded briskly toward figures of dancing women, eagles, lions, flowers. "You think they're chiseled out of stone, eh? Wrong! They're cement ..."

"Yonder we're studying the inefficient machine called man."

"The community flour mill" ... We grind all our flour for bread and pies, in the basement is a modern electric oven we bake everything on the spot.

"That's the Temple de Junk. Most important thing in the place ... Want to buy some plows? Here's seventy-five I'll sell you."

Col. Fabyan was dressed for his part of a millionaire country gentleman. He wore a frock coat, fancy vest, lavender stock around his neck and bowler hat. And unlike his fellow scientists he smoked no corncob pipe, but burned up rapidly many costly cigarettes. In the coat lapel he wore the rosette of the Legion of Honor of France. The colonel, you remember, backed Sir Francis Bacon as a "dark horse" against William Shakespeare in the famous Elizabethan sweepstakes. He also was the "father of the aue Fourth" idea in Chicago. He received the thanks of the allied military intelligence for his work in cryptography during the war.

Col. Fabyan acquired a large fortune through investments in Chicago and the development of his mercantile business . . . Bliss Fabyan & Co. 82 West Washington Street.

Don Williams commented briefly about the baboon and lions in relation to an expression dealing with the droppings of a bull. According to Don, there were monkeys but never a baboon and definitely no lions. Don had great difficulty in accepting the reason why some of these articles were included in this book and took many statements appearing within some of these articles to task. However, after it was established that the reason these articles were included was to point out why the colonel was so controversial, Don reluctantly accepted the idea, but with reservations. However, when reviewing these articles, Don still found it appropriate to reference the animal world often. Bull droppings were popular, as were hogwash and sheep dip. Thus let it be known that some of these articles do not please all those who knew the colonel or Riverbank.

Not all newspaper accounts dealing with Colonel Fabyan were as complimentary and positive as the preceding two, and not all relied on the truth: One

example involved Helen Morton, the daughter of the Salt King, and her elopement with a jockey. Needless to say, a scandal ensued and because of his friendship with the Mortons, Colonel Fabyan became enmeshed in the affair by allowing Helen to stay at Riverbank. Once they discovered where the Morton heiress was, reporters swarmed the place, all looking for a scoop. However, all were denied access by the colonel's many able-bodied employees.

Frustration abounded among the journalists who were eager to talk with the girl — in a number of accounts, she was characterized as a prisoner, being held against her will — until finally one enterprising young man, a fledgling reporter for the Chicago *Evening Journa*l named Lowell Thomas, published a story recounting a river journey; an interview; and a litany of miseries that the poor, lovesick Helen confessed.

The story created quite a stir, but, as it turns out, Thomas had fabricated the whole thing. In his book, *Good Evening Everybody, From Cripple Creek to Samarkand,* he explained how it all came about:

> Early in 1915, I got a chance to cover another big story — and this one almost ended my career in journalism for all time. That spring, every paper in the country was headlining the elopement of a Chicago heiress, Helen Morton, with Roger Bailey, her father's jockey. You can see the possibilities, a juicy scandal with everything from pathos to comedy — her father's jockey? The fact that the nubile Helen's father and his brother Joy were matter-of-factly referred to as the Salt Kings of America, and that her uncle, Colonel Fabian [sic] could be tabbed the Woolen King [cotton would have been a better choice] only piqued the natural appetite for every minute detail of this human drama. Alas! Helen and her horseman were caught in Kentucky — it was around Derby time — and the poor girl brought back in disgrace, and thereafter an iron curtain clamped down on her uncle's Fox River estate [Riverbank]. It was suddenly surrounded by a battalion of guards armed with pitchforks, and not a morsel of news trickled out to the hordes of waiting newsmen, of whom I was one; consequently there was no word, either of solace or spite, that we could pass on to the panting public. Day after day we sat around Wheaton, the nearest town [Many other towns, especially Geneva, are much closer. Either Mr. Thomas referenced the wrong town, or perhaps what he meant was at the time Wheaton was the closest passenger railroad station.], playing cards or shooting craps and waiting for lightning to strike.
>
> When it finally struck, Webb Miller of Hearst's Evening American and I were the ones bathed in its light of divine inspiration. Our stories were spread over page one of both our papers. We told how we had walked some miles up the Fox River by a circuitous route, found a flat-bottom scow and, hiding in the bottom, drifted downstream. Undetected, we managed to sneak ashore at the Fabian [sic] estate and, since such enterprise could not go unrewarded, we found the pensive Helen in a hammock, happy, at last, to be able to unburden her heavy heart. We were able to tell the world how she felt (melancholy) and what she thought about jockeys in general (not much) and hers in particular (she missed him). Anyway, she said, she believed in romance.

The story was a sensation, as well it should have been. During one of those waiting days, Webb, who didn't enjoy shooting craps any more than I did, had started us speculating on the "what ifs" that led to our farfetched yarn. We had simply invented the whole thing.

We might have gotten away with it, at that, if our papers hadn't insisted on photographs. The Mortons and Colonel Fabian [sic] were making no statements, acknowledging or denying nothing. But the morning after our big newsbreak, there was a fresh clutch of press people at the Wheaton railroad station, including the *Journal's* faithful Japanese photographer, Saito, hoping for a glimpse of anybody named Morton or Fabian [sic]. And as luck would have it, the kings — both salt and wool — showed up.

Little Saito scurried forward for a close-up, and the next thing I realized, one of the Mortons had him by the throat and his camera was flying through the air, to come crashing down on the brick platform. As no one else seemed about to intervene, and as poor Saito was, after all, my cameraman, I suddenly found myself flying across the station and, with the rage of the righteous, I began flinging Morton salt kings hither and yon. At least that's how Ben Hecht, who by then was with the Chicago *Daily News,* reported it. I only knew that when Saito and I got back to the *Journal,* my watch was smashed and I could otherwise tell that I'd been in a losing fight.

An hour later I was called to the office of John Eastman, owner of the paper. The Morton lawyers had already given him their version of the encounter; now he wanted mine. When I finished, he rather sourly said, "My boy, if we lose this case, we'll have to give them the *Journal* and owe them the rest."

Well, luckily we didn't lose it, or at least we won round one. In the Wheaton justice of the peace court a few days later, Saito, Miller and I confronted the Mortons and some of Chicago's most formidable legal talent. We won an assault and battery judgment against them for five dollars plus costs. I suppose you could call it an early test of freedom of the press, and Webb Miller and I, two vindicated, ink-stained wretches, celebrated our victory. Webb went off to Europe to become a top foreign correspondent and eventually head of the United Press London Bureau, and I went back to Alaska. But both of us, for years afterward, heard the rumblings of the Mortons' multimillion-dollar libel suits which, I believe, eventually outlived both our newspapers and all the Mortons.

The story at Riverbank is that while Helen Morton was a guest of the colonel, she was trained by his sculptor Silvestri in the art of sculpting. In the laboratory's second-floor conference room, above the fireplace, is a picture sculpted from cement that depicts a farm scene with various animals, a road, bunched corn stalks, pumpkins, a stream, a wooden fence, and a few other farm scene items. The sculpture is signed, Helen Morton.

In many ways, Thomas's tall tale, reads like a romance novel, but some of the tales told about alleged goings-on at Riverbank read more like novels of a steamier, seamier variety. Bringing into account everything from reform school girls to risqué scientific experiments, these often-related stories, when

taken together, paint a picture of Riverbank as a kind of exotic paradise and Colonel Fabyan as the satyr in charge.

An article published in the September 1923 issue of the *Scientific American,* "A Small Private Laboratory," by Austin C. Lescarboura, Page 154, illustrates — if not establishes — the tone that accompanied these tales:

> There was much mystery connected with this laboratory. The staff in charge moved about like so many Egyptian priests of old guarding the darkest secrets. To deepen the mystery still further, a *pretty girl* was brought in. We were ushered into a small booth with dull black curtains for walls. It reminded us strongly of our psychic experiments back in New York, when we exposed one of the leading mediums after three sittings. At the command of the colonel, the demonstration got under way. In a few minutes we were astounded at what we were witnessing. It seemed unbelievable, yet it was there, in plain black and white. We had been brought face to face with certain facts regarding the human mechanism which we would hardly dared to have surmised in the absence of such a convincing demonstration. We were shown how — well, at this point we can go no further. Colonel Fabyan made us promise that nothing would be said about the nature of this investigation until some later date, when the experiments have progressed further. It may take weeks or months or years. Meanwhile the public must wait until the scientists reach a point somewhere nearer to their objectives.
>
> So, big, startling things are being done at Riverbank under the cloak of secrecy. It is such work as this, conducted by such an institution which will unfold to us wonders within the next few years. We shall learn more about the human body than ever before; we shall wrest certain secrets from nature which have never been suspected; a new epoch will most likely open up. Every so often the world reaches a point bordering on stagnation, because everything seems to be fully developed, just as a field, after being cultivated year after year, exhausts itself if fertilizer is not added. But the scientist, pegging away at the secrets of nature, sooner or later breaks down existing barriers, opens the way to a new field, and we are soon confronted with brand new opportunities for exploration.

Is your curiosity aroused? What Lescarboura actually saw was a girl standing behind an X-ray screen and the images it created.

Regardless of the truth or the validity of the experiments, the Lescarboura article was transformed through the years into a story beyond belief. As the yarn was told and passed on from teller to teller, the one girl highlighted in the story became naked. Later on, the one girl became many girls. Then, the Geneva detention home for delinquent girls, which was a neighbor to Riverbank, became a part of the tale, and the whole incident took an even more sordid turn.

Years earlier, the colonel had donated money to the Geneva State Training School for Girls for the construction of a new dormitory for the girls who resided there. The new building was located adjacent to the northeast corner of the colonel's estate. In appreciation for Colonel and Nelle Fabyan's generosity, school officials installed a sign above the entrance to the building

that simply said Fabyan, and the building became known as the Fabyan Cottage. Because of the name and the previous article and other, similar stories, local gossip eluded that the cottage bearing the colonel's name was a kind of recruiting station, and the girls who lived there were the colonel's private chattel. The story changed as years passed, and eventually, the cottage was no longer mentioned as part of the school but simply as a house the colonel built for attractive young women who were at Fabyan's disposal for special events at Riverbank.

In truth, the girls who lived at the detention home were brought to Riverbank but not for anything scandalous. Rather, they were part of a class sponsored by Nelle to improve the poise, posture, and etiquette of these wayward girls. The colonel's medical staff was also involved because of its studies regarding the physiology of the human body, and the likelihood of medical examinations exists. Although the examinations would have been relevant to posture-related studies, there is a strong possibility that the girls would have disrobed for the posture-related measurements, thus originating the sordid stories about what was truly a genuine scientific project.

Nelle Fabyan's class was a success. A few girls who were released from the detention center found a career in modeling. They were employed by agencies run by two of the women hired to assist in conducting Nelle Fabyan's class.

Although many of the myths that surrounded the colonel were just that, the story about mistresses, who at times resided on the estate and were known to Nelle Fabyan, is true. As the story goes, the colonel wanted a child, but Nelle was unable to bear any. Rather than leave Riverbank in the hands of strangers anxious to get their hands on the property after both the colonel and Nelle were dead, they decided it was imperative that they have an heir. Why adoption was never considered is a mystery, although it is possible that the colonel felt if he fathered a child, it would indeed be a Fabyan and have a legitimate claim to any inheritance. With one of his mistresses, he came close to having a child, but she lost the baby while in the hospital.

While his mistress was in the hospital recovering, the colonel learned that a woman who already had a very large family had just given birth to a daughter. Although it negates the notion that he had to be the child's natural father, Fabyan offered to buy the newborn. Because of the economic hardships of the Depression and because the colonel could provide wealth and an education for her child, the woman considered giving up the baby. However, motherhood and love for her daughter won out in the end, and the colonel remained childless.[5]

Even though he did not leave an heir, the colonel did leave a legacy rich in both the eccentric — as the previous stories attest — and the scientific. His reputation in the eccentric category is based on both truth and folklore, but his reputation in the area of science has a more solid, verifiable foundation.

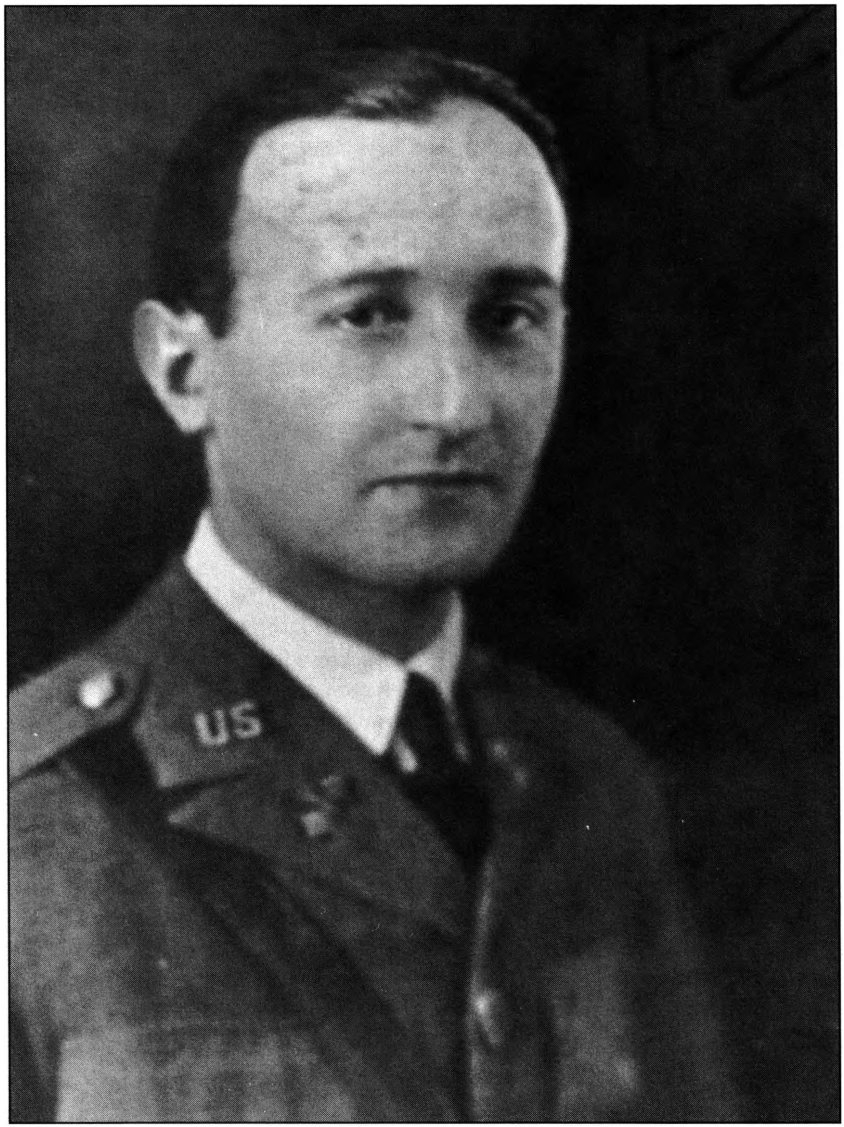
George Fabyan was an idea man, intelligent and innovative. Although he lacked the technical and academic degrees and the scientific knowledge required to carry out a particular project, he was, nonetheless able to see the potential in a project and because of his wealth, he could go out and hire people who could get the job done. In addition to his contributions to the world of science, Colonel Fabyan was a patriot, an American who took pride in his country and who, again because his wealth allowed it, was able to contribute in spectacular ways to the nation, particularly to the military.

One summer weekend in 1918, the colonel opened up the west portion of Riverbank to the public and used his Fox Valley guards to stage a huge demonstration of modern wartime tactics. Included in the presentation were many foreign and U.S. military guest speakers along with area politicians and dignitaries. As one observer noted, the gathering of more than 4,000 people was "one heck of a recruiting show," an appraisal borne out by the fact and referenced earlier that many of the area's young men enlisted on the spot, and many more signed up the following week.

The colonel's patriotism was evidenced in other ways as well. Every day at Riverbank began with a bugler playing reveille and the raising of the flag. At sunset, taps was played, a small brass cannon was fired, and the flag was lowered and folded. Those who were not on hand to witness these ceremonies were reminded of their obligation by a sign posted next to the middle road that read, "Men Passing Here Will Please Salute the Flag."

By 1918, there were almost 100 regular army officers stationed at Riverbank. The primary purpose for about eighty of these officers was entirely different from the purpose of those participating in war games. Their involvement began when the British government, by way of Scotland Yard, sent a coded message to Washington. Accompanying the message was the statement, "Here is an example of the code England plans to utilize during this campaign, and as you can see, it is completely undecipherable." The British purposely failed to include a key. The United States was embarrassed because the country did not have a cryptography department or code facility. Fortunately, someone in government remembered that Colonel Fabyan in Geneva, Illinois, had volunteered his cryptography facility to the government. The coded messages were delivered by special envoy to Riverbank. Within three hours of receiving the messages, the code was broken by William and Elizebeth Friedman. Immediately, a message was cabled back to London in the British code, "This cipher is absolutely undecipherable," which was the original message received from the British. Needless to say, the British code was never used during the campaign.

As a result of the Friedmans's brilliant success, the U.S. government contacted the colonel again and arranged for Riverbank to become the first U.S. military code school. Many of the officers assigned to the school later became involved in army intelligence. Although there are accounts stating that River-



William Friedman.

bank is the birthplace of the CIA, the connection is not obvious. If you include William Friedman's career you may make some connections from Riverbank to the Army Signal Corps, their code and cipher sections, G2-Army Intelligence, the signal intelligence service (SIS), the Signal Security

Agency (SSA), and the Army Security Agency (ASA, later part of INSCOM).

Establishing direct links to the Black Chamber Group, Military Intelligence Section M1-8, the Office of Strategic Services (OSS), and the Central Intelligence Agency (CIA) is not obvious. However, as the National Security Agency (NSA) in 1993 recognized Colonel Fabyan for his pioneering effort in cryptoanalysis, perhaps a link between Riverbank and the CIA is possible, although unlikely. Although a few code-related documents were available before Riverbank became involved with codes for the army, navy, the U. S. State Department, the U. S. Department of Justice, and the U.S. Post Office, Riverbank was the first institution charged with creating a cryptology curriculum and a textbook and, in essence, the science of cryptology. According to Elizebeth (Smith) Friedman, she and her husband, William, and others at Riverbank were pioneers, simultaneously teachers and students, working together to chart the course of this new science.

One of the first government tasks undertaken by the Riverbank codebreakers was to decipher correspondence between Germany and South America. To assist with the job, Colonel Fabyan brought in Spanish and German translators, and for eight months, the small group at Riverbank performed all code and cipher work for the government. It was also during this period that the army sent the officers to Riverbank for instruction, primarily in learning existing code structures and in writing codes. Although critics contended that the officers should have been taught how to decipher codes, it was the feeling of the Riverbank cryptologists that to be able to decipher codes, it was first necessary to know how they are structured and written.

Interestingly, Elizabeth Gallup, whose work with the Baconian ciphers was the genesis of cryptology studies at Riverbank, did not conduct any of the classes. Some surmise that at the time, it was unlikely a woman would be allowed to instruct military officers. Other accounts state that Gallup was well into her senior years at the time and preferred to remain in a side room and monitor the proceedings. When time allowed, she would consult with William Friedman, the instructor. Just how many classes were conducted at Riverbank is not known. Because there is only one graduation-day portrait, it is assumed that there was just the single class, but the colonel stated in a few articles that the picture represented the second graduating class from Riverbank. The first class consisted of four to six officers who came to Riverbank in the fall of 1917. Their primary purpose was to evaluate what the colonel and his Riverbank staff could provide in training the military in code work. One account said that all told, eighty officers graduated from Riverbank. The class shown in the photo had only seventy-one officers, including those from the initial group along with five civilians, which means there might have been a third class as well; this speculation is based on a file document stating that another eight to ten officers were involved in a code class offered after a much larger class of officers had graduated.[6]

Apparently, as the following letter suggests, the Riverbank graduates did quite well:

FM/V

GENERAL HEADQUARTERS
AMERICAN EXPEDITIONARY FORCES
GENERAL STAFF, SECOND SECTION (G.2)

France, May, 14, 1918.
Colonel George Fabyan,
Riverbank, Geneva, Illinois.

My dear Colonel:

I have just received your valuable and interesting pamphlets on ciphers and wish to thank you, not only for them, but also for your generous interest in our work. Graduates of Riverbank are now doing the greater part of the work in our code office, and Colonel VanDeman has been requested to send us the other men recommended by you.

We regard this cipher work as of great importance, and thoroughly appreciate the value of your assistance and the patriotic spirit in which it is rendered.

Hoping for your continued support, I am, with best regards to both yourself and Captain Powell.

Very respectfully yours,

D. E. NOLAN,
Colonel, General Staff,
A.C. of S.(G.2)

By accounts of some of the officers at Riverbank, being stationed there was "like being stationed in paradise." Meals were served with all the finery that goes with elegant dining: candles, flowers, linens, fine silverware and china, and imported wines. The meals included homemade bread, pastries, fresh milk, eggs, vegetables, and meat — all from the Fabyans' farm. The officers were billeted in a hotel with all the luxuries afforded to VIPs. To top it off, there were various social events — parties, teas, box-lunch picnics, and trips — and many dances, including an exquisite military ball that was said to be equaled by no other, all of which were attended by many of the young girls from the area, invited by the colonel that they might do their part for the boys and the war effort.

One of the officers, a young soldier known only as the cowboy, was so smitten with a girl he met the night of the gala that he could not get her out of his head, and he told his fellow officers that his heart had been captured. Unfortunately, according to the cowboy, the girl's father controlled her life,

the mail, and the telephone, leaving him with only the memory of a wonderful evening at a marvelous dance with a golden-haired angel in Geneva, Illinois.

The signing of the armistice on November 11, 1918, effectively brought an end to the military code classes at Riverbank, and eventually, the U.S. cryptography facilities were assigned to Washington D.C. However, the end of the war did not bring an end to Colonel Fabyan's patriotism. Involvement in military affairs remained central to his life and to life at Riverbank.

Those who lived in nearby Geneva were certainly aware of what Riverbank had been during World War I. The serene way of life local residents cherished was clearly affected by the colonel who had no reservations about disturbing the peace and quiet of the Geneva area with his military projects. There were moments, to be sure, when many Genevans probably thought that the war had reached the city limits — especially when the soldiers arrived, trenches were dug, explosive research took place, and an army Flying Jenny biplane swooped in — but, there are no accounts of the colonel having ever been interrupted by community action or protest.

Riverbank was, in fact, considered a community unto itself by Geneva residents, a distinction that suited those who lived on the Fabyan estate because they viewed themselves as a separate entity as well. Not that there was any hostility between the two — it was simply a matter of pride, nothing more, nothing less. However, this atmosphere of mutual isolationism contributed to the Riverbank mystique. It was not until after World War II that Geneva extended the city limits to incorporate the Riverbank estate.

Fortunately, as far as the local residents were concerned, most of the military research after World War I was of the indoor variety that didn't affect the serenity of life in Geneva. Even after the death of both Fabyans, the research at the laboratories continued, the only post-World War II military project that created turmoil among the area residents was the development of a speaker transmitter for voice propagation from a low-flying aircraft to the ground. Because the recorders and monitors were located in the cubicle on the laboratory's roof, a B-26 aircraft made low passes from all four compass directions at different hours and under all weather conditions. On each flyover, a taperecorded message was transmitted. One day, though, because of mist and fog, the aircraft made a run at a much higher altitude, and the sound carried over Geneva. Unfortunately, the test message that day was, Damp dark places are bad for romance. Apparently all Geneva heard a garbled message that sounded like, "Damn dark places are bad for romance." Because few people were aware of the project, the voice from the sky was considered by some to be that of the devil itself. When it was learned that Riverbank and not Satan was responsible, the feelings toward the source remained virtually the same.

CHAPTER

3

Riverbank Is Fabyan, or Is It the Other Way Around?

A local speaker once started a lecture about Colonel Fabyan and Riverbank by stating, "In order to truly understand Colonel Fabyan, one must first fully appreciate Riverbank and all that it stands for." Paradoxically, an article that appeared in an early edition of a scientific journal about Riverbank read, "In order to fully appreciate Riverbank, you must first understand its owner, Colonel Fabyan, and all that he stood for." Which is more accurate? In truth, the answer is probably both because Fabyan was Riverbank, and Riverbank was Fabyan.

Like his estate, the colonel was larger than life, and his ambitions matched his image. One of his goals was to gain for himself national, perhaps even international, renown: he pursued this goal chiefly by establishing Riverbank as a self-sustaining community where, as mentioned earlier, scientists and other researchers on his payroll conducted experiments and then reported their findings to the world. Many of them went on to establish names for themselves after leaving the colonel's service.

William Friedman, one of the code breakers of the British cipher, became one of Riverbank's most famous figures for his work in cryptology, but he did not come to Riverbank originally for that purpose. A graduate of the Michigan Agricultural College, with an advanced degree in genetics from Cornell University, Friedman was hired to improve various agricultural products on the colonel's farms. On occasion, he was also to assist a leading horticulturist, Charles McCauley, in the colonel's greenhouses where award-winning roses (Killarney and Columbia), along with new varieties of carnations, snapdragons, chrysanthemums, and other flowers, were developed.

Also developed at Riverbank were various strains of vegetables, including a hybrid corn strain that became popular throughout the midwest.

Because of an aptitude with mechanical devices and his skills in photography, young Friedman was persuaded by the colonel to assist Elizabeth Gallup on her Bacon-Shakespeare project. As it turned out, Friedman had no reservations about leaving his study of genetics and agriculture. He had fallen in love with one of Gallup's researchers, Elizebeth Smith, and decided that he was more interested in code work with Little Liz than in greenhouse endeavors.

Elizebeth Smith, after graduating from Hillsdale College in Michigan in 1915 with an English degree, was sent by an agency to the Newberry Library in Chicago. The librarian there informed her that a position involving Shakespearean research was available. A wealthy man, interested in the disputed authorship of Shakespeare's plays, was looking for a young, personable, attractive college graduate who knew English literature. Elizebeth telephoned the man to inquire about the position; shortly thereafter, Colonel Fabyan arrived at the library. Elizebeth's written account of the event follows:

> When he arrived, he turned out to be a large man, bearded, which was very unusual in those days, not too well dressed, but with a very dashing, imperious manner, who called himself Colonel George Fabyan. He wasted no time talking there but at once invited me to go with him overnight to his estate at Geneva, Illinois. Though I was a bit taken back and at first refused, he was the kind of man who did not take "no" for an answer. His city car, with a chauffeur, was waiting outside and I was almost forced to proceed with him to the Chicago Northwestern station where we took a train.
>
> He talked about everything except the possibly forthcoming position, until we were seated on the train. Then after a very few moments of silence he turned to me and shouted, "WHAT DO YOU KNOW?"
>
> By this time I was realizing that I must appear to be a demure little nobody. Although I had a reputation for volubility in college, I had done no talking whatsoever for he had kept up a constant stream of conversation. So when he thundered at me, "WELL, WHAT DO YOU KNOW?" I leaned against the window as far away as possible, and looked at him quizzically out of my half turned head and said, in a firm but low tone, "that remains, Sir, for you to find out." My answer pleased him and he burst forth in a loud guffaw which could be heard all over the car.
>
> After that, the restraint between us somewhat eased and the rest of the short journey was passed in pleasant conversation by his narrating to me in a more or less calm and restrained manner, that a woman employee of his, Elizabeth Wells Gallop [sic], had discovered a cipher which proved that Francis Bacon had written Shakespeare.
>
> At Geneva, we were met by a limousine and driver who drove us a short distance to Riverbank, Colonel Fabyan's three hundred acre estate (later it became larger). On one side of the highway, there was a high stonewall with impressive gates. He told me that his own residence, swimming pool and stables were in that part of the estate. Our car, however, turned off on the opposite side of the highway and we shortly reached a house known as The Lodge. This was where Mrs. Gallup and her sister, Miss Kate Wells, resided and where they had all of

> their accouterments to prove their certain claim that Francis Bacon was the author of the Shakespeare plays and sonnets. This lodge was staffed with servants and it was there that I was to spend the night in a guest room.

Elizebeth Smith also mentioned that she was introduced to Elizabeth Gallup and some young men during dinner at the lodge. She described Gallup as an elderly woman of extremely aristocratic appearance. Her conversation while at the head of the dinner table was of travel and residences abroad where she had stayed with various distinguished families who believed in her cause and had financed her efforts through the years. Elizebeth deduced from that meeting that Elizabeth Gallup had dwelt only among those who agreed with her premise and that she had little personal contact with the viewpoint of those who did not believe in her theory.

The position that Elizebeth Smith accepted made her part of a contingent of intelligent young women who were taught to master Gallup's cipher proof of Bacon's authorship of the plays. By proceeding over the same ground that Gallup had covered, they would prove that the earlier deciphering was correct. They would then go on to read other portions of the cipher from the plays and other works of the Elizabethan era because Gallup's research had led her to believe that Bacon had authored many other distinguished works of the Elizabethan age in addition to those of Shakespeare.

Elizebeth Smith's presence among Gallup's researchers was, as mentioned previously, a key reason behind William Friedman's switch in his attentions. His infatuation was reciprocated and, as the following passage notes, resulted in matrimony:

> Colonel Fabyan was also interested in genetics and had established a greenhouse and adjoining laboratory for the conduct of experiments in the field. His geneticist was a dark-haired young man, who experimented with the fruit fly and with plants, testing the Mendelian Law of Heredity. There was a windmill in the center of the area where the geneticist worked and Colonel Fabyan had constructed a sort of studio on the second floor where the young man lived. I saw him at meal times and on off hours when all of the young people on the place were swimming, bicycling and riding. As time went on, the geneticist was found to be an accomplished photographer. So he was pressed into service by Colonel Fabyan who believed that enlarging the type forms in Elizabethan books would show up the differences which Mrs. Gallup claimed were there. This work threw us together a very great deal, and we were married within the year.

As marital, as well as professional, partners, William and Elizebeth Friedman were able to decipher many foreign and domestic codes as well as develop various coding machines and deciphering devices. In 1918, William Friedman accepted a lieutenant's commission in the army and spent the last five months of the war on General Pershing's staff in France. In 1919, the Friedmans returned to Riverbank and began their series of Riverbank publications. Number 22 was the most noted: "The Index of Coincidence and Its

Application in Cryptography." In large part as a result of their work on the Index of Coincidence, the army contacted the Friedmans and offered them a six-month trial period as civilian code breakers in Washington, D.C. The Friedmans accepted and, in 1922, left Riverbank for good, establishing themselves in the years that followed as two of the world's leading cryptologists. During World War II, William Friedman, a colonel himself in the army, became known as the man who broke the Japanese Purple Code, a feat no one considered possible.

Although the Friedmans loved Riverbank, they had many reservations about Colonel Fabyan because he had broken many promises, involving back pay, title recognition in regard to published documents, and other fringe benefits. When discussing the Baconian ciphers, the Friedmans stated that they spent years working on Bacon's writings, and the results of their efforts were documented by them. However, when their book *The Greatest Work of Sir Francis Bacon* was printed in 1916, the author listed was George Fabyan. They also cited other published documents about codes that were written by them but credited to the colonel.

Although theses references to Colonel Fabyan by the Friedmans are, in part, true, there are some exceptions regarding published Riverbank documents from the same period and even about codes. For example, one book was entitled *Ciphers for the Little Folks.* On the front cover was written, "The Dorothy Crain Series—A Method of Teaching—The Greatest Work of Sir Francis Bacon, Baron of Verulam, Viscount St. Alban, Riverbank Laboratories Educational Department, Dorothy Crain, Director of Kindergarten, Geneva, Illinois." The second page repeated everything on the cover but included "Designed to Stimulate Interest in Reading, Writing and Number Work, by Cultivating the Use of an Observant Eye. With an Appendix on the Origin, History and Designing of the Alphabet by Helen Louise Ricketts." On the third page was the only reference to the colonel: "Copyright, 1916 George Fabyan."

Another book was published in French in 1918 by the Riverbank Press: *Methode Pour Enseigner et acquerir une connaissance practique du Chiffre Bilitere A l'usage des ecoles primaires (Method for Teaching or Acquiring a Practical Understanding of Binary Codes for Use in Primary Schools).* Again, Dorothy Crain is listed as author. On the next page, Crain is given credit, as again was Helen Louise Ricketts who provided some technical information for the book. On the third page, there is a reference to the colonel, preceded by the following: "Vulgariser la science sans jamais l'abaisser; vulgariser sans vulgairiser" ("To popularize science without ever debasing it; popularizing without vulgarizing") and, at the bottom of the page, "Copyright 1918, George Fabyan."

The aforementioned examples show that the colonel did not intend to take full credit for either book but gave credit to Dorothy Crain and Helen Louise

Ricketts. Because the Friedmans were not mentioned perhaps their accusations are justified.

As stated earlier, in 1918 it was William Friedman, rather than Elizabeth Gallup instructing the U.S. Army in codes. The course he taught, however, was not on deciphering codes (it came much later) but on the development of new ciphers. At the end of the class, Friedman's first students gathered in front of the Aurora Hotel in Aurora, Illinois, to have a graduation photograph taken.[7] What is most unusual about this picture is, if observed closely, some of the officers and five civilians are looking directly at the camera, but others are looking away. This configuration was a human tableau of Bacon's biliteral code. Those facing the camera represented one symbol; those looking away the other. The tableau spelled out the message: "Knowledge is power,"[8] the same phrase the colonel had his sculptor Silvestri cast in stone above the door of the laboratory.[9] Through the years, the Riverbank staff has enjoyed the published accounts about the graduation picture. Typically, the accounts would identify the colonel and the Friedmans correctly but never the lady sitting next to the colonel. She was identified as Elizabeth Gallup. Although staff members knew that the lady next to the colonel was Cora Jensen, a Riverbank secretary, they purposely would not inform the authors of their error. The reason for not telling was that no one knew who many of the soldiers were as well as who the other mysterious third lady was. Staff members decided that if left as the authors stated, someday, someone would come forward and say that the lady identified as being Elizabeth Gallup in a certain publication is really Cora Jensen. Then, we would know that the caller was a valid source and perhaps could provide us with the names of the others in the picture—especially the mysterious third lady.

In 1987 our plan succeeded. Dr. Edward Williams, son of Riverbank's Don Williams, was attending his patient Phyllis Fletcher in Santa Fe, New Mexico. She mentioned that her picture was in the Smithsonian magazine (June 1988) and then showed him the picture. Dr. Williams recognized the picture and informed his father, who, in turn, informed me. After I had spoken to Phyllis on the telephone, I persuaded Don to interview Phyllis while he was visiting his son the following month.

What follows is a list of Don's questions and Phyllis Fletcher's answers:

(Q) When and why were you at Riverbank?

(A) I was at Riverbank for about a year during 1917 and 1918. I was twenty-one at the time and was one of a group of young ladies working for a Mrs. Gallup at Riverbank. Although I worked on the Baconian Ciphers, I mostly attended classes on codes conducted by the Friedmans. Mrs. Gallup often stated that things were very obvious when commenting on her findings, when, in truth, no one else could see the relationship.

(Q) What was Mrs. Gallup like? Was she shy?

(A) Mrs. Gallup was definitely not shy. She was very boisterous and al-

ways announced that she, and she alone, was the boss regarding the code work at Riverbank. She was very prim and proper, a woman of the old school if you know what I mean.

(Q) Do you have any recollections of Colonel Fabyan?

(A) He was a big man that had a hearty laugh and created situations that were often open to criticism. Yet once he started something involving science he was quick to learn the relevant terminology and in acquiring knowledge of the subject matter.

(Q) How about the Friedmans?

(A) The Friedmans worked very hard on various codes that came into Riverbank. Each day the Friedmans would give the class puzzles involving codes, and I was very good in breaking them which was why I was picked to participate in the classes involving the army officers. I still remember that the Friedmans taught us that the letters E, T, O, A, N, I, H, and D were the most used letters. Daily I still work the crossword puzzles in order to make sure I keep my mind active. Once that goes you're dead.

Then Don held up the military graduation picture and asked who were the people sitting in the picture? Phyllis Fletcher answered, going from left to right, those seated are Colonel Fabyan, Cora Jensen, me (Phyllis Fletcher, my name was Phyllis Rudd at that time), next was Elizebeth Smith (Friedman), and then William Friedman. We were given the answer we wanted. Later in the interview, Phyllis Fletcher stated that the military classes took place in a large new laboratory that was constructed near a large windmill pump house near Elizabeth Gallup's house. (The pump house and windmill were removed in the 40s). However, this laboratory was never mentioned or shown in any other published document. So ended another unsolved Riverbank mystery. Now, as far as Riverbank is concerned, Phyllis (Rudd) Fletcher is the mysterious third lady in the picture.

In addition to research on acoustics and cryptology, not to mention the myriad of other experiments being carried out at Riverbank, another, little-known, though apparently quite extensive, research project was being conducted. The box of glass negatives that contained Wallace Sabine's aerial photographs also held evidence of fingerprinting.

The photos showed, as most people now know, that fingerprints were definitely the most accurate method of identifying an individual. Many of the plates dealt with methods of identifying each fingerprint, including a list of terms (rings, swirls, arches, and so on) used to describe the various contours. One plate in particular showed pictures of three different men who were virtual look-alikes. Under the picture of each was his fingerprint. The wording below stated the significance of fingerprints for proper identification. Just what impact the Riverbank study had on the development of fingerprinting is not known, but it is obvious that this particular project was completed to develop a particular methodology for proper identification. It appears that the federal

government was the client, which might explain why no other documents or files exist at Riverbank on this extensive project. Most of the documents dealing with government work involving codes and war research are also not found in the Riverbank files. Probably, the material was shipped off and either stored in some national archive or destroyed. If the files were stored in any of the Riverbank warehouses, then they might have been burned during one of the many major cleanups that occurred after Colonel Fabyan died.

If Riverbank researchers were, indeed, pioneers in the field of fingerprinting, it would be no great surprise. Given the colonel's aforementioned desire for recognition, charging a team of scientists with an exploration such as research in fingerprinting seems the kind of endeavor the farsighted Fabyan would have undertaken. His vision and enthusiasm were the driving forces behind Riverbank in its first decades of existence, as is made clear in the following excerpt printed in the September 1923 issue of *Scientific American,* page 204:

> The Riverbank idea is the colonel personified, and we must therefore sketch a word picture of this remarkable man. Colonel Fabyan, we gathered, is a self-made man and looks the part. He is a big man, well along in life but in the very best of health, as depicted by his rugged appearance. He has prospered in the cotton business. Although not a technician himself, he has always taken a keen interest in mechanics and medicine and other branches of science, and it has been his one ambition to establish a private laboratory for the purpose of prying into Nature's secrets. He devotes his time and much of his money to this work in memory of his mother, and we noted a tablet to that effect in one of the laboratory rooms.
>
> The colonel secures specialties in various lines and gives them every facility for delving into old problems yet unsolved. The laboratory workers live in what is called "The Community," which is a very essential part of Riverbank. In our short stay at this institution, we noted the wonderful spirit of good fellowship and happiness which permeates throughout the Riverbank Laboratories, as well as the admiration, intense friendship, and loyalty in which the workers hold for the colonel, who is ever interested in the activities of each and every worker.

Not to be forgotten in the portrait of Colonel Fabyan is the man's sense of humor. Although maligned, particularly by the Friedmans, for taking credit as author of articles or books he did not write, he did write a book entitled What I Know About the Future of Cotton and Domestic Goods, copyright George Fabyan, Chicago, 1900. A reader venturing inside this slim volume would find a publisher's note explaining that "yielding to the many requests of friends the author has consented to inflict on the public this Second Edition." Beyond this page are 100 blank pages, the colonel's own self-effacing appraisal of his position as a cotton king. As was true with most of what Fabyan did, reactions to the book have been mixed. Some have found the book sophomoric, and others have found the humor clever and ironic.

Another account of the colonel's writing ability—or lack thereof—appears in the fall 1988 issue of the *Geneva Quarterly Magazine,* which highlighted Riverbank. In the article, "Colonel George Fabyan," the author states that under a portrait of the colonel displayed in the Fabyan villa museum, there is an inscription that reads

Florence—
The world would be a far
pleasanter place
and in heaven more
friends took,
If women were all they
wished to be
and men as good as
they look.
1923 – Colonel

Regardless of how people viewed his antics, the colonel was not above a good practical joke—sometimes at his own expense, other times at the expense of the unsuspecting. In fact, much about the laboratory itself seems to have been constructed for the amusement of its owner. For example, immediately inside the entrance to the laboratory office, beside a sturdy bronzed grill partition, a bell was mounted on the wall. A sign fastened to the grill encouraged people to "Ring Bell for Service." Any first-time visitor who did so, however, found himself on the receiving end of one of the colonel's jokes. Unknown to the newcomer, the bell, although it appeared solidly attached to the wall, was actually free swinging, held in place only by a small metal catch that was hooked under the bell's lip. When the strap attached to the clapper was pulled, presumably to bang the clapper against the sides of the bell, the small catch would let go, too, and the heavy bell would swing around wildly, setting up a din that threatened to raise the dead. Just about the time the sound subsided—usually about eight to ten seconds because of the reverberant qualities of the solid concrete walls—and the disoriented bell ringer regained some of his composure, he found himself face to face with Adele Cumming, the colonel's secretary. Adele was often addressed as Belle by those who knew her, a name that she preferred and used to sign many Riverbank documents. Hands on hips, her eyes narrowed in a stern, disapproving look, she was able to cow even the most stalwart of guests for disturbing her peace. This momentary humiliation was most certainly what the colonel had in mind when he rigged up the bell and was no doubt his way of initiating a by-now-addled visitor into the world of Riverbank.

Over the years a number of individuals who could not have cared less about disturbing the peaceful atmosphere of the laboratory rather enjoyed creating a commotion. One delivery truck driver took great delight in seeing how long he could make the bell clang on the strength of one mighty swing. Every time

he arrived, he made his presence known by continuing his experiment. Of course, it meant that the laboratory's real experiments—at least those not being conducted in an isolated test chamber—came to an abrupt halt because the manufacturers whose products were being tested did not appreciate seeing large periodical noise peaks on their product data graphs. Thanks to the trucker's diligent research, the bell was removed in the mid-1950s.

Unfortunately, there is no account of how Paul Sabine handled the bell dilemma, but if he did, indeed, receive the full treatment, his initiation to Riverbank was just beginning. The next step in the scheme of things would have been for the secretary to inform the visitor that Colonel Fabyan was expecting him in the rear office and then merely point toward the rear wall of the next room. By stepping into this room from the north, Sabine would have observed that, except for three small windows on the west wall and three wood doors on the east, all walls, including the one to the south, were solid. If he had opened the first door, he would have seen a staircase leading to the second floor. Behind the next door, he would have found a small closet and, through the third, another small closet with a heavy vault door in one wall. By this time, too, the colonel's secretary would have slipped out the foyer door, leaving the poor visitor on his own in a room with no known outlet other than the one he came in. Either by luck, a process of elimination, or more likely, because of the merciful return of the secretary, Paul Sabine or any other first-time visitor would eventually have discovered that to get to the colonel's office, one simply entered through the vault door. Solicitors, of course, were more often than not left to their own devices in the hopes that they would grow discouraged and leave without peddling their wares.

For those who did make it inside the colonel's office, there was even more to boggle the mind. Then, as today, the west wall had actual sailing ship portholes and segments of a prism from a lighthouse lamp mounted on it. A monstrous desk took up a great share of the room, causing many to wonder how such a large piece of furniture had been maneuvered into place through the narrow vault door. In truth, there had been no struggle to get the thing inside because the desk was built first and then the wall separating offices was put up.

Strategically placed on the colonel's desk were a few unusual items kept solely to stimulate the mind of any visitor and present an aura of scientific mystique. One of these items was a twelve-inch long, one-inch-diameter glass tube that stood upright. The tube was one-third filled with water and sealed at each end. Although it is only speculation and the scene fictitious, Paul Sabine was probably far more curious about the tube's purpose when it was immobile on the desk than he was after the colonel picked it up during their conversation. The colonel rotated his wrist so that the water inside struck first one end, then the other. Instead of flowing through the tube, the water moved as a solid chunk and when it hit either end of the tube, it thudded rather than splashed.

Paul Sabine would have had no problem deducing that (unless the tube contained ice, which was unlikely in the nonrefrigerated office) the colonel held in his hand an airless, airtight glass cylinder, or a vacuum.

The next item displayed, a horizontal shadow box with glass top and sides and small figurines inside, would have been, as they say, a piece of cake for Paul Sabine. As the colonel talked, he purposely moved his arm in such a way that the sleave of his wool sweater brushed across the surface of the glass, causing the figurines to dance around. Paul Sabine would have needed no introduction to this phenomenon because he was quite familiar with the effects of static electricity.

Although the new director of Riverbank Laboratories would not have been duped by Colonel Fabyan's scientific toys, he surely had to have a good sense of humor and a good sense of his own abilities to put up with his employer's eccentricities. A prime example of one of these mind boggling ordeals follows:

One morning, a construction crew showed up and began erecting what appeared to be another one of Colonel Fabyan's undefinable examples of architecture, a mere twenty feet from Paul's laboratory. All that he or anyone else was able to find out was that the building was to be a garage for a Stutz automobile. As time went on, however, it became obvious that this would be no ordinary garage.

One of the colonel's hobbies was to purchase, sight unseen, boxcars full of unclaimed freight from the railroad salvage yards in Chicago. In a particularly large shipment delivered to the Geneva siding, Fabyan discovered he now owned several carloads of fifteen-foot steel I beams. Undaunted, the colonel returned to his office and contacted a local contractor. After the contractor arrived, Fabyan informed him that he wanted a garage built and that the contractor was to use up every one of the I beams doing it. The contractor, much less undaunted than the colonel, asked if he might be provided with some sort of design to complete the job. The colonel then opened a drawer and removed a large number of empty Phillip Morris tin cigarette boxes and began stacking them up on his desk and against the wall. When he finished his design, he stated that this was exactly what he wanted the garage to look like.

This garage, which still stands today, is roughly 150 feet wide and 200 feet long at the base. It stands five stories high and appears to have been constructed entirely of 15-foot-square concrete modules. The modules are stacked in a three-sided pyramid—the back is flat, as was the model Fabyan built against his office wall—topped with a single module. The building might have ended up being even taller had the contractor provided underground footings to bear the weight; if he had gone up any more, it is possible that the whole structure, the whole garage, would have slid down the hill.

As it turned out, the garage housing the Stutz took up only a small section of the building. The rest was used by Bert Eisenhour, who conducted a multi-

tude of the colonel's experiments. Eisenhour was the same engineer who was brought to Riverbank during the early 1900s to construct the so-called Baconian Acoustical Levitation Machine. From 1917-1918, he directed the construction of the Riverbank Acoustical Laboratories and from 1922-1923, he was the principal engineer and inventor who established the tuning fork operation; he remained many years as its manager. His contributions to Riverbank were significant and noteworthy. In fact, Paul Sabine's files indicate that he arranged for Eisenhour to present a paper at the fifteenth meeting of the Acoustical Society of America, held May 5, 1936, at the La Salle Hotel in Chicago. Eisenhour's paper was entitled "Control of Temperature Variation in the Frequency of Tuning Forks (with demonstrations)."

During the seventeen years between Paul Sabine's arrival at Riverbank and his own death in 1936, Colonel Fabyan continued to live his life the way he wanted to live it. He invested time and money in scientific pursuits; added to his menagerie and his collection of railroad junk; entertained dignitaries from around the world; and, in short, created his own legend. Reality set in, however, when the stock market crashed in 1929.

The collapse of the market cost the colonel a considerable amount of money, and although his personal life was not affected in any visible way, he was forced to reduce the Riverbank staff and, more importantly, to encourage Paul Sabine to find a way of making the research he conducted pay for itself. Thus, the Riverbank Acoustical Laboratory started testing for dollars. As I discuss in a later chapter, Paul Sabine did not hesitate in carrying out Fabyan's wishes because his work at the time was leading him toward the formation of the Acoustical Materials Association and assuring Riverbank a key role in the establishment of standardized tests and their execution.

Although the market crash did cause some financial hardships for the colonel, he remained generous to others in need. He would often go into Geneva and give the grocer a list of supplies for a needy family, then tell him to deliver a similar amount of groceries each week until he was told to stop. If he wanted to keep the colonel's weekly business, the grocer should never tell the family where or from whom the groceries came.

Perhaps the most often-told story of Fabyan's Depression era kindness concerns a drainage ditch or, rather, a series of drainage ditches and the men who dug them. Depending on the storyteller, either one man, a few men or three teams of men were put to work. Regardless of the specific number of individuals involved, what is known for certain is that the colonel ordered these workers to dig the trench, fill it, dig it again, refill, then dig it once again. Some people find Fabyan's action to be a cruel joke, but as it turns out, the colonel's motives were most humane. The true story can now be told.

During these hard times, a group of local men—out-of-work professionals, merchants, factory workers, and day laborers—were contracted by the colonel to dig a ditch. Instead of prolonging the work so that their wages

would be greater, the men formed three teams and made a contest out of the task. The rules were similar to those of a typing test, with deductions for errors in the ditch's straightness, contour, and depth counted against the team's speed. The colonel was impressed not only by the rapidity and quality of work but also by the use of a monitor within each group who checked for discrepancies and by the fairness of the appointed judges (one from each team) in rating each other's performance.

Rather than pay the men for their work, however, Fabyan told them the ditch wasn't quite what he wanted and had them refill it. Once that was done, he ordered a new ditch, making a few modifications in location. One month, excluding Saturdays and Sundays, and two diggings later, the colonel stated that he was satisfied. What was not mentioned by those who thought the colonel was either trying to break the spirit of those involved or just flaunting his image was what happened after the third digging was finished: One team won two out of three times. The colonel praised them all for their efforts; threw them a party, which included their families; and gave each of the workers a bonus, with the second- and first-place teams each receiving a little more, respectively. The colonel then made a speech about how great it was to see men who might be down but definitely not out, showing that they still had pride in their work. Each family also received a basket of food stuffs; besides the food, each basket contained five silver dollars and a note stating that if any mention of this gift became public knowledge, the family would be barred from any future Riverbank activities. If they honored his wishes, the colonel promised that more work or some kind of assistance would be made available to each family at a later date.

A son of one of the men involved on the work crew reported that the colonel had also assisted his father in reopening his business, which had been forced to close right after the market crash. Again, the same promise of anonymity regarding the colonel's involvement was required. There was apparently one other family-owned business that was helped in a similar fashion.

Around March 13, 1936, at the age of 69, the colonel's health suddenly deterioated and by May 1 it was recognized as being serious. He was admitted to the hospital on May 17, 1936, and at 9:30 AM George Fabyan passed away. The cause of his death was listed as Carcinoma of Mediastinum (lung cancer). Some say that the lung cancer was caused by his years of chain smoking. He was buried in the family plot in Boston.[10]

Although he was gone physically, he was still very much present in spirit: the work he had begun, the research he had founded and funded, the very essence of Riverbank. All these lived on as did all the folklore, stories, and tall tales told about him and Riverbank.

One strange occurrence, in particular, bears mention because of its connection with the colonel's death. According to the story, Colonel and Nelle Fabyan owned a parrot that loved to torment children. After nipping them

and making them cry, the bird would continue to tease them by laughing. The harder they cried, the louder the parrot laughed. Legend has it that the parrot stopped laughing the day the colonel died.

After the colonel's death, his widow continued to remain active, and with the assistance of Belle Cumming, Nelle saw to it that things continued to run smoothly. Although not as flamboyant as her late husband, Nelle Fabyan was still very much an individual in her own right.

Don Williams recalled an event that occurred that showed Nelle's compassionate and humorous side. It was a summer day, and Don and his friends were swimming. Nelle Fabyan came up to where the boys were and asked Don if he would not mind driving her to another location on the estate. Don, who was eighteen then, loved driving, said he would be glad to; he quickly changed clothes and raced to the car. He started the engine up and threw it into gear, but when he reached their destination, he applied the brakes, and the car began to skid on the damp ground. "Whoooooa, Nellie!" Don cried as the car slowly came to a halt. As soon as the words were out of his mouth, Don realized what he had said and who was sitting in the back. As he slowly sank in his seat, he did not dare look back or into the rear-view mirror as Nelle Fabyan got out. As he sat there, mortified, waiting for her to return, he wondered if it were possible that she did not make the connection with his poor use of words. When Nelle returned, she jumped on the running board, held onto the center column, slapped her thigh, and yelled, "Giddy-up, Donnie! Make your Nellie take this Nelle home!" Don also mentioned that he was often allowed to drive Nelle Fabyan to her favorite shopping place, Marshall Field's in Chicago and that she was a generous tipper.

Although most of Nelle Fabyan's energies were directed toward the management of the Riverbank estate rather than the laboratories, she did get involved in some of the goings-on up the hill from her home. Roger Ames—a Riverbank employee for more than thirty years; an accomplished organist; and the inventor of the Ames tube, the forerunner to the Riverbank choir chimes— recalled an incident that illustrates not only Nelle's attention to her late husband's enterprise but also a side to the woman that was not often seen. On this occasion, Ames was visiting the Riverbank recording studio operated by Vaughan Morrison to see if the organ there required tuning. The studio, which was fully carpeted and contained a baby grand piano, a Hammond organ, and a set of chimes, was located in the tuning fork facility, in what was later the electronic calibration room. Quite often, Nelle Fabyan would visit the studio to practice on the organ or piano, and she was there when Ames arrived. The sound of a raised voice in the tuning fork shop interrupted Mrs. Fabyan's playing, and she went to the door to see what the fuss was. After watching for a minute or two, she started toward the two individuals making all the noise: the foreman, who was doing all the shouting, and an employee who was having no luck stating his case. Just as Nelle

Fabyan approached the two, the foreman screamed, "You're fired!" "No sir," said Nelle, drawing herself up eye to eye with the angry man. "You are wrong," she continued, "totally wrong, and this gentleman will remain in my employ until I tell you differently." The foreman apparently realized that the look in her eye and the determination in her voice meant he could easily be the one without a job if he weren't careful. Despite a reputation for being forceful, demanding, and unable to back down regardless of the circumstances, the foreman mumbled, "Yes, ma'am."

Roger Ames stated that not one employee dared look up at the foreman after he apologized to Mrs. Fabyan because each one knew he would be in for it later if, their still-fuming supervisor detected even the slightest hint of delight at his comeuppance. Nelle Fabyan must have realized what was going on, too, so she turned and started back toward the studio, saying as she left, "Thank you, gentlemen. Continue on with the business at hand." A few minutes later she was once again playing the organ in the studio.

Unfortunately, not long after that incident, Nelle's health began to fail. Cancer, apparently, was the cause. On July 22, 1939, after a long and painful struggle, Nelle Fabyan died. She was seventy years old. Because of her graciousness, her kindness, and her steadfastness, Nelle Fabyan, unlike her husband, was remembered fondly by everyone. Like her husband, her mark was made on Riverbank, both in the care and attention she had always given to the grounds and in the way she lived her life.

As Paul Sabine wrote in a letter to a friend, "Mrs. Fabyan died Saturday morning. She will be buried in Boston beside the colonel. Her death leaves a cloud over Riverbank that seems to mark the end of an epoch."

Adele Cumming and Maulsby Forrest were the executors of the will of Nelle Fabyan. Originally, Forrest was the colonel's financial adviser and he maintained a similar position for Nelle Fabyan. Under the will, both Adele Cumming and Maulsby Forrest were appointed trustees, with the latter nominated as president of the board of trustees. In accordance with the will, the trustees were given the authority to delegate a third. Emil J. Benson became the third trustee. Belle Cumming, the lady from Inverness, Scotland, and Riverbank's top sergeant for many years, continued to run the various daily activities until 10:50 PM on the night of May 12, 1946. On that evening, Belle Cumming, Elizabeth Gross, a visiting friend from New York, and Harriet Fowler, a companion, were riding into Geneva in Harriet Fowler's 1941 Pontiac. They stopped at the railroad crossing and waited for a local train to pull out of the station. Supposedly, it was the last train of the evening. As the last car of the local train passed, the car continued across the tracks and was struck by the oncoming Los Angeles Flyer; all three were killed. There were no gates or watchman at the time, and on this particular day, the Los Angeles train was unusually late, by 30 minutes. Many of the area residents would typically cross the tracks after 11:00 PM, after the local train pulled out,

Colonel Fabyan in his "Hell Chair."

without any thoughts of any more approaching trains until the following morning. The tragedy led to the hiring of a watchman, and eventually, crossing gates were installed. In any case, the Riverbank estate lost its primary caretaker. In line with this chapter's title, one could also ponder if besides the colonel, was it Adele Belle Cumming that made Riverbank or was it the other way around.

Paul Sabine.

CHAPTER

4

The Right Scientist for the Job

Although Paul Sabine's initial reaction his first day at Riverbank is not known, it stands to reason that, he would have been anxious to see the unique sound test chamber (reverberation room) designed by and named after his cousin. No doubt, too, Fabyan took great delight in showing him the chamber, which, thanks to the manpower, raw materials (the stone came from a Riverbank quarry), and engineering skills (Bert Eisenhour was in charge) available to the colonel, only cost about $100,000 to build.[11]

By today's standards, the test chamber is still considered one of the best of its kind. Its walls consist of bricks, concrete, sand, mortar, and spring steel. Each of the eighteen-inch-thick walls of the inner and outer rooms contains a fire-hardened brick core, which is, basically, two double layers of interwoven bricks combined with a meshing of sand, spring steel, and poured concrete. The core is covered on both sides with dense concrete followed by a very dense multilayered plaster that was painted on the inside surface of the test room. The chamber was designed in such a way that the highly reverberant walls, floor, and ceiling would resist any force from an external (outside) source, avoiding internal structural vibrations. The room effectively restricts being excited at audible frequencies other than those introduced internally into it.

The inner room is separated from the outer room wall by an eighteen-inch airspace and sits on jacklike supports that are seated on a special blend of sand and gravel, which, in turn, covers a bed of loose stones. The outer wall extends deeper into the ground, and both of these rooms are constructed within, and totally isolated from, the confines of the larger main building. The inside test-room volume is 10,311 cubic feet. The size indicates the considerable amount of work and material incorporated not only into the inner test room but also the larger second (exterior sound shield) room and the main building, giving rise to the nickname Fort Riverbank.

It is often asked whether Wallace Sabine ever had a chance to conduct a test in his Riverbank test chamber? The answer is yes. A logbook (now in the Riverbank Museum) includes notations regarding test results of sound absorption of hair felt.

What had puzzled researchers for years is that the data in Wallace Sabine's logbook and the three sets of data found in Paul Sabine's test chamber qualification files presented a mystery. Paul labeled the three sets of data as 1. Old room data. 2. New room data. 3. Jefferson Laboratory data. The researchers were able to establish that the new room data was obtained in the existing Riverbank main test chamber and the Jefferson laboratory data was obtained in Sabine's Harvard constant temperature room. The researchers were also able to show that both Wallace's and Paul's data were in agreement. It was the old room data that the researchers could not duplicate or recognize and thereby a mystery was created. Many researchers thought that the old room data was obtained in either one of the two Riverbank side chambers that adjoin the main test chamber or it was the main test chamber before the fixed diffusors and rotating vanes were installed. However, follow up tests in the two side chambers and in the main test chamber without the fixed diffusors and rotating vanes proved that there was no data agreement with Paul's old room data. The latter data indicating increased absorption of the empty room condition at two test frequencies. Additional "old room" data was found in other Paul Sabine files and one set was identified as Sabine's old room data. The latter also indicating the empty room, high absorption results at the same two test frequencies.

Finally around 1992 the mystery was solved. While browsing through some material stored at the Kane County Fabyan villa museum, I came across a drawing of the colonel's scientific barn that has long since been torn down. On the drawing in the southwest corner of the scientific barn there was a room designated as "W. C. Sabine, Sound Test Chamber, all hard wood." Underneath that line was the words "Old Room" pencilled in. Apparently, Wallace Sabine had an all hardwood reverberation room constructed at Riverbank before the existing test chamber was built. As it turned out, both Wallace and Paul recognized that the all hardwood reverberation room had unwanted resonances at two test frequencies and therefore was not acceptable to their research needs.

Paul Sabine was forty years old when he came to Riverbank in January 1919. Many modern-day acousticians believe, perhaps because of the student-teacher relationship Paul had with Wallace Sabine, that Paul must have been in his twenties and, in essence, just beginning his scientific career when he went to work for Colonel Fabyan. This was not the case.

Paul Earls Sabine was born in Albion, Illinois, on January 22, 1879. He graduated from McKendree College in Lebanon, Illinois, in 1898 and received his Bachelor of Arts from Harvard University in 1903. On December

27, 1906, he married Mabel Johnson of Newton, Illinois, the daughter of lawyer Hale Johnson. From 1906 to 1912, Paul Sabine was an instructor at the Worcester Academy in Massachusetts. His first son, Hale Johnson Sabine, was born October 23, 1909, in Worcester.

Paul returned to Harvard in 1912 and, while serving as an assistant instructor, took graduate courses in pursuit of a Ph.D. Most of his courses were offered in the Graduate School of Applied Science, the dean of which was his cousin Wallace. Hale Sabine recalled asking his father if he ever took a course by, or worked on any projects with, Wallace. His father replied that although he never took a course offered by Wallace, on occasion, he was able to sit in on some lectures and also assist with a few experiments.

In 1915, Paul received his Ph.D. and remained at Harvard as an assistant instructor until 1916, when he accepted the position of assistant professor at the Case School of Applied Science in Cleveland, Ohio. On February 17, 1916, Richard *Wallace* Sabine, the Paul Sabines second son was born.

During World War I, Paul Sabine took a civilian position with the United States Navy in Washington, D.C., where his principal work involved the calibration of a wind tunnel for experimental studies centered on airfoils and airplanes. The development of the NC-3 and NC-4 flying boats, the latter used by naval aviators to make the first successful transatlantic flights, was owed in part to the scientific findings of Paul Sabine.

While Paul was working on the navy project, Wallace Sabine was also in Washington — as director of the Department of Technical Information in the Bureau of Aircraft Production. One task of this department was to cooperate closely with the Naval Aviation Department and exchange technical information. Given the connection, there is no doubt that Wallace and Paul Sabine conversed on various matters associated with their respective positions; families; and, perhaps, Riverbank. Wallace Sabine might even have asked his cousin if he were interested in running the operation for Colonel Fabyan.

This conjecture is not that far fetched because had Wallace Sabine lived, chances are he would not have made Geneva, Illinois, or Riverbank Laboratories his permanent residence. Besides his commitment to Harvard, he had a strong attachment to the Boston area. His wife, Dr. Jane Kelly Sabine, was a physician with a thriving practice; their two daughters were involved in their schooling; and Wallace's mother, Mrs. Hylas Sabine, was still alive and very much a part of the professor's life. When Professor Sabine completed a similar research facility for the Johns Manville Corporation and was offered the directorship, he declined, suggesting a former student, Clifford Swan, be hired to fill the position.

If Wallace Sabine were reluctant to leave Boston and the family ties there, whose name would he have given to Colonel Fabyan as his choice to run the new lab? John Connors, the professor's assistant at Harvard, any other assistant or student, or perhaps Riverbank engineer Bert Eisenhour could all have

been put forth as likely candidates. Contrary to the Sabine historian Leo Beranek's opinion that either an assistant or a student was more likely, however, I believe that Wallace Sabine's candidate would have been Paul Sabine.

Unlike his cousin, at the end of World War I, Paul Sabine was not bound to any institution. Although he was still working for the navy, his duty was to end soon. He could have returned to the Case School of Applied Science, but no evidence suggests that this was his plan. Given his uncommitted status and his presumed knowledge of Riverbank, I believe that Wallace's conversations with Paul during the war years would have addressed the laboratory facilities and the family connections in Illinois, which would have contributed to Paul being the man Wallace Sabine would suggest to oversee the lab.

If the two men did discuss Riverbank and their respective futures there, the ease with which Paul Sabine assumed his duties at the facility might in part, be explained. Under similar circumstances, many individuals would have required a much longer breaking-in period than did Paul Sabine. In 1984, a copy of his first report to Colonel Fabyan was discovered. The date on the report was April 1919, only two months after Paul Sabine arrived at Riverbank; it contained significant information pertaining to the research program he initiated.

Much of the research relied on the Wallace Sabine formula for measuring sound absorption. Briefly stated, the modified Wallace Sabine formula used today measures the time it takes sounds at different test frequencies to decay 60 decibels (dB) when all the other variables in the testing room — volume, temperature, speed of sound, etcetera — are constant. The amount of time it takes for the sound to decay 60 dB (for example, from 100 dB to 40 dB) is called the *reverberation time.*

In a typical experiment, a sound source is turned on. After a stabilized sound level is obtained, the sound source is turned off. The time it takes for the sound to decay in the test room 60 dB is recorded. A highly reverberant room is preferred because it provides a longer period of time for the sound to decay, which, in turn, provides for more accurate overall time measurements. Typically, in an empty reverberation room, the reverberation time for low frequencies is longer than it is for high frequencies. In the Riverbank test chamber, the low frequency of 100 hertz (Hz) (the sound of a transformer hum or a fog horn) takes almost 7 seconds, and the high frequency of 5000 Hz (the sound of a whistling tea pot or a navy boatswain's pipe) takes approximately 3 seconds.

Basically, to determine the absorption of a test specimen, one measures the reverberation time of the empty room at the prescribed test frequencies and then repeats the measurements with the specimen installed in the room. The ratio of the reverberation times is inserted into the appropriate formula. The absorption of the specimen is determined at each test frequency in units of sabins. From there one can determine the absorption coefficients and calcu-

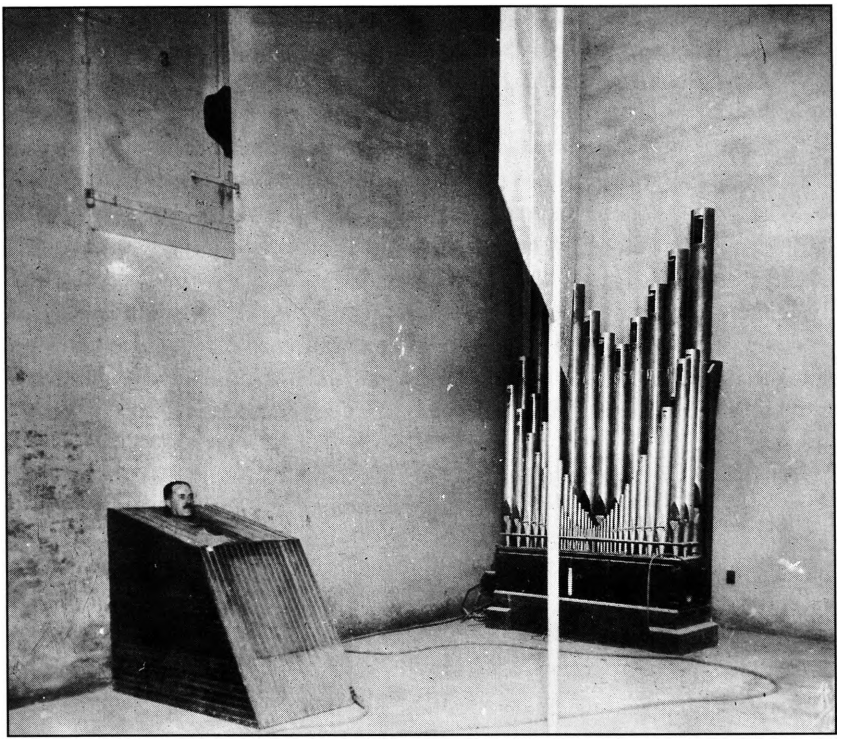
late the noise reduction coefficient of the test specimen. This value serves as a one-number designator that ranks the various specimens.

Today, to conduct an absorption test at Riverbank, a shaped broadband sound of white or pink noise consisting of all the test frequencies controlled by computer is broadcast into the designated test chamber. After proceeding through an equalizer, crossover networks, amplifiers, and an array of speakers, the input airborne sound is detected by sensitive microphones, which, in turn, send the various sound levels through a precision filter network. The specific sound levels of each test frequency band are fed to a spectrum analyzer, compiled by the computer and displayed on a monitor. If the tester so chooses, the computer can also provide plots of each decay slope and print out the decay times and all other required data, complete with the corresponding standard deviation and combined confidence limits, in a matter of minutes.

What acoustical instrumentation did Paul Sabine have in 1919? Very little. The September 1923 issue of *Scientific American* highlighted Riverbank and emphasized radio engineering as the latest craze. Battery, transformer, and electron-tube advertisements appeared throughout. One article disclosed that the cathode ray oscillograph was just being considered for laboratory use. In other words, there was a decided lack of reliable instrumentation available in 1923. The *sabin,* the unit defining sound absorption, and the *decibel* (dB), the unit, relating the relative levels of sound, had not been developed yet.

In 1919, the equipment used at Riverbank to conduct an absorption test consisted of a rank of organ pipes. The test frequencies were individual musical notes generated by the organ. The measuring device was a listener sitting in a wooden box with only his head protruding through an opening at the top, similar to a person sitting inside a steam box. The listener's ears were the microphone. The range of decay was determined from the instant the listener stopped the relay-controlled organ note at the prescribed test frequency until the listener could no longer hear the diminishing sound of the note. The listener timed the sound-decay limit of audibility with a chronometer or stopwatch his only instrumentation, and recorded the time using a pencil and pad, his data-acquisition equipment. There was a small observation window on top of the box so that the observer could see the notepad and the timing device.

In a 1930 article on the history of architectural acoustics, Paul Sabine wrote that in 1925, the "man-in-the-box" test was still the most reliable method used by the various laboratories. The listener sat inside a reflective wooden box so that he remained in a fixed location for all tests, ensuring that the sound absorption or reflection by his body and clothing did not affect the results of the test. These restrictions and the crudeness of the measurements made the information in the following report, Paul Sabine's first, all the more interesting and remarkable.



Conducting an Absorption Test.

RIVERBANK LABORATORY OF ACOUSTICS.

Report for April, 1919.

The first stage in the general problem is the calibration of the Sound Chamber for notes of the various pitches used. This consists in finding the absorption of the room for these tones. The rate of emission of the pipes must be known for this purpose. This latter can be determined in the first instance only by doing the four organ pipe experiment in a room. In the present case, the pipes to be used have been timed in the large lecture room of the Jefferson Physical Laboratory, where Professor Sabine did the four organ pipe experiment in 1906. Two sets of C pipes had been thus timed. The Austin pipes, #1 at 5 1/4" pressure had been timed by Professor Sabine and John Connors. For this reason these pipes were chosen for the calibration of the Sound Chamber rather than the Laws pipes, which had been timed only by John Connors. The mean of the three sets of observations together with the known absorption of the Lecture room with the settees, was used for the determination of the rates of Emission of the pipes. From this, together with the measured duration of the residual sound, the absorption,

and finally the absolute rate of decay of sound in the Sound Chamber can be determined for each of the seven C pipes. From this, a curve can be drawn giving the absorption for intermediate tones. Knowing the absorption for any frequency, the rate of Emission of any pipe of that frequency can be determined by determining the period of the residual sound produced by the given pipe.

The work for April has been:

1. The training of observers.
2. The determination of the period of the residual sound for each of the seven Austin pipes.

Trials by a number of observers showed that considerable practice is required before the observations of a novice are reliable. This is particularly true in this Sound Chamber where the rate of decay is small, making the instant when the decaying sound crosses the line of minimum audibility hard to determine with precision. As a result, most of the observations have been taken by Mr. Eisenhour and myself.

The period of residual sound has been found to depend in a marked degree upon the position of the reflectors and also that of the observer. Therefore, for the work of calibrating the room, considerable pains have been taken to insure getting enough observations to make the average reliable with a high degree of precision. Five hundred independent timings of each pipe with the observer in a single position have been made. In addition, to allow for variation in time with position of observer, fifty observations, using each of the seven pipes in each of eight different positions in the room have been made. The completion of this part of the work will call for four more positions. In this way the final time taken for the residual sound from each pipe will be the mean of 1100 observations. This may seem excessive, but when one considers the number of variable factors, and the extremely fundamental character of this work for all measurements that are to follow, extreme care justifies itself. When completed, data will be available for the determination, with a relatively small number of observations of the absorption of any material brought into the room, the rate of emission of any pipe sounded in the room, and the transmission of wall surface that replaced any portion of the present wall.

It is incredible to imagine listening to and timing the decay of the same note 1,100 times and then proceeding to the next note. Shortly after these initial experiments, Sabine conducted a linearity calibration on all seventy-three notes of the organ. If he maintained the same precision requirements, it meant that some duty-bound individual(s) sat in the box and timed 80,300 notes. Then, to calibrate a room accurately, the same individual would have had to repeat the observations at another time to determine repeatability and then periodically do them again to show that none of the room's qualities had changed. Because Paul Sabine, in the tradition of a true scientist, calibrated the room often, it is indeed a wonder that the employee turnover rate among those assigned to sit in the box and listen was negligible.

In his next report to Colonel Fabyan, Sabine outlined his plans for the month of May:

PROGRAM FOR MAY, 1919.

1. Continue time of residual sound of 7 C-pipes of Austin #1 set in bare room with all doors closed, observer in different positions.
2. Determine the time of residual sound with observer's position fixed and the organ in each of five different positions.
3. Determine the time of residual sound from the set of Laws' pipes. Five sets in each of different positions.
4. Determine the time of residual sound from the pipes of the small portable set. Five sets in each of five different positions.
5. Begin the study of the fine wire sound detector.

Tasks 1 through 4 were for laboratory calibration, and from Sabine's outline, it is apparent that he settled on seven specific notes for calibration. Task 5 on sound-level meters addresses the first acoustical research project planned by Paul Sabine at Riverbank. Three sound-level meters were developed during this project and proved to be extremely sensitive and operated uniformly to sound pressure. These three meters are now located in the Riverbank museum; printed on the face of each are the words *"Riverbank Sound Meter."*

It is not clear what degree of influence Colonel Fabyan had on Paul Sabine and the type of acoustical activities that took place at the laboratory, but it appears that in the beginning, Paul Sabine had something of a free hand. Although records indicate that he and the colonel did not always see eye to eye on every issue, as long as Sabine was advancing the science of acoustics, not just architectural acoustics, his employer was satisfied.

Only after the stock market crash of 1929, which put a dent in the colonel's holdings, was there any indication that he insisted Riverbank conduct architectural acoustical testing to bring in additional revenue. This demand marked the beginning of the testing procedures, documentation, and standardization that are still used at Riverbank today, forever affecting the science of architectural acoustical testing.

Still uncertain is what the colonel's full intentions were in 1919 regarding Paul Sabine and the acoustics laboratory. The first letterhead contained a circle with *Riverbank Acoustical Laboratories and Geneva, Illinois,* written inside its perimeter. To the left of the circle was the title, *Faculty,* under which were listed two titles, *Dean,* followed by *Paul E. Sabine* and *Secretary,* followed by *Belle Cumming.* To the right of the circle were two addresses, one for the Geneva facility and the other for the Chicago office. It appears, then, that the colonel intended to establish a school of acoustics at Riverbank, but no actual indication other than the one letterhead exists to verify or refute this notion. Shortly thereafter, a new letterhead surfaced, listing Paul Sabine as laboratory director; all reference to faculty status was deleted.

It is difficult to say what Paul Sabine's first project or area of investiga-

tion was at Riverbank. He took a shotgun approach to his original research, simultaneously tackling various problems involving many different areas of acoustics. Besides room calibration and absorption measurements involving hair felt for measurement purposes, he continued Wallace Sabine's experiments on plastered walls. The latter work translated into the development of *sabinite,* an absorptive acoustical wall plaster.

During Paul Sabine's early laboratory work at Riverbank, he was assisted by Professor Floyd Firestone from the University of Michigan in testing the previously mentioned sound-level meters. With Dayton C. Miller, the dean of the Physics Department from the Case School, Sabine contributed to the development of a mechanical voice synthesizer. With Dr. Augustus Pohlman and Fred W. Kranz, he began his first studies on listening devices (ear trumpets). Of the many disparate tasks he undertook, it appears that the sound transmission of walls was Paul Sabine's first research effort and that his study of listening devices was his first completed project.

During that first summer, Paul Sabine also published two articles in *The American Architect.* The first article, dated July 2, 1919, was entitled "The Life Work of the Late Wallace C. Sabine: An Appreciation." The second article, published July 30, was entitled "The Wallace Clement Sabine Laboratory of Acoustics, Geneva, Ill." and began "This Laboratory was built for the research of the late Professor Wallace C. Sabine by his friend, Colonel George Fabyan." The article mentioned that the design of the Riverbank test chamber was suggested by the arrangement of the constant-temperature room in the Jefferson Physical Laboratory at Harvard.

Sabine further explained the purpose of the laboratory and discussed the sound source as a complete rank of seventy-three pipes, giving all the tones of the musical scale from C,64 vibrations a second to C,4096 vibrations per second.[12] The longest period of reverberation recorded and measured at Harvard by Wallace Sabine was 8.69 seconds at 100 Hz, compared to 12 seconds in the Riverbank chamber.[13]

Paul Sabine went on in the article to explain,

> The work in the laboratory so far has been by way of calibrating the sound chamber and the various instruments to be used in the continuation of the work. Fortunately, calibration had been carried far enough by Professor Sabine to make it possible to proceed without repeating for the new conditions experiments which he performed years ago. Two sets of pipes whose rates of emission were determined by him only a few weeks before his death are the basis of this calibration. Without this, work in the laboratory would have been delayed months, perhaps years.

He closed the article with this statement:

> The laboratory is dedicated to the task of carrying out so far as possible the research program that Professor Sabine had laid out for its altogether admirable equipment. The laboratory staff will value most highly the interest of those ar-

> chitects to whom its purpose appeals, expressed either as inquires or suggestions, regarding the practical aspects of problems in architectural acoustics with which they may be confronted.

Sabine's next article "The Absorption of Sound by Rigid Walls," appeared in the December 1920 issue of *Physical Review.* He compared the Wallace Sabine equation of absorption to the absorption theories of noted English mathematician and physicist Lord Rayleigh (1842-1919) and German physicist Gustav Kirchhoff (1824-1887), stating,

> Qualitatively, the theory of sound absorption is simple. The dissipative forces through which the sound energy is converted into heat are introduced in two ways. The yielding of reflective surface as a whole, or in large units of area under alternating pressures of the sound wave calls into play damping forces, which dissipate the sound energy.

The principle being described here is that one way sound is absorbed by means of a transfer of energy. When a sound wave enters an absorptive material, such as a mineral fiber, the pressure from the wave causes the fibers to vibrate accomplishing work. In doing work, heat is dissipated and the energy of the sound wave is exhausted. The energy transfer is from sound-pressure wave energy to mechanical vibrating energy to thermal energy.

After nine months of investigation Sabine published "Architectural Acoustics — The Transmission of Sound through Flexible Materials," a two-part article that appeared in the September 28 and October 12, 1921 issues of *The American Architect.* He followed up on the work originally published by Wallace Sabine in 1915 about the evaluation of sound transmission through various barriers. Interestingly, in comparison to the methodology of today, Sabine measured the decay rate of the source room against the decay rate of the same source but from the other side of the test barrier in the receiving room. The equation he utilized to achieve his results was

$$\log I_s/I_r = .126\ a\ (t_s - t_r)$$

where I_s = Intensity source chamber
I_r = Intensity receiving chamber
a = absorption source chamber
t_s = duration of audible sound heard in the sound chamber
t_r = duration of audible sound heard in the receiving chamber

The ratio $\log I_s/I_r$ called the *sound intensity reduction* by Paul Sabine was changed to *transmission loss* in 1930 at the suggestion of professor Vern Knudsen of University of California at Los Angeles. Knudsen felt it would avoid confusion because the term reduction factor was used for many other different meanings. Ironically, many acousticians today feel that the expression sound transmission loss is really an oxymoron and that it should be replaced by *sound insulation* or *sound isolation.* Also, some acousticians feel that trying to explain to concerned individuals that the greater the sound

transmission loss is of a sound barrier the better it is for noise control purposes adds to the confusion in explaining the meaning of the expression sound transmission loss.

One question often asked is who were Riverbank's first transmission loss (TL) test clients. In a 1939 letter, Paul Sabine wrote that two of Riverbank's first clients for TL testing were the National Door Manufacturer's Association and United States Gypsum. In 1921, Paul Sabine was able to foresee the effects of an increasing population and the resultant increase in noise. He stated in his two-part article on sound transmission:

> The ever increasing congestion of living and working conditions of modern life, the rapid multiplication of mechanical devices, with their inevitable noise and the consequent wear and tear upon nervous and mental power, make the problem [of noise control] one of vital importance and would seem fully to justify the time and labor necessary to secure the quantitative data required for its solution.

Paul's versatility in his research was highlighted in his article entitled "The Efficiency of Some Artificial Aids to Hearing," which appeared in the November 1921 issue of *Laryngoscope.* This article marked the beginning of a twenty-year personal crusade on the study of the human ear, coming to the aid of the otologist and the hearing impaired. Once again, Paul Sabine cited the work accomplished in this area of acoustics by Wallace Sabine. As later discussion bears out, Paul Sabine reached the same pinnacle of achievement in studying the human ear as Wallace Sabine did in his study of architectural acoustics, despite the limited recognition he received for his accomplishments.

Although Paul Sabine's research in the 1920s dealt primarily with hearing trumpets, he was later instrumental in the development of the electronic hearing aid. During the early period, Sabine did research with Fred Kranz and two medical doctors, Dr. J. Gordon Wilson and Dr. A. Pohlman. Later, from 1935 to 1941, Pohlman and Kranz were still involved with hearing aids, but Kranz was also doing his own research for Bell Telephone Laboratories at the Western Electric Company near Chicago. Correspondence between Kranz and Sabine on the subject of hearing aids also attested to Sabine's knowledge and the assistance he provided his colleague.

In 1921, Sabine had this to say about ear trumpets:

> Viewed in the light of our present attainments in artificial aids to hearing, the immediate prospects for the alleviation of extreme deafness by such means are not bright. However, recent developments in telephony, notably in the use of the thermionic vacuum tube as a means of amplifying telephone currents, afford considerable grounds for hope of securing the necessary increase of intensity. The problem of securing increased amplitude without increased distortion of the wave form is one that presents many physical difficulties. It is essential to know at the same time the distortions of sound produced by the defects in the mechanism of hearing. It is obvious, therefore, that the general problem is one calling for highly specialized knowledge and skill in the fields of both otology and

physics, and it is to be hoped that the very near future will see a combined attack upon the problem from both the physiological and physical sides.

In 1922 Paul Sabine began providing services as an acoustical consultant. His first large-scale consulting problem involved the Federal Reserve Bank Building in Boston. The work area was highly reverberant and noisy. Sabine remedied the problem and published three articles entitled "Architectural Acoustics 1, 2, & 3" and subtitled "The Nature and Reduction of Office Noises." The three articles appeared in the May 24, June 7, and June 21, 1922, issues of *The American Architect.* Photography of actual reflecting sound waves and the use of painted plaster, various absorption materials, and acoustical tiles were demonstrated. Paul Sabine also became involved with the noise contributed by typewriters, which later led to a specific project on quieting typewriters.

In 1922, another event of historic significance took place at Riverbank. A select committee, known as the National Research Council Committee on Acoustics, met and compiled a bulletin on thirteen topics in acoustics for the National Research Council. The committee consisted of G. W. Stewart, professor of physics, State University of Iowa; A. L. Foley, professor of physics, Indiana University; L. V. King, professor of physics, McGill University; D. C. Miller, professor of physics, Case School of Applied Science; P. E. Sabine, Riverbank Laboratories, Geneva, Illinois; F. R. Watson, professor of experimental physics, University of Illinois; and A. G. Webster, professor of physics, Clark University. All were physicists.

The historical significance of this meeting is that about seven years after the bulletin was printed, these same individuals were involved in the development of the Acoustical Society of America (ASA). Although the actual formation of the ASA in 1929 is credited to thirteen individuals, the previous association of these seven men has to be considered a significant forerunner to the development of the ASA.

The thirteen topics and the author(s) of each discussion, as printed in the first bulletin, were:

1. Audition, Sabine and Stewart
2. Acoustics in Navigation, King
3. Propagation of Sound in Liquids and Solids, Webster and King
4. Propagation in the Atmosphere, Foley and Webster
5. Reflection, Absorption, and Transmission at the Surface of and Within Certain Materials, Sabine and Watson
6. The Measurement of Sound Intensity in Absolute Units, Sabine and Webster
7. Detection and Measurement of Sound, Miller and Webster
8. The Efficiency of Sound Generators, Webster and King
9. Sounds of Musical Instruments and Speech, Miller

The National Research Council Committee on Acoustics.

10. Analysis and Synthesis, Miller
11. Photography of Sound Waves, Foley
12. Sound Waves of Finite Amplitude, Webster, Foley, and Stewart
13. Conical Horns, Webster and Stewart

Because Riverbank was the committee's meeting place, and because Colonel Fabyan was the official host, providing housing, meals, and whatever other services were required, when a group picture was taken of all the scientists, the tall gentleman in the center would be none other than the colonel himself.

In 1923 Paul Sabine published the article, "Transmission of Sound by Standard Masonry Partitions," which appeared in *Industrial and Engineering Chemistry Journal* (Volume 15). In that article Paul states:

> The ratio of sound intensities in two rooms separated by a given partition has been called the *reduction factor* for that partition. The logarithm of this factor is a fair measure of the relative loudness as perceived by the ear, and may be used as a numerical measure of the sound insulating merits of the partition in question. A logarithmic reduction of six would render loud conversation in an unfurnished office room inaudible in an adjoining room; one of four would render it faint and unintelligible, but still fairly audible.

From the above Sabine developed a graph that showed a theoretical relationship between the mass (pounds per square foot) and the reduction factor,

commonly referred to as the *mass law.* He stated that there is a definite relationship between mass and noise reduction and ended the segment stating:

> Sound reduction and mass per square foot follow the same order regardless of material. On the other hand there is no obvious correspondence between stiffness and sound reduction and that mass rather than stiffness is the determining factor in the general reduction of sound intensity.

Today, the relationship between transmission loss and the mass (pounds per square foot or kilograms per square meter) is used by many architectural acousticians as an important guide for noise control. The relationship is commonly referred to as the *mass-law curve* or the *limp mass-law relationship.*

Paul Sabine followed this article with "Transmission of Sound by Masonry Partitions," which appeared in the July 4, 1923, issue of *The American Architect.* Although the primary discussion again dealt with massiveness and stiffness, the two articles are quite different. Most important in the second article was the discussion of the three most important factors (properties) that must be considered for good sound transmission results. Besides mass and stiffness, Paul inserted a third — damping. Many present-day technical publications discuss that the theoretical derivation of a barrier's performance is broken into three areas: (1) the stiffness region (low frequencies), (2) the mass-related region (middle frequencies), and (3) the damping and seals region (high frequencies), essentially the same areas documented by Sabine in 1923.

Also in 1923, Sabine applied for and received a patent on an absorptive plaster called sabinite. A room at Riverbank, called the Sabinite Room by Paul Sabine (but later changed to Hall B), has all its surfaces covered with this material. One wall bears the statement "Typical Modern Fireproof Construction Modified with the Resultant Reverberation as is." Hall D has the same inscription except for the word *modified,* which was deleted. In other words, one room is treated with sabinite, and the other is not.

In the September 1923 issue of *Physical Review* was an article by Sabine entitled "Acoustical Power of Certain Sound Sources in Absolute Units." With this article, Paul Sabine began his studies on sound intensity with regard to musical instruments (musical acoustics) and speech. Interestingly, the article mentions William Friedman, an accomplished violinist as well as a cryptologist, who assisted with the sound experiments. Friedman played what he referred to as his "junk fiddle" and a violoncello developed by a Cornell University professor and cited as very imperfect and sluggish. The instruments were bowed forte and maximum toned and were compared using vibrato tones and stopped string. Overtones were also investigated.

In the same article, Sabine described tests that compared loudness levels to twelve vowel sounds in speech. The male speaker was Professor Dayton C. Miller of the Case School of Applied Science, who correlated the tests to the development of a mechanical synthesizer. The female voice in these tests was a

distant Sabine relation, Louise Wallace Hackney of New York.[14] A memento of this testing is still on display in the Riverbank museum. Framed and dated and signed by the speaker, Dayton Miller, is a photograph of a graphic recording of a one-second-long voice signature of Professor Miller saying FABYAN.

The same Sabine article also included information about his investigations of sound intensity. Paul's sound intensity investigations correlate with what we now refer to as our sound power tests. A sound power test is conducted on any noise-making device to determine just how loud that device is. A basic definition of sound power is the rate at which acoustical energy is radiated from a source. Sound intensity, a term often mistakenly used synonymously with sound power, is defined as the acoustical power that passes through a unit area.[15]

When Paul Sabine came to Riverbank in 1919, his son Hale, who would later become involved with Riverbank testing as a physicist, was just ten years old. By the mid–1920s, the young teenager was already participating in the events going on at his father's laboratory. Two accounts in Paul Sabine's early files refer to his son during this period. The first was in a letter to Dayton Miller in 1923 in which he mentions that Hale had the keenest sense of hearing available and was most valuable in helping Dr. Augustus Pohlman, Fred Kranz, and himself evaluate listening devices. The second account appeared in another 1923 letter to a family friend:

> Perhaps it would be wiser if I delayed penning this letter, for at the moment, I am having great difficulty in keeping presence of mind. It is the noon hour and the Riverbank bell is being struck with excessive force, or as you may say fortissimo. I fear that I have only but myself to blame, for I fully suspect that the perpetrator of this extreme effort is no other than Hale. For it was only yesterday, that while he and I observed the bell ringer going through his twice daily ritual of appearing and disappearing up the tower by holding on to the bell rope that I expounded upon, and in great length the many laws of Physics taking place. Then today when I mentioned to Hale that his mother will be a little late with the lunch, I should have been more suspect when he accepted the news most favorably, since we both are aware of how he usually regards mealtime. My immediate concern is that his mother does not arrive earlier than anticipated. Observing her son rising and falling while dangling precariously from a rope would be most injurious to her state of mind, if not her health.[16]

CHAPTER

5

The 1920s
The Paul Sabines Get Involved

While Paul and Hale Sabine made reputations for themselves in acoustics, one other Sabine made a mark of her own during the mid–to–late 1920s. Mabel Sabine, wife of Paul and mother of Hale, was an accomplished organist. She was also instrumental in establishing Geneva's Little School, a private institution where education was based on the philosophy of progressivism, a method of instruction that ran counter to the more common passive learning techniques of most other schools. At the Little School, learning was tied closely to doing, and teachers were encouraged to educate the whole child — to develop all the faculties, not just fill the mind with facts. As a further sign of the newness to this pedagogy, report cards were typed assessments rather than letter grades.

Founded by Mr. and Mrs. William Bangs in 1919 in the Bangs Barn, the school moved to the home of Paul Sabine on Fourth and Hamilton in 1922 where Mabel Sabine became the school's first kindergarten teacher. In 1925, the Little School expanded to offer education from kindergarten through grade eleven, which meant expansion or relocation. A building on Sixth and Fulton St. became part of the Little School scenario. In 1927, a group of citizens obtained the funding for a much-needed larger building. It was constructed on the corner of Western Ave. and South St. by the eminent Chicago architectural firm of Holabird and Roche of Chicago's Soldier Field, Palmer House, Board of Trade, and City Hall fame. In addition to the new building, classes continued at all the previous locations, including the barn. The school was also renamed, known for a while as The Adventure School and eventually, as The Geneva Country Day School.

By the 1930s, reforms in the free public school system and economic difficulties brought on by the Depression forced many parents to abandon

private education. Consequently, because of declining enrollment and the corresponding drop in tuition, the Geneva Country Day School was forced to close in 1939. Mabel Sabine, remembered by former students as an outstanding and caring instructor and by Geneva residents as a concerned, involved member of the community, was not alive when the school finally closed. Ten years earlier, on September 29, 1929, she had suffered a stroke during a telephone conversation and died.

Hale Sabine had just started his senior year in the Physics Department at Harvard University when he received the news of his mother's death. A letter written at the end of the school year by Paul Sabine perhaps best sums up the situation: "Hale has done us all proud with his studies, the one regret is that his mother will not be able to attend the commencement ceremonies, although I feel she will in spirit."

Without Mabel, Paul still remained involved in community affairs, which included membership on the library board.[17] Although his personal life took precedence over his work during times of crisis or triumph, Paul Sabine continued with his acoustics research throughout the 1920s, publishing a number of articles about his findings in a wide variety of areas. In 1924, for example, he wrote "Acoustics in Auditorium Design," which appeared in the *American Architect* and the *Architectural Review.*

Interestingly, this article, when compared to contemporary papers on the same subject, lacks only the support of sophisticated instrumentation and intricate drawings and methods of data acquisition; his theories are as sound today as they were when he wrote them. This publication was perhaps one of his first technical articles where he made use of subtle humor while he emphasized what not to do in auditorium acoustics:

> The auditorium architect has two courses, he may either ignore acoustics in his original design whereby if there are any problems after completion then they could be solved by absorptive treatment. The architect's second course is to consider acoustics in the design right from the beginning.

The result of the first course, he goes on to say, can be an acoustic horror, and the second can produce an architectural monstrosity. He adds that, generally speaking, rooms are usually acoustically good, not so much because they possess positive virtues but because they lack defects. The designer's problem then, as far as acoustics is concerned, becomes largely a matter of what to avoid. The aim of this article, as much as anything, was to point out, in as practical a way as possible, these acoustic "thou shalt nots."

What makes Paul Sabine's "Acoustics in Auditorium Design" interesting is his use of photographs of sound waves to demonstrate problems that he classified under two general headings. He defines that on the first page: "those arising from the concentration of sound reflected from extended concave surfaces and those arising from excessive reverberation." Indeed, be-

cause of recent acoustical catastrophes in auditoriums, perhaps Paul Sabine's 1924 article on auditoriums should be a reading must. If some consultants were to read Paul's list of "thou shalt nots," fewer acoustically disastrous auditoriums might be constructed in the future.

In May 1926 Sabine wrote an article on architectural acoustics entitled "Sound Insulation by Double Partitions." Once again, he went into detail about sound insulation and the sound-reduction factor referred to today as the sound transmission loss. What makes this paper noteworthy is that the derivation of the formulas is figured in terms of sound intensity, which is considered a new and relevant issue today. The article included the following paragraph on page 131, which refers to a psychological view of sound intensity and sound reduction:

> Investigations by experimental psychologists have shown that the sensation of loudness produced by a sound is roughly proportional to the logarithm of the physical intensity of the sound, so that the average value of the logarithm of the reduction factor makes a very good numerical expression for the sound insulating properties of partitions as judged by the ear.

In current parlance, this statement means that sound intensity is roughly proportional to the sound pressure squared, or more precisely, sound intensity is equal to the square of the sound pressure divided by the product of the density of the material (in this case, air) times the velocity of sound (in air).

Other topics covered in the 1926 paper were acoustic insulation by solid partitions, bridged and unbridged double partitions, the effect of filling the airspace, and a comparison of double-wall and single-wall partitions. An interesting side issue about this particular article was that Sabine wrote it for *The Armour Engineer,* which indicates that he was in contact with someone associated with the Armour Institute of Technology, now the Illinois Institute of Technology (IIT). Of course, the IIT Research Institute (IITRI) predecessor, the Armour Research Foundation (ARF), was not established until 1936. The article indicates a relationship between Paul Sabine and IIT that can be traced back to the 1920s.

The article on single- and double-partition walls was followed by "Transmission and Absorption of Sound by Wood Stud Partitions," which appeared in the August 5, 1926, issue of the *American Architect.* In this piece, Sabine writes:

> An examination of the literature of the subject of the transmission of sound by walls of different types and materials discloses a wide divergence in the findings of different investigators working in this field. These differences may be ascribed in the main,
>
> 1. to the intrinsic difficulties of sound intensity measurements,
> 2. to failure on the part of investigators to recognize all the factors that enter into the transmission of acoustic energy and a consequent failure to control all of these factors, and
> 3. to important differences in test conditions and methods of measurement.

> In the seven years that have been devoted to this problem at Riverbank Laboratories, the plan has been to carry on a systematic and ordered program of research to determine the factors that really control the transmission of sound from room to room by way of partition walls, rather than to investigate the sound insulating merits of the many possible constructions and materials that can be used. It is hoped that by employing a single method under conditions that are maintained constant throughout the entire program, the whole series of investigations will in the end present a consistent picture of the essential facts, from which conclusions of general significance may be drawn.

The results of Paul Sabine's early work at Riverbank Acoustical Laboratories were far more accurate than those of a similar investigation conducted at the National Bureau of Standards (NBS). By comparing technique, methodology, and overall conclusions, Paul essentially tore apart the bureau's findings. Despite the disagreement in the years that followed, Riverbank and the NBS worked together on many acoustical investigations, and the rapport between the two organizations was and is good. In 1988, the NBS name was changed to the National Institute of Standards and Technology (NIST). Today, Riverbank falls under the auspices of the NIST National Voluntary Laboratory Accreditation Program (NVLAP) of the U.S. Department of Commerce. Undoubtedly, the early cooperation between Riverbank and the NBS was a shining example in establishing a standard method of sound measurements for laboratories. In 1929, documented acoustic results initiated by Paul Sabine and V. L. Chrisler of NBS were most likely the first such reference to acoustical standards.

Perhaps one of the more controversial issues involving sound absorption which still exists today is how can you have absorption coefficients, or noise-reduction coefficient (NRC) values greater than 1.0 or, as some would say, coefficients greater than 100 percent.

The confusion started when certain writers, in trying to explain absorption, modified the definition of the sabin unit. The original definition was that a sabin is equal to 1 ft^2 of an open window. Later, because of arguments associated with possible reflections off the inside window frame (depth) portion, "open window" was replaced with "perfect absorber." Then, in some writings, the phrase "perfect absorber" was erroneously replaced with "100 percent absorption." Often, these writers used examples such as an NRC of 0.65 means 65 percent absorption. Unfortunately, this example is incorrect. Neither the absorption coefficients or the NRC are percentages.

> From the American Society for Testing and Materials (ASTM) standard, the unit of absorption, sabin, (A), is derived as follows:
>
> $$A = 0.9210\,(V)(d)/(c)\ , \qquad (1)$$
>
> where
>
> A = absorption, measured in units of sabin.
>
> 0.9210 = room decay constant.

V = room volume (ft^3).

d = N/T.

N = decibel (dB) decay measured.

T = the time in seconds, accurate to hundreths of a second it takes the sound to decay N dB.

c = speed of sound = [49.022(459.67 + temperature F) $^{1/2}$] (ft/sec).

Because the reverberation time is defined as the time it takes sound to decay 60 dB, N becomes 60, and T is rewritten as T_{60}.

Thus, equation (1) becomes

$$A = 0.9210\ (V)(60)/(c)(T_{60})\ . \qquad (2)$$

Then, after the temperature is recorded, four quantities (0.9210, V, 60, and c) are entered as constants and designated in the next ASTM formula as (K). Thus, the only variable is the time in seconds it takes for the sound to decay 60 dB. The ASTM C423 shows the formula as follows:

$$A = K/T_{60}\ . \qquad (3)$$

where

$$K = .9210\ (V)\ (60)/c\ . \qquad (4)$$

At Riverbank, V = 10311 ft^3, and the room temperature is held at 72 degrees; so c = 1130 ft/sec.

Thus

$$K = .9210\ (10311)\ (60)/1130 = 504.2\ . \qquad (5)$$

$$A = 504.2/\ T_{60}\ . \qquad (6)$$

The latter formula is then used to determine the absorption at each of the 1/3-octave band test frequencies.

The *absorption coefficient* is defined as the difference between the room absorption with and without a specimen divided by the area of the specimen. The ASTM formula is as follows:

$$\text{Absorption coefficient} = A2 - A1\ /\ S\ . \qquad (7)$$

where

A is the unit of absorption, measured in sabins, derived from equation (3).

A_2 = room absorption in sabins with the specimen in the room.

A_1 = room absorption in sabins without the specimen in the room.

S = the area of the specimen (ft^2).

The noise reduction coefficient (NRC) is calculated as follows: Sum the absorption coefficients obtained at 250, 500, 1000, and 2000 Hertz (Hz) and divide by 4 (average). That's it.

Nowhere in any of these formulas are there any percentage terms or units. Both the NRC and absorption coefficients are not percentages, and values greater than one are possible.

Factors that come into play when an absorption coefficient or NRC of greater than 1.0 is obtained are: shape, size, and edge effects.

Specimen Shape: Odd-shaped specimens create additional absorption as a result of interactions between them. For example, absorption coefficients are meaningless when testing theater seats. The absorption of theater seats or hanging absorbers is expressed as sabins per unit rather than sabins per area.

Large Specimen Size: If a specimen is large relative to the test room, increased absorption can be observed. If the specimen takes up too much space, diffusivity is decreased, and depending on the location or the closeness of the microphone to the absorption material, higher absorption can occur.

Diffraction-bending Wave Dffects: Certain-sized or certain-shaped specimens can cause the sound waves to bend. The energy in the sound wave expended in diffraction is measured as increased absorption.

Edge Effects: Edges can induce bending wave effects if the edges represent a relatively wide absorptive surface in relationship to the total absorptive surface of the specimen.

Additional Explanations: The one explanation regarding NRCs greater than one that appears to achieve the highest degree of comprehension among clients is when the relationship of thickness is projected into the following question: What would you expect to see if originally you tested a 4-inch-thick layer of absorptive material and achieved an NRC of 1.0 and then added another layer of 4-inch-thick material? Surely you would expect to achieve more absorption rather than limiting the NRC to 1.0.

Paul Sabine and V. L. Chrisler had to come up with a test procedure that would give both laboratories similar results. At the time, the only absorptive material readily available was one-inch thick John's Manville hair felt. Both labs had similarly sized rooms and both scientists came up with comparable results. Although Paul Sabine originally stated that a specimen eight feet by eight feet (64 ft^2) would be sufficient, both scientists later agreed to change the size to eight feet by nine feet (72 ft^2) because the size of 1-inch-thick hair felt yielded a coefficient of 0.50, which would normalize on a graph perfectly. Accordingly, they sized the specimen to provide data that would center on a graph from 0 to 100. Neither scientist anticipated that in the future, 4- to 6-inch-thick material would be common and that, on occasion, specimens as large as 18-inches-thick or more would be tested. Thus, about twenty years later, when thicker materials were introduced, the normalized graph was breached, and the problem of coefficients greater than unity surfaced. Nonetheless, all coefficients are technically acceptable as long as you do not think in percentage terms.

As a famous radio commentator says, "Now you know the rest of the story!"

In 1926, Paul Sabine became the acoustical consultant for the Fox-Case Corporation, assigned to work on the design of the first sound motion picture studios in New York and the first Hollywood sound stage. In 1928, he presented to the Society of Motion Picture Engineers a paper entitled "The Acoustics of Sound Recording Rooms." He discussed the idea of making

sound recordings in a studio and then synchronizing them with the visual images later rather than relying on the quality of an on-location recording. After explaining how much easier it is to produce quality sound recordings in a studio under controlled conditions, Sabine went on to say,

> In listening to a stage production, the audience hears the voices of the actors as they are modified by the acoustic conditions of an actual stage. What is the best means of securing this illusion in the case of the talking moving picture? Is it to make a record that is entirely free from "room effects," and then put in the room effects by reproduction upon a stage that will introduce them, or will it be better practice to record under conditions that will include the "room effects" in the sound record? Only trial can answer this question, but once answered, I think it is safe to say that our knowledge of acoustics is at a point where the desired conditions for recording, whatever they may be, can be secured without further experimentation.

In 1929, Paul wrote three articles: "The Measurement of Sound Absorption Coefficients," which appeared in the March 1929 issue of the *Journal of the Franklin Institute;* "Architectural Acoustics — Sound Absorption Coefficients of Materials," which appeared in the *American Architect,* June 5, 1929; and "Transmission, Reflection, Reverberation, and Absorption of Sound," printed in the *International Critical Tables,* Volume VI, 1929. These articles indicate that the state-of-the-art acoustic absorptive testing and documentation of manufacturers' products data were advanced in 1929, and the Acoustical Materials Association,[18] helped publicize the existence of absorptive data.

These three articles alluded to absorption data of thirty-nine specimens, listed as follows:

1. Acousti-Celotex type A, a 13/16-inch-thick perforated fiberboard, plain side exposed
2. Acousti-Celotex type B, same as Type A but perforations exposed
3. Acousti-Celotex type BB, 1-15/16-inch-thick
4. Acousti-Celotex, originally tested 1924, 1-inch-thick
5. Akoustolith tile, 7/8-inch-thick fine texture cemented to clay tile
6. Balsam wool, 1-inch-thick soft wool fiber, paper backing, scrim facing
7. Balsam wool, same as #6 but with a perforated metal cover
8. Standard Celotex, 7/16-inch-thick on wood furring
9. Standard Celotex, same as #8 but on 2 x 4 studs
10. Draperies, 10 ounce per square yard, cotton fabric, in contact with wall
11. Draperies, 14 ounce per square yard, cotton fabric, in contact with wall
12. Draperies, 18 ounce per square yard, velour fabric, in contact with wall
13. Draperies, same as #12 but hung 4 inches from wall
14. Draperies, same as #12 but hung eighteen inches from wall
15. Cotton fabric, 14 ounce per square yard draped to 7/8 of its area
16. Cotton fabric, same as #15 but draped to 3/4 of its area

17. Cotton fabric, same as #15 but draped to 1/2 of its area
18. Felt, standard, 1-inch-thick all hair
19. Felt, Asbestos-Akoustikos (hair and asbestos fiber), 1/2-inch-thick
20. Felt, same as #19 but 3/4-inch-thick
21. Felt, same as #19 but 1-inch-thick
22. Felt, same as #19 but 1-1/2-inch-thick
23. Felt, same as #19 but 2-inch-thick
24. Felt, same as #19 but 3-inch-thick
25. Flax-Linum semistiff flax fiberboard, 1/2-inch-thick
26. Masonite Standard 1/2" board (pressed wood fiber) on 1-inch furring
27. Masonite, same as #26 but nailed to 2 x 4 studs
28. Masonite, same as #26 but nailed to 1 x 2 furring
29. Nashkote AAX 1-inch felt with cotton fabric, two coats of paint
30. Nashkote B-332 1-inch felt with perforated oil cloth
31. Plaster gypsum on wood lath on wood studs, rough finish
32. Plaster, same as #31 but lime putty and smooth finish
33. Plaster, lime on wood lath on wood studs, rough finish
34. Plaster, same as #33 but smooth finish
35. Plaster "Calacoustic" 1/2-inch-thick
36. Plaster Sabinite, 1/2-inch-thick
37. Stockade slab, 1-inch-thick wood fiber cemented with magnesite
38. Stockade slab, same as #37 but 2-inch-thick
39. Plaster Sabinite (1929 version)

Realizing the significance of two of his three papers, Paul Sabine applied for copyrights in 1929 through the law firm of Parkinson & Lane. Perhaps it was the copyrights themselves that restricted the circulation of these articles and limited Paul Sabine's opportunities for widespread national recognition.

In almost all the articles written by Paul Sabine, especially those published in the 1920s, the work of Wallace Clement Sabine was invariably cited, as was that of the professor's Harvard associate, John Connors. This generous attribution, although noble and notable, might have worked against Paul Sabine in achieving national recognition for the research he conducted. In essence, he presented most of his own contributions as follow-up or as secondary to what had been achieved earlier by Wallace Sabine.

Both Sabines — Wallace and Paul — shunned publicity and, in certain cases, avoided opportunities that might have brought them fame. For example, Paul Sabine's work in the motion picture industry, had he continued, would certainly have kept him in a position of high visibility and earned him accolades. One reason for his abandoning efforts in the field might have been his religious convictions and their bearing on his life. Because the motion picture industry at the time was not a regulated industry — the Hays office and the strict rules it imposed regarding the morality of films were still in the

future — Paul Sabine, given his beliefs, might have chosen to separate himself from it. In addition Paul Sabine was an academician, a scientist whose research was meant to advance science itself and not the scientist.

In December 1928, approximately forty individuals, invited by letter, gathered at the Bell Laboratories in New York with the hopes of forming an acoustical society. Although he was sent an invitation, Paul Sabine did not attend the conference. At this meeting, a decision was made to form the Acoustical Society of America. A temporary set of four officers was nominated, which, as it turned out, were the same individuals officially nominated in May 1929: H. Fletcher, V. O. Knudsen, W. Waterfall and C. F. Stoddard. These four officers, along with D. C. Miller, J. P. Maxfield, F. A. Saunders, R. V. Parsons, F. K. Richtmeyer, and F. R. Watson, were appointed to draft a constitution and bylaws.

In 1929, the Acoustical Society of America (ASA) was formed.[19] The first open meeting was held in May of that year in New York City. It was a joint session with the motion picture industry, attended by 168 members and held in the auditorium of the Bell Telephone Laboratories. The first paper given on May 10 at the society's portion of the session was a thirty-minute presentation by Paul E. Sabine entitled "The Measurement of Sound Absorption Coefficients by the Reverberation Method," followed by a paper dealing with absorption coefficients given by Vern O. Knudsen. Also on the program was V. L. Chrisler of the NBS.

The ASA conducted its first election of officers as follows:

Officers
President: Harvey Fletcher, Bell Telephone Laboratories, Inc.
Vice-President: Vern O. Knudsen, University of California at Los Angeles
Secretary: Wallace Waterfall, The Celotex Company
Treasurer: Charles Fuller Stoddard, American Piano Company

Executive Council
Paul E. Sabine, Riverbank Laboratories
G. R. Anderson, University of Toronto
J. P. Maxfield, Electrical Research Products, Inc.
Dayton C. Miller, Case School of Applied Science
C. W. Hewlett, General Electric Company
F. R. Watson, University of Illinois

Publication Committee *(later called the Editorial Board)*
Wallace Waterfall, Chairman
Paul E. Sabine
F. R. Watson
Charles Fuller Stoddard

The first honorary member of the ASA was Thomas Alva Edison, who was unanimously nominated by the executive council. Edison graciously accepted in writing from his Florida residence.

The first official ASA constitution and bylaws were adopted May 10, 1929. In addition to the business of the organization's formation, talks were given at the meeting on such topics as description and demonstration of artificial larynx, the hearing of speech in auditoriums, acoustic properties of the Salt Lake Tabernacle, and the science of musical sounds. On May 11, six papers were presented on speech as well as papers on a spark chronograph, piano playing as used in making Ampico records, a new just scale (with a proof that an additional just scale is impossible), human factor in piano-tone production, methods for measuring the noise audiogram, and psychological measurements of annoyance as related to pitch and loudness.

The ASA's second scheduled meeting was held in Chicago in Lincoln Hall at the Northwestern University School of Law on McKinlock Campus on December 13 and 14, 1929. Attendance at the meeting was low, primarily because of two events that had occurred earlier in the year: the stock market crash and the St. Valentine's Day Massacre. Both gave members second thoughts about attending any meeting in Al Capone's backyard.[20]

The year 1929 also marked Paul Sabine's tenth year at Riverbank and the end of a significant decade in the advancement of architectural acoustics. Because of Sabine's efforts in establishing a standardized testing technique for sound absorption and because of the data repeatability obtained in the experiments he directed, findings could finally be documented and circulated with a great deal of confidence in their validity. He had, in essence, helped make a science of architectural acoustics.

CHAPTER

6

The 1930s Standardizing Acoustical Laboratory Testing

The 1930s proved to be the foundation years for standardization of acoustical laboratory testing. The decade also marked the beginning of the careers of a number of researchers recognized as prime contributors to the science of architectural acoustics. Although many of these acousticians have since retired or passed away, their pioneering efforts live on in the documents—many of which are now part of the library at Riverbank—that they wrote over the last fifty-plus years.

During the 1930s, although he was in his fifties, Paul Sabine, like his colleagues, continued his work in acoustical testing as well as undertook a new subject that was to be of equal, if not greater, importance to him throughout the rest of his life: addressing and reconciling the philosophical rift between science and religion. Although his writing on this topic flourished later, it was during this period that he first raised the questions that perplexed—and still do, to a great degree—both the theological and scientific communities.[21]

Science, in general, was marked during the 1930s by great advances, and acoustics was no exception. A new wave of theories, the development of improved instrumentation, and more sophisticated testing methodologies resulted in an ever-diverging, ever-more disparate kind of research. Realizing the need to standardize and unify the work being done, Paul Sabine wrote a number of articles intended to illustrate the need for sound testing and prudence.

Sabine's first article, "Transmission of Sound by Walls," which appeared in the January 1930 issue of the *Journal of the Acoustical Society of America, (JASA),* dealt with the calculation of the noise-reduction factor by measuring the sound intensity and then mathematically converting the results in-

to decibels (dB), the new unit for sound measurement, to help establish a common unit for measuring noise reduction.

In the article, Sabine discussed the merits of various wall constructions, including continuous masonry (concrete blocks, bricks, gypsum board, plaster), double walls (separated), double partitions (partially connected), wood stud partitions, and steel stud partitions—and various fills—such as sawdust, felts, slags, and various airspaces. He also incorporated a discussion of porous materials to express the definition of sound as demonstrated through testing. On page 184 Paul states:

> Transmission of acoustic energy by partitions of wood, glass, steel, or masonry, which are impervious, must take place by means of the minute vibrations of these structures set up by the alternating pressure of the incident sound. Sound, considered as undulatory motion of the air particles cannot pass through such barriers. For this reason, the gross mechanical properties of mass, stiffness, and internal friction or damping of these constructions determine the reduction of sound intensity which they afford. On the other hand, porous materials allow the alternate condensations and rarefaction to pass through, so that such materials may be said truly to transmit sound as sound. In porous materials, the Reduction Factor varies in a continuous manner with the pitch. At a fixed pitch the increase in the logarithm of the Reduction Factor for a porous material is directly proportional to increase in the thickness.

He then went on to describe further the relationship between the dB- reduction number obtained at certain frequencies and the density (mass) of the specimen. As mentioned previously, the mass law relationship to the noise-reduction qualities of a barrier remains a helpful tool in designing sound barriers that address specific needs. All indications are that the mass-law curve that appears today in virtually every book covering barriers and their respective sound transmission loss characteristics was derived by Paul Sabine.

In a July 1932 *JASA* article, "Weight as a Determining Factor in Sound Transmission," Sabine again used the mass-law relationship. In both articles, there are a variety of data on wall configurations, including doors, windows, plaster, gypsum board, gypsum tile, clay tiles, bricks, concrete, wood, steel, glass, lead, and hair felt as well as various fills and insulations—a fairly comprehensive set of data that provided the test results of 69 different specimen types in approximately 80 different configurations. Data from other laboratories were also included in these articles, giving Sabine an opportunity to raise questions about testing because of differences in procedure among laboratories.

What also became a controversial issues was the use of the arithmetic average value that was discussed in an April, 1931 *JASA* article entitled "Sound Transmission Coefficients and Reduction Factors," which included formulae and a summary of what should be considered by anyone making acoustic measurements. Again, Sabine took issue with others who employed different test-

ing methodologies. Although the last two publications will be discussed at more length later, it is important to note them here as an introduction to his July 1931 *JASA* article aimed at standardizing absorption tests. The piece, "A Critical Study of the Precision of Measurement of Absorption Coefficients by Reverberation Methods," included formulations and comparative data to prove his point. Perhaps Sabine's closing statement best states the issues at hand:

> First of all, it should be recognized that even given all the data, the computation of the reverberation time in any given actual case is a matter of approximate estimate rather than precise determination. The more or less arbitrary setting of an optimum reverberation time for rooms of a given volume is an academic straining for a precision which does not exist in fact. The architectural profession should come to recognize this in specifying reverberation requirements. Second, considerable variation in the absorption coefficients of materials used for acoustical correction may exist without producing appreciable differences in the observed acoustical properties of rooms. Third, present methods of measurement do not give mathematically precise values of the absorption coefficients of materials, but under proper conditions and with skill and care, they do give values which are quite precise enough for application to practical problems. Commercial interests should come to recognize this fact and to lay less emphasis upon the practical numerical values obtained at this or that laboratory. In the vast majority of cases, advantages due to other physical characteristics, such as color, permanence, appearance, adaptability to desired modes of interior treatment, may well outweigh the difference between 0.60 and 0.70 in the value of the absorption coefficient. Just how an architect is to write specifications so as to insure his client's getting his money's worth in acoustical satisfaction has still to be agreed upon, but what one may call the present "war of coefficients" is, in the writer's opinion, a quite meaningless wrangle over practical unessentials.

It is interesting to note that even today these issues of precision, reporting of data, and exactness in methods of mounting a specimen in obtaining absorption coefficients remain unresolved, although certainly not ignored; acousticians frequently discuss these issues at conferences but have yet to reach agreement. Another example of a constant dilemma prohibiting an overall solution centers on the fact that most laboratories test in accordance with the prescribed standard; so, in essence, no particular lab performs its test incorrectly. Nonetheless, when you compare one lab with another, they have some differences. Besides the more obvious physical aspects of the test chambers, there are also irregularities in mounting procedures, instrumentation techniques, calculations, precision determinations, and reporting. Total conformity in testing facilities would require tremendous financial commitments and as seen with various laboratories (including Riverbank), changes made in a chamber might not result in appreciable changes in data anyway. Still, any alterations that do move all facilities toward uniformity will result in more precision and standardization, two goals Paul Sabine strove to achieve throughout his career.

As Paul Sabine's previously discussed articles point out, the only way acoustical testing would ever make any sense at all or provide any meaningful results was if a group of manufacturers joined together and developed an organization to develop a standardized acoustical testing method that would be recognized and used by everyone. The creation of such a test method would provide the much-needed common denominator for data comparison of one product with another or of the same product tested at different facilities. If standardization was not achieved soon, then only chaos would occur, and the manufacturers of acoustical products would suffer the most. Among Paul Sabine's files are many letters to manufacturers, suggesting that standardization be a high priority for their companies.

With about seventy absorption tests already documented, the National Bureau of Standards (NBS), Riverbank, and the manufacturers whose products were involved in these tests realized that differences in data were beginning to create problems. Indeed, the work of Paul Sabine to standardize acoustical testing became increasingly important. Realizing that their own financial interests needed to be set aside to resolve this issue, competing manufacturers agreed in 1933 to form the Acoustical Materials Association (AMA).

The manufacturers agreed to participate in a program in which their acoustical product lines would be subjected to a controlled sequence of tests governed by a committee of representatives from each of the member companies. They also agreed that all testing activities, including the publishing of an annual bulletin containing the new data, would be subjected to review and would be policed by an independent technical advisory committee. The committee would have to include individuals involved in the essential factions of architectural acoustics and the association would not be formed until a suitable advisory committee was established. The latter was only one of many hurdles facing the formation of such an association. After many ballots, the proposed membership of nine manufacturers finally agreed on seven advisers that they felt would satisfy the needs of this newly formed association.

The original nine manufacturer representatives and their respective companies were R. E. Bennett, Thermax Corporation; H. R. Berlin, Johns Manville Sales Corporation; C. W. Bowyer, Calicel Corporation; R. F. Burley, National Gypsum Corporation; F. C. Lloyd, Armstrong Cork and Insulation Company; R. T. Miller, Masonite Corporation; W. Waterfall, Celotex Corporation; S. P. Walker, United States Gypsum Company; and J. A. Will, Atlantic Gypsum Company.

Paul Sabine was elected chairman of the advisory committee, a group that also included V. L. Chrisler, Bureau of Standards, Washington D.C.; Carl A. Erickson, American Institute of Architects, Chicago; V. O. Knudsen, University of California at Los Angeles; R. F. Norris, C. F. Burgess Laboratories, Madison, Wisconsin; F. R. Watson, University of Illinois at Urbana; and S. K. Wolf, Electrical Research Products Inc., New York. In 1938, Wolf was replaced by J.

P. Maxfield, also of Electrical Research Products Inc.. By 1940, R. F. Norris and his corporation, C. F. Burgess Laboratories, were no longer members.

Essentially, the AMA's basic program started in 1933 when Riverbank, designated as the official AMA laboratory, started testing the various AMA member products. Soon the first set of data was compiled, and the first official *Bulletin* (Bulletin No. 1) *A.I.A.* No. 39-6, was issued in February 1934. Another publication, entitled "Theory and Use of Architectural Acoustical Materials," was distributed at the same time with the same reference number.

It should be mentioned that although Riverbank was still using the man-in-the-box technique for data measurement in 1930, Paul Sabine and his technician, Carl Anderson, began developing an acoustic clock that measured sound decay. By 1931, they had received a patent on it, introducing the notion of obtaining acoustical data by way of electronics before the AMA series began.

The number of AMA member firms appeared to rise and fall annually. As early as 1938, the list was down to six members, and in the 1960s, the AMA involved fifteen members. By 1960 as many as thirty corporations had been members of the AMA at one time or the other. Many were absorbed by other corporations, others dropped from the acoustical product market, and some simply dropped out of the organization. Listed below in alphabetic order, followed by the year each member first appeared in the bulletin, are all the firms that have been a part of the AMA:

1. American Hair and Felt Company, 1936
2 American Gypsum Company, 1936
3. Armstrong Cork and Insulation Company (Armstrong Cork Company), 1934
4. Atlantic Gypsum Products Company, 1934
5. Baldwin-Hill Company (Baldwin-Erret-Hill Inc.), 1959
6. The Calicel Company, 1934
7. The Celotex Company, 1934
8. Dant and Russel Sales Company, 1950
9. David E. Kennedy, Inc., 1940
10. Detroit Steel Products Company, 1950
11. The E. F. Hauserman Company, 1947
12. Elof Hansson Inc., 1960
13. The F. W. Wakefield Brass Company, 1951
14. Fenestra Inc., 1957
15. Gustin-Bacon Manufacturing Company, 1959
16. Industrial Sound Control Inc., 1953
17. The Insulite Company, 1953
18. Johns-Manville Sales Corporation, 1934

19. Kaiser Gypsum Company, 1959
20. Koppers Company Inc., 1957
21. Luse-Stevenson Company, 1940
22. Masonite Corporation, 1934
23. National Gypsum Company, 1934
24. Owens Corning Fiberglass, 1940
25. Pioneer Division of the Flintkote Company, 1950
26. Reynolds Metals Company, 1958
27. Simpson Industries (Simpson Logging Company), 1948
28. Thermax Corporation, 1934
29. The United States Gypsum Company, 1934
30. Wood Conversion Company, 1936

Just for the record, during the 1920s, the first official Riverbank pre-AMA absorption test for a paying client was on balsam wool for the Wood Conversion Company. It was tested on a layer of gypsum board from the United States Gypsum Company. The first AMA client testing, depending on which of the following viewpoints you take, was Thermax or Celotex. Some of the test data that appeared in the first AMA bulletin were actually gathered by Paul Sabine prior to the actual formation of the AMA. The dilemma is that Thermax was tested on June 6, 1933, and Masonite on July 12, 1933. The AMA wasn't established until August 1933. The Celotex product was tested August 29, 1933. Therefore, the question arises, does a product truly qualify as being tested for an association before that association officially exists? Written on top of the data sheets for Thermax and Masonite was Paul's note "tested earlier" and on the "For" line were the names of Thermax and Masonite, respectively, but test #3 had "For AMA." Paul Sabine redesignated the Thermax and Masonite tests as AMA tests #1 and #2, respectively, and they were designated as such in the first AMA bulletin.

The AMA test book #1, which included tests 1 through 60, helped establish the actual date for the founding of the AMA as August 1933 rather than just 1933, as noted in an AMA twenty–five year anniversary publication distributed in 1958. There was some doubt about the actual month and day that the AMA was founded, not to be confused with the date that the AMA became incorporated (1934). Although the actual day on which the AMA was founded is still uncertain, we now know that it occurred after August 1 and on or before August 29.

Most of the preAugust 1933 correspondence to Paul Sabine regarding the formation of the AMA involved questions or problems about legal matters, personal biases, or the formation of the technical advisory council. Quite often, Sabine would forward problems not related directly to acoustics to Wallace Waterfall of the Celotex Corporation, and it was he who would resolve certain administrative matters. The Riverbank files disclosed that some of the

manufacturers were having difficulty with the formation of such an association. Nevertheless, the AMA was finally established in 1933, and the first bulletin was distributed in 1934.

To get an idea of the importance of the AMA bulletin to subscribers and users alike, it is instructive to look at Bulletin No. VII, which was published in April 1940; it dealt with three topics: (1) theory and use of architectural acoustical materials, (2) sound absorption coefficients, and (3) sound insulation.

Pages 2 and 3 contained the names of the members, directors, technical advisory committee members, and a lengthy preface.

On pages 4–9, segment 1, the AMA recommended three acoustics texts that just so happened to be published by three members of the AMA Technical Advisory Committee: (1) *Acoustics of Buildings,* Watson; (2) *Architectural Acoustics,* Knudsen; and (3) *Acoustics and Architecture,* Sabine. Then the bulletin briefly defined the following acoustical terms: (1) pitch, (2) intensity, (3) reflection of sound, (4) echo, (5) multiple echo, and (6) reverberation.

Explanations of the following concepts were also given:

* Effect of reverberation on hearing
* Effect of volume and absorption on reverberation time
* Desirable reverberation times
* Computing reverberation time—numerical example
* Reverberation at different frequencies
* Location of absorbing material
* Decibel scale
* Noise level in rooms
* Judgment of relative loudness
* Coefficients of materials
* Frequencies for different purposes
* Sound insulation
* Rating sound insulating constructions
* Sound-insulating methods
* Effect of sound absorbing materials
* Sound leaks

Page 10 documented an alphabetic list of trade names. Only one product example from each of the listed members is included in this list, although forty product names in all were given:

Absorbatone	Luse Stevenson Company
Absorbex	The Celotex Corporation
Acoustex	National Gypsum Company
Acoustone	United States Gypsum Company
Airacoustic	Johns-Manville Sales Corporation
Corkoustic	Armstrong Cork Company

Fiberglas Acoustical Tile	Owens-Corning Fiberglas Corporation
Kencoustic	David E. Kennedy, Inc.

Page 11 included typical light-reflection values and a classification of specimen types. Pages 12 through 18 tabularized various products for each company. The following example exemplifies one obvious drawback of the AMA bulletin:

Company name	AMORE Company
Material	Limpa Massa
Thickness	25.4 mm
Type	VI
Mounting	No. IV
Test frequencies	128, 256, 512, 1024, 2048, 4000
Coefficients	.05, .10, .12, .18, .22, .30
Noise-reduction Coefficient	NRC = .15
Unit size tested	4 ft by 9 ft. (2)
Light Reflectance	Color W (white), value D (71–75 percent)
Weight	20 pounds
Surface	Irregular and slightly fissured
Test No.	0000

Although this information would be invaluable to users, the AMA neglected to provide a space for a detailed physical description of the specimen. Without such a description, users would not know that the specimen was a one-inch–thick, multilayered composite, more commonly referred to as lasagna (without sauce, of course), placed directly on the laboratory floor.

Did Riverbank ever test a composite layer of lasagna? Keep in mind that the Riverbank staff cannot divulge a client's data without written permission (or, as in some instances, permission is granted to illustrate unusual data but the client's actual name is withheld). Thankfully, the Jello, laundry lint, and oatmeal (dry) issues are not pertinent to this discussion.

Regardless of a few inadequacies, the AMA annual publication did provide a user with pertinent data obtained under controlled conditions, in the same manner, and at the same place. It allowed for direct comparisons and eliminated opportunities for conflict among manufacturers. Each AMA member had the right to withdraw any test results before the bulletin was published. Because results were obtained in an independent laboratory, there was no worry about a manufacturer using his own laboratory and creating any data to keep pace with or to stay ahead of, his competitors. Because the AMA was overseeing product information, many poor acoustical products were never put on the market or in a few cases, removed from the market. Equally beneficial was that some very good acoustical products were developed or improved on as a result of the organization and its standardized testing.

The AMA bulletin was not updated during World War II although older versions were still circulated. In 1947, the AMA resumed operations and once again began publishing an annual bulletin. The name of the bulletin changed, however, no longer was it designated as the "Official Bulletin of the Acoustical Materials Association" but rather as "Sound Absorption Coefficients of Architectural Acoustical Materials." The AMA was cited, however, on a separate line, followed by the number of the bulletin. Additionally, the postwar publications no longer included a list of technical committee members or the AMA officers.

The original technical advisers were a notable group of experts responsible for developing an acoustical testing program used today. In point of fact, the AMA testing without a doubt pioneered standardized acoustical laboratory testing, and the organization's overall contributions are still cited by acousticians as significant in the evolution of architectural acoustics as a science.

To highlight the accomplishments of the AMA as well as to point out the loss suffered in 1977 when the organization disbanded, a list of important events, summarized in the AMA's twenty-fifth anniversary publication, follows:

1933 The AMA was founded to establish procedures that could supply architects and others with reliable data on acoustical efficiency and other physical properties of architectural acoustical materials.

1934 AMA is incorporated.

First research program on sound absorption data was instituted.

First annual bulletin distributed listing sound absorption coefficients of thirty-six products.

Riverbank Acoustical Laboratories established as the official testing laboratory to rate acoustical materials for sound-absorbing efficiency.

1939 An independent testing laboratory selected to rate acoustical materials for light reflection; data included in the official bulletin.

1942 Began cooperation with, and support of, the National Noise Abatement Council.

Defined and established the term "Noise reduction coefficient (NRC)".

1944 Initiated a two-year research program on industrial noise at Colgate University.

1948 Published and distributed theory and use brochure.

1949 The AMA joined American Society for Testing Materials (ASTM) and the National Fire Protection Association (NFPA).

Inaugurated public relations program.

Established fellowship in acoustics laboratory at Massachusetts Institute of Technology (MIT).

C-20 Committee formed to establish test method for rating properties of acoustical materials.

1950 Bulletin name changed to "Sound Absorption Coefficients of Architectural Acoustical Materials"

Received award for exceptional merit from Producers Council and American Institute of Architects.

1953 Selected an independent testing laboratory to rate acoustical materials for resistance to flame spread and included data in official bulletin.

1954 AMA contributed to the initial publication of noise control magazine, a previous publication of the ASA.

1956 Completed a visual aid program, A Picture Story of Architectural Acoustics and Acoustical Materials, in cooperation with Syracuse University and Producers Council to be distributed to architectural schools and colleges.

1957 Endowed Wallace C. Sabine Silver Medal to be awarded by the ASA for outstanding contributions to the science of architectural acoustics.

Initiated research program on test procedure for sound attenuation of acoustical ceilings.

1958 Published and distributed brochure, "How to Quiet Noise in Your Home."

By 1958, membership in the AMA had dropped to thirteen. In December, the same month in which the anniversary was celebrated, Paul Earls Sabine died. Although it is not known whether he ever had a chance to read the anniversary issue, it can be assumed that he would have reflected with pride on the quarter-century of history he had helped shape and on the journal to which he had contributed so often and had made so influential.

As recently as 1987, ten years after the AMA faded away, the publication "The Sound Absorption Coefficients of Architectural Acoustical Materials" still appeared in newly published technical papers, journals, or texts on architectural acoustics. Unfortunately, in some cases, the older versions of the publication were used, and the data that appeared in some documents had been obtained during the 1930s. Besides the outdated data, surely the designated products would have changed as well, if they still existed at all. The authors of these documents, however, did not have anything more recent, a problem that is only now apparent to current technical authors of architectural acoustic literature.

What made the AMA bulletin such a unique publication is perhaps more appreciated today than it was back then. Now that it is no longer available, numerous architects and consultants contact Riverbank every year to ask if there is anything currently being published. They lament the desperate need for a continually updated compilation of acoustic materials performance data. Unfortunately, no such document is available.[22] Two "Compendiums on Materials for Noise Control" were issued by the National Institute of Occupational Safety and Health (NIOSH) in 1978 and 1980, but they, too, are out of print.

Through the years a few publications were produced by other firms, but they, like the others, are not easy to come by. Fortunately, individual corporations publish their respective data extensively, and some associations which are again engaged in testing programs, advertise their respective product lines.

Although Riverbank's affiliation with the AMA was, for the most part, beneficial to both parties, problems did exist, particularly with the scheduling of tests and the establishment of testing prices. From 1933–1947, having only one test chamber to use (not six as Riverbank has today), Paul Sabine tried to set up a schedule to accommodate clients, but for a variety of reasons, some manufacturers had problems getting their product developed and to the lab on time. Sabine noted in one correspondence how amazed he was that virtually all the delays in manufacturing seemed remedied just before an AMA publication deadline when the testing was at its peak. Complicating matters even more during the annual rush period was the manufacturer who would demand additional testing when he received a lower rating than a competitor. This issue prevailed until it was decided that each manufacturer would learn only the results of his tests and his tests only until all results were published. Thus, Riverbank would hold all data until they were released on a predetermined day for publication.

Test pricing was another problem. AMA members felt they deserved a price reduction on their testing. Paul Sabine wrote that he felt like a minnow trying to obtain food from a school of hungry sharks every time he suggested an increase. To satisfy the member-clients, Sabine first suggested an annual fixed fee that reflected a considerably reduced rate. This suggestion was refused, however, because, it was argued, some members had only one product, while others had many. Sabine, then, developed a percentage scheme based on product-testing volume, but this, too, was refused because it was deemed too complicated. Eventually, because he was operating at a loss, Paul Sabine submitted a flat increase and stated that not one more test would be conducted for the AMA until the price was agreed on. Naturally, his proposal resulted in a counterproposal from a number of AMA members: They would discontinue testing at Riverbank if the fee went up. Finally, after Sabine agreed to include a free test for a certain number of paid tests (a discount policy still in practice), the manufacturers accepted the price hike. For a

while Riverbank was able to meet operational expenses. Once during this period (1939), Riverbank employees received a whopping five cent-per-hour raise!

By 1967, however, the AMA membership had dwindled to twelve: Armstrong Cork Company; Kaiser Gypsum Company, Inc.; Baldwin-Erret-Hill, Inc.; National Gypsum Company; The Celotex Corporation; Owens-Corning Fiberglas Corporation; Gustin Bacon Manufacturing Company; Simpson Timber Company; E. F. Hauserman Company; United States Gypsum Company; Johns-Manville Sales Corporation; and Wood Conversion Company. The organization changed its title to the Acoustical and Insulating Materials Association (AIMA), hoping that a new name might bring more members.

The first AIMA bulletin didn't indicate that Baldwin-Erret-Hill, Inc., and the E. F. Hauserman Company were still members, but it did note that the Gustin Bacon Manufacturing Company had become a division of the Certain-Teed Products Corporation and the Wood Conversion Company became part of the Conwed Corporation. One new member appeared, the Keene Corporation. Total membership in the AIMA in 1970 was eleven members.

The AIMA membership decreased to ten in 1972 when the Certain-Teed Products Corporation dropped out. Two notes pencilled in the 1971–1972 bulletin stated that the Jim Walters Research Laboratories was part of the Celotex Corporation and that the Gold Bond Company was part of the National Gypsum Corporation. Some individuals still get these respective associations confused. Nevertheless, the AIMA ended in 1975 and became the Acoustical and Board Products Association (ABPA). The six ABPA member-manufacturers listed in Bulletin XXXIV for 1975 ("Performance Data Acoustical Materials") were The Celotex Corporation, National Gypsum Company, Conwed Corporation, Owens-Corning Fiberglas Corporation, Johns-Manville Sales Corporation, and United States Gypsum Company. By 1976, two of the members withdrew, essentially ending the acoustic products bulletin.[23]

In a poll of manufacturers that participated in the AMA program, most agreed that the bulletin had been a good idea, especially for the various needs of architects, acoustical consultants, and manufacturers requiring absorptive products. They also felt, however, that it had been limited in providing other information that would better promote their products. In essence, each found that the company would rather publish and advertise their data in house publications using their own time frame. By doing so, many of the problems of meeting a deadline were eliminated. Also, because the bulletin indicated some products had lower acoustic properties and, therefore, would be considered inferior by a reader, the manufacturer, in its own publication, found it easier to explain merits of those products not dealt with in the AMA bulletin, particularly the features of products designed for lower cost, special applications, unusual designs, and so on.

In summary, withdrawal from the AMA was primarily a matter of advertising preference rather than a way to alleviate testing expenses. Ironically, as far as Riverbank's records indicate, after the AMA, AIMA, and ABPA series ended, many of the same manufacturers did, indeed, continue testing at their own pace. When averaged over a three-year period, in fact, their testing volume increased over what had been averaged for three years in the annual bulletin.

Although the need for a bulletin today is obvious, it is also obvious that changes in the old AMA, AIMA, ABPA format are needed. Information involving esthetics, cost effectiveness, applications, as well as acoustical data and other test-related parameters, is essential. Laboratory credibility and independent product policing must also be considered. Current-day testing policies used by some manufacturers explain why such a publication does not exist today. In some cases, many go well beyond the scope of the old bulletin, but a few might even publish data that are somewhat suspect or misleading. In any respect, the thought of having such an up-to-date publication will most likely persist among acousticians, especially those who remember the convenience and credibility of the old AMA bulletin.

CHAPTER

7

Acoustics
Some Of This, Some of That

Besides the testing he oversaw for the Acoustical Manufacturers Association, archive files — and his own articles — indicate that Paul Sabine was involved in many other acoustical projects at Riverbank during the 1930s.

During the first two years of the decade, Paul completed his book *Acoustics and Architecture.* (The book was printed by the Maple Press Company of York, Pennsylvania, copyrighted and distributed by McGraw-Hill Book Company of New York and London, 1932.) The book contains much material that was undoubtedly the first of its kind. Besides being an excellent reference source, much of what Sabine explained back then fits various acoustic-related situations of today. The book was written in a clear and easily understood manner. A book that engineers, architects, and laypersons alike would find most useful. Paul Sabine's Preface, says it all:

> The last fifteen years have seen a rapidly growing interest, both scientific and popular, in the subject of acoustics. The discovery of the thermionic effect and the resulting development of the vacuum tube have made possible the amplification and measurement of minute alternating currents, giving to physicists a powerful new device for the quantitative study of acoustical phenomena.
>
> As a result, there have followed remarkable developments in the arts of communication and of the recording and reproduction of sound. These have led to a demand for increased knowledge of the principles underlying the control of sound, a demand which has been augmented by the necessity of minimizing the noise resulting from the ever increasing mechanization of all our activities.
>
> Thus it happens that acoustical problems have come to claim the attention of a large group of engineers and technicians. Many of these have had to pick up most of their knowledge of acoustics as they went along. Even today, most colleges and technical schools give only a scant instruction in the subject. Further,

the fundamental work of Professor Wallace Sabine has placed upon the architect the necessity of providing proper acoustic conditions in any auditorium which he may design. Some knowledge of the behavior of sound in rooms has thus become a necessary part of the architect's equipment.

It is with the needs of this rather large group of possible readers in mind that the subject is here presented. No one can be more conscious than is the author of the lack of scientific elegance in this presentation. Thus, for example, the treatment of simple harmonic motion and the development of the wave equation in Chap. II would be much more neatly handled for the mathematical reader by the use of the differential equation of the motion of a particle under the action of an elastic force. The only excuse for the treatment given is the hope that it may help the non-mathematical reader to visualize more clearly the dynamic properties of a wave and its propagation in a medium.

In further extenuation of this fault, one may plead the inherent difficulties of a strictly logical approach to the problem of waves within a three-dimensional space whose dimensions are not great in comparison with the wave length. Thus, in Chap. III, conditions in the steady state are considered from the wave point of view; while in Chap. IV, we ignore the wave characteristics in order to handle the problem of the building up and decay of sound in rooms. The theory of reverberation is based upon certain simplifying assumptions. An understanding of these assumptions and the degree to which they are realized in practical cases should lead to a more adequate appreciation of the precision of the solution reached.

No attempt has been made to present a full account of all researches that have been made in this field in very recent years. Valuable contributions to our knowledge of the subject are being made by physicists abroad, particularly in England and Germany. If undue prominence seems to be given to the results of work done in this country and particularly to that of the Riverbank Laboratories, the author can only plead that this is the work about which he knows most. Perhaps no small part of his real motive in writing a book has been to give permanent form to those portions of his researches which in his more confident moments he feels are worthy of thus preserving.

Grateful recognition is made of the kindness of numerous authors in supplying reprints of their papers. It is also a pleasure to acknowledge the painstaking assistance of Miss Cora Jensen and Mr. C. A. Anderson of the staff of the Riverbank Laboratories in the preparation of the manuscript and drawings for the text.

In conclusion, the author would state that whatever is worth while in the following pages is dedicated to his friend Colonel George Fabyan, whose generous support and unfailing interest in the solution of acoustical problems have made the writing of those pages possible.

P.E.S.

Much difficulty in providing a befitting explanation to what appears in this book just cannot be given in a few words. For those involved and those with more than a passing interest in architectural acoustics, read it, and appreciate the foresight and magnitude of what Paul Earls Sabine had to say about the subject in 1930.

Proceeding along to Sabine's other endeavors during this period, auditorium acoustics, for example, was the subject of two of his articles: "Acoustics of the Chicago Civic Opera House," which appeared in the April 1930 *Architectural Forum,* and a followup article, "Acoustics in Theater Design," in the September 1932 edition of the same publication.

Sabine continued researching another problem: His "Sound Transmission Coefficients and Reduction Factors," referred to earlier, showed the actual formulated differences between his term "reduction factor", Vern Knudsen's term "transmission loss", and Buckingham's terms "transmissivity" and "transmission coefficient", none of which, when the mathematical differences were inserted, could still explain the differences in transmission loss data among the labs.

In February 1932, Paul Sabine corresponded with Wilbert F. Snyder of the National Bureau of Standards (NBS) on the topic of sound transmission. What makes this correspondence interesting to current-day acousticians is not necessarily that the expression "noise-reduction factor", originated by Sabine, was dropped in favor of what is now used, transmission loss, but rather the way that the term transmission loss came into play and was officially defined in 1932.

Snyder stated that the NBS preferred to use the term *transmission loss,* which was defined as

Transmission Loss = 10 log I/r = 10 log I_1/I_2 + 10 log S - 10 log A in decibels, where

r = transmissivity, as defined by Buckingham.
I = intensity
I_1 = diffuse steady-state intensity in source room.
I_2 = diffuse steady-state intensity in receiving room.
S = area of test panel.
A = total absorption in receiving room.

NBS decided to use the following nine test frequencies: 128, 192, 256, 384, 512, 768, 1024, 2048, and 4096 cycles per second, each a midpoint frequency having a bandwidth of 10 percent of the test frequency. Thus, at 512, the frequency band is 468–538 cycles per second. Also, the bureau stated that an average of these values was satisfactory as a measure of relative merit between various test specimens. Sabine, however, wanted to incorporate a different method; so, he organized a subcommittee of the Acoustical Society of America (ASA) to investigate sound transmission measurements and put together the following questionnaire, which, it was hoped, would help standardize testing:

Points in Sound Transmission Tests on which agreement is to be reached.

1. Shall measurements be made on transmission of diffuse steady state or a directed beam? The former is employed at the Bureau of Standards, Riverbank,

and the University of California at Los Angeles. The latter at the University of Illinois.

2. Shall we agree to state results in terms of Transmission Loss in Decibels as defined by Knudsen:

Transmission Loss = 10 log I/r
r = Jt / Ji
Ji = flux intensity incident upon the test partition on the source side
Jt = flux intensity away from partition on receiving side.

For a diffuse steady state
Ji = $CI_1/4$, where I_1 is the average sound energy density in the source room.

For the diffuse steady state in both source and receiving room
$T.L.$ = 10 (log $I_1 A_2/I_2 S_1$)
where I_2 is the average sound energy density in the receiving room, A_2 is the absorbing power of the receiving room,and S is the area of the test wall.

3. Please indicate the number and distribution of test tones which in your opinion should be employed. At the Bureau of Standards six frequency bands 150–187, 250–285, 500–547, 1000–1070, 2000–2175 and 3000 to 3165 have been used in their latest published data. At Riverbank Laboratories, 17 frequencies from 128 to 4096 have been employed, four in each octave below 1024, and two in each octave above this frequency. The current practice in both laboratories gives twice as much weight in the average to frequencies below 1000 cycles as to frequencies above 1000 cycles.

4. Should the average Transmission Loss for the whole series of test frequencies be taken as a measure of the sound insulating qualities of partitions? If not, how would you suggest that these qualities be expressed?

5. Are precise specifications as to mounting and size of test panels desirable? The Bureau of Standards tests have been made on panels approximately 85 x 70 inches. Riverbank tests have been made on panels either 74 x 87 inches, or 31 x 84 inches. Identical constructions in the different sized openings have shown no appreciable differences in transmission loss. If specification of minimum dimensions for test panels is desirable, what in your opinion should these dimensions be?

6. Please outline suggestions for any other items of standardization which you think desirable.

Paul Sabine had incredible insight into the problems regarding sound transmission. Unfortunately, after some sixty odd years, many of the discrepancies Paul Sabine wanted to rectify then are still in existence.

Another Sabine-written publication, previously referenced, was "Weight as a Determining Factor in Sound Transmission," in which the Riverbank director utilized the *limp mass law* concept to discuss a common problem — leaks around doors:

In the door tests, on the other hand, the variations were almost wholly one of weight. The metal sheets were incorporated in the door construction in such a

way as not to stiffen them to any great extent, while the thickness was nearly the same throughout the series. In this case, we find the relation between mass and reduction to agree more nearly with the predicted for the idealized case of true piston movement of a rigid partition.

The tests on doors provided an opportunity for measuring the effect of the threshold crack upon the sound insulation of a door. The doors were provided with automatic devices, whereby the crack at the threshold was sealed by a felt strip when the door was closed. The threshold clearance when the plunger was not forced down was 0.5 inches. Measurements with this crack opened and sealed showed that an opening of this size reduced the transmission loss from 33 dB to 26.6 dB. If we complete the transmission loss of the door with the crack, assuming that the transmissivity of the latter is unity, the value so obtained is 22 dB.

We can compute the transmissivity of the crack from the measured values of the transmission losses with the crack opened and sealed with felt. The computed value is 0.29 instead of unity. These measurements show the very marked effect which small openings may have in decreasing the sound insulation of doors.[24]

In his next publication, Paul Sabine, like his current-day counterparts, learned that his research had been preceded by the research of someone else and that his own findings, gained through technological advances, were no different from those that had been gathered years earlier. This article, "Recent Developments in Architecture Acoustics," printed in the *Journal of The Franklin Institute* in 1934, also mentioned the acoustician who had performed the original testing: Wallace Clement Sabine.

It was almost exactly nineteen years ago that Franklin Institute was addressed on the subject of Architectural Acoustics by Professor Wallace Sabine of Harvard. The distinguished speaker was well worthy of the distinguished audience that heard him on that occasion. As a lone worker in what was then a hitherto untilled field of investigation, he came to present a record of individual achievement, which, viewed in the perspective of the intervening years, marks him as a truly great scientist. The problems to which as a very young man he had set himself some twenty years before were as old as the architecture of ancient Greece. His solution of those problems came not through the acquisition of new research tools more powerful than those his predecessors had used. Rather it came as a result of the skillful and persistent application of the scientific method to a problem that had not before been the object of any thoroughgoing scientific attack. The necessary instrumental equipment was all available fifty years before Sabine undertook the problem. So far as experimental equipment was concerned a scientist with Sabine's skill, patience, and insight might have anticipated his results by half a century.

Tonight I cannot report any such record of outstanding individual achievement. Rather as one of a fairly numerous group of workers I am here to tell you briefly of the advance that has been made during the last decade and a half along the trail which Sabine blazed some thirty years ago. New and powerful aids to acoustic research have come to hand during that period. It is quite con-

> servative to say that since 1920 more progress in the development of instruments for the making of acoustical measurements has been made than in the whole prior history of the study of sound.

The changes in instrumentation Sabine alluded to included a switch from organs and tuning forks to vacuum tubes, vacuum-tube amplifiers, and oscillators. The development of loud speakers and microphones and improvements in telephony, sound recording, and sound reproduction all bettered the acoustician's tools. The advancements also allowed researchers to rely on the decibel as the unit of measurement, along with absorption coefficients to determine the absorption of specific materials and transmission loss qualities in decibels to determine the barrier performance of a partition.

In the article, Sabine continued with his explanations of different test series as well as the use of the results in applications within various structures. To illustrate, he referred to his own acoustical consulting work and how he used previous test data for the Fels Planetarium and Rockefeller Center Radio City Music Hall projects:

> In conclusion, we may say that while we cannot report any spectacular achievement in the field of architectural acoustics since Sabine's time, yet substantial progress has been made in the practical application of the scientific principals which he enunciated. Well authenticated data on sound insulation are now available. A wide variety of materials that have excellent sound absorptive properties and which have desirable structural properties have been developed to meet almost any desired mode of auditorium treatment in place of unsightly hair felt of the earlier days. The new developments in the recording and reproduction of sound have given us both new problems and new tools with which to solve them. The wilderness of guesswork and uncertainty into which Sabine as a pioneer plunged forty years ago is today a region of cultivated and well ordered scientific knowledge. Architectural acoustics may well lay claim to being an established and self respecting branch of engineering sciences.

After the publication of "What Is Measured in Sound Absorption Measurements?" in the April 1935 issue of the *Journal of the Acoustical Society of America (JASA),* Paul Sabine wrote a follow-up to the article, "The Beginnings of Architectural Acoustics," which was published in the April 1936 issue of JASA. In the article he further substantiates his cousin's claim to the title Father of the Science of Architectural Acoustics by quoting other experts in the field about Wallace Clement Sabine's contributions. Dayton Miller, a professor of physics at the Case School of Applied Science, expressed his admiration for Sabine's foresight:

> In the concluding chapter of his delightful Anecdotal History of the Science of Sound, Professor Miller says "More progress has been made in the realm of sound in the first third of the 20th century than in all of the preceding centuries." This room may well be called the birthplace of one important branch of the new science of acoustics for it was here that forty years ago Wallace Clement

> Sabine, a young man of twenty-eight, began that series of researches upon the behavior of sound in rooms that was ultimately to take auditorium acoustics out of the realm of guess work and chance and to establish it as a reputable branch of engineering science. ... Sabine may have found a few rough loose pieces of material here and there, but for the most part he had to blast his building blocks out of the solid earth. The structure which he reared still stands.

Paul Sabine adds to Miller's comments, noting that the work at Harvard on the Sanders Theater and the lecture room of the Fogg Art Museum was without precedent:

> ... in all of Wallace Sabine's published papers there was not one single reference to previous work. The reason is that there was not none. In fact later in Professor Watson's exhaustive bibliography of the "Acoustics of Buildings" containing 600 titles, there are just nine that antedate the year Wallace Sabine began his work. Here and there one finds suggestions of the part played by reverberation and the absorption of sound as possible factors in the acoustic properties of rooms, but almost uniformly prior work deals with the problem from the geometrical point of view. In the second edition of the "Theory of Sound," published in 1896, Rayleigh discusses theoretically the absorption of sound by porous walls, suggests that "a loosely compacted haystack would seem to be as effectively an absorbent of sound as anything likely to be met with," refers to the well-known mitigating influence of thick carpets in reducing the "prolonged resonance" in large rooms with nonporous boundaries and suggests applying similar materials to walls and ceiling as a means for further improvement. Nothing more definite than this was to be found anywhere in the literature. Truly the young investigator was not cramped in his chosen field by the prior work of others.

Paul Sabine acknowledged the work done by German physicist Wilhelm Wein in 1903 dealing with threshold intensity and the impact of the Weber-Fechner Law contributions and then added a summary of the difficult problem faced by Wallace Sabine at Harvard: "What is the behavior of vibrational energy in a three dimensional medium bounded by imperfectly reflecting walls and what light does the answer to this question throw on the age old problem of the acoustic properties of rooms?"

The article continued with a lengthy discussion of what Wallace Sabine accomplished. It concluded with a reference to his resignation from the War Department on November 30, 1918, after which he returned to Harvard and the problems he was studying when he left in 1915. The Riverbank-Sabine connection was also mentioned in the article on page 247:

> The new laboratory in Geneva was completed. This had come from his meeting in 1913 with Colonel George Fabyan and the warm friendship into which their acquaintance had ripened. There, in the country, free from disturbing noises of the city and the difficulties that beset his researches in buildings that house other activities, in a laboratory of his own planning, were to be conducted further tests on sound transmission. But, first, new sound sources must be calibrated. This must be done in a room in which the rate of decay had been determined by the

> four organ experiment. From his notes, we know that on the night of December 11th, just one month after the signing of the Armistice he was in the large lecture room of Jefferson Laboratory measuring the times of reverberation from the new set of organ pipes that were to be used in the new laboratory. These measurements would serve to link the work that was to come to that which had gone before. The notes record that again on the 14th and for the last time on the 16th he was at work with only his faithful friend, John Connors, to bear him company. These last three nights bear eloquent testimony to the almost super-human degree to which the demands of Professor Sabine's mind dominated the ills of his body. On January 5, he entered the Peter Bent Brigham Hospital, where two days later was performed the operation, which had it come earlier, might have saved his life.
>
> I have tried to give you a picture of how and with what heroic labor, the foundation of architectural acoustics was laid single-handed by a great scientist. If perchance, I have, in this, assumed too much the attitude of hero-worship, I can only plead that Wallace Sabine was one of those rare natures who inspired that attitude in all who knew him.

Paul Sabine was still not finished writing the history of architectural acoustics. After writing "Effects of Cylindrical Pillars in a Reverberation Chamber," for the July 1938 issue of *JASA,* for the first time, he penned a *JASA* article with another Riverbank employee, Luther G. Ramer; it was entitled "Absorption Effects in Sound Transmission Measurements" and appeared in October 1938. "Architectural Acoustics: Its Past and Its Possibilities" was published in the July 1939 issue of *JASA.*

In the beginning of the October 1938 article, Sabine repeated much of what he had previously said in his other articles about the history of architectural acoustics. In his July 1939 article, however, he presented new information. He discussed continuing the four-organ–pipe experiments and the wall sound transmission experiments that Wallace Sabine had started and explained how these experiments led to his own with humidity and porous flexible materials for sound absorption. He then reported on his research involving mass relationships for sound transmission and impact studies on typewriters.

He also explained that during the early 1930s, the stop watch and ear method was replaced by relay-controlled chronometers (acoustic clocks) operating in conjunction with frequency oscillators, amplifiers, loudspeakers, attenuators, and microphones. During the same period, he added, important work was being done by E. A. Eckhardth and V. L. Chrisler at the NBS, the Bell Telephone Laboratories, and the Electrical Research Products Laboratories in New York; Vern Knudsen's laboratory at the University of California; and the Johns-Manville Laboratory in Manville, New Jersey. Equally vital research was being conducted abroad as well, including at the Osswald's Laboratory in Zurich, the Heinrich Hertz Institute in Berlin, and the National Physical Laboratory in Teddington, England. Sabine also stated that by 1939,

there were at least seven acoustical laboratories in the German Reich, two in Switzerland, and one in Italy.

Another issue raised in the July 1939 article is how Wallace Sabine's formula came to be accepted, with some modifications, as the basis for architectural acoustical research:

> On the theoretical side, the original reverberation formula developed both empirically and theoretically by Wallace Sabine was accepted without question. As early as 1903, Franklin in this country gave a mathematical derivation of the To = 0.164V/a formula based on the kinetic theory of gases in which the theoretical constant appeared as 0.162 instead of 0.164, Sabine's experimental value. Yaeger's derivation of the theoretical formula was published in 1911 eight years later. Parenthetically, I may say that the tendency in Germany to call it the Sabine-Yeager formula, or occasionally the Yeager-Sabine formula has little justification in view of Franklin's prior publication. The Sabine formula is derived on the assumption that the decay of sound is a continuous process or what amounts to the same thing that the number of reflections is sufficiently large that the series $1 + (1 - a) + (1 - a)$ squared $+ (1 - a)$ cubed etc. has its limiting value, namely $1 / a$ and further, that the distribution of intensity is uniform and there is a random distribution of directions of energy flow during the decay period. These assumptions are good enough as long as we are dealing with large rooms in which the average absorptivities are low, and decay rates are measured over a large drop of intensities as is the case when the threshold of hearing is the lower limit of decay. Broadcasting studios and sound stages with their high empty room absorptions depart widely from the assumptions of the Sabine equation, and with the improved methods of measurement the discrepancies between theory and fact appeared. As a result, modifications of the Sabine formula have been proposed. In May 1929, in a discussion of a paper given before this Society, R. F. Norris proposed a modification of the older formula which in effect amounted to the substitution of $-\log e\ (1 - a)$ for a, the arithmetically averaged value of the absorption coefficients of the bounding surfaces of the room. In the derivation of this formula, account is taken of the finite number of reflections which can occur during the time of a 60 dB decrease in intensity of the reverberant sound. The Sabine formula is the limiting case as the absorption coefficient becomes progressively smaller and the number of reflections during the decay correspondingly greater. At the January meeting in 1930, Dr. Eyring gave a much more detailed and comprehensive treatment of the subject, arriving at a reverberation equation essentially the same as Norris had proposed. In 1932, Millington and also Sette presented a third equation which differed from Eyring's by substituting for the single product of the total area by the weighted average reflection coefficient of the exposed surface of the room, the sum of the separate products, obtained by multiplying each area by its respective coefficient. As Eyring later pointed out, the difference simply amounts to a difference in obtaining the average coefficient of reflection of the bounding surfaces of the room. Eyring's formula is open to the objection that it may lead to coefficients greater than unity, Millington's, to the objection that there would be no reverberation in a room with an open window, no matter how small.

A still-contested topic, the single-number rating, was also discussed in the 1939 article, in the context of the open-window concept; widespread doubt was expressed that there truly is a single-number coefficient of absorption for a given material.[25] References were also made to work done by Vern Knudsen, professor at UCLA, in his laboratory; Werner Heisenberg, the founder of quantum mechanics uncertainty principle, and his research related to the quantum methods presented by M. J. O. Strutt; and the research conducted by Hendrik Antoon Lorentz, a Dutch physicist; which related not only to Wallace Sabine's work but to Strutt's work as well. Paul Sabine stated that Strutt proved, on broad theoretical grounds, the validity of Lorentz's proposition in systems with absorption and, as a result, developed logarithmic decay of sound in large rooms. Strutt's work, Sabine noted, led to the research of P. M. Morse which, in turn, influenced the work done by Lord John William Strutt Rayleigh. Sabine characterizes Morse's analysis as

> ...being based on the quantum treatment of the possible modes of vibration, which is mathematically impressive and gives a neat mathematical explanation of what we already know. It gives a new conceptual background of the phenomena of sound in rooms, which to younger minds not too thoroughly impregnated with the older conceptions, may lead to new and more successful attacks both theoretically and experimentally on what must now be recognized as an unsolved fundamental problem of architectural acoustics.

References were made to the scientific studies of James Hopwood Jeans (an English physicist and astronomer), Peter Joseph William Debye (an American physical chemist) and Max Karl Ernst Ludwig Planck (a German physicist). Planck's fundamental law about energy from emission and absorption from electromagnetic radiation referenced how this research related to Wallace Sabine's formula, as well as his other work. Thus Paul Sabine accomplished his goal of illustrating the impact and importance of Wallace Sabine's original theory and establishing him as the founder of architectural acoustics. Despite this article, which refers to most of the other pioneers in the field and notes the debt they owed to Wallace Sabine, it is often these individuals who are offered up as challengers to Professor Sabine as father of the science.

Paul ended his 1939 *JASA* article with what he saw in the future for architectural acoustics:

> As to the practical possibilities, we are assured I believe of a steadily increasing market for the products of our minds and factories in the way of cheaper, and more practical methods of sound control. Low cost housing offers a promising field in the development of cheap wall and floor construction that shall be as good in the matter of sound insulation as, or possibly better than, the construction of the more expensive homes today.
>
> The last word in materials for acoustical correction has not been said in the porous and perforated materials now so widely used. A more practical criterion

of acoustical excellence in auditoriums, particularly for broadcasting studios of the auditorium type, than the measured reverberation times is something that might well be sought. It is worth noting that one of the best if not the best orchestral program on the air today comes from a hall which was built without any acoustical engineering whatsoever, in the days before the acoustical expert and the sound engineer were ever heard of.

The aim of architectural acoustics is a social one, directed toward the alleviation of the evil of noise and the enhancement of the enjoyment of speech and music. As long as our civilization moves toward social ends, architectural acoustics will continue an important branch of engineering science.

The last article that Paul Sabine wrote for *JASA* during the 1930s was "Measurement of Sound Absorption Coefficients from the Viewpoint of the Testing Laboratory." In the article, published in July 1939, he implored his colleagues in the field to strive for precision and standardization:

a It should be recognized that reverberation values of sound absorption coefficients are conventional values arrived at by standardized test procedure under arbitrarily specified test conditions.

b It is the responsibility of independent testing laboratories whose tests are to be recognized as authoritative to see that test procedure is standardized and that methods used in any one laboratory are maintained constant so that the results of all measurements constitute a self-consistent body of data.

c Further, it is the responsibility of such laboratories to work out among themselves and to agree upon test conditions in each laboratory, such that measurements made on identical samples in these laboratories shall agree within a reasonable tolerance.

Such a procedure might be carried into effect by the choice of some particular material as a standard material, identical samples of this material being measured in all of the laboratories concerned, each laboratory keeping a sample of the standard material as a standard for control measurements.

In this way, it ought to be and I believe, would be possible to make of published figures a self-consistent body of data which could be reduced to some more absolute basis, if when and as the time arrives that some more nearly ideal method of arriving at a figure of merit for sound absorbing efficiency shall have been discovered. Thus the confusion of the present situation could be alleviated and the way paved for a better means of forecasting and measuring the reverberation characteristic of rooms.

Although various standard samples have been discussed under the auspices of the American Materials Association and American Society for Testing Materials since the 1930s, never has a correction factor to normalize all pertinent laboratory absorption data been augmented or, for that matter, formally proposed. Thus, not much has changed since 1939, other than precision requirements in data acquisition. However, even this point can be argued when you consider the "man in the box" recording 1,100 decays with human ears as the microphone, the organ as a sound source, and a stop watch

as the sole instrumentation resulted in the same levels of precision as today using the most sophisticated equipment. The only real gain over the years has been the amount of time needed to conduct the tests, an economic rather than scientific advance.

Besides the articles he wrote for *JASA*, Paul Sabine wrote a textbook during the 1930s, *Acoustics and Architecture,* and applied for a patent in April 1937, along with Carl A. Anderson, on "Devices for and method of measuring sound absorption by materials and the like"; the patent request was later withdrawn. On April 16, 1938, about eight and one-half years after Paul's first wife Mabel died of a stroke, he married Cornelia Corron Manley, whom he had met at his son Hale's wedding.

If all this were not enough to keep him busy, Paul Sabine's work during the 1930s also included revising an encyclopedia entry on acoustics[26] and hosting an esteemed Hungarian scientist.[27] Perhaps the best way to appreciate the scope of Sabine's efforts is to read the biographical notes, covering the years 1923–1938, which appeared in the *National Cyclopedia of American Biography:*

> Have published some fifteen papers dealing with the absorption and transmission of sound by building materials and the acoustic properties of rooms. Have served as acoustical consultant in the design of the Chicago Civic Opera House, The Fels Planetarium of Philadelphia, the theaters of Radio City, and numerous other important auditoriums in various parts of the country. Invented and patented a sound absorbing plaster, and a sound insulating door which have found wide commercial application.
>
> Member of Editorial Board, *Journal of the Acoustical Society of America* 1929–1936. Member Executive Council of Acoustical Society 1929–31. President of Acoustical Society of America 1935–36. Author of "Acoustics and Architecture" (Mc Graw-Hill, 1932). Chairman Technical Advisory Committee, Acoustical Materials Association, 1933–38.

Although the 1930s were a pivotal decade in the development of acoustical testing, much of the research has been forgotten or simply stored away. The intervention of World War II, which put an end to product testing until 1949, marked the end of these early years. After the war, the introduction of new personnel, equipment, and materials resulted in a new beginning for acoustical testing, unfortunately dismissing much of the earlier work as archaic. One need only read through archive files, however, to see that the research undertaken in these developmental years is not only historically interesting but also scientifically germane today.

CHAPTER

8

Laboratory Versus Field The Dilemmas and Hazards of Acoustical Consulting

Riverbank files kept since 1918 reveal not only how Paul Sabine utilized the laboratory to resolve various field-related acoustical consulting problems but how many consultants did likewise. Because the files disclosed a particular dilemma associated with acoustical consulting, this chapter is dedicated to these decibel chasers in the field.

Acoustical consulting is a field that requires a working knowledge of various engineering and scientific principles tempered with an ample mix of conventional wisdom, practical and technical know-how, business smarts and common sense, personal insight and vision, responsibility, and dedication. Even if one possesses all these traits, many acoustical consultants will add good luck and charm as fundamental requisites as well. The acoustical consultant, whose efforts can have tremendous impact on the aesthetics of any construction, has as his or her primary concern, solutions to help control the world's fourth and growing major form of pollution: noise.

Typically, the acoustical consultant is contracted to provide a better acoustic environment for either part or all of a building or, as is more often the case, to correct various noise-related problems, after the fact. If the acoustical consultant has completed a job well, his or her efforts are often not noticeable, especially if the designed aesthetics of the structure were maintained. As one experienced consultant puts it, "Good acoustics is heard and not seen." Paul Sabine wrote in a letter, "The interesting thing about being an acoustical consultant is that quite often all that is required to project ones' need to a perspective client is to explain the problem that he already knows about in a language he absolutely cannot understand."

Many acoustical consultants spend an entire lifetime resolving acoustical problems for business, industry, private individuals, and government agencies at all levels. When given the opportunity, some consultants will take on the challenging aspects of major civic and performing arts centers, drama theaters or churches; however, for reasons that might not immediately be obvious, the one consulting assignment that creates the most challenge (some would say *risk*) is a hall for music performances — primarily large halls, such as Boston's Symphony Music Hall and New York's Carnegie or Avery Fisher halls.

Each hall and its respective acoustical consultants are compared to other halls not only in terms of the acoustics but also the effects that the acoustical treatment had on the aesthetics. Unfortunately, acoustic control measures are not always compatible with the appearance as it was envisioned by the architects of the hall; therefore, conflicts can arise between acoustical consultants and the architects, contractor, or the clients. Designing a successful hall for every possible type of musical performance and the full musical literature — one that pleases everyone, patrons, performers, and owners alike — is analogous to a baseball pitcher throwing a perfect game in the World Series; although it has happened, the odds against it are astronomical. Also consider how few world-class pitchers have ever pitched a perfect game or even a no hitter. When you consider the career statistics of one pitcher, Don Larson, who did pitch a perfect game in a World Series, much more is involved than just Larson's pitching abilities for him to accomplish this remarkable feat. His pitching ability was a required basic ingredient, but to achieve the ultimate, he had to have the perfect situation, the right environment, administrative backing, managerial and fan support, teamwork, communication, cooperation (willingly, his team; reluctantly, other team), control (be physical in charge), acceptable results along the way, and good luck.

It doesn't take to much imagination to substitute acoustical consultant for pitcher in this analogy and performance hall for World Series. With the latter in mind, it is the *performance hall* that becomes the primary source in creating the dilemma or hazards that many acoustical consultants must face. To satisfy the sensory responses of its patrons, a large performance hall must be pleasing to the eye and have an overall ambience that is conducive to enjoyment by a wide range of individuals. Seats must be comfortable; lighting and sound systems must be adequate; and the air cannot be too dry, too humid, too hot, or too cold. The line of sight to the performers should not be impeded by pillars or overhangs. The building itself should be accessible and provide the necessary ancillary services. Add the acoustical consultant's concern — the virtual elimination of noise and distortion — and specific considerations for performers, administrators, and maintenance and service personnel, and a clear picture of the immensity of the task becomes apparent.

In the past two decades, the relative physical, acoustic, and aesthetic attributes of different performance halls have been the subject of numerous re-

search studies and publications. In write-ups on certain projects, the acoustical consultant's efforts were considered essential to the hall's success. The acoustical consultant is often the one held primarily responsible if a hall is not successful acoustically. However, as most experienced consultants know, a successful hall results only from a truly symbiotic and cooperative relationship among all the participants in the great drama of creating frozen- music architecture for the arts. This cooperative relationship must start in the early planning and programming stages of the hall's design and continue throughout its construction and the initial stages of the hall's use.

If a hall gains a deserved or undeserved reputation for acoustic limitations, the consultant can live forever with the failure, in spite of any past credits. Often, unjust ridicule from competitive consultants within the profession can be the most damaging because it affects not only the individual consultant but the entire field of acoustical consulting as well as the science of architectural acoustics.

When a new hall is deemed unsatisfactory, another consultant is often called on to correct the situation — without the desired collegiality between the two. Some consultants regard the position of second consultant as somewhat easier because the hall and its problems are real now rather than on paper. Sometimes, the opportunity for change is dramatic, that is, making the hall livelier (more reverberant) or more dead (more absorbent). More often, however, the difficulties are more subtle and less quantifiable because as indicated earlier, concert hall acoustics is a complex mix of interdependent variables. Of course, handling the desired aesthetics and dealing with architects and owners on corrective measures are always challenges for any consultant, regardless of when he or she enters the project. If there is sufficient pressure from music critics, the musicians, or the public, clients might have relinquished some demands, impeding the efforts of the original consultant. Oftentimes, the second consultant can insist on more freedom than his or her predecessor ever dreamed of having. If successful, the second consultant's reputation should be enhanced; however, praise for these consultants more often than not is overshadowed by the negativity of the comments about the failure of the first consultant. The late George Szell, leader of the Cleveland Symphony Orchestra, said in chastising a fledgling acoustical consultant at the opening of a school auditorium, "You American acousticians know nothing about music"; too often, old and ingrained prejudices of the musicians, clients, architects, and acousticians themselves have contributed to the perpetuation of stories of acoustic failures, if not to the failures themselves.

Until recently the risks in deviating from the traditional hall designs of the past have limited the creative contribution of acoustical consultants and architects alike: conservatism was the status quo. Any attempt to change was usually discouraged at the onset. No one wanted to risk paying for something new and different and chance being stuck with an acoustical lemon. In the

past few years, however, many new auditorium designs have evolved all over the world, much to the delight of the audiences. No longer do concert halls have to be rigid rectangular, decorated shoe boxes. The vision and involvement of some acoustic scientists and consultants have resulted in halls that are appealing to both the eye and ear.

Because of innovative efforts, many cities can now boast of new halls that identify with designs of the time, provide many new visual and added comforts, and have outstanding acoustics. No longer do patrons of the arts feel they have to observe a performance inside a Boston Symphony Hall-like chamber to enjoy it. Some critics who had remained true to their conservative ways for many years are now changing their rules because of the new aural and visual aesthetics provided in performance halls located throughout the world. Of late, the word "intimacy" has come into vogue with critics, consultants, and architects providing an agreed-upon way of assessing the merits and flaws of a performance venue. Consultant Leo Beranek first made widespread use of this term and measured it in halls with his initial time-delay gap. Beranek's *Music Acoustics and Architecture* has had more influence on the musical, architectural, and acoustic community than he ever could have possibly imagined — especially in framing a common dialogue in discussing a design. Many architectural acousticians regard Beranek's contributions to architectural acoustics on a par with Wallace Clement Sabine's original work in defining room reverberation time.

Yet Leo Beranek was a victim of a consulting dilemma regarding New York's Lincoln Center Philharmonic Hall (now Avery Fisher Hall). After Beranek had submitted his drawings and concept for what he felt would be needed to achieve good acoustics in the original design of Philharmonic Hall, many modifications to that original design followed. When completed, opinions regarding the halls acoustics varied. The word that the hall had poor acoustics began to spread and those in charge of the hall reacted. Instead of allowing Beranek the opportunity to test and make any corrective measures, a team of consultants was brought in and after their suggestions failed, another consultant was hired to remedy the situation. Eventually that consultant was successful and received credit for his excellent efforts.

In his book, *Science of Sound,* Northern Illinois University physics professor Thomas Rossing (recent ASA silver medalist in music acoustics) discusses the entire modification process that occurred at the Philharmonic/Avery Fisher Hall. Rossing also mentions that the original modifications instituted were made without the knowledge or support of either the consultant or the orchestra and that those modifications created design changes that contributed to the hall's deficiencies.

Beranek's consulting dilemma was as follows: although hired as the chief acoustical consultant and delineating the initial acoustical design parameters for the hall's original design, he was never informed about the various

changes to that design instituted by others. Since the modifications to the design contributed to poorer acoustics, Leo was never allowed to make any tests or corrective measures. Yet, it was he who took the brunt of criticism for the hall's poor acoustics.[28]

In May 1988, Beranek presented papers at the 115th ASA meeting in Seattle, Washington and evoked laughter from his audience through numerous self-deprecating remarks made about the Philharmonic Hall phase of his career. At the conclusion of his presentation he received a standing ovation.

Another noted acoustical consulting dilemma involved the now acoustically sacred Boston Symphony Hall. From the early 1920s to the present day, this hall has been regarded by many critics as a magnificent hall for music — near perfect for some repertoires. The acoustical consultant, as noted earlier, was Wallace Clement Sabine. After his death, a memorial ceremony was held at which a number of noted speakers extolled Sabine's many accomplishments. One, a music critic, commented that Boston's own symphony music hall is one of the best in the country, primarily because of the efforts of Wallace Sabine.

Since Sabine's death, Boston Symphony Hall has received nothing but high praise, yet when it was completed in 1902, Sabine's work was mercilessly panned. At the time *The Boston Evening Transcript,* Boston's then influential newspaper, printed an article written by a scientist, Frank Waldo, who included the remarks of another scientist, J. B. Upham, both of whom commended the acoustics of the symphony hall. Appended to their article, however, as a sort of counterpoint, was the viewpoint of the *Transcript's* music critic, William Foster Apthrop, who stated,

> This is all very well; but, like many essays on musical subjects by scientists, it arrives at conclusions with which most musicians find it difficult to agree. To begin with, neither the late Dr. Upham nor Mr. Sabine can be deemed competent to express a musical opinion of any weight whatever; both came musically in the amateur class, and, to conclude with, we have not yet met the musicians who did not call symphony hall a bad hall for music. Expert condemnations of the hall differ, as far as we have been able to discover, only in degrees of violence.

Apthrop's opinion, although weighty at the time, did not stand up for long. After a two-year hiatus from consulting, Wallace Sabine returned to the line of work, perhaps not so coincidentally at a time when public acclaim for the excellent acoustics of Boston Symphony Hall was at its peak. In any case, Sabine was vindicated and the hall remains an excellent place to make and hear music.

Around 1993 Leo Beranek reported that in 1987, he had received some documents from Emily Thompson, a doctoral candidate in history at Yale University who was writing a dissertation on architectural acoustics before 1930. One document was a letter from Wallace Sabine to the architect regarding the completed Boston Symphony Hall. In this correspondence was Sabine's answer to the question, How did you react to the negative criticism in the period just after the opening of the hall in 1900? The letter was dated

May 1, 1901, and although Sabine was defensive, he discussed in detail the "loudness, clearness, interference, resonance, and reverberation" of the symphony hall. He concluded, "On the certainty of my work in this respect I shall not yield." The other document dated about a year later (1902) and sent to the same architect was from a Mary Elliot of Boston. In the letter was the following comment: "A friend of ours who is a Musician told me the other day that Gericke (the conductor) and the musicians generally are feeling differently about the Acoustics of the Symphony Hall this winter, the music sounds beautifully and they think that the general drying out of the materials has made a great difference in the resonance."

A hall can be labeled or rated good or bad based on its opening performance alone and can be left with this label, despite the fact that it might be nothing more than the opinion of a noted conductor, performer, journalist, or, as is most often the case, a professional music critic. The critic, whose job is to evaluate, compare, and judge a performance and the facility, especially on opening night, serves a useful function. Not only does the critic inform the public of the merits or faults in a particular arena or program, but the critic is also responsible for noting flaws in the design of a hall. On what criteria does a critic base his or her judgment? What factors besides the performance and the hall, might he or she be weighing when sitting down to write a review? These questions are often discussed.

If on opening night a performance hall were labelled as having bad acoustics and if there were no obvious contributing noise sources and if the performers were vindicated as being the cause for the bad acoustics, then the most obvious candidate for a critic to blame would be the acoustical consultant. Even if the critic had some reservations regarding the actual cause for the bad acoustics, meeting his or hers immediate press deadline would surely outweigh any notion of delaying the review in order to conduct a full investigation into the matter first. After the critic's comments are printed and various reputations (hall, consultant, owners, city officials, etc.) are tarnished if not ruined, the critic could be the individual responsible for the damaged reputations. Simply put, a critic could be wrong and cause unwarranted damage.

How often has a movie critic given a movie a low or thumbs-down-rating and therefore many movie goers didn't go to see that movie. Yet those that did see the movie actually found it very good. Thus, because of the critic's review, the movie producers, directors, actors, as well as the movie theater owners all could have suffered both financial losses and loss of reputation. Hopefully, the use of "intimacy" as a criterion may help correct the performance hall situation.

To this point, the examples in this chapter have focused on consultants whose initial work on a hall was not fully appreciated by the architects, owners, and music critics. What about performing arts halls that have problems no one seems willing to recognize or even publicize? In a sense an acoustical

consulting dilemma, but in reverse. The hall is bad, but the original consultant was credited by the performers and critics as providing a good hall and everyone else thinks likewise.

Consultant-historian Ewart A. Wetherill tells of one notable instance: An opening performance featured a renowned conductor leading a celebrated orchestra in a hall so elaborate in design that there couldn't possibly exist a chance that anything was wrong with the acoustics, especially when the audience rose in unison and responded so enthusiastically that an encore and many curtain calls followed. The following morning, the beautiful hall, the performance, and the owners all received rave reviews in local and national newspapers.

Years later, however, many performers realized through conversations with their peers that most of them found the hall to be a difficult place to perform. The reviews that they had received were kind, but the performers were upset by subtleties such as "she sang her entire solo in pianissimo"; the performer, however, knew she had sung with a full voice. Another review commented, "How beautifully a solo violinist blended in with the strings of the local orchestra," when in actuality, the soloist felt the accompanying strings were playing too loud and drowned him out.

No one suspected this fine, oft-praised hall actually had poor acoustics in the upper frequencies — even though time-decay measurements conducted during a renovation confirmed the excessive high-end loss. The new consultant had great difficulty convincing the owners that modifications in the amount of absorption could significantly alleviate the problem. The owners, however, wanted exact conformity with the original design. The consultant agreed to add the original amount of absorptive material if the owners would agree to listen to a performance with 60 percent less material; he was able to prove his point. The hall is still regarded as one of the best, but now the orchestra's string section is getting reviews that are typically reserved for winds and percussion.

Another performance hall dilemma involves the Kleinhans Hall in Buffalo, New York. It is critically acclaimed as one of the better music halls in the United States. At its dedication in 1941, another consultant — another Sabine, Paul E. Sabine — was on the receiving end of the negative criticism. However, perhaps because of the consulting work he had done prior to the Kleinhans Hall project, Paul Sabine's reaction was much different from that of Wallace. He was ready for criticism and ready to respond. In 1934, for example, having recently completed a consulting job for Radio City, Paul Sabine published an article in which he explained why he had designed the rooms the way he had, using Wallace Sabine's description of the basic requirements for an auditorium as an introduction:

> In order that hearing may be good in any auditorium, it is necessary that the sound should be sufficiently loud, that the simultaneous components of a com-

> plex sound should maintain their proper relative intensities, and that the successive sounds in rapidly moving articulation, either of speech or music should be clear and distinct, free from each other and from extraneous noises. These three are the necessary, as they are the entirely sufficient conditions for good hearing. As an engineering problem it involves the shape of the auditorium, its dimensions and the materials of which it is composed.

In the same publication, Paul Sabine referred to Radio City Music Hall, where all sorts of vocal, music, and, most particularly, movie presentations would take place. Because of the varied forms of entertainment planned, Sabine decided on a reverberation time of 1.8–1.9 seconds as a compromise in the 1,800,000 cubic foot hall. After explaining his rationale, he went on to say that he suspected not everyone would agree with his decision:

> The organist and orchestral leaders will complain that the room is too dead i.e., too little reverberant for organ and orchestral music. On the other hand a room that is more reverberant would have called forth a fire of criticism from the motion picture engineers. A compromise that will placate if not please both extreme demands is about the best that can be hoped for. How well this compromise has succeeded in pleasing public taste one can only judge by the fact that up to the present no criticism of any kind as to the acoustic properties of the room has been received. I believe that the architect ordinarily considers that this is about the most in the way of public approval that he can expect in this "best of all possible worlds."

Paul Sabine received good reviews on the hall as he did for his consulting on the Chicago Civic Opera House, the San Francisco Memorial Opera, the Ravinia Theater, the Fels Planetarium in Philadelphia, Bankers Life Building and Joslyn Memorial Hall in Omaha, Nebraska, as well as the auditorium for the Christ Church in Little Rock, Arkansas, the Wurlitzer Corporation, the U.S. Air Force (Army Air Corps) auditorium at Wright Field, the Jewish Center in Detroit, the Goodyear Theater in Ohio, and many others. Yet as mentioned earlier, Paul Sabine also had to face unnecessary criticism. What follows is a history of sorts of the Kleinhans Hall project, reconstructed from Sabine's files at Riverbank. It serves as an example of the forces acting in opposition to an acoustical consultant.

The Hazards of Acoustical Consulting
The Kleinhans Music Hall Dilemma

The Best Man Available, But!

In late 1938, Paul Sabine completed his report on the revision he felt necessary for obtaining good acoustics in a proposed design of a concert hall in Buffalo, New York. The design had been submitted to him for comment by the architectural firm of Eliel and Eero Saarinen of Bloomfield Hills, Michi-

gan. The Saarinens indicated they were impressed with Sabine's observations and offered him the position of consultant if they were awarded the design commission.

In January 1939, the acting director of the Kleinhans Music Hall Inc., Ester Link wrote Sabine a letter of praise on his contribution to the Saarinen design, which had won the contract. She then informed him of the embarrassing situation that now faced the Saarinens. The Kleinhans Board of Directors had already subcontracted with the local architectural firm of F. J. and W. A. Kidd, who, in turn, had already granted the position of acoustical consultant to the Electrical Research Products Institute (ERPI) of New York. However, Link preferred Sabine's design over ERPI's because she felt ERPI's recommendations would lead to an acoustically dead hall. She hoped that Sabine could be retained and that ERPI could simply be eased out.

In Sabine's reply, he mentioned that he had sensed there was some problem when he visited the Saarinens at the Cranbrook Academy of Arts. However, he also sensed from their comments that they still desired his service in some capacity: "I have worked with a great many architects in this manner and I am convinced that only by close cooperation between the architects and the acoustical consultant can the best results be secured."

Ester Link, apparently motivated by the idea of acquiring Sabine's services, responded with a lengthy letter. She explained how the board had agreed from the onset that to have a good hall, good acoustics were essential. Therefore, they needed the best person available:

> At that time you (Sabine) were on holiday, Vern Knudsen in California was too far away and Fay was on an island off the Maine coast. Then Leopold Stokowski who had great success working with ERPI on his radio broadcast recommended that in the east Mr. Stanton was the best man. Stanton also was recommended by Ralph Walker, an architect for the New York telephone company. Since one of our directors also is a director for the same telephone company and since ERPI is a subsidiary of theirs, ERPI was given the contract.

Link went on to say that although Saarinen was allowed to use whatever acoustician he wanted, the privilege only continued until the preliminary design was completed. Saarinen and Fouilhoux (who had worked with Sabine on Radio City Music Hall) preferred Sabine to ERPI. Link added her hopes,

> ... that the building committee would still retain Paul and relegate ERPI to the position of technical consultant. Yet to explain away an organization of such magnitude and unlimited self confidence, plus such tremendous output and the backing of Stokowski would indeed be most difficult. Although the Saarinens prefer you, they under the circumstances are forced to recognize ERPI. Representing ERPI is Mr. Potwin. Fortunately he did study the violin for nine years and since I do prefer a musician who is a physicist or a physicist who is a musician, rather than a non-musical engineer, I still feel confident that ERPI will be inclined to make the hall overly dull.

In the next follow-up letter, Sabine mentioned that the outstanding reputation of ERPI was justified by the successful work that the firm had done on many theaters and auditoriums; however; "As I observe the general trend at the moment I have a feeling that there is a tendency towards [sic] over absorption and that unless the acoustical engineer has someone like yourself to hold them in check the music halls are apt to come out on the dull side."

Sabine then reminded Link that he could not act officially unless retained by the Saarinens. Immediately, Link informed them to, at least, have Sabine make some decisions before it was too late, especially because the board had decided to install air conditioning for which no noise-reducing recommendations had been made. Sabine wrote to her:

> My situation is somewhat ambiguous since I have not been officially retained by the Board of Directors and neither Mr. Saarinen, nor his son, had definitely indicated in just what capacity I am supposed to be acting. I shall of course be very glad to render any service that I can toward the realization of your ideal of an acoustically excellent hall.

Link mentioned that the president of the Kleinhans Music Hall, E. H. Letchworth, had instructed the local architects, the Kidds, to inform ERPI that they were to work with Sabine on the final acoustical conditioning. In this way, the Saarinens were spared the embarrassment of seeming to be doing something contrary to the board's or the Kidds's wishes. She also mentioned that because Sabine had the plans that perhaps he and Potwin might confer together with the Saarinens. Link then confirmed that the following had been accomplished:

> 1. Our President is sponsoring you. 2. The local architect has the job of informing Mr. Potwin and getting him to cooperate with you and 3. The Saarinens are supportive. They have succeeded in getting Mr. Potwin to take over most (perhaps you'll only say "much") of your original plans. Now, let's hope since Potwin has been collecting honors on your work, that he will be eager to accept the rest of it. I hope with the Saarinens enthusiastic support which I know you now have, that you will take a stick to them. Take cover and hold fast. If Mr. Potwin really wants to shine he'd better get underneath your light.

Paul Sabine demonstrated his comprehension of, as well as apprehension about, this whole matter when he explained:

> In view of all the complications, I think it would be very wise for me to withdraw from this situation entirely. There is no situation that I am aware of which is more full of dynamite from the standpoint of public criticism than the acoustics of a concert hall which is in the nature of public enterprise. People do not agree on just what is desirable, but everybody thinks he knows good acoustics when he hears them, with the result that no matter how carefully planned a room may be in this regard, there will always be plenty of people to remark on how abominable the acoustics are (or is, I never know which).

Sabine added that Potwin and ERPI understood his reason and because, un-

der the circumstances, responsibility for the results would be defined and because no doubt by this time the plans were fairly fixed, Sabine believed that he could not render much further service. He ended by saying he would merely send his bill to the Saarinens and relieve them of a great deal of embarrassment. "Please understand there is nothing of pique in the matter. It seems to me as the simplest way out of the situation." On August 28, 1939, Sabine billed the Saarinens the sum of $99.00 for his services. Before the Saarinens paid Sabine, they received a letter from the architectural firm of F. J. and W. A. Kidd:

> We can see no reason why you should not consult Mr. Sabine concerning the acoustics at the Kleinhans Music Hall provided it does not entail any additional expense. We mean by this that the board will not want to pay additional fees or any extras that may be entailed by Mr. Sabine's suggestions.

The Saarinens decided to pay Sabine the $99.00, and on September 29 Eero Saarinen wrote, "I am a little embarrassed about the way we left the whole situation unsettled for such a long time. I believe, however, that the electrical research products engineers should finish this job as they are now working quite hard on it. I hope that sometime in the near future we shall be able to work together on another problem."

Sabine acknowledged this letter and stated that he understood the situation and that there was no occasion for embarrassment. Although he appeared to be attempting a dignified exit, it was not to be.

Make the Welkin Ring

On October 4, the persistent Ester Link reminded the Saarinens of the September 22 letter from F. J. and W. A. Kidd. She stated that they should take her into their confidence in regard to any additional expenses procured by Sabine. She emphasized that "The acoustical problems are the crux of the whole hall. Therefore, we should give great consideration to any recommendations that Mr. Sabine might make."

To help guarantee that Sabine would still be involved, she wrote another official letter to the Saarinens in which she stated that they had received permission for Sabine to do the final conditioning. Eero Saarinen was pleased but remained cautious. He requested that Letchworth put it all in writing. Link then wrote Paul Sabine, "Now that you are in the saddle again, I hope you will take courage and Make the Welkin Ring."

She further reminded Sabine how delighted she was in knowing that the hall was now in good hands and that they could not be allowed to jeopardize the hall by over conditioning. She ended the correspondence with a P. S. that was critical of Potwin:

> I read in Potwin's two articles in the architectural forum where he expounded on the principle of acoustics and how they were applied in the Kleinhans Music Hall apparently by him. When you consider that the main acoustical problems

were determined by you and the essential design of the hall determined by the Saarinens and/or us, the Forum article is really astonishing.

Apparently, Sabine was back on the job, although as his letter of October 10 indicates, it was not a qualified and entirely wholehearted return:

My anxiety arises from the fear that I am not able to justify the hopes which you have with regards to the acoustics of the hall. As I wrote earlier, there is so much psychology involved in public opinion with regard to the acoustical properties of a room that one is almost afraid to trust his scientific knowledge and experience in the face of possible adverse public opinion.

Sabine also stated he believed that his services could be applied without offense to Potwin. In fact, if the architect, Potwin, and he would get together in conference, they should be able to iron the matter out. Link responded with much flattery and some apparent knowledge of acoustical terms and people. Her return letter stated,

Your anxiety fills me with confidence. After all, it is the angels who fear to tread. You are considered by everyone competent to judge as one of the great acousticians of the country. Wallace Sabine, Knudsen, Watson, Miller of earlier days with such people as Fay, Cooke, and a few others you have the assurance of being one of the best available. I realize that Mr. Potwin has unlimited background on movie houses, where you would absorb the noises incident to the vitograph but your experience in music halls would intend to make it livelier. That is why you differ on reverberation length.

Link's follow-up letter was much more frantic in nature. She explained that Potwin was changing Sabine's original concepts, and now it would not be practical for numerous reasons. As far as she was concerned, they had to convince the Saarinens to change back, although the expense would be great. To this comment, Sabine once again mentioned that if Saarinen would contact him, he would discuss the matter. This time, Link responded to the previous suggestion of a conference. On December 11, 1939, she wrote, "I called Eero and conveyed to him that working with you now instead of later might save him a great deal of needless work and worry."

Then, to Sabine she stated, "Your presence, even though in the shadowy background has been a pillar of light, your emergence now into the activities is a great source of rejoicing. By the way you are now in the employ of the owners — so your expenses are covered."

Sabine reminded her in a letter dated December 14:

You realize that professional courtesy pretty well ties my hands since the architect is the captain of the ship. I am sure that Mr. Saarinen will contact me, however, since I am retained by the owners, I suggest you ask Mr. Saarinen to let me have the latest blue prints. This reminds me of a similar incident in the past. It is nearly the situation as it developed in connection with the acoustical design of the large music hall in Radio City. In that instance I was employed by the architect and together we worked out the acoustical features of the design. This was

then submitted to Mr. Clifford M. Swan of New York who was employed by the owner of the building as an independent consultant.

Sabine realized that although he was retained by the board, professional ethics required him to be summoned by the Saarinens or the Kidds.

Too Many Cooks

On December 23, Link showed concern for Sabine's physical status, including a possible hospital visit, because he might be summoned to prevent Potwin from using a patented Flexwood covering for the interior that she said looked "chewed up and tacky."

Sabine regarded his current status as "like the farmer with a leaky barn roof. He couldn't patch it when it was raining and did not need to when it wasn't raining." He would be ready if called.

Finally, on January 25, 1940, E. H. Letchworth officially engaged Paul to work with Saarinen. Letchworth was also faced with another problem: If the project were not finished by June, they would forfeit 45 percent of Public Works Administration contract money.

Shortly thereafter, the Saarinens turned down the use of Flexwood. Stuart Welch, who was attached to the Kidd staff representing the interests of the Kleinhans Hall group, was instrumental in engaging Sabine and insisted that someone representing the owners should put it in writing. Miss Link wrote:

> You can imagine with what delight and alacrity I dictated that letter. However, at the moment the Kleinhans roof is being constructed and the inside being finished. Please make speed. I realize how open and direct I must appear, however, it is the only way for me to obtain results. For my only wish is to have a good hall.

In a February 16, 1940 letter, Link showed concern for the involvement of the Saarinens in the Finnish Relief Program: "Although the situation is acute and serious for the Finns, my only hope is that in the present situation the Kleinhans Music Hall will not get lost by the Finns to the Russians." She also mentioned how Potwin was being squeezed by Welch to come around to Sabine's plans.

At this time (February 15 and 16), Sabine was faced with an emergency operation for a troublesome gallbladder. Link stated that she was sure Sabine would get well fast if only owing to curiosity about the Kleinhans plans. On February 20, Sabine received the plans from Edger Rollins Kimball of the Eliel and Eero Saarinen firm.

Still recovering from his operation, Sabine managed to forward his report on the large auditorium to the Saarinens on March 12, on rehearsal room #110 on March 18, and on the Chamber Music Hall on March 19. He maintained his original concepts from 1938, with recommendations to counter some changes already incorporated: "While in detail it is not exactly what I should have recommended, yet I feel sure the results will be satisfactory, and

I do not want this to be a case of too many cooks spoiling the broth." Later, Sabine had to revise his recommendations on the rehearsal room.

What Are They Doing to the Place?

Sabine's next task from Link was to decide between the recommendation of Leopold Stokowski, who wanted the orchestra to sit on the flat stage, or Serge Koussevitzky (another orchestra conductor), who wanted the orchestra to use risers. In addition, because a Steinway piano was used in the auditorium, what piano should be used in the chamber and rehearsal room?

Sabine answered that he was not a piano expert but that Kleinhans could not go wrong with a Steinway, and for psychological reasons, he preferred risers so that the people can see or be seen by those in the rear of the orchestra:

> Personally I often entertain myself during dull moments in the music by watching the activities of the tympani and double basses. Yet a departure from tradition needs something more than a personal preference to justify it. There is of course no weight or authority in the forgoing so do not breathe this to Leopold.

Link followed with a three-page letter arguing for or against each point made by him and then ended with, "I hope you enjoy this desultory discussion, but as I insisted before, I just have to have the best." Sabine tactfully replied:

> When it comes to questions of this sort involving taste and personal preferences, the scientist, if he is wise, will tread softly and not try to carry his scientific prestige over a field where other people's opinions are worth more than his. Besides like the late lamented Will Rogers, "All I know is what I see in the papers."

Later he mentioned how rewarding an experience it was to read Link's files of correspondence with Leopold Stokowski:

> I am glad to see that I am in very good company since you also differed quite frequently with Stoki. Back in 1932 I talked with him about a plywood shell. I used this in the design of the orchestra set for Ravinia (in Chicago). I realized that Mr. Stokowski's recent concerned remarks about humidity have a certain theoretical base, yet the effect is in practice negligible as far as acoustical properties are concerned. The pockets of the lighting covers are quite shallow and will not depreciate the volume of tone. My computed reverberation time for the Kleinhans Hall with the added treatment is now 1.9 secs and an audience of 300. This compares with 1.93 secs for the Boston Symphony Hall (650,000 ft3), 1.75 sec Carnegie Hall (737,000 ft3) and 1.9 sec Chicago Auditorium (975,000 ft3). Therefore it still is all right.

Potwin was still promoting Flexwood in a letter dated May 23, 1940. He favored a considerably shorter reverberation time and, unfortunately, found a mechanical way to put holes in the Flexwood. Saarinen figured out a pattern for the Flexwood instead of the hit-or-miss patches. Link stated her case on this subject:

> If this means that your recommendations are to be abandoned because the Saarinens are trying to avoid strained relationships — I don't know. After all, an architect can serve his client only to the extent that his client supports him. I agree there is no pleasing all the public. My procedure has been to engage the most competent experts available to determine our needs as exactly as possible and to support them in every way. To help them against all chiselers and would be modifiers, the reactionaries and the timid. More or less as a catalytic agent among the experts to help them bring about the things of which they were capable. I was confident the hall would be right fitting and appealing; the fact that the majority of people at first would find so modern a structure objectionable would not bother me at all. I know that those competent to judge would admire it immediately and that ultimately the rest would follow. That is why I want you as top man. So would it be ethical for you to check up with Saarinens as to just what they are doing to the place?

With the deadline near, the Kidd firm finally contacted Eliel Saarinen and asked if he would please confer with Sabine about the advisability of applying glued fabric to the finished plastered surfaces on the rear wall underneath the balcony. Letchworth would rather not make this change unless Sabine agreed.

At this time, Link was removed from her position. Nothing in the Riverbank files says why but speculation offers various possibilities: Sabine wrote Link on June 17 and mentioned that he did not know whether to extend condolences or congratulations on the loss of her job. He went on by reminding her that she had the most difficult task and, therefore, had the greatest satisfaction of a job well done.

Sabine's files indicated no further correspondence until October 10. The opening performances took place on October 12, 13, and 14, 1940. In the October 10 letter, he wrote Miss Link and said he was sorry that he wouldn't be able to make the opening performance:

> I am of course tremendously interested in knowing the popular verdict with regard to the acoustical properties of the room as well as the enlightened opinion of musicians. I dare say neither of these will be unanimous because like art, the acoustics of concert halls is something that everybody knows what he or she likes.

Letchworth remarked in a letter to Paul Sabine that "Everything is going marvelously well. The acoustical properties of both halls seem to be perfect." However, Miss Link stated in her letter:

> The hall is dead — acoustically. Singers complain they cannot hear each other, tones are not permitted to build up and develop overtones. Everything is very precise, even transparent. The hall is super sensitive and very critical. The tone stops too quickly. Such a condition will mitigate against the cause of music. I do not care if every last note of the clarinet and viola comes transparently to the fore. I and every other ardent musician will want opulence of tone, the color of overtones, the arabesque of musical splendor, and this cannot be secured where precision only is the ideal. People in the choirs complained that they felt as

> though a candid picture, musically speaking, were being taken of them — every slight error is shown up so clearly. I feel rather that it is like taking a photograph through a fluoroscope, giving every detail, including the buttons on your underwear. Discriminating listeners and performers seem to hanker for a less precise and more natural tone. You were right, the perforations on the side walls should be eliminated. The problem is most prominent people are perhaps insensitive tonally. Some of them were so beglamoured by the entire building that they just knew everything must be right. What is missed is people can no longer hear Autori [Link's reference to Arturo Toscanini] hum or Koussevitzky will now be forced to stand in front of his orchestra rather than sit in the hall and be able to judge and listen what the audience should hear.

On November 2, 1940, Link wrote Saarinen and explained that Sabine had objected to the perforated Flexwood on the walls but Potwin insisted, and now it was too dead. She emphasized how the hall was still thrilling until the carpet went down and how Arturo Toscanini played the piano before the carpet was laid, and afterward it was like putting a heavy mute on a violin. Also, she noted Marion Anderson's concert was beautifully delivered but failed to thrill people. One person said, "Of course the hall's acoustics are wonderful, but why doesn't she let her voice out?" Another said, "I believe Miss Anderson is using that mezzo voice in imitation of her rival, Dorothy Maynard." Link explained how Arthur W. Quimby, a keyboard virtuoso and musicologist in whom she had great confidence, found the hall in need of improvement. On November 5, 1940, Sabine wrote Link:

> I do not suppose a new hall was ever built in which the acoustics properties fitted all tastes. The acoustics of concert halls come to be a matter of tradition, and I still have hopes that this will be the case with the Kleinhans Hall. I know there are a great many musicians who insist upon the support which a highly reverberant room gives to voices and orchestral ensembles. There are, I think, an equal number who prefer the clarity and nice annunciation of less reverberant rooms. The result is that the acoustical engineer has to steer between Cylla and Chivytis with the usual result that one group, or the other will insist that he has landed on the rocks.

Paul continued,

> I have observed so many times where acoustical reputations, either good or bad, are made in the early history of a concert hall, and popular opinion once formed seems not to be subject to change either with, or without, notice. I should like to see the new hall after the test of time and to know the spontaneous reactions of orchestra leaders and enlightened listeners before definitely deciding that we "pulled a boner," and certainly before making any attempts to alter the conditions.

Will the Full Carpet Expediter Please Rise?

On November 29, 1940, Sabine asked why the floor was completely carpeted? "All my calculations and specifications were based on carpets in the aisles only."

Sabine learned that Potwin was also surprised when full carpeting was specified. Carpeting under the seats undoubtedly made a marked difference in conditions in the empty room or when partly filled. Only when completely filled would the carpeting not have the same effect. On June 3, 1941, Link wrote:

> Our friend, Stokowsky, was charmed with the hall in all respects except the acoustics. The local acoustician was quoted in the newspaper as the reasons why there was a lack of reverberance in the hall. Nelson Eddy approved the halls acoustics. Thus his comments were printed. Marian Anderson and Kirsten Flagstad who found the hall dead were not given any publicity. The directors know that not everybody considers the hall's acoustics ideal.
>
> Here is Leopold Stokowsky's reaction to the hall:
>
> Most enthusiastic about the whole hall, saying that for once simplicity was almost achieved. Keen about the dressing rooms, other creature comforts.

Acoustics: Stokowsky went all over the hall, platform, downstairs, and balcony, clapping his hands and listening for the reverberation.

> Hall too dead, result no ensemble, reverberation too short.
>
> (1) Objected to perforations on side walls.
>
> (2) Objected to carpet.
>
> Loss of sound (1) through holes in ceiling. (Asked me if we were playing for the sparrows). (2) Objected to fins, especially on stage, felt side walls, back wall, and ceiling of platform should be unbroken.
>
> His conclusion was that inasmuch as the place is finished there is nothing to do now, although he did speak of a kind of rubber that could be put under the seats which would be much less absorbent than carpet and yet would dull the impact of any late-comer's feet.
>
> I spoke with students who were in the rehearsal who were not playing, and they said that they could hear no ensemble, they all felt as though they were soloists; moreover, they could not hear the instruments in the different choirs of the orchestra.
>
> One newspaper said that Stokowsky did not use his shell because he said the acoustics were good enough, but the assistant conductor told me that it was only because of the physical difficulties in putting it up on our platform that they were unable to use it.

On June 5, 1941 Sabine wrote, "I cannot find who was responsible for carpeting the floor. It would indeed be fun to come to Buffalo for a concert and I think very illuminating to get the effect which ERPI's patchwork treatment gives."

End of the correspondence in the file ... end of project.

It is somewhat difficult to comprehend that throughout the construction phase, Paul Sabine was never asked to visit the site or funded for his advice during the construction. In fact, from all indications, he never actually saw the Kleinhans Music Hall, but he became known as the leading acoustical consultant on the Kleinhans Music Hall Project, a semantics trick that worked to the advantage of others; soon after the hall opened, Paul Sabine learned from oth-

er sources that he was credited as the consultant responsible for providing the dead hall. Although he explained his actual part in the project to many, he was never able to reverse what had spread throughout the country and, in turn, saw his reputation as a consultant irreparably damaged. Ironically, he, like Wallace Sabine, had stopped consulting to do war research.

An interesting follow-up regarding Charles C. Potwin is included here. After his death on September 25, 1941, the editor of the *Journal of the Acoustical Society of America* inserted a page titled Charles C. Potwin. The page appeared in *JASA,* 13(3):319. The write-up was typically complimentary, and mentioned the many accomplishments achieved by Charles Potwin. Besides his many work-related achievements Potwin became a Fellow of ASA and also served for a short term as ASA treasurer. What is interesting is the editor's comment about Potwin's contributions to the work on the Kleinhans Music Hall project:

> Serge Koussevitzky, conductor of the Boston Symphony Orchestra, said "Never have I found any music hall so perfect acoustically."

Apparently, Serge Koussevitzky felt entirely different about the Kleinhans Hall acoustics than did Ester Link, Leopold Stokowski, Arturo Toscanini, and the critics. Which only adds fuel to the fires of acoustical consulting.

CHAPTER

9

The 1940s National Noise Abatement, War Research, and a Sabine Retires

Hard as it might be to imagine, Paul Sabine's time during the 1940s and beyond was divided among even more endeavors than ever before. In addition to the usual teaching, research and testing, technical writing, and consulting, he also became involved with the war effort; the development of hearing aids; and the formation of an organization dedicated to noise abatement — an undertaking that proved to be one of the most political of his long career.

Paul Sabine began the 1940s by writing an article for the January 1940 issue of *The Architectural Record* (the Design Trends section), entitled "Control of Sound in Buildings." He described the problem of taking absorption data obtained in the laboratory on a small sample and applying it directly to a large-scale application. He broadened the problems by involving buildings that have multiple sources generating frequencies not involved in laboratory tests of the time.

Sabine went on to list a variety of new materials and applications being developed that could be used to control noise put out by sources such as heating, ventilation, and air conditioning (HVAC) equipment. Although the onset of World War II eventually put the development of these materials and applications on hold until the late 1940s, the article both predicted things to come in architectural acoustics and illustrated why Sabine was courted by the organizers of the National Noise Abatement Council (NNAC), a group that sought to establish a widespread and unified effort to solve the problem of noise in this country.

Although Paul Sabine's dedication to the NNAC was made evident by the

many letters on file at Riverbank, it is impossible to know if, at the time of his initial commitment to the organization, whether he knew how convoluted and difficult the task would become because of World War II and political elections as well as a series of confrontations with the Acoustical Society of American (ASA).

Heeding the advice of colleagues in the American Materials Association (AMA), Paul Sabine applied for membership to the advisory committee of the newly established NNAC. On September 26, 1940, he received a letter from F. Edgar McGee, secretary pro tem for the organization, stating that he was delighted with Sabine's interest and explaining the objectives of the NNAC, which centered primarily around the advent of Noise Abatement Week, October 21–26. McGee also included a list of participating companies and individuals and ended the letter by reaffirming how much Paul Sabine's services would be appreciated and used.

In the beginning, the NNAC held its meetings the day ahead of the annual ASA sessions. Because Sabine was a fellow and past president of the ASA and had recently become a member of the Advisory Committee of the NNAC, he hoped to establish a platform of unification, whereupon the NNAC and the ASA could jointly combat problems of noise pollution.

By July 1941, the NNAC was gaining recognition through its small news bulletin. Local committees, including the Chicago Noise Reduction Council, were forming across the country. In order for any of these committees to propose programs, they needed recognition by the ASA. The ASA had much more expertise and experience in establishing and administering programs of this kind.

Recognizing this need, C. P. Little, president of the NNAC, and Wallace Waterfall, secretary of the ASA, approached the executive council of the ASA and proposed the two groups combine their efforts. Shortly thereafter, Edward C. Wente, president of the ASA, appointed Paul Sabine as liaison between the organizations. In July 1941, he began preparing his presentation, which would be given at the October ASA meeting in New York, by sending out a questionnaire to the membership. In response to the question, Do you think the Acoustical Society should actively support a nation-wide anti-noise campaign? 178 responded yes, and 10 said no; the remaining 12 voted in the affirmative but expressed some reservations about the importance of noise abatement with U.S. involvement in the war in Europe an almost forgone conclusion.

On October 20, 1941, Paul Sabine presented his findings and recommendations to the executive council of the ASA, formally requesting a vote on the following three referenda: (1) The appointment of a standing committee on national noise abatement to promote and coordinate the ASA's efforts for less noise and to cooperate with the NNAC; (2) the formal endorsement by the executive council of the ASA of the noise-abatement program of the NNAC; and (3) the authorization of the use of the ASA name in noise-abate-

ment publicity and in appeals for the support of national, state, and municipal authorities in promoting the movement for less noise.

The executive council voted only for the first referenda and the matter was held in abeyance pending further information and considerations.

On October 31, Paul Sabine wrote F. Edgar McGee stating his deep concern for the lack of progress by the ASA, although he was fully aware of their reasons. In an earlier discussion with Wente, Paul was informed that the ASA executive committee members were hesitant to sponsor the NNAC program because they felt that the organization had too many political and commercial attachments. The committee's primary concern was to avoid the possibility of being accused of having any conflicts of interests and, in turn, endangering the credibility of the ASA.

Although the merger was, at least, temporarily halted, the NNAC realized the effort Paul Sabine had made and, on November 11, 1941, granted him honorary membership. Sabine acknowledged his appreciation to the group and added, "I hope to be able to do my share in the splendid work which the council has inaugurated."

As part of this membership, Sabine was asked to investigate a number of problems including the noise created by airplanes flying over Manhattan, a complaint lodged by E. H. Peabody, president of the League for Less Noise in New York. Sabine advised Peabody that "because of the problems associated with the world situation, the most advisable and immediate solution to try to enforce is to ask for specific flight paths and approaches at higher altitudes." Another problem, this one registered by Clinton Jones of Lenox, Massachusetts, asked for legislation to define "an adequate muffler equipment for commercial vehicles." Paul Sabine started to collect data on this matter but was eventually stalemated because of the vagueness of the term adequate.

At this same time, prodded by McGee's constant reminders, Sabine started to consider candidates for a standing committee to further explore the ASA-NNAC connection. Immediately, he suggested Haldon Leedy of Chicago and H. A. Erf of Cleveland, Ohio. Wallace Waterfall and Burris Myers were also mentioned as was Harold Shugart of Los Angeles. Sabine wanted his committee to be geographically distributed, but he knew that besides having a qualified committee, he would also need a common cause to unite acousticians nationally. As it turned out, he was able to unite them internationally.

A letter from Charles W. Glover, an acoustical consultant from London and the publisher of *Practical Acoustics for the Contractor,* provided the catalyst Sabine was seeking. In his letter, Glover stated that there would be an enormous need for noise abatement and that their Noise Abatement League, which had been formed by Lord Horder in the autumn of 1933, was working on various programs — including the unreasonable use of loudspeakers, horns, gramophones, street musicians, and pneumatic drills — even while the war was on. Glover also cited programs on early milk deliveries (solved

by putting rubber tires on the carts and rubber shoes on the ponies and using nonglass containers), the use of train whistles, car regulations, and legislation on the misuse of wireless operators. He ended by stating that his organization "would be pleased to cooperate with the council of nation wide abatement noise in the USA by exchange of literature, technical and legal data, and that I look personally forward to a long and happy association in a campaign for less noise."

Sabine immediately distributed details of the letter, particularly the British offer of cooperation, and Glover was put on the NNAC active mailing list. A cablegram from England followed: "Paul Sabine — ASA Whole hearted co-operation. Noise Abatement League, London. Glover, Member."

Realizing that the time was right, Sabine began contacting candidates for his standing committee. In some cases, acousticians contacted him either to volunteer their services or to nominate a colleague. Harold Shugart and Arthur Nye of the University of Southern California volunteered to supply data, and both suggested that Vern Knudsen of University of California at Los Angeles be on the committee. Because Sabine had already considered Knudsen, he wrote him to ask for his help and ended the correspondence with, "Of course the main problem will be quieting the big noise started by Hitler-Jap and company." Knudsen replied, "Yes, the war effort has to be first and foremost. However, you have such a manner of asking that I cannot refuse you. I will be glad to participate. First though the nuisance in Germany and Japan; fortunately Italy apparently already is pretty quiet."

On February 2, 1942, Paul Sabine submitted the five names of his standing committee to E. C. Wente: Harold Burris-Myers, Stevens Institute, Hoboken, New Jersey; H. A. Erf, Cleveland, Ohio; Haldon Leedy, Armour Research Foundation, Chicago; V. O. Knudsen, University of California at Los Angeles; and ex officio member, Wallace Waterfall.

On February 9, Wente replied, "Congratulations on selecting such a capable group of men and I will see to it that the ASA will take this matter up at the Ann Arbor meeting May 15th and 16th. You will have to present a total update of your committee's findings." He continued, "The atmosphere will be more favorable in Ann Arbor than it was in New York, if for no other reason than the fact that here we seem to have become quite calloused to noises which in many other places are thought to be above the threshold of feeling." He charged Sabine with the additional chore of ensuring that pertinent information from and about the committee be presented at Ann Arbor and stated that he had informed Floyd Firestone, who was chairman of the program committee, about his and Sabine's intentions. To help implement the process, Wente officially recognized the standing committee.

Then, a second breakthrough occurred. The U. S. government, through its Office of Civil Defense, provided a project, requiring a joint effort, for obtaining all available information about sirens. With a great deal of assistance

from Leedy, Sabine organized a plan to involve acousticians nationally. He wrote Firestone and had him send, with the ASA meeting notices, an open invitation for all available members to cooperate on providing any information or obtaining any data on sirens.

Although the government's proposed project provided the momentum his movement required, Sabine continued to lobby for it, first by asking McGee to provide copies of the NNAC booklet, *Let's Stop Noise* to be given out at the Ann Arbor meeting and then by writing seven steps for proposals for action by the Noise Abatement Committee of the ASA, which he presented at the Ann Arbor meeting.

On May 22, 1942, the ASA officially endorsed the movement for the abatement of excessive noise so that air-raid sirens could be heard as a civilian defense measure. The organization also requested that the American Standards Association establish a committee to formulate standards pertaining to noise abatement. By the end of May 1942, fifty cities had organized committees for noise abatement. On August 5, 1943, Sabine was made an honorary member of the Noise Reduction Council of greater Chicago. Also, as under his leadership of the NNAC, the organization won the Group 1 Achievement Award in 1943, 1944, and 1945.[29]

In retrospect, it is interesting to note the parallels between the formation of the ASA and that of the NNAC. As mentioned in an earlier chapter, the ASA's roots can be traced to a small group of scientists, the Acoustical Committee of the National Research Council, who first convened in 1920. Some twenty years later, another small committee pioneered the creation of the National Noise Abatement Council, which later became part of the ASA. In both cases, these founding committees had the same chairman: Paul E. Sabine of Riverbank.[30]

The War Years and the Winding Down of a Scientific Career

The affairs of the NNAC and the ASA became less important in light of what Vern Knudsen referred to as "the nuisance in Germany and Japan." By May 1942, U.S. efforts in both theaters were escalating, and it became increasingly apparent that civilian activities would have to take a back seat to any projects the government requested.

Immediately following the December 7, 1941 attack on Pearl Harbor, Paul Sabine contacted the U.S. government, offering Riverbank as a site for acoustical testing of any variety deemed appropriate by any branch of the military.[31] Rather than take up the offer, however, the government invited Sabine to come to Harvard University to join a team of scientists who were engaged in submarine detection research at the Underwater Sound Laborato-

ry, directed by F. V. Hunt. By the summer of 1942, Sabine had been granted a leave of absence from the Geneva lab and was in Cambridge, Massachusetts, hard at work.

In a congratulatory letter, Riverbank trustee Maulsby Forrest promised that he would take care of all administrative and financial problems while Sabine was away. He also mentioned that the entire board of trustees was proud of both Sabine and Luke Ramer, who was Paul's research assistant, and who had already been called back into the service. Forrest stated, too, that Belle Cumming and Elizabeth Tinberg, Paul Sabine's secretary, would also contribute their efforts and that they all would welcome Paul and Luke back when the shooting was over.

There were many inquiries at Riverbank during the war years, to which Elizabeth Tinberg either responded with a form letter ("Paul Sabine is on a leave of absence from the laboratory doing war research at Harvard University and your letter will be forwarded to him"), or she sent the correspondence directly to Sabine in Massachusetts. Riverbank did not, however, close down entirely, and on occasion, tests were conducted at the facility. In most cases, testing was done under the guidance of technician Robert Kerfoot or, if necessary, Hale Sabine, who would come in from the Celotex Corporation.[32] As far as any official acoustical tests done by Paul Sabine, none bore his signature or initials from mid–June 1942 to January 1946.

When he went off to do his part at Harvard, Paul Sabine was 63 years old, but his age did nothing to lessen his enthusiasm for his country's involvement in the war, diminish his mental capacities, or slow him down physically. From various accounts, it appears that it was the younger Harvard assistants who had difficulty keeping up with Paul Sabine rather than the converse.[33]

This same energy and enthusiasm was just as evident in Sabine's other endeavors as well, chiefly his renewed interest in hearing loss and the development of hearing aids. The war put an end to his efforts in this field, but between 1940 and his departure for Harvard in 1942, Paul Sabine devoted a great deal of time to the problem.

Although he had done some previous work on hearing during the 1920s and had published "The Efficiency of Some Artificial Aids to Hearing" in 1921, Sabine's files after this date indicated he had diverted most of his research efforts to architectural acoustics. However, around 1938, he returned to hearing research with a newfound fervor. Perhaps it was in part that he, himself, was no longer responding to certain high frequencies — the ring of a telephone, for example, was almost inaudible to him — and perhaps in part that his wife, Cornelia, had a hearing impairment. He corresponded with a number of doctors about his wife's problem — describing it as an "otosclerotic case with a 50 dB loss in the frequency range of 512–4096 cycles" and explaining that she used a carbon-type boneconducting instrument to en-

hance her hearing. Eventually, an operation was performed by Dr. George Shambaugh Jr. at Wesley Hospital, Chicago. The surgery was a success, resulting in a 33 dB increase in his wife's hearing.

Because electronic hearing aids were appearing on the market at an increasing rate and because his involvement with the National Noise Abatement Council dealt with hearing loss, Sabine began investigating and evaluating the various products. From the beginning, he tried to convince others that hearing aid tests were essential. To this end, he wrote an article for the Council on Physical Therapy that was published in the November 9, 1940, issue of the *Journal of the American Medical Association* entitled "Acceptance Tests of Hearing Aids." The article addressed two important questions: What type of instrument and what particular make of instrument will give me most nearly normal hearing? Does the particular instrument which best meets my hearing needs have serious defects of a practical nature that would make its purchase inadvisable?[34] Sabine was always careful not to make general statements about hearing aids, and he would never answer the question, What is the best hearing aid? because he thought that doing so was a good deal like trying to answer the question, What is the best pair of glasses?

Sabine also corresponded with various doctors during the early 1940s about a report entitled "Tentative Standard Procedure for Evaluating the Percentage of Hearing Loss in Medical Legal Cases." The report was proposed by a committee of consultants on audiometers and hearing aids. Sabine derived a weighted audiogram, and the method he devised — referred to as the "consultant's method" — was accepted by the American Medical Association, although not without a good deal of discussion among physicians in the organization, especially within the Council of Physical Therapy.

Because of this project Paul Sabine found himself corresponding with other doctors on follow-up projects, including a simplified audiometric and hearing-loss chart. He also assisted in the development of acoustically weighing audiograms and designed equipment for otological and audiometric testing.

His most extensive correspondence was with an otologist, Dr. Augustus Grote Pohlman, with whom he had a relationship that was both professional and personal. The two of them bantered back and forth in their letters, yet they were both serious about their interest in the ability of people to hear properly. In one letter, Paul Sabine admonished Dr. Pohlman's colleagues "who would rather operate when a hearing aid would do the job," stating that if it were a case of a man losing all his teeth, it would stand to reason that "there would be no use for him to acquire dentures because a miniature food chopper would be even more successful and less expensive."

Like so many projects started at Riverbank before World War II, Sabine's work in hearing aid and hearing-loss research was put on hold until after his return. At the same time, inquiries about the lab's ability to conduct testing for a variety of potential clients did not slow down much during the war. In

fact, in 1942 before Sabine even left for Harvard and his submarine detection work there, one forward-looking customer, the manager of the Louisville Memorial Auditorium, wrote asking for Paul Sabine's consulting services in the future, heading his request "Post War Planning" — either a sign of great foresight or, perhaps, a reaction to the recent U.S. naval victory in the Battle of Midway. In any respect, the manager wanted Sabine's guarantee that his auditorium would have results similar to the Metropolitan Museum of Arts Auditorium, as reported in the *New York World Telegram* a year and a half earlier. Although he was unable to undertake the Louisville job at the time, Sabine did consult with the administrators of the auditorium in 1945, and the desired results were achieved.

By January 1945, inquiries for testing at Riverbank were coming at a faster rate. Simpson Logging, U.S. Gypsum, Celotex, Johns Manville, Armstrong Cork, Great Lakes Steel, Maizewood Insulation, plus many others were requesting tests on their products. One letter came from the government of Portugal, asking for absorption measurements on cork. The responding letter had, by this time, been revised and instead of announcing that the laboratory was closed, there was a more hopeful note:

> Thank you very much for your letter, which was received today. The members of our acoustical staff are as yet on leave of absence doing war research in the East and we, therefore, are unable to do any work for you at this time. We hope to be able to re-open this division of our laboratories within the next few months. Our plans are contingent upon the ending of the war in Europe and the need for the members of our staff to continue their research.
>
> We regret that we cannot be of more assistance at the present time, but hope that we may be of service to you in the future.

As the letter indicated, the end of the war seemed imminent and Paul Sabine's focus in response to the situation began to shift back to Riverbank. He contacted General Radio to have his sound-level meter calibrated and to complain about the noisy electron tubes used in the meter. He suggested an updated circuit to eliminate such noise. He also contacted E. F. McDonald at Zenith Radio regarding the quality of hearing aids and suggested that the devices could now more easily be tuned to match the critical frequencies of a subject's ear.

Sabine had hoped to return to Riverbank in June 1945, but it was October before he finally arrived. It took three months for him and Luke Ramer to update the equipment and begin testing again. In a letter to the AMA Sabine wrote, "The number of things that can happen to an electronic set up must be experienced to be fully appreciated." When the lab was ready in January 1946, it ended a three-and-a-half-year period during which Riverbank was — except for a few emergency-type tests conducted by either Bob Kerfoot or Hale Sabine — essentially closed.

On January 25, 1946, Paul Sabine lamented that for all the good it was supposed to do, modern technology was not all it was cracked up to be:

> Loving all the problems we are having with this so called state of the art equipment. Proper filtering, oscillator stabilizing, microphone inconsistencies, gave us many headaches until we finally got things right. I suspect our future expenditures will correspond to what ever piece of new equipment suddenly appears on the market. Oh for those good old Man-in-the-Box days when things were so much simpler to maintain. Yet, they say this is progress, although I am not quite sure if the *this* refers to ulcers, undue pressures or countless issues of immediate concern rather than the development of electronic instrumentation. Perhaps future generations of laboratory scientists will reap the rewards of fool proof instrumentation, but I suspect that will never be the case. They will probably have devices far more sophisticated and complicated than we could ever imagine, even to the point where electron tubes will be obsolete and just understanding what all each instrument can do will require as much skill as knowing how it does it.

At the time, frequency drifting with a model 79 B beat frequency oscillator was causing problems. Finally, the Clough Brengle Corporation of Chicago resolved the situation and, for $42.75, repaired an L&N galvanometer. Sabine's response to the expense was that for that kind of money, instrument repair will be the downfall of many labs. (I wonder what Paul would have thought of a recent $8,000 repair bill for one piece of equipment?) He also complained about having to pay $6.00 for a year's subscription to *Electronics.*

On January 31, 1946, a manufacturer asked to have an acoustical paint tested at Riverbank, even though Sabine expressed his reservations to the manufacturer about the unlikelihood of paint, less than 1-mil thick, painted on a hard surface having much absorptive value, especially at the low and middle frequencies. The data proved Sabine right, but convincing the client that there wasn't anything wrong with the data became a major task, one that is repeated even today whenever promoters of acoustical paint contact the lab.

In February 1946, Sabine started the client test-numbering system referred to in an earlier chapter. A more detailed explanation of the test-number history follows:

Initially, Paul Sabine used the year and the test number as an indexing system (for example 46-01, 46-02). In 1947, Luke Ramer inserted an A, which stood for absorption test, or a TL, which stood for transmission loss test, before the numbers (for example A47-100, TL47-200), offering an even more thorough system of tracking the test results. This system remained until 1983, when RAL™ (Riverbank Acoustical Laboratories) was registered and added it to the test numbers (for example RAL™-A83-525).[35]

In the spring of 1946, Wallace Waterfall returned to Celotex Chicago from New York were he had spent the war and made arrangements through George I. Smith of the same organization to have Paul Sabine write "Theory and Use of Architectural Acoustical Materials," a paper that was eventually published in the AMA bulletin.

Throughout 1946, Sabine was characteristically busy, his time devoted to a

number of diverse projects. In July of that year, for example, two inquiries — one from a Wichita, Kansas radio station and the other for a theater, the Lyceum — for consulting services came in. Additionally, Sabine's interest in hearing aid research continued; he corresponded frequently with the secretary on physical medicine for the American Medical Association and participated in a symposium on hearing aids for the American Otological Society.

In December 1946, Paul Sabine wrote to a Mr. Jackman, chief test engineer for the Consolidated Vultee Aircraft Corporation, who previously had visited Riverbank in regard to a project involving sound control on aircraft. The letter is the first written account to a client of his intentions to leave Riverbank:

> In regards to your question about "What were my future plans?" At the moment I am preparing to leave Riverbank and that Mr. L. G. Ramer will carry on the absorption and transmission loss measurements. My address will be 1939 East Mabel Street, Tucson, Arizona. I will retain my membership on the Riverbank Board of Directors and plan to carry on consulting services.

On January 3, 1947, Paul Sabine signed a test report on a product called Econacoustic for National Gypsum Company, the last such report that would ever bear his signature. On January 16, 1947, Paul Sabine left Riverbank for Tucson, Arizona. He was succeeded as director by Luke Ramer, who also became the first administrator to perform his duties under the auspices of the Armour Institute of Technology's (AIT) Armour Research Foundation (ARF), which later became the Illinois Institute of Technology (IIT) and the IIT Research Institute (IITRI). Paul Sabine was instrumental in arranging for Armour to oversee the Riverbank operation, but because the organization did not assume official control until February 1, 1947, he was never an employee.

Just as the deaths of Colonel George Fabyan, Wallace Clement Sabine and Nelle Fabyan marked the end of eras at Riverbank, so, too, did the retirement of Paul Sabine. Under his guidance, the laboratory had become a national model for similar facilities, and with his guidance, the science of architectural acoustics had made great strides toward achieving recognition as a legitimate science.

Indeed, Paul Sabine's feats in acoustics are well documented but what about Paul Sabine himself? What kind of man was he?

Bob Kerfoot, who stood in for Sabine during World War II, was asked in 1983 to answer that very question. His first response, of course, was that Paul Sabine was a person always doing something — not necessarily active things but, rather, always reading or writing. On a trip together to Dayton, Ohio, for example, Kerfoot recalled that Sabine would whip off crossword puzzles as fast as he could read each clue — and with a pen. He also remembered that Paul Sabine always knew what he wanted and how it should be done, but when it came to performing the task at hand, he would take the supervisor's role, watching the action over the top of his glasses.

Kerfoot recalled, too, how frustrated Sabine would get when a door installer would meticulously and interminably hang his company's door for a test, making sure that everything was perfect by checking and adjusting over and over. Sabine told Kerfoot that there had to be something wrong when it took all day to install a door for a test and would only take thirty minutes to install in someone's home or place of business.

Although Paul Sabine was a serious individual when it came to his work, he also possessed a keen sense of humor that often emerged when the pressures of his job were not present. He was capable of a sharp wit that could be self-deprecating but was always provocative. For example, often introduced as an acoustical expert, Sabine would define an *acoustical expert* "as a man who could collect money from a person by telling him something he already knew in a language he doesn't understand." He defined *female intuition* as "that property of the female mind, which enables a women to start from a false premise perceived by faulty logic, and to *always* arrive at the correct solution."

Bob Kerfoot recalled one incident that illustrates the humorous, human side of Paul Sabine. It occurred on a cold day when Sabine drove to Kerfoot's house to pick him up.

Just as Sabine pulled up in front of the house, Lorana Kerfoot, wearing only a nightgown and a lightweight robe, stepped out onto the porch — her foot holding the door open — for the morning newspaper. Still bent over, she spotted Sabine coming up the walk and, realizing her state of dress or undress, became startled and lost her foothold on the door, which slammed shut behind her.

Now it was she, trying to cover and hold herself together, and her husband's boss standing on the porch. As Paul Sabine started to reach toward her, she gasped, only to realize that he was merely reaching past her to ring the doorbell. Kerfoot came to the door, and Paul Sabine said, "Good morning, Bob. I believe your wife would like to come in out of the cold. I'll meet you in the car."

As he turned, he tipped his hat and said, "Have a good day, Mrs. Kerfoot. It's always a pleasure," and proceeded to his automobile. Only after both men were in the car did Paul Sabine describe the scene. Bob Kerfoot said that by the time they got to Riverbank, they were laughing hysterically. Kerfoot stated that it was the only time he ever saw Paul Sabine laugh so hard.

Elizabeth Tinberg, who worked as a secretary at Riverbank from 1940 to 1953, remembered Paul Sabine as a many-sided man, a man of principle and loyalty, and a man who always enjoyed a challenge. He was equally happy raising roses or, in his seventies, learning how to operate a typewriter. He was, as she recalled, one of Riverbank's most notorious practical jokers. Regardless of the side he revealed, Paul Sabine was, in all areas, a man guided by a sense of morality, a code of ethics that he would not compromise. Elizabeth Tinberg recalled an incident involving Belle Cumming that shows clearly how

Paul Sabine dealt with the world. Apparently, Cumming was famous for her habit of using foul language, a trait that Sabine repeatedly asked her to curtail. She made an effort to do so and asked Sabine if he were aware of the fact. When he said, "No," Cumming replied with a cuss word. Sabine responded, "See?"

As chronicled elsewhere, Paul Sabine was not only a scientist and a family man but a concerned, involved citizen as well. His career as a Geneva alderman was highlighted by many hours of work on zoning ordinances for the town and, again, by his sense of justice and moral rightness. As one fellow alderman noted, "This fellow Sabine is the limit. He asks more questions than all of the rest of us put together: He wants to know *all* about what he is voting on before he votes."

Leo Beranek reported that the only time he ever heard Paul Sabine speak of the father-son professional relationship in a negative tone was at the November 1946 ASA meeting in Chicago. Beranek reported that during an open discussion period following an architectural acoustics session, one of the speakers had referred to a published paper as the result of excellent work done by Hale Sabine. Paul immediately stood up, obviously angered, and said, "All my professional life my work often has been attributed to the elder Sabine and now my work is being attributed to my son." Paul continued and when finished, Leo recalled how apparent the hush was that settled over the room as well as how the incident obviously embarrassed Hale.

By the mid-1950s, Paul Sabine's life had moved in a direction that was not fully realized until after his retirement: the integration of science and religion. He had, of course, continued with his consulting practice and his writing, but less and less time was devoted to these endeavors. It should still be noted, however, that it was Paul Sabine who headed the acoustical testing during the remodeling of the House and Senate Chambers in the U. S. Capitol. The results of this testing were published in the March 1952, issue of the *Journal of the Acoustical Society of America.* He was assisted in the project by his son, Hale, and Wallace Waterfall.

This undertaking and other lesser projects notwithstanding, it was the scientist and his relationship with God that occupied Paul Sabine's thoughts and time. In the 1950s, he wrote two books on the subject: *Modern Science and the Will to Believe* and *Atoms, Men and God.* The latter book, for which Sabine became best known, was reviewed for the ASA by Floyd A. Firestone in the September 1953 issue of *JASA* and again by F. V. Hunt in the January 1954 issue of the same publication.

Both reviews found Sabine's work to be thought provoking and scientifically thorough. The opening and closing passages of each review are given here.

According to Firestone,

> This book does not pertain specifically to the science of acoustics but will nevertheless be of great interest to acousticians because it is the work of one of the most distinguished contributors to our field of science. Dr. Sabine is the son of a Methodist preacher and cousin of Professor Wallace C. Sabine, who founded the Science of Architectural Acoustics. He has been a professor of Physics at Case School of Applied Science and is a retired director of Riverbank Laboratory of Acoustics. This book which has been fifteen years in preparation, will answer those of Dr. Sabine's friends who have wondered what he was doing in retirement, other than defense work and the planning of the acoustics of the remodeled House and Senate Chambers in our National Capitol. He addresses himself to the problem: "Can I be intellectually honest in believing what, as a Christian, I profess to believe and at the same time accept the teachings of modern science and psychology regarding the nature of man and God and the physical world?"
>
> In searching for the answer to this problem the histories of science and religion are thoroughly reviewed, pertinent facts of chemistry and physics are surveyed, and our knowledge of psychology is explored, an attitude of rational criticism of any proposed philosophical conclusion being maintained throughout.

Firestone continued by discussing the merits of various topics raised in the book and the conclusions reached. He closed his review by stating,

> Though this reviewer has a will to believe in a modified mechanistic hypothesis as an explanation of all the phenomena of both mind and matter with a minimum number of assumptions, he enthusiastically recommends this book as a most interesting and scholarly philosophical dissertation, to be classed with the writings of Sir Arthur Eddington and Sir James Jeans. On account of the broad interest in its subject matter, the sales of this book will probably be in orders of magnitude greater than the sales of Dr. Sabine's textbook on "Acoustics and Architecture." Many scientists give but little thought to religion, but when the scientist's child reaches the age when his friends are going to church, a day of decision has been reached. Dr. Sabine has skillfully explored the coupling between science and religion; the extent to which the reader agrees with the author's conclusions will depend on his personal coefficient of coupling.

F. V. Hunt's review, like Firestone's, begins by noting both Sabine's reputation and his attempt to address faith on an intellectual plane:

> This book has nothing to do with acoustics. But when an elder statesman of acoustics, a founder and former President of the Acoustical Society of America, requests a hearing, it behooves all to give ear — and all the more so when the voice is that of the man who has been "Uncle Paul" to a whole generation of acoustical scientists. A good many engineers and scientists seem able to extend the concept of separated variables far enough to insulate themselves against any demands on faith that go beyond reliance on tight connections and a good impedance match. These will find Sabine's book too full of words to satisfy them. Another group is likely to go so far as to concede that the problem of science and religion is important and that they intend to think it when they get a little spare time. These people should add this book to their shelf now so that it will be at hand in case that spare moment should turn up without warning. To

still another group who grow troubled by divergence between faith of their fathers and their daily scientific bread, "Atoms, Men and God" may be the word that can make them whole again. The question to which Sabine addresses himself is one that must be faced sooner or later by every thoughtful scientist who is neither a confessed schizophrenic nor a determined atheist. Put simply, the question is whether it is possible to adhere to a deep religious faith and to accept the teachings of modern physical science and psychology, without invoking a double standard of intellectual honesty. The frame of reference is that of a Protestant Christian, but the arguments will sting with almost equal force the complacent of any faith.

Let it be said firmly at the outset that here is not an example of an old man (may we all stay so young!) seeking to mend his religious fences by maundering metaphysics in his dotage: far from it. Here is incisive introspection presented with candid frankness and a keen alertness for the pitfalls of self-deception.

The pattern of exposition follows the sound scientific practice of marshaling objectively the data, the facts and observations, so that they can be studied as a whole to see what conclusions they support.

Hunt's review continued with specific attention paid to subjects such as entropy, organic evolution, relativity and wave mechanics, behaviorism, Freudian psychology, and inner psychology. It ended:

Those who have been privileged to know Uncle Paul will know without being told that he answers his basic question in the affirmative; otherwise he wouldn't have written this book. This answer, that he felt driven to pursue, is unobtrusively presented without becoming diffidence, and with a total lack of brash insistence. Of course, every apostle of newly-perceived truth desires the fulfillment of having his perception shared. And yet, I don't think Uncle Paul will mind very much if your own convictions and the evidence presented lead you to a different terminal conclusion from the one he reaches. But mark this well: whether you come out where he does or not, the evidential reasoning set forth in "Atoms, Men and God" will haunt you till you make your own peace with it one way or another.

Excerpts from *Atoms, Men and God* were included in *Creative Power of The Mind,* a publication of Prentice-Hall containing the best thoughts of outstanding men of modern time. As a result of this publication, Sabine was invited to be a guest on the Edward R. Murrow radio program, *This I Believe,* in September 1954.

In his late seventies, his eyesight failing, Sabine still possessed a quick and inquisitive mind and an ever-growing faith in God, as seen in a letter sent on August 1, 1958, to a friend, Wilmer T. Bartholomew, of Gaithersburg, Maryland:

You'd never guess that this letter was typed by a youth of 78 summers and no winters apparently.

That last was written at the end of my day, and since I had that crack some time ago, just when I can't remember, I find it difficult at times to orient myself

properly in the "space-time manifold" in which we live and move and have our being. It's much more comfortable for me to think of myself as sane and all the rest of the world except a few choice souls like you as just a little "teched in the head."

Your letter has been very helpful to me who still believes that God's in his heaven though "all" is far from right with the world. Your analysis, ending up as it does with a "leap of faith" that all is right, I find most helpful.

This world wouldn't be crazy if there weren't so many crazy people in it. So we'll put our trust in the Almighty and ignore the folly of the fools who say in their hearts "there is no God." They just don't know what they're talking about.

I am interested, along with many thoughtful men of today, in the trend of technical scientific thinking on spiritual implications of scientific realities. You may know the writing along religious lines of Clarence Randall, retired president of Inland Steel. I knew him at Harvard and have always admired him.

When scientific and religious thinking go far enough they discover that they both are facets of a single shaft of eternal truth. One is reminded (by turmoil of the present world situation) of the book of Job, where "the sons of God came together" and "Satan came also" and got permission of the Almighty to give Job a workout to test his loyalty. Was the author of that book unrealistic in giving it a happy ending for poor old Job after he'd been put through the wringer, just to show that the Devil had underrated Job's staying powers? You'll have to come out here so we can talk this out. Being coherent while typing is for me like the stunt of rubbing my head and patting my tummy at the same time — it's hard.

This letter to his friend was one of the last Paul Earls Sabine would write. He died on December 28, 1958 and was buried in Geneva, Illinois.

Hale Sabine.

CHAPTER

10

Sabine Acoustician Number Three

In 1957 Hale Johnson Sabine came back to Riverbank. His arrival marked a special kind of homecoming; although he had periodically dedicated his time, effort, and services over the past thirty-eight years to further the development of the Riverbank Acoustical Laboratories, he was never officially on the payroll. Now, however, he was. As a senior physicist for the Armour Research Foundation (ARF — now the IIT Research Institute [IITRI]), one of his duties was to correlate and conduct research projects involving acoustics, either at IITRI, in the field, or at Riverbank. Shortly after joining IITRI, Hale Sabine arrived at the Geneva laboratory to perform some preliminary work on a siren project. Along with the greetings and well wishes of the staff, he was handed a written message: "Congratulations, you finally made it." Although written by the secretary, the note was in regard to an earlier telephone call and the message given by Hale's father, Paul E. Sabine.

As Hale Sabine wandered from room to room, acknowledging how much had changed and yet how much was still the same, one could only imagine his thoughts, his memories of the place where he had not only worked but grown up. Did he remember back to February 1919 when he was only ten years old and, with his parents, first saw his father's new laboratory? Did he recall how he assisted his father and other scientists during the early tests because of his excellent hearing and tone perception? Did he see himself again hanging from the Riverbank bell rope or involved in turning the laboratory into a haunted castle as he did on one Halloween?

After graduating from Geneva High School, Hale Sabine attended Knox College in Galesburg, Illinois and following in the footsteps of his father and Wallace Clement Sabine, he entered Harvard and majored in physics. After Harvard, he returned to Chicago and, in 1930 took a position with the Celotex Corporation, which got him involved with Celotex Director Wallace Waterfall, the Acoustical Materials Association (AMA), and various Celotex

tests being conducted at Riverbank. One of Hale's tasks at Celotex was to format data for inclusion in the AMA bulletin.

During the late 1930s and early 1940s, in addition to his duties at Celotex, Hale Sabine assisted his father and Augustus Grote Pohlman on an extensive program involving the evaluation of hearing aids. During this same period he wrote three papers that appeared in *JASA*. The first, coauthored with R. Lindahl, was entitled, "Measurement of Impact Sound Transmission through Floors;" for Celotex and *JASA,* he wrote "The Absorption of Noise in Ventilating Ducts." Both of these articles were published in 1940. In 1942 he wrote "Notes on Acoustical Impedance Measurement."

During World War II Hale Sabine found himself doing a variety of tests at Riverbank while Paul Sabine continued his research at Harvard University on antisubmarine warfare. Luke Ramer was in the service as well, and the only Riverbank staff members left were Elizabeth Tinburg, the secretary, and Robert Kerfoot, a part-time technician. Because Kerfoot wasn't always available, it was Hale Sabine's responsibility to come in whenever time permitted and conduct scheduled tests. Only because of his voluntary efforts, usually requiring work on the weekends or in the evening, were certain Riverbank clients able to fulfill their testing needs to obtain a contract.

Hale Sabine's conscientiousness became even more evident in a letter he wrote to a manufacturer during this time. After running a test and rechecking the calculations a week later, he realized he had made a small error. He immediately contacted the manufacturer and offered to pay for reshipment and do a retest. Eventually, he reran the test and, later, explained it all in a letter sent to his father at Cambridge. "I fully realize that I will undoubtedly make many more errors in the future, which is somewhat disturbing" he wrote, "however, let me assure you, never again that one."

In 1944, pleased with son's voluntary work at Riverbank, Paul Sabine signed the deed of his Glen Ellyn home over to Hale and his wife, Marjorie Ballard Sabine. At the time, the Hale Sabines were living in the home and still had eleven years to go on a purchase contract with the elder Sabine. Until this incident, however, Paul Sabine had always demanded that his son pay his fair and full share. The Riverbank files contain a number of notes in which Paul Sabine would request reimbursement from Hale for instrumentation or parts purchases; meeting or consulting trip expenditures such as hotel bills, meals, gasoline, and parking; or other incidental expenses. The notes would usually be brief: "Dear Hale, Your full share comes to exactly" and then the amount to the penny would be given. The notes would be signed "respectfully" or "affectionately yours, PES."

At the end of the war, Paul Sabine and Luke Ramer returned to Riverbank, and Hale Sabine turned all his attention to his duties at the Celotex Corporation. In 1947, when Paul Sabine retired, Luke Ramer took over as Riverbank manager. Although the elder Sabine might have enjoyed handing control

over to the younger, Ramer had earned the position because of his many years of service to Riverbank.

Like both Wallace Clement and Paul Earls, Hale Johnson Sabine was a committed researcher and writer. He wrote a book, *Less Noise, More Hearing,* in 1941, and his articles appeared in national journals and were indicative of the range of his knowledge as well as the depth.

In 1943, he coauthored a paper with R. Allen Wilson, also of Celotex, entitled "The Application of Sound Absorption to Factory Noise Problems," which, like his previous articles, appeared in *JASA.* In 1947, "Sound Absorption and Impedance of Acoustical Materials" was first presented at the Society of Motion Picture Engineers (SMPE) convention in Chicago, and later it was printed in the September issue of the *SMPE Journal.*

During the 1950s, Hale Sabine continued to write papers based on his work for Celotex, starting with "A Review of the Absorption Coefficient Problem," published in the May 1950 *JASA.* For a 1951 symposium on acoustical materials and the American Society for Testing Materials (ASTM) Special Technical Publication No. 123, he authored "The Measurement of Sound Absorption." On October 10, 1952, he wrote and presented a paper at the Third National Noise Abatement Symposium, "The Use of Acoustical Materials in the Control of Industrial Noise." This symposium was held at the ARF.

In the same year, Hale Sabine wrote "The Exploratory Study of Sound Absorption by Thin Structures" followed by "The Relation of Fiber Characteristics to Acoustical Properties." In 1953, he presented a paper, "Room Acoustics," for a seminar — "Acoustics for the Radio Engineers" — organized by the Institute of Radio Engineers Professional Group on Audio for the IRE National Convention; it was later published by the organization.

In 1954, Sabine's papers included "Manufacture and Distribution of Acoustical Materials over the Past 25 Years" and "Industrial Noise Survey." The latter led to another paper completed on May 17, 1954 that was entitled "Progress Report IV"; however, it contained an in-depth extension of the work originally done by Uno Ingard of the Massachusetts Institute of Technology, entitled "Sound Absorption by Perforated Porous Tiles." Hale Sabine added much to the paper and it was later retitled "The Sound Absorption of Acousti-Celotex Core Tile." Hale Sabine's calculations and explanations were so thorough that the paper is still used for reference purposes at Riverbank.

Appearing in the *Bulletin of the School of Education* at Indiana University was a paper given by Hale Sabine at the Midwest School Building Planning Conference in 1955, "Sound Control in School Building Planning." Sabine also marked his twenty-fifth year at Celotex in 1955. On October 25 of that year, Wallace Waterfall wrote to congratulate him:

> I am told that on Thursday of this week you will be celebrating your 25th anniversary with Celotex. It doesn't seem like 25 years ago that I hired you but it is just another indication that time passes swiftly.

> During the past 25 years you have attained national stature in the field of acoustics and you have done much to give Celotex the technical prestige which it enjoys in the field. I know that Celotex is as proud as I am of your accomplishments and we wish you the best of luck for continued success.[36]

In January 1956, ASTM Bulletin No. 211 included a paper entitled, "An Apparatus for Measuring Air-Flow Resistance of Acoustical Materials," by Hale J. Sabine, secretary of Committee C-20 on Acoustical Materials. During this same period, Sabine worked on a Celotex project conducted by the ARF. The report was entitled "The Relation of Fiber Characteristics to Acoustical Properties." Soon after, ARF conducted another project headed by ARF's William E. Lawrie. The final report was dated June 1956. The report, "The Development of New Sound Absorbing Materials for Noise Suppressors," listed Hale Sabine of Celotex as a contributor to the project.

In 1957, ARF Director Hal Leedy made his move to obtain the services of Hale Sabine. Leedy had been a member of the National Noise Abatement Council that had been headed by Paul Sabine during the early 1940s and was instrumental in the takeover of Riverbank's activities when Sabine retired. Leedy was also a member of the American Standards Association's Z24 Committee, Sub Committee E, which included among its members Hale Sabine. Needless to say, Leedy was familiar with Sabine's talents and work and offered him a position in ARF's Physics Department; Hale Sabine accepted.

The September 1957 *ARF News,* under the headline "Appoint Four to High Foundation Positions," devoted a page to new employees of the organization. The four individuals were Howard Betz, Hale J. Sabine, Narinder S. Kapany, and Mildred Wyatt. In regard to Hale Sabine, the article stated the following:

> Hale Sabine, a specialist in acoustical materials, joined the Physics staff as senior scientist in the acoustics design section. Sabine came to the Foundation from the Celotex Corp. where he served as chief acoustical engineer. He had conducted research in acoustical building materials for 26 years. He attended Knox College and received his degree in physics from Harvard University in 1930. He also wrote a textbook on architectural acoustics engineering, entitled "Less Noise — Better Hearing."

The Thursday, August 1, 1957 edition of the Chicago *Daily Tribune* had this to say:

> Hale Sabine, of Glen Ellyn, a specialist in acoustical materials, has been named senior physicist for the Armour Research Foundation of the Illinois Institute of Technology. The announcement was made by Dr. Leonard Reiffel, manager of the physics research department.
>
> Sabine will conduct research in the acoustic design section of the department, working in areas of sound propagation, sonics, ultrasonics, loudspeaker design, and microphone development. Before joining the research foundation, Sabine was chief acoustical engineer for the Celotex corporation, where he conducted research in acoustical building materials for 26 years. His previous research in-

cludes field engineering for the correction of auditorium acoustics and noise reduction and the development of acoustical products.

Hale Sabine was assigned to the Acoustical Design Section, which was managed by Mahlon Burkhard.[37] Shortly after his assignment to this section, he came to Riverbank for the siren project. As an ARF-IITRI staff member, he conducted a variety of projects associated with acoustics at IIT and Riverbank and in the field. One project that Hale Sabine worked on at both IITRI and Riverbank was for the Building Research Institute, Division of Engineering and Industrial Research, National Academy of Sciences–National Research Council, which was written up and printed in publication no. 798 under the title "Acoustical Design Criteria for Sandwich Panels." On November 6, 1959, Hale Sabine completed a project entitled "Sound Transmission on Characteristics of Folding Partitions."

One of Sabine's tasks at Riverbank for ARF was to conduct a project and write an article for the March-April 1960 issue of the ASA publication *Noise Control,* "The Effect of Painting on Sound Transmission Loss of Lightweight Concrete Block Partitions." On September 14, 1960 Hale Sabine completed his report entitled "Fundamental Study of Noise Reduction of Pneumatic Tools," followed in May 1961 by "Measurement of Sound Transmission through Door Seals." In October of the same year he completed "Design of Electromagnetically Shielded Anechoic Rooms" and turned in a lengthy progress report on the extension of the same project on December 10. Also in December was his report entitled "Sound Propagation Near the Earth's Surface as Influenced by Weather Conditions." This research also involved an extension that resulted in another report completed in January 1961.

In 1961, Sabine left IITRI-Riverbank to become manager of the Owens Corning Acoustical Laboratory. He presented a paper at the sixty-first meeting of the ASA in Philadelphia on May 10, 1961, which involved his work on the IITRI-RAL project, Measurement of Sound Transmission through Door Seals.

In 1968, the Acoustical Society of America awarded Hale Sabine the Wallace Clement Sabine Award. Following is an account of the award presentation, written by William A. Jack and then ASA President Robert T. Beyer:[38]

> The Wallace Clement Sabine Award was presented at the 76th meeting of the Society in Cleveland, Ohio, to Hale J. Sabine. The award was made at the banquet of the Society on 20th November 1968.
>
> The Wallace Clement Sabine award is presented at 1- to 3-year intervals to an individual of any nationality who has furthered the knowledge of architectural acoustics, as evidenced by his contribution to professional journals and periodicals, or by other accomplishments in the field of architectural acoustics. The award is named for the virtual inventor of the field, the late Professor W. C. Sabine of Harvard University.

The citation to Hale J. Sabine read as follows:

For his contributions to the theory and practice of architectural acoustics, for his studies of the theory of sound absorbing materials, and particularly, for his vigorous leadership in the development of standard procedures for measuring the acoustical properties of materials.

The career of Hale J. Sabine was highlighted in a brochure distributed at the banquet:

This evening, The Acoustical Society honors a man who was born into the acoustical materials sphere. He has grown with it, studied its problems, contributed greatly to needed solutions, and has taken an honorable part in activities of an industry that strives to manufacture commodities that fit the market in a competitive world.

Hale J. Sabine is the elder son of the late Paul E. Sabine, a man remembered with affection and respect by those of us who were privileged to know him. During his father's tenure as head of the Riverbank Acoustical Laboratories at Geneva, Illinois, Hale grew up in an atmosphere of acoustical science and engineering.

On joining the Celotex Corporation in 1930, he moved into a field where the broad principles of application of sound absorbing materials to auditorium correction and to office noise reduction were understood, but sales were small. The Mazer discovery — that a pattern of relatively few holes drilled into a painted block of suitable material makes an excellent and repaintable sound absorber — resulted in a valuable patent acquired by Celotex. The Norris discovery — of well-distributed small openings in a rigid and otherwise impervious facing, over a blanket absorber — arrived to spur competition. Business in the industry grew, despite a recession. Hale grew with it, rising to be Chief Acoustical Engineer.

His four years with Armour Research Foundation, where he participated in, and directed, a variety of contract research projects in architectural acoustics, and in other acoustic fields, enlarged his experience and his circle of acquaintances and colleagues.

For the last 7 years, he has been manager of the Sound Laboratory, Owens-Corning Fiberglass Technical Center, directing acoustical research and technical support activities of this important company.

The acoustics of building materials is a subject covering a wide range of concepts, mathematical analyses, and test methods. Suitable commodities must be developed, manufactured, and merchandized; and they must serve the purchaser properly. Hale has contributed in important ways to measuring flow resistance and impedance, to evaluating and predicting the performance of lined ducts, and to developing testing techniques for transmission loss and reverberation chamber absorption.

He has served the Society well on its committees, and as its president in 1959–1960. He is a charter member of ASTM Committee C20, which has the responsibility for the standard test procedures used in architectural acoustics, since its foundation in 1948. In his capacity as Vice-Chairman of the Committee and as chairman of the subcommittee on sound absorption, he is a leading spirit in standards writing activities and associated projects. In industry circles, he has

been active on the Technical Committee of the Acoustical Materials Association.

The award of this medal is a deserved tribute to a man who combines in a most happy fashion the talents of scientist-experimenter-engineer in a field where the entire gamut, from the conception of a project to its successful in-place performance, is the measure of the service.

Like his father before him, Hale Sabine was not only a scientist but a humanist as well. Although Paul Sabine's interests led him into the realm of metaphysics, Hale Sabine's avocation was music, a discipline befitting a man whose career dealt with acoustics. As noted in an earlier chapter, Hale Sabine's mother was an accomplished organist, and she passed her talent to her son. With his innate sense of pitch, his diligence to perfect anything he set his mind to, it is not difficult to accept that he became an accomplished musician at a very young age. On January 1, 1929, in fact, he gave a recital in Geneva, Illinois, playing pieces by Mendelssohn, Tschaikowsky, and Bach.

In addition to performing music, Hale Sabine at one time had ambitions of becoming a music teacher. After graduating from Harvard, he began working on an education degree at the University of Chicago. In the Riverbank files are three term papers he wrote while a student in the Education Department there. The first, dated June 16, 1934, was entitled "The Psychology of Music Reading." The other two, both undated, were "The Evolution of Teaching Methods in the United States" and "Music and the Church."

Still employed at Celotex, he fulfilled the requisites to become a teacher and was registered with the Clark Brewer Teachers Agency. He applied for a teaching post at Worcester, where his father had taught, and was accepted as an instructor of math, physics, and music. From his letters to a professor, it appeared that he was lined up for a position for the fall semester. Apparently, something happened to change his mind about a teaching career, but because no other correspondence or mention about pursuing this career have been found, the reason might never be known.

Hale Sabine did, however, continue with work involving music. On October 20, 1960, he presented a paper, "Decay Characteristics of Piano Tones," to the ASA in San Francisco. The paper was an extension of work done by Daniel W. Martin of the Baldwin Piano Company, who had published "Decay Rates of Piano Tones" in the July 1947 *JASA*.[39]

The only other tidbit available in this Hale Sabine music file was a small note that interestingly was paper clipped to the outside cover, with one word, "Yes" added and underlined. The note stated, "The Long Trail," Kipling Verse, Inclusive Edition, 1885–1918. "And it's time to turn on the old trail, our own trail, the out trail, Pull out, pull out, on the long trail — the trail that is always new!"

In 1976, Hale presented a paper that, in 1977, would be his last published

work. In "Building Acoustics in America, 1920–1940," besides the science itself, Hale Sabine discussed the contributions made by Professor Wallace Sabine, Paul E. Sabine, Colonel George Fabyan, and Riverbank.

My first contact with Hale Sabine occurred a summer's day in 1976 — a day that turned out to be a memorable day for both of us.

I had just transferred from fire and explosives research and was a veteran of Riverbank and architectural acoustics all of a whole day and a half. The rest of the staff had for reasons mostly forgotten — but never forgiven — left me alone to take care of things. As I recall one member, Don Zedonis, Riverbank employee 1949–1978, was on a field project, and the other two, Don Williams (1949–1986) and Arline Mundy (1953–1983) were on vacation.

That day the questions asked by six individuals succeeded in substantiating that I had little to absolutely no experience in architectural acoustical testing. Mostly confused and frustrated, I began paging through various handbooks hoping to establish one way or another that either acoustical testing was indeed strange or those six questions were a set up by the Riverbank staff members long recognized for such pranks.

Near the end of that very frustrating day an individual called, identifying himself as Hale Sabine. My immediate reply was, "Say, are you the person whose name is on our front door?" After a pause his reply was, "Sorry, same family, same profession, different person." "Oh, that's still great!" I replied. "That means if you are indeed involved in this profession, hopefully you may know something about this acoustical testing business. You see, Mr. Sabine, I have been asked some very strange questions today, and I sure could use some expert advice, whereby I may determine if the calls were only a prank arranged by my coworkers or if they were for real."

Once again there was a pause and then in a soft voice and in a polite manner, Hale Sabine stated,

> Somehow I have the sensation that I am being complimented; however, although I have spent a life time associated with acoustical testing in one form or the other, you have suddenly made me realize that I have now reached that critical stage in my life whereupon there obviously exists a generation gap within my own profession, and thereby if I fail to answer your questions, I could devalue my present professional status significantly.

Now, totally embarrassed, I apologized to Hale for my obvious extreme ignorance about architectural acoustics and those involved in it. After explaining my past history at IITRI and my very short career in acoustical testing, Hale Sabine eased my embarrassment immensely by stating that an apology was not in order and that my sincerity was most heartwarming to say the least. He went on to advise me that as long as I convey the truth about what I know or do not know to various inquirers, in time, I should do Riverbank proud. Then he said, "Now let's tackle those questions."

After each question, Hale Sabine would chuckle ever so politely and then

... as those who knew Hale would expect, he responded in an explicit, detailed, and definitely informative manner.

Originally I had intended to omit the questions with my original answers — professional pride, you know. However, fellow ASA members who were aware of the questions stated that under the circumstances, it was a must and most appropriate. Their premise was that everyone has to start somewhere, and my introduction to acoustical testing is a classic example of the problems one could possibly face. If for any reason, any knowledgeable acoustician feels he or she must remind me of my lack of acoustical knowledge on that day over twenty years ago, please be kind.

Actually, those not aware of what the questions actually mean in regard to architectural acoustics will realize the dilemma I faced when entering the field. Thus, for what it is worth, here was my initiation and introduction into architectural acoustical testing:

The first question was from Al Shiner. "Where can I buy an ILG?" "A what?" I replied. "An ILG," he repeated. "Spell it," I requested. "I ... L ... G, an ILG," he stated. Not realizing that I was speaking to a knowledgeable acoustician, I replied, "It sounds more like a fish disease. Are you sure it has to do with acoustics?" "Yes, I'm quite sure," stated Al. I asked for his telephone number so that one of the other fellows could call him when they returned. Alas, my very first inquiry, and I failed. I can't believe I said that about fish. By the way, an *ILG* is a broadband reference sound source that was made by a company named after its founder, Robert Ilg.

The second question came from Keith Walker, then a U. S. Gypsum engineer, now retired, who asked, "What color is your noise source?" Because I was sitting in Riverbank's control room trying to figure what the mass confusion of instruments was used for. My response was based primarily on the fact that Don Williams had applied labels to certain pieces of equipment and right in front of me was the label "NOISE SOURCE." Thus, boldly and proudly I replied, "It's green with black knobs on it." Keith Walker replied in a very polite and courteous manner, "Oh, excuse me. I wasn't referring to the outside color of the source but rather the noise type color, pink or white, that the source generates. Sorry for not being specific."

Fortunately, I noticed that Don's labeled noise source had a pink noise-filter module on its output and thereby was able to respond to Walker by saying, "Oh! I didn't realize that's what you meant (ahem). Sorry, Riverbank's present noise type is pink." Although Keith did receive a correct answer, he did say, "I take it you're new at Riverbank." By now, professional suicide was my only recourse and for Riverbank's sake — if not my own — it would be best if I just took messages.

From Ron Moulder, then of Owens Corning, came the third question, "How high can you go before you have a flanking problem that would affect your sound transmission?" I replied, "I'm new and as soon as someone re-

turns I'll have them return your call." I wasn't about to mention that during my four-year tour with the U.S. Air Force I hadn't noticed any problems with my flanks or speech at any height. By now, I knew that that wasn't what Ron was inquiring about, and I'd better start learning about this crazy discipline fast.

For those who might not know, *flanking* describes alternative routes that sound might take to get from one side of a sound barrier to the other, such as through side walls, the floor, or ceiling thereby reducing the sound transmission performance of the barrier.

The fourth question came from another consultant, Bruce Davy. "What are the weight, height, dress, and shoe requirements for a lady floor-walker, and could I recommend one?" Since the only floor-walkers I knew were heavy men who worked in Chicago department stores, I told Bruce that I would have someone call him tomorrow.

For the unknowing, one method that was once used to measure the structure-borne (impact) noise transmitted through a floor-ceiling configuration was to have a 115-pound woman, wearing a cotton dress and size 7-1/2 shoes with 3-inch high heels, walk on the test floor and the sound-pressure levels were measured in the test room below. I was told that in one instance, the testing had to be postponed because the standard floor-walker had become pregnant. Also, supposedly, a policy written somewhere states that no human being can be considered a standard test specimen. Eventually, the floor-walker was replaced by a tapping machine that has five calibrated weights (hammers) alternately striking the floor from a prescribed height. You have to see it to appreciate it. It is a commercially available product. However, if you purchase one, be careful when taking it through airport security. The one and only time I took the machine into the field I had to fly. When entering the airport security station, the security agent asked me, "What is it?" I replied, "a tapping machine." "What does it do?" "It goes tap, tap, tap, tap, tap." Immediately the machine and I were taken to a nearby office. You should have seen the expression on their faces when after carefully inspecting it and taking safety positions behind a barrier, they allowed me to plug it in. The machine went tap, tap, tap, tap, tap, whereby I replied, "See! Just as I said." It took quite awhile before I was able to convince them of my sanity and the reasons for needing such a machine.

Getting back to the original discussion, the fifth question asked of me that first day was, "What do you have that behaves like a limp mass?" I wasn't about to touch that one, besides it sounded a little personal to me.

In an earlier chapter, I explained the Limp Mass Law as related to sound-transmission loss of a barrier. A true limp mass-type barrier is one that is preferably massive yet very limp and if allowed to hang freely (unrestrained), it restricts vibration when exposed to noise. It is considered a good sound barrier.

At this point, the sixth question didn't even phase me. It was Hale's favorite question, although he was laughing hard by question five, number six caused him to become hysterical.

A client, stated, "I am considering using my spray on products that Riverbank tested earlier this year in bathrooms; although I have data on a number one and a number two situation, do you think I should do a number four on the floor, or do you think a number seven up in the air is more appropriate or perhaps both? What is your expert opinion on this matter?"

I was not about to relate to the caller what a number one or a number two meant to me involving bathrooms, and it took a lot of will power not to ask what on earth were numbers three through seven. Fortunately, individuals such as Hale Sabine would come to my rescue. Oh yes, the numbers actually referred to various types of mounting for absorptive specimens that were incorporated by the AMA. Today, the ASTM uses letters.

During my conversation with Hale Sabine, he mentioned that he was now retired and had moved to Florida. After our initial conversation, he periodically called Riverbank to talk over various items or changes in acoustical testing, see if the old gang were still around, or check on my progress. He had inspired me to actually use, as my initial requisite of study, these six questions: If I fully understood their significance to acoustical testing, I would indeed have acquired some very usable and worthwhile acoustical knowledge. Hale was correct.

Conversations with Hale were always inspiring. We would discuss various issues, and he always managed to provide me with a wealth of information. One day, I was able to provide him with information about a particular series of transmission loss tests that I conducted that had resulted in frequency shifts that differed from previous results. At first, he thought that perhaps my deductions were the result of some incorrect conclusions and that I had better check certain parameters and recheck my calculations before expressing my findings to others. After I proved to Hale that I had already considered these parameters he had referenced plus I did a few additional tests to prove my conclusions, he confirmed my formulations were correct, but he pondered my conclusion for the moment. After we both agreed on what was actually happening in the wall, he concluded our discussion by first stating, "This was most inspiring." Then, he congratulated me by saying, "John, you have just graduated." As simple as his latter two statements were, to this day I feel most proud of the fact that Hale Sabine had accepted me as a fellow acoustician and gave me a verbal diploma from his school of architectural acoustics. In some ways, it is the best kind of diploma one can receive — from one's peers.

Hale Sabine would often ask if I had any unusual inquiries or findings. He realized that in many instances, I could not respond because of client proprietary reasons and accepted the fact most honorably. However, he always enjoyed my disclosure of what I regarded as strange, different or weird. One of

Hale's favorites was the question from a science teacher who apparently had been misinformed about the definition of decibels. Her question was, "Is it true that 130 dumbbells can cause you to go deaf?" If you stretch your imagination a little, I suppose that under certain circumstances if 130 individuals were designated as being dumbbells they could become violent and cause deafness. I suppose, as well, that under extraordinary circumstances, if, 130 dumbbells of the weight-lifting kind were dropped in a specific way, they could also cause deafness. In any respect, I clarified the teacher's question by stating that I believe she meant decibels, not dumbbells, and went on in great length about decibel levels and the threshold of pain (130 to 140 decibels).

Unfortunately, in my explanation about the development of the decibel unit by the telephone company, I did mention that deci meant one-tenth of a Bel. Later, I complicated matters by referencing the fact that distance was significant in regard to noise sources and that if one were in a bell tower, the noise level could cause deafness, whereas if one were some distance away, the same bells chiming might be regarded as serene and pleasant to the listener. Obviously, I was inserting the definition of noise and sound into my oral presentation. Noise is merely unwanted sound. I later realized that under the circumstances, by commenting on the unit bel, then a bell in a tower, I was confusing the caller. As I finished my response, the caller said, "How can I calculate the actual size of the section that I could remove from a bell that I have in my storeroom in order that I could show my class what one-tenth of a bell actually looks like and if I strike it ... sounds like? One hour later, I hoped that the science teacher was better informed. Somehow when I had finished, I had a much better appreciation of the often-stated expression, "I went to college to become an engineer and now I are one."

As they say, never assume anything. Sometimes, you might think you are stating something clearly but later suffer the consequences. For example in 1989, there was a caller who stated, "How do I determine the 'E' (error) factor for sound absorption?" I was at a loss trying to remember what kind of error functions appeared in certain texts that involved sound absorption. Realizing that the caller was waiting, I said, "Could you give me some more specifics because at the moment I am at a loss." He replied, "Don't you remember at the ASTM acoustical workshop, you said that the units of absorption are called Sabins, named after Wallace Sabine, minus the *E,* and I don't recall you saying how to calculate the *E."* I wanted to cry, except that apparently, I perpetrated this caller's problem. After explaining that Sabine is spelled with an *e* at the end and that the unit of absorption is spelled sabin with no *e,* which is what I was referring to at the workshop, the caller simply stated, "Oh! I guess I can't calculate the *e* factor then. Oh well, thanks anyway. Bye." Another expression came to mind, "What we have here is a failure to communicate."

In 1978 Hale Sabine agreed to be my technical reviewer on my Paul

Sabine–Riverbank history. My original task was to document the acoustic work of Paul Sabine when I stumbled upon the Wallace Clement Sabine files. Then, because of the great interest in Wallace Sabine, Riverbank was asked to document the work of Wallace Sabine. Now of course, we have a book that addresses the work of all three.

In any case, in 1979 I mentioned to Hale Sabine that I had finished compiling the Wallace Sabine files but because I used the files themselves as the story line, many gaps existed. Hale suggested that I contact Leo Beranek, who had quite a file on the life of Professor Sabine and perhaps could fill in some of these gaps. Indeed, what eventually developed was a coauthored article on the life of Wallace Clement Sabine that appeared in the January 1981, *JASA*. Leo Beranek's contribution in extracting and incorporating the technical highlights was significant. To have been tutored by Leo Beranek, Hale Sabine and so many others was an honor — as well as an education beyond description for which I am most grateful.

Although Hale Sabine and I had exchanged letters and discussed many issues at great length over the telephone, I never had the honor of meeting him in person. We discussed our first possible meeting in Miami during the then forthcoming ASA meeting in the fall, but as things turned out, it was not to be. Hale had just finished reviewing some material for these writings about the AMA, Kleinhans Hall and the material regarding the National Noise Abatement Council. I received his edited versions and telephoned to thank him, when I was informed that he had just passed away that day, a personal loss that will never be rectified fully in my own mind. I had so wanted to talk with him about many issues about Paul Sabine, the colonel, and Riverbank.

Hale Sabine was my first adviser in acoustical testing and continued to be an inspiration, as well as a technical reference source, until that day, October 11, 1981, when he just wasn't around any longer. His passing marked nearly a century of involvement by his family in the science of acoustics.

I had the great honor of presenting the Hale Sabine Riverbank story at a special session at the ASA Cincinnati meeting dedicated in his honor. In my presentation I stated,

> So many of us involved in the science of architectural acoustics owe so much to the Sabines. What was started by Wallace Clement Sabine, carried on by Paul Earls Sabine and his son, Hale Johnson Sabine, continues today, but only because of the contributions made by these three dedicated, committed scientists.

End Notes

Chapter 1

1. It should be pointed out that the outer-shell portion of the supposed levitation device, currently displayed in the Riverbank museum, is far too heavy for the small amount of acoustical energy produced. There were other discrepancies in the re-creation of the experiment as well. The engineer for the re-creation used piano strings, and the piano had not been invented at the time of Bacon's original experiment. In addition, most of the strings were not the frequencies that yield the maximum acoustical energy and many more of the predominant energy frequencies would be required. Tuning the strings might have been achieved by adjusting the strings located on the stationary outer shell while the cylinder was rotating to arrive at the exact resonance of each pair. When contemplating all the factors, some wonder if the Rosicrucian's original experiment ever did work. One thing is for certain, because of all the comments and jokes about the machine through the years, no one at Riverbank has dared to attempt the experiment again, but that's not saying no one ever will.

2. A few other items from Professor Watson's informative paper are worth mentioning. Professor Watson referenced 46 distinguished papers, none of which preceded the early 1900 papers involved in the 1922 release of Wallace Sabine's collected papers. The earliest was a paper entitled "Qualités Acou-stiques de certaines salles pour la voix parlee," (Acoustical Properties for Speech in Large Halls) *Compt. Rendus,* 142, 878, 1906. Anyway, before the professor got into various aspects and derivations dealing with building acoustics, he acknowledged work done by famous scientists throughout the world. When discussing the United States, he mentions the work of Wallace Sabine, F. A. Saunders, C. M. Swan of Harvard, Dayton Miller, A. L. Foley, A. G. Webster, G. W. Stewart, L. V. King, V. O. Knudsen, E. A. Eckhardt, E. Buckingham, V. L. Chrisler, W. F. Snyder, F. C. Wente, H. Fletcher, and L. R. Crandall. The reason they are mentioned here is that twelve of these scientists, including Professor Watson, used Riverbank at one time or another and their names appear throughout this book.

Professor Watson's reference to Riverbank was as follows: "The experiments of Wallace Sabine have been continued at the Riverbank Laboratories at Geneva, Illinois, under the patronage of Colonel Fabian [sic] with Paul E. Sabine, a cousin of Wallace Sabine, as director, who has conducted numerous investigations on absorption and transmission of sound."

3. From the same issue of *The American Architect* was the following editorial comment:

An Appreciation of the Late Wallace C. Sabine

Probably in no branch of the higher technical research in which the profession of architecture

is directly interested has greater progress been made than in that of acoustics. Professor Wallace C. Sabine, at the time of his death, had reduced to an exact science the theory of the acoustic properties of auditoriums.

At the outset, his work was largely in the direction of the improvement of acoustically bad auditoriums. In the progress of this work he succeeded in establishing certain well sustained laws that ensured the acoustic perfection of new buildings.

To have accomplished so much in the span of a relatively short life demonstrates the great mental force of the man and the sheer grit and indomitable will that enabled him to continue despite a malady which daily sapped his physical powers.

Professor Sabine was actively engaged in his work up to within a month of his death. To the very last he attacked with a mentality nothing short of the marvelous, those abstruse and difficult problems which were the basis of his research, and he brought to completion the plans for an experimental laboratory the completeness of which stands today as a monument to the man.

Qualities of enduring patience and untiring energy enabled Professor Sabine to complete a research so valuable that its transference to other and competent hands will ensure the most satisfactory progress in a work in which every architect will take the utmost interest.

In his life and death Wallace C. Sabine showed so unselfish an attitude toward his work that after his master mind was withdrawn from participation, the path was so free from obstacles as to ensure progress to a successful finality.

Chapter 2

4. Today, like the colonel, the Japanese garden is often an interesting topic: What is the meaning behind the image presented? In 1990 when a contingent of Japanese visited the lab, I gave them a tour of the garden. After telling them my interpretation of the story involving the colonel and the garden, I decided to ask them if they could explain the garden to me as they see it. First, they corrected me on one issue about my story when I referred to the teahouse as part of the shrine. They mentioned that a teahouse is a place you can rest, lodge, or dine, and, while doing so, can pay respects and offer prayer. You can even worship through a traditional ceremony whereby the visitor can find peace within himself or herself and cleanse the spirit of any evil. Thus, a teahouse is never considered a Shinto Shrine, as such, and should not be confused with what might commonly be referred to as a Shinto Temple, which, in actuality, is more of Buddhist origin. Shintoism is an indigenous religion that has gone through many modifications and has interacted with Buddhism considerably. A true Shinto Shrine usually appears outdoors in the form of a small altar or, in some cases, a pictorial image relating to a mystical hallowed spirit represented by the area it is placed. According to the visitors, the following description is a combined perspective of what the Fabyan garden represented to them: By entering the garden through the Torrii, one enters the Shinto Shrine, or Buddhist Temple. The layout of scaled smaller mountains leading to a replica of Mt. Fuji is symbolic because it looks over all the teahouses and gardens of Japan. Likewise, the two linking goldfish ponds are appropriately symbolic because they connect (two unite as one) under the half-moon bridge. The various Japanese lanterns are periodically spaced throughout to light your passage through time. Combining this setting with other symbolic elements set within various traditional Japanese plants, the Fabyan garden represents the intrinsic spirit of man and nature. The Japanese Garden has been restored to some of its original magnificence by the Geneva Garden Club and the Kane County Forest Preserve Commission. Maintenance is provided by the forest preserve rangers. Today, the Japanese Garden is very popular for wedding ceremonies. The Geneva Garden Club's phase 2 of the garden restoration took place in 1992.

5. A follow-up regarding this incident appears in the Postscript under A Potential Fabyan Heiress.

6. Besides Captain John Powell, who is mentioned in Elizebeth Friedman's written account of the Riverbank class, we know that two other officers in the picture were Major Joseph O. Mauborgne and Major Parker Hitt. In 1912, Major Mauborgne broke the Playfair British Army cipher and wrote a twelve-page pamphlet about it. Major Hitt had written a small booklet briefly covering the solution of general ciphers and cipher systems, entitled *Manual for the Solutions of Military Ciphers,* which was used for some instruction in the army. Later, as a retired colonel, Parker Hitt wrote another small booklet entitled *The ABC of Secret Writing,* which was published in 1935. According to Elizebeth Friedman, Major-General Mauborgne became chief signal officer of the Army and retired in 1928, and Parker Hitt retired as a colonel in 1941. Both Hitt and Mauborgne were awarded the Distinguished Service Medal, which was unusual because it was earned for contributions made during the period between two world wars. Another officer involved with Riverbank codes and mentioned by Elizebeth Friedman was Major Frank Moorman. He became the head of the Code and Cipher Branch at GHQ France, where Lieutenant Friedman was eventually assigned.

The Riverbank Laboratory files disclosed only brief information about two other officers appearing in the graduation picture. Each remained in the service but was involved in areas other than cryptography. One was stationed at the Philadelphia Arsenal where he developed a research facility for the study of acoustics and acoustical devices for military purposes. The other was a captain in the cavalry. His interest in codes was strictly a hobby, but in a letter to Colonel Fabyan, he stated that he was hoping to be assigned to the signal corps. He also mentioned that he missed those beautiful Swedish night-in-gales of Geneva. Also, a copy of a letter was received in 1987 from Raymond Dorn stating that one of the officers in the picture was Francis X. Hufford. According to Dorn, Hufford became a high school principal in St. Charles, Illinois; taught physics; and talked about working in "the black chamber."

Chapter 3

7. Resolving the hotel controversy: The Aurora Hotel was built in 1917 and the Leland Hotel (originally called the Leland Towers) was built in 1928. Because the picture was taken in 1918, there is no controversy. The Aurora Hotel was Aurora's first large hotel, eight stories, the largest building downtown at the time. The hotel was built on a landfill covering an old swimming hole and mill race and was designated fireproof. It had an elaborate sheet metal cornice and a two-story dining area that cantilevered over the Fox River and was built to elevate Aurora's position as a regional center of commerce. The hotel represented the cornerstone of the future to be secured with the fulfillment of a landfill project involving Stolp Island; it is listed in the National Register of Historic Places. In 1988, an article in the local paper mentioned that the Aurora Hotel and surrounding area were being considered for new developments.

8. In addition to the binary code itself, one other little curve was thrown in just to further confuse anyone trying to decipher the message. The Roman alphabet was used in establishing the coded phrase. There was also another problem because each letter required five bits of input; the expression "knowledge is power" contains sixteen letters and, therefore, requires eighty bits of input or, in this case, eighty individuals would be needed to fully represent the code. Unfortunately, there were only seventy-six people in the picture. To make up for the deficit of individuals required, they strategically positioned a few people differently. Either by standing fully sideways or moved up or back (out of line), these people served as keys to direct the decoder in either direction to help fully decipher the coded message.

One account of the photo and its coded message was sent to Riverbank (1988) by Louis Kruh, a coeditor for *Cryptologia,* a quarterly journal devoted to all aspects of cryptology. An article written by Kruh appeared in the Volume 3, Number 4 issue; it was entitled "The Day the Friedmans Had A Typo in Their Photo." Kruh's itemized explanation appears to be one of the more descriptive accounts of the graduation-class photo. There were other opinions. Because

there weren't the required eighty individuals, many agreed that there were significant key individuals positioned differently to complete the message. What is obvious is that cryptology is a most fascinating and puzzling field, which is probably what the colonel was conveying in the picture.

9. Besides the knowledge is power inscription on the building, the colonel had his sculptor etch one word on each of three sides of the laboratory. On the south was the word *wisdom,* on the east was the word *caution,* and on the north was the word *science.* A clever bit of word-play by the colonel, the first letter of each word coincides with the initials W. C. S. located on the cornerstone, representing Wallace Clement Sabine.

10. Don Williams visited the Fabyan burial plot in 1989 and was able to bring back the following information: a 500-square-feet plot at the Forest Hills Cemetery in Jamaica Plain, Boston, Massachusetts, on Magnolia Avenue, Lot No. 3005, Section 16. The burial site was established by the estate of G. and G. F. Fabyan, October 7, 1874, for $1,500. The trust deed established the burial site for the twelve family members listed here:

No.	Name	Date of Death	Remarks
1.	George Fabyan	May 1874	Colonel's grandfather
2.	Abigail J. Fabyan	July 1881	Colonel's grandmother
3.	George F. Fabyan	January 1907	Colonel's father
4.	Isabella F. Fabyan	April 1909	Colonel's mother
5.	Sarah A. Fabyan	December 1917	Colonel's sister
6.	Julia A. C. Fabyan	June 1921	Colonel's sister
7.	Abbie M. Fabyan	December 1927	Colonel's sister
8.	George Fabyan	May 1936	The colonel
9.	Nelle Wright Fabyan	July 1939	Colonel's wife
10.	Marshal Fabyan	October 1952	Colonel's brother
11.	Isabel F. Lombard	April 1960	Marshal's daughter
12.	Elenor M. Fabyan	December 1961	Marshal's wife

Chapter 4

11. For many years (during the 1960s and 1970s) the Wallace Sabine reverberation room was referred to by the Riverbank staff as the Big Room and was documented as such when staff members conducted tests in it. This designation was used because in the 1960s, four additional reverberation test chambers were constructed. These four test chambers are slightly smaller and are designated as rooms one through four respectively. The additional test rooms were built primarily so that Riverbank could expand its sound transmission and sound impact testing. These four rooms were constructed in the true Fort Riverbank tradition, each room having solid high-density double-block walls, where each 10- by 16-inch block weighs ninety-nine pounds. The designer of these chambers was Frank Tyzzer, then manager of the laboratory.

On completion of the four test chambers, the staff at the time simply referred to the larger Wallace Clement Sabine reverberation room as the Big Room or the Big Absorption Room. As it turned out, the additional four rooms, as well as the Wallace Sabine Big Room, could be used for sound power, sound absorption, and sound transmission tests. On occasion, problems in the room designation, as interpreted by the client, would occur. With the advent of the motor vehicle test room (1979), which is three times larger than the Wallace Sabine Big test chamber, Riverbank had to eliminate the Big Room designation entirely because it created even more confusion and controversy with visiting guests and clients.

Because the motor vehicle chamber became the sixth reverberation chamber, and reverberation rooms one through four were originally designated as such, the motor vehicle test chamber became room five, and the Wallace Sabine room was changed to room zero so that each reverberation room would have a number indicative of its place in the order (time) of construction.

Now that the room designations appear to be arranged satisfactorily, discussions about the redesignation of all the Riverbank rooms, including reverberation rooms zero through five; the open office plan (landscape screen) test facility; the impedance tube, light-intensity, and air flow test rooms; the museum; the classroom; the conference room; the main control room; and all the offices. There was a suggestion to change the room designations to bear the names of various Riverbank personnel who are distinguished in the field of architectural acoustics from 1918 to today. Room zero would revert to its original 1918 designation as the Wallace Clement Sabine test chamber.

In any case, this situation is being documented here and now; otherwise, in the future, some poor uninformed Riverbank employee could experience even worse trauma than I trying to correlate various bits of old data.

12. Paul Sabine referred to the lowest-octave test frequency on the organ as the musical note C at 64 vibrations per second and the highest-octave musical note C at 4096 vibrations per second, which at the time was acceptable. However, through the years, various changes have occurred. The frequencies of the musical scale have been altered. For example, middle C, which was 512 hertz, remains as the physical standard. The middle C on the international standard is 517.3 hertz, and the concert standard middle C is 523.2 hertz, which constitutes a change acoustically. The terminology associated with frequencies has also changed. Although vibrations per second (vps) still appears for other purposes, the term *cycles per second* (cps) replaced vps as the test-frequency designation as conveyed by Paul Sabine. The cps meant frequency in the United States until the push for metric conversion began. Then, the unit for frequency was changed to *Hertz* (Hz) after Heinrich Hertz. By definition, Hertz is a unit of frequency equal to one cycle per second. Unnerving isn't it? Fortunately, the word *octave* remains as a designation of a range of test frequencies.

Today, the primary center test frequencies in each octave band corresponding to the octaves used by Paul Sabine are 63, 125, 250, 500, 1000, 2000, and 4000 Hz. Notice how every number doubles from 125 up; however, half of 125 is 62.5. If you want to believe that it was raised to 63 Hz was to maintain whole numbers (rounding off), which sounds feasible and is what many believe, be my guest. However, the next octave center frequency below 63 Hz is fixed at 31.5 Hz, thus eliminating the round-off theory. Care to guess the next octave center frequency below? You're right if you said 16 Hz. As you are most likely determining by now, the science of architectural acoustics is really not regarded as an exact logical science. In fact, by the end of this book, you will be even more certain of this. Many acousticians have lost a lot of sleep, their career credibility, and their wits in tying to apply the acoustical knowledge they had to a current problem in the hopes of obtaining a logical conclusion.

In any case, the test frequencies used by Paul Sabine were the C notes on the organ, which he designated from the low C to the high C as C-1, C-2, C-3, C-4, C-5, C-6, and C-7.

13. The reference here was to the total decay time, not just the time it took to decay 60 decibels (dB). Total decay is ten to twelve seconds as opposed to the five to six seconds of 60 dB reverberation time at 100 Hz. Remember, at the time of Paul Sabine's article, the dB unit or reverberation time (60 dB) range was not incorporated yet, and the total decay time is the time in seconds that it takes from the instant the sound is turned off until the moment it is inaudible. Obviously, it was a subjective measurement.

14. Because Wallace Clement Sabine's first name was a family name, Louise Wallace Hackney could have been another Sabine relative, but no more information about her identity is currently available.

15. The fascinating thing about Paul's article is that his designated unit for sound (power) was ergs/sec. Not that there's anything unusual about Paul's preference of units, but the use of different unit designations in acoustics has periodically created some confusion, especially for the apprentice. Depending on the year of publication and the academic or technical background of the

author, various inconsistencies in unit references from one document to another can be quite commonplace. Knowledge of unit conversion is virtually a must for the acoustician. A few typical examples of acoustical unit cross-references are as follows: ergs, joules, and newton-meters for work or energy; ergs/sec., joules/sec., or watts for power; dynes, kg-m/sec. squared, or newtons for force; and psi, dynes/cm squared, newtons/m squared, or pascals for (sound) pressure.

Additional acoustical units such as phons (loudness), sones (linear unit of loudness), noys (linear unit of noise) and rayles (airflow resistance) can create other uncertainties if not properly defined.

16. When questioned in 1979 about that day long ago, Hale Sabine indicated surprise that the event was actually documented. He chuckled ever so slightly, cleared his throat, and stated, "Yes, that was most exhilarating; however, my father was most persuasive, so that occurrence was my first, last, and only time I ever got to ring the Riverbank bell."

Chapter 5

17. Paul Sabine felt it was important to become an active citizen and to support those institutions and activities in Geneva that he found worthwhile and important. Paul Sabine's civic energies were channeled into the public library on whose board he served for 26 years.

During the 1920s, while serving on the library board, Paul Sabine became acquainted with another board member, William C. Wood. At the time, Bill Wood was an employee of the First National Bank of Geneva. Unknown to Paul, in the years to come Bill Wood would play a significant role for Riverbank. However, back in the 1920s, Wood was just then establishing himself as perhaps one of the more highly respected citizens of Geneva.

Bill Wood's success story begins soon after he graduated from high school. Then a nineteen-year-old farm boy delivering milk to Geneva, he was offered the opportunity to become involved in the banking business by the bank's first cashier, A. R. Dow. Bill accepted, and from that day on he began a most distinguished career in serving Geneva. Not only was Bill Wood acknow-ledged for his outstanding accomplishments in the banking business, going from handyman to cashier to president but he was also Geneva's city treasurer for two years, mayor for four years (1937–1940), a member of the library board for eight years, and a war veteran who became the first adjutant of the Fox Valley post of the American Legion and later post commander. Wood also served over fifteen years on the executive board of the Boy Scouts of America. In 1942, he was nominated vice-coordinator of civil defense (Kane County) and later became one of the pioneers in establishing the Geneva Historical Society. In his spare time, he was a master craftsman in woodworking.

However, it is Mr. Wood's tremendous efforts as trustee for Riverbank until 1986 that is most appreciated by us. Without his efforts, much of what is Riverbank as we now know it today might not have been. The Riverbank success story was as much a part of Bill Wood as anyone else. William Wood passed away in April 1990.

18. Many acousticians incorrectly claim that the first published data were from the American Materials Association (AMA) in the 1930s. Yet, Paul Sabine released manufacturer's product data before the 1930s as did the National Bureau of Standards. The AMA journal, however, was the first manufacturers' periodical on the acoustical properties of various products.

19. Today the Acoustical Society of America has more than 6,000 members and is continually growing. The expertise of the members covers a magnitude of topics that fall basically under the following twenty primary categories: (1) architectural acoustics, (2) biological response to vibration, (3) engineering acoustics, (4) musical acoustics, (5) noise, (6) physical acoustics, (7) psychological acoustics, (8) physiological acoustics, (9) shock, (10) vibration, (11) speech communications, (12) underwater acoustics, (13) nonlinear acoustics, (14) general, linear acoustics, (15) ultrasonics, (16) quantum acoustics, (17) signal processing, (18) bioacoustics, (19) aeroacoustics, (20) macrosonics. A more detailed list of categories is presented in the Postscript.

20. The St. Valentine's Day Massacre still has a negative impact on some individuals visiting Chicago. Nevertheless, attendance at the ASA's 100th meeting in Chicago in 1983 placed it among the top twenty of all ASA meetings from 1929 through 1987.

Chapter 6

21. Others also recognized Paul Sabine's expertise in science and religion, including the famed American news commentator Edward R. Murrow. On Paul's seventy-fifth birthday, January 22, 1954, he appeared on Murrow's television show and discussed various issues on the subject.

22. In 1991, Cyril Harris contacted Riverbank to find sources for a book he wanted to publish with more recent absorption data.

23. The individual responsible for maintaining the official data, administrative records, and much more throughout the last years of the Acoustical Materials Association, Acoustical and Insulating Materials Association, and Acoustical and Board Products Association was Robert LaCosse, who still possesses many of the acoustical records from these groups. Currently, he is connected with the American Hardboard Association, which still publishes fire ratings but has not dealt with acoustical data since 1977.

Chapter 7

24. In 1985, an American Society for Testing Materials (ASTM) task group was formed to investigate the door-leak problem, with me as delegated chairman. After the first eighteen months investigating the leak effect with the latest state-of-the-art equipment, we were somewhat proud in coming up with the current conclusions stated in the proposed standard; however, we found afterward, when reading through Paul Sabine's publications, that he came up with virtually the same conclusions back in 1932 with using crude equipment.

25. At the 1988 American Society for Testing Materials (ASTM) meeting in Toronto, Canada, the chairman of the task group evaluating the noise-reduction coefficient (NRC) single-number rating announced that after reviewing various combinations, there does not appear to be any valid reason to change the existing single-number rating scheme.

26. In September 1939, A. H. McDannald, editor in chief of the *Encyclopedia Americana,* contacted Paul Sabine to revise or rewrite the section on acoustics originally written by Wallace Clement Sabine. Paul agreed. He found that someone had incorrectly revised the original article by inserting material that could not have been written by Wallace Sabine, such as "Emil Berliner acoustic discs." Paul stated that the article says that these discs are a means of correcting acoustical difficulties; however, this information did not surface until after Wallace Sabine died, and their ability to correct acoustical problems was virtually nil. Paul thought that because so much had been added to the science of acoustics since Wallace Sabine, the article should be rewritten completely. The editor agreed; the rate was $7.50 a page for revisions and $15.00 a page for new material. By October 26 Paul submitted 22 pages. They were printed in their entirety in the next issue of the encyclopedia. Paul referenced six other publications: (1) *A Text Book on Sound,* E. H. Barton, London, 1914; (2) *Modern Acoustics,* A. H. Davis, New York, 1934; (3) *Speech and Hearing,* Harvey Fletcher, New York, 1929; (4) *The Science of Musical Sounds,* Dayton C. Miller, New York, 1916; (5) *Applied Acoustics,* H. F. Olson and F. Massa, New York, 1934; (6) *Acoustics and Architecture,* Paul E. Sabine, New York, 1932.

27. Paul Sabine met with Charles Moller of Budapest. They had dinner at the Cliff Dwellers in Chicago. Then Moller visited Paul's laboratory at Riverbank. Apparently, they discussed politics because shortly after Paul wrote to Moller and he referenced their discussions about how FDR's New Deal was not checking the Depression. The pump-priming practices were causing many problems. Paul ended his letter by stating, "All thinking people realize that the United States like

the rest of the world is facing a profound change in our economic system. Our greatest hope is that this change can be effected without the destruction of those values in social life and political liberties which we cherish." Apparently, things have not changed much.

Chapter 8

28.As recently as September 11, 1989, the article "Resounding Success" by Gino Del Guercio appeared in the Tempo section of the *Chicago Tribune.* In this article there appeared this question and statement: "What makes a concert hall perfect? Art and the magic of science." The article included a picture with the following caption: "The New York Philharmonic's Avery Fisher Hall reopens after reconstruction: When it was born it was an acoustical turkey." The author briefly explained the many problems involved in designing concert halls. He discussed such noted halls as Boston's Symphony Hall; Philharmonic — Avery Fisher Hall; Grosser Musikvereinsaal in Vienna; Berlin Philharmonic; and the Evangeline Atwood Concert Hall in Anchorage, Alaska. The author referenced acoustical consultants Wallace Sabine, Leo L. Beranek, Cyril Harris, and Christopher Jaffe as well as electronic acoustical engineer, Mark Holden and Boston Symphony Hall violinist Harry Ellis Dickson.

Chapter 9

29. Because of his war work at Harvard, the Riverbank files have no record of Paul Sabine ever working on any project for the National Noise Abatement Council (NNAC) after 1942. It appears that when the war ended so did the NNAC.

Although the Acoustical Society of America (ASA) dropped the NNAC logo, it maintained a technical committee on noise that is still active. Thus, Paul's original efforts in getting the ASA involved were not in vain. The ASA is continuing to do its part to resolve community noise problems. If it and the new American Society for Testing Materials (ASTM) subcommittee decide to combine efforts, it could be another giant step for more quiet.

Another organization that is still active in community noise is the National Association of Noise Control Officials (NANCO). As a member, I enjoy reading the monthly bulletin entitled Vibrations. The NANCO slogan is "working together for a quiet environment." Perhaps NANCO, ASTM, and the ASA could provide the much-needed catalyst to provide quiet to the world. There is even some speculation that Washington might reconsider involving the government again in noise abatement, especially in regard to product labeling, truly a competitive plus factor in lowering the noise levels of various noise-emitting devices.

30. With Paul Sabine's help, these two groups established the basic criteria by which community noise standards were measured nationwide. During the following three decades, various projects to provide quiet were started throughout the United States, primarily with financial support from the government, which became active in community noise control and established specific departments within the Environmental Protection Agency and the Office of Safety and Health Administration. Unfortunately, during the early 1980s, these departments were victims of cutbacks, and many government noise-control programs, as well as the noise control departments themselves, simply disappeared. A few states and communities maintained noise codes, but enforcement became limited.

Fortunately, in 1988 a contingent of individuals concerned with the ever-increasing community noise problems was able to organize an official American Society for Testing Materials (ASTM) subcommittee in E33-09 entitled Community Noise. The subcommittee's intention was to establish either an Acoustical Society of America or an ASTM standard that could be used in community noise ordinances and could provide a basis for enforcement.

31. One year earlier in January 1941, Paul Sabine offered the lab to the National Bureau of Standards (NBS). Paul wrote letters to NBS Director Lyman, J. Briggs, V. Chrisler and Alexander

Elliott. Paul felt that because all their efforts to standardize the sound absorption tests between both facilities had succeeded, perhaps the same could be done with hearing aids. Three months later Paul wrote William F. Snyder, also of the NBS, about Riverbank's participation in hearing aid testing. In all instances, the bureau's responses were courteous, somewhat hopeful, but after one year, nothing materialized. Perhaps the threat of war was why nothing ever got off the ground.

32. In 1943 Robert Kerfoot became an invalid with arthritis and was in a wheelchair for a short time during which Hale Sabine took charge of the testing. Also in 1943 Kerfoot was asked to assist in the war effort, and he left Riverbank for Waltham, Massachusetts where he started work on radar for the Raytheon Corporation.

33. Paul Sabine's magnificent efforts on submarine detection at Harvard are not included in the Riverbank files, thus the limited explanation of what Paul Sabine was doing during most of the war years. Much of what appears here about this work was obtained from other sources. Leo Beranek, who was involved in the same work, has many interesting accounts of what took place during these hectic years.

In researching Paul's career, it was mentioned that the Smithsonian Institute had some slides donated by Paul Sabine. After visiting the Smithsonian and coming up short, one of their dedicated staff members continued to search the records for the slides and three days later located them. The telephone account of what the staff member saw in the slides was that they dealt with "some kind of Harvard submarine project." The staff member said that they had trouble locating the slides because they were donated by Cornelia Sabine, not Paul.

34. The Riverbank files contained an entire portfolio of published papers on hearing that Paul Sabine wrote. The titles of the last six papers he published before retiring are as follows:

1. "The Acoustical Society and Noise Abatement." Presented at the twenty-sixth meeting of the ASA, October 24–25, 1941; 1942, *Journal of the Acoustical Society of America (JASA)* 13(3):207–209.
2. "On Estimating the Percentage Loss of Useful Hearing." *Transactions of the American Academy of Ophthalmology and Otolaryngology,* January-February 1942.
3. "Noise Abatement." *Hospital Management,* May 1942.
4. "Acoustical Properties of Small Cavities," *JASA,* 14(1):74–78.
5. "The Problem of Industrial Noise." Presented before the Industrial Hygiene Section of the American Public Health Association at the seventy-second meeting in New York, October 13, 1943. *American Journal of Public Health,* 34(3).
6. "Acoustical Amplification by Hearing Aids," 1944, JASA 16(1):38–44.

35. As noted, individual companies frequently make public the data about their own products. Even though most of the companies are honest, there have been documented cases where a particular manufacturer has falsified data results to better his competitors. In some instances, these data have even included a test-number designation similar to that of a reputable laboratory. For example, Riverbank used to list an absorption test as follows: A83-525, where A equaled absorption test, 83 equaled the year tested (1983), and 525 indicated that this test was the 525th test that year. Riverbank questioned the use of this type of designation by another party but was informed that there was nothing legally binding in this particular form of designation. Riverbank then registered its logo RAL as a trademark; so, now the same test designation appears as RAL™-A83-525.

Chapter 10

36. Hale's director of engineering, Wallace Waterfall, is another individual whose name would pop up quite often when I researched the Riverbank files. When discussing Waterfall with certain Acoustical Society of America (ASA) dignitaries, I noted that he is regarded as perhaps the

most predominant rulemaker and policymaker of all ASA members ever. Apparently, many of the stringent ASA policies that remain today were initialized by Wallace Waterfall, especially the policies establishing what is printed in the journal and what procedures take place at ASA meetings.

Waterfall was a pioneering member of the ASA, the ASA's long-time Secretary, and late Treasurer. Waterfall was also a predominant and powerful factor in many Acoustical Materials Association (AMA), National Noise Abatement Council (NNAC), and ASA matters that also involved Paul Sabine and, later, Hale Sabine in one capacity or another. When you consider Hale's diligence and tenacity for procedure and detail, Paul's scientific and technical expertise, and Wallace Waterfall's administrative and power-based influences, the three were truly an effective team. Waterfall would eventually leave The Celotex Corporation. His name surfaced often and his correspondence usually had The American Institute of Physics or the ASA letterheads.

37. Mahlon Burkhard is also a member of the Acoustical Society of America (ASA). Mahlon has served on many local (Chicago chapter) and national ASA committees and is still very active in ASA affairs.

After leaving IIT Research Institute Burkhard served as chief administrator of the Industrial Research Products Corporation. In 1989, he retired from that corporation. By 1990, he decided to utilize his background and experience to organize Electronic Architecture Techniques, Inc. After many years of residing in the Chicago area, Mahlon and his charming wife Charlotte moved to West Virginia.

38. Robert (Bob) Beyer is well known throughout the society; he is a past president and is the current treasurer. Beyer's expertise in physics, acoustics, and many other subjects is understood as a matter of fact throughout the society. Bob contributed to this book in his willingness to talk with me, clarify some statement or event, or find a reference that appeared to be a dead end. Brown University truly had a well-versed professor, and I envy those students who had the opportunity to be instructed by Professor Robert T. Beyer.

39. I am acquainted with Dan Martin, who during my work on this book served as president of the Acoustical Society of America (ASA). He had a 35 year acoustical research career with the Baldwin Piano Company. Martin is active with Acoustical Society matters as editor-in-chief and is currently an acoustical consultant and a member of the National Council of Acoustical Consultants (NCAC). During the 1994 Wallace C. Sabine Centennial in Cambridge, Massachusetts, I conducted the ASA taped oral history of his life.

Postscript

For those interested in the Riverbank Community, this postscript is a collection of notes that although related to are not intended as part of the preceding Sabines at Riverbank story.

I was permanently assigned to Riverbank Acoustical Laboratories by my parent organization, the IIT Research Institute in 1976. After reading the Wallace Clement Sabine biography, I began digging through the junk room (now the museum) to find all I could about Riverbank. I became intrigued by the history and constantly pestered Don (Mr. Riverbank) Williams about anything and everything I could about this fascinating place. Don decided that because he was getting close to retiring, he would pass the duties of client tour guide over to me. Thus, with Don's help, I also gained a job-related purpose to learn all I could about Riverbank. Then, one day an article about Riverbank, the third article within a year, appeared in a local paper. After reading it, Don threw it down on his desk saying, "Garbage! Garbage! Garbage! Why can't anyone print the truth about Colonel Fabyan rather than all the garbage that others managed to come up with?" Don then turned to me and said, "If you really want to know all about the history of this place, I'll tell you what I can recall on one condition...if and only if you promise me, you will document what I say or from whomever or whatever you find about Riverbank that can be regarded as fact. Just so I can retire from Riverbank knowing that at least one document about this place tells it like it was." I agreed, not at the time anticipating that a book would result.

In this book, I have tried to be true to my promise to Don. I focused on the Sabines to provide the chronology for the story. A number of anecdotes were omitted, because they were tangential to the story line, but I have assembled them in the postcript, rather than omit them.

Colonel Fabyan

The following material expands on the information and stories already given about Colonel George Fabyan and Riverbank.

Fabyan Villa Museum

Colonel Fabyan's villa is now a museum operated by the Kane County Forest Preserve District. The story of how that came about and some updated information regarding the museum follows:

In 1939 Kane County purchased the Fabyan property east of route 31. It included the villa, which was turned into a museum housing many of the artifacts that were previously displayed or stored in the Riverbank laboratories across the highway. The viewing space of the museum dwindled until the late 1970s when only the living room remained open to the public.

During the 1970s the colonel's villa was used as living quarters for various county employees and other temporary help. Needless to say some damage resulted and a few of the colonel's artifacts, such as a magnificent authentic Chinese gong, were either stored, sold, or perhaps confiscated. With luck, some, if not all, of the missing artifacts might surface someday and be returned.

In 1975 the county closed the museum and it remained so for five years pending various options being considered by the county forest preserve officials. Fortunately, a group of concerned citizens known as the Friends of Fabyan made an offer to the county to reorganize the villa-museum and reopen it to the public. The county accepted the group's offer and it re-opened in the summer of 1981. On a positive note, because the villa was owned by the county, it was spared possible owners who might have modernized it, thereby changing the original architecture. It was not common knowledge that the villa was a Frank Lloyd Wright endeavor. It was the Friends of Fabyan who located the original preliminary plans for the Frank Lloyd Wright designed villa at Talieson West archives and they presented copies to the Kane County Commission.

The county then hired Edward and Marie Frasz as caretakers. The Fraszs, with the assistance of the Friends of Fabyan and the county, began renovating the villa as well as the rest of the estate. They were able to bring back much of the Fabyans's original Riverbank image.

Shortly after the villa museum opened to the public, Edward Frasz passed away. Fortunately, Marie Frasz stayed on, maintaining the villa and serving as curator for the villa museum until 1995. Marie scheduled tours of the villa and conducted most of them herself. Currently, more than 10,000 visitors a year enjoy the villa and the Dutch windmill. Indeed Marie, the Kane County Forest Preserve District, and the Friends of Fabyan deserve most of the credit for preserving the important structures located on what is now known as the Fabyan Forest Preserve.

The villa museum displays much that was located elsewhere on the estate when the colonel resided there. This included artifacts representing the animal kingdom such as a large swordfish and stuffed and mounted animals including fish, bear, birds, buffalo, and miscellaneous small game. In the museum is a glass case containing a mummy holding a child. Inside the case an inscription reads "bone" and an arrow points to the bone exposed through an opening in the mummified-look wrapping around one leg. A few years ago an anthropologist performed a nondestructive scientific investigation that disclosed the only thing in the mummy that ever had to do with anything living was this one bone which once belonged to a dog. Perhaps the origin of the mummy can be explained by the colonel's close friendship with P. T. Barnum of circus fame. There are many authentic items in the museum, however, such as natural history exhibits, historic photographs, a Japanese Samurai suit of armor, oriental artifacts, as well as Fabyan scientific and war memorabilia.

In 1996 most of the natural history exhibits were relocated to Tekakwitha Woods Nature Center, north of St. Charles, Illinois. During the summer months, the villa museum is open to the public for guided tours on Wednesday, Saturday, and Sunday afternoons.

The Friends of Fabyan

The Friends of Fabyan group, organized in 1979 with eighteen charter members, has grown to more than 100. The primary purpose of the group is to preserve and restore the historic structures on the Fabyan estate. Without the Friends of Fabyan's diligent efforts, fortitude, and tenacity of purpose, the restoration of the villa museum, the replacement of the two historic statue eagles, plus many other restoration-preservation projects would never have happened.

After the villa museum had been closed for five years, the Friends of Fabyan cleaned, reorganized, and reopened the museum in 1981. Since that time new acquisitions have been made and additional exhibits provided. A protective enclosure for the Japanese samurai suit of armor was built after it had been cleaned and repaired professionally.

The Friends of Fabyan provided much of the Fabyan historical data that are currently available at the museum and have researched documents and conducted interviews to establish authenticity in what is printed or restored throughout the estate. The group provides educational programs and has developed a long-range (ten-year-plus) restoration plan. Eventually, the significant historic elements that were once part of the Fabyans's estate will once again be enjoyed and appreciated by the public.

On December 13, 1988 the Kane County Board of Commissioners and the Kane County Forest Preserve District honored the Friends of Fabyan with Resolution #F.P.-R-12-88-599. The resolution honored the Friends of Fabyan, a non-profit organization, for restoring and preserving the historic

structures on the Fabyan Forest Preserve. It conveyed Kane County's sincere appreciation on behalf of the residents throughout the district — truly a well-deserved recognition.

In 1995 the Kane County Forest Preserve District contracted with Preservation Partners to operate the Fabyan villa museum. Friends of Fabyan continues to function as a volunteer support group for the overall Fabyan site. Its main focus includes artifact acquisitions for the Fabyan Villa and the development of an archivist-staffed villa resource center. The group also offers a public lecture series and provides active assistance in restoration projects.

Preservation Partners

Preservation Partners of the Fox Valley, a nonprofit organization that operates two historic house museums, supports preservation projects throughout the county and promotes preservation education through its programs and resource center. During the 1996 season, twenty-two Preservation Partners volunteer docents conducted tours and were active in the intepretive program of the Fabyan Villa.

The Eagle

The original Silvestri tower eagle mentioned on the first page of Chapter 1 was struck by lightning on July 25, 1986. Fortunately, just two weeks earlier, a contingent of the Friends of Fabyan had taken measurements and pictures of the tower eagle so that it could be duplicated to replace the deteriorated eagle statue on the island. It was thought that because of the lightning damage, the insurance would cover the costs for replacing the damaged eagle and that a duplicated eagle could be made at less expense. It was this scenario that Richard Schlindwein, then supervisor (now owner) of Riverbank Inc., agreed to with Darlene Larson, president and restoration chairman of the Friends of Fabyan. In the following months, a model together with a mold, was made, a masterful work according to all who saw it. The sculptor was Gloria Ann Rovelstad of Elgin, Illinois, daughter of the renowned sculptor Trygve Rovelstad, who, in the 1930s trained with Silverio Silvestri.

Gloria Rovelstad spent many hours on the new Riverbank eagle, in some ways outdoing Silvestri's attention to detail. Although the observer is aware that the new eagle model is a composite of clay, sand, wire, steel, and whatever, there is this incredible sensation that the soaring eagle could ruffle its feathers. One person commented, "The feathers are so realistic in appearance that although your brain tells you otherwise, you cannot escape the feeling that they would actually fluff if you brushed them."

After making the clay model, Gloria Rovelstad began the lengthy process of making the plaster mold; when completed, Riverbank Inc. and the Friends of Fabyan arranged to have a positive casting made. The Riverbank tower eagle was to be the first casting. Unfortunately, the company hired to make

the concrete casting broke the wing mold. According to the fine print in the casting company's contract, the firm could not be held responsible if the mold broke during casting. Naturally, Richard Schlindwein was disappointed when he had to report the news to the Riverbank trustees that the casting company required another wing mold. It would cost several more thousands of dollars with no guarantee that the second mold would not break. Because the insurance money for the damaged eagle was diminishing, it appeared that the eagle project was doomed.

Fortunately, Darlene Larson and the Friends of Fabyan were not about to quit. With the assistance of Schlindwein and the Riverbank trustees, it was decided that with the remaining insurance money — and to prepare for the possibility of additional problems — the sculptor would cast a plaster-of-paris mold. Then, Darlene Larson, with the support of the Friends of Fabyan, explored a variety of ways to complete the project so that two eagles could still be cast. Research began again for another company to do the casting. Orlandi Studios in Chicago came highly recommended, and the suggestion was made that fiberglass, instead of concrete, be used.

The first mold, as well as the newer plaster-of-paris model, was delivered to Orlandi Studios for consideration and a bid. After investigating the new molds, its answer was, "no problem." By using Gloria Rovelstad's original mold with a fiberglass composition that looked like the original concrete, Orlandi Studios was able to make both eagles at considerable cost savings. Eventually, combining Riverbank Inc.'s remaining insurance money and additional finances provided by the Friends of Fabyan, the casting portion of the project was completed when both eagles were cast. One eagle was mounted on the island in September 1988. The Kane County Forest Preserve District paid for mounting as well as the mold.

All was not going well, however, with the tower eagle. Schlindwein announced that a new problem centered on providing adequate insurance. Apparently, no one wanted to take responsibility for all the hypothetical calamities that could occur in putting up the eagle. Once again, it appeared that an eagle would never be installed on the tower. Eventually, though, through the determination of concerned parties who would not allow the problem to remain unresolved, the contractor agreed to install the eagle. On October 7, 1988, an eagle once again soared atop the tower at Riverbank Acoustical Laboratories.

The Riverbank Acoustical Laboratory Tower Bell

Riverbank is often asked about the bell located in the laboratory tower. It was manufactured by Henry McShane & Company of Baltimore, Maryland in 1885. It is constructed of two inch thick bronze and measures thirty-six inches diameter at the base, twenty-two inches diameter at the top (neck), and is twenty-nine inches high. Its key is in the A, A# range of 440-450 Hz. The bell is operable and rung on special occasions.

The Lion

In 1983, although quite weatherworn, the still-intact Silvestri lions were damaged by an overzealous truck driver attempting to maneuver a wide truck between the columns adjacent to the two laboratories where the big cats perched. The lions were replaced by locally purchased replicas of a quality that rivaled that of the originals.

The Windmill

In 1979 the Fabyan windmill was placed on the National Register of Historic Places. In 1980 the windmill was honored as part of a U.S. postage stamp series that featured five windmills in this country. When a crew was reshingling the windmill, a listing was found of some of the men who originally rebuilt the mill in 1915. Those listed were Oscar Wilson, Charles Lindahl, Ben Anderson, Carl Peterson, Martin Seastrom, Dick Swanberg, and Eric Swanson. Friends of Fabyan have been instrumental in assisting the county in interpreting and maintaining this historic landmark. The windmill is open to the public on Saturday and Sunday afternoons during the summer months.

A Potential Fabyan Heiress

When leaving the lab one night in November 1984, a car pulled up in the driveway and a middle-aged woman got out and asked if this was the house Miss X (the name of a mistress of the colonel) had lived in, pointing at the grey house next to the lab. I said, "Yes." Curiosity aroused I asked, "Were you or someone you knew ever involved with Riverbank?" She replied that her mother was involved with the colonel once. She immediately stated, "Oh! no, not in the way you may be thinking, but rather under a strange set of circumstances. You see, my mother was in the hospital having me and she shared the room with Miss X, who had just had a miscarriage." She continued, "My mother had told the story many times about the wealthy colonel who had offered a lot of money for me. So while growing up, my mother and I often discussed the fact that I could have been very rich as the colonel's daughter but the love my mother and I shared could never have been equalled. Of course, there were times I recall daydreaming of living the life of a wealthy heiress at Riverbank." Then, she paused and continued, "You see, we were very poor, especially then ... by the way, my mother and Miss X remained in touch for some time and I remember one time we joked about what if the colonel had purchased me and if by chance my real mother was visiting Riverbank, in the same room with Miss X, and Mrs. Fabyan, and if I yelled Mommy! Who would have responded? Imagine if all three had, it sure could have created an embarrassing situation." She chuckled, even while telling me, a perfect stranger; however, I remembered chuckling too. Anyway, it was a heartwarming event primarily because of her attitude toward the entire situation

and because of her obvious love for her departed mother. I explained the current status of Riverbank to her. She took a few pictures and departed saying, "Money isn't everything ... right?" "Right!" I replied and then spent the next hour driving home thinking, "right? ... right ... well ... partially right, well ... ok, right." Writing about a millionaire has certain drawbacks.

The Kobayashi Family

On November 13, 1939, after both Fabyans had passed away, Susumo (Oscar) Kobayashi, his wife Suye and children Sumiko, Noboru, and Michiko left Riverbank for San Leandro, California. They lived there until 1942 when because of the outbreak of World War II, the U. S. government interned all Japanese Americans. The government relocated the Kobayashi family to the Tanforan Assembly Center (a race track) and then to the Topaz, Utah Relocation Center. In 1944 the family was relocated to Hartford, Connecticut and later moved to Wallingford, Pennsylvania. The Kobayshis have remained in the eastern area ever since. In 1963, at the age of 71, Susumo retired from active gardening, took a trip back to Japan after a 40-year absence, and then returned to Philadelphia. He passed away in December 1975.

The Kobayashi family had apparently developed a close friendship with Paul Sabine. A letter in Paul's files, addressed to Miss Sumiko Kobayashi in San Bruno, California, indicated his concern about the ordeal the family was facing about possible internment during World War II. Paul was also concerned about the difficulty Sumiko had in entering a college and he offered some encouragement and assistance.

Don Williams and his sister, Ethylmarie, gave a talk at the Riverbank Acoustical Laboratories, during the late 1980s about their childhood days at Riverbank. They told a story about Sumiko Kobayashi and Colonel Fabyan that illustrated Fabyan's brusqueness. According to Ethylmarie, she and Sumiko plus some other children were all at the pool one day when Colonel Fabyan happened to come by. The colonel noticed that the only one not going into the deep water was Sumiko. After finding out that she could not swim, the colonel ordered her to jump off the diving board stating that it was the only way she would ever learn how. Although petrified, Sumiko jumped, panicked, and had to be rescued after almost drowning.

A Fabyan Scientific Tribute

In researching one of many of the colonel's scientific projects, Marie Frasz, then the curator of the villa, was able to provide me with a photocopy of a written account that substantiates the colonel's valuable efforts in completing one of these projects. The project, as well as the Colonel's efforts, are best stated in the photocopy of the cover, dedication, and acknowledgments of a book that resulted from the completion of a successful project. The book is entitled *The Thinking Body, A Study of the Balancing Forces of Dynamic*

Man, by Mabel Elsworth Todd. From 1937 to 1979, the book had seven printings. Here are a some portions of what was stated about the colonel by the author. The dedication on page 14 read, "Dedicated to the memory of the late Colonel George Fabyan of the Riverside Laboratories of Geneva, Illinois. In grateful appreciation of his vision of the importance to life of the subject matter of this book and of the many aids extended in furtherance of its science."

From Acknowledgements on page 15:

> In dedicating this book to the memory of Colonel George Fabyan, I record my lasting sense of obligation to him for his help during a friendship of many years. The tangible quality of his aid is indicated by the fact that he established a room in his laboratory equipped especially for the use of myself and my assistant teachers, in the study of physics, physiology, and anatomy, as applied to our problems of bodily balance; and by his generosity in furnishing professional instruction and laboratory materials for our use; and by his interest in providing appliances to be used in correction and reeducation of physical maladjustments, including electrical appliances for experimentation in muscle action. All these and many other aids were extended to me because of the vision of a truly great humanitarian.

Mabel Todd recognized the assistance of another Fabyan in the acknowledgements. She wrote: "To Dr. Marshall Fabyan, of Boston, I wish also to express gratitude for his generous and helpful expenditure of time and thought in the years of preparation of this work."

Fabyan-Riverbank Articles after 1936

Newspaper articles about the colonel or Riverbank often appeared in the years following the colonel's death. The inaccuracies in many of these articles is the raison d'être for this book. For example, one author mixed up Colonel Fabyan's X-ray project with Nelle Fabyan's poise classes:

> Not so Scientific, but interesting, were his experiments in developing a "Blue Ribbon Flapper." Disturbed by the languorous droop of the debutante of the 20's, Col Fabyan engaged a staff of physical culture experts to work with some volunteers of the younger set. Attributing their slouched posture to the peculiar dances of the time, he asked: "What will the next generation be like if the women of today have hollow chests?" Announcing later that postures were improving, he remarked: "They are learning to stand erect, not like anthropoid apes just learning to walk."

In any case, the Fabyan legend expanded because of such inaccurate reporting. What follows is a list of a few articles, some good, some inaccurate, which appeared after the death of the colonel:

Aurora *Herald,* August 6, 1939, "Shakespeare Mystery Key in Fabyan Books" by Jayne Miller.

Aurora *Daily Beacon-News,* December 14, 1939, "Buy Fabyan Estate for Park." Reporter unknown (same story printed in other local papers).

Chicago *Tribune,* September 7, 1950, "Fabyan Estate as Fabled as Its Onetime Squire," author unknown.

Chicago *Sunday Tribune,* June 28, 1959, "Estate's Days of Glory Gone; Beauty Stays, Col. Fabyan Home Now Is Forest Preserve" by George Budrean.

Chicago *Sun Times,* September 25, 1960, "George Fabyan Eccentric Genius" by Sarah Boyden.

Geneva *The Chronicle Enterpriser,* January 25, 1984, "Recalling the Days of Col. Fabyan" by Ann Pierotti.

Chicago *Sun Times,* July 1, 1984, "Fabyan's Fabled Legacy" by Gary Wisby.

Geneva *The Chronicle Enterpriser,* July 24, 1985, "Our Own Mad Scientist?" by Molly Bolger.

Chicago *Tribune,* August 10, 1987, "Out of Success Came Legends of Col. Fabyan" by Katherine Seigenthaler.

Illinois Magazine, March–April 1987, "The Far-From Average Fabyan Forest Preserve" by Susan M. Kryger.

"Deciphering Secrets Is Fascinating Occupation" by DuBois K. Wiggins (Newspaper and date unknown).

Historic Illinois, December 1987 "The Fabyans' Fabulous Geneva Retreat," by David Newton.

Geneva Quarterly Magazine, Fall 1988, "Historic Fabyan Forest Preserve" by Ann Wilson (the winter issue of the same magazine covered the scientific goings-on at Riverbank).

The Riverbank Ghost

Through the years a number of odd occurrences or sightings at Riverbank Lab have been attributed to the ghost of Colonel Fabyan. Although I have spent many a night at the lab and have heard some eerie noises and observed strange happenings, I cannot claim to have actually seen the colonel's ghost. Since the night the eagle was struck by lightning, however, no sightings or ghostly noises have occurred.

William Friedman

During World War II, cryptoanalyst William Friedman was reinstated in the army, eventually rose to the rank of colonel and became known as the man who broke the Japanese Purple Code. A book highlighting his career at Riverbank and in Washington D.C. was entitled *The Man Who Broke the Purple.* In the book, the Friedmans did not refer to the colonel very favorably, but it was clear that they loved Riverbank and Nelle Fabyan very much.

There were some at Riverbank who felt that Elizebeth Friedman was perhaps better in breaking certain types of code than her husband. She assisted many civilian companies and police agencies throughout the world. As a team, they were extraordinary. William F. Friedman died November 3, 1969 at the age of 78, and Elizebeth Smith Friedman died on October 31, 1980 at the age of 88. Both were justifiably recognized in the press for their efforts involving codebreaking. Interestingly, one of their last published efforts was in 1957, *The Shakespearean Ciphers Examined.* In the book, they included a

cipher that stated, "I did not write the plays. F. Bacon." In their own clever way they stated their opinion of the initial project that had launched their professional codebreaking and marital careers in 1915 at Riverbank.

The Bacon-Shakespeare Controversy

Besides the Friedmans's repudiation of her findings, others also feel that Elizabeth Gallup's theory about Sir Francis Bacon was out of the realm of fact and that she never would have been able to provide substantial proof to convince historians and the British Parliament of her theory. However, an ever-increasing number contend that Gallup's theory is correct, and it is only because of the arduous task of changing the history of Shakespeare and the money his name provides to England that the British Parliament ruled her findings nonpersuasive. Also there were allegations made by Gallup that Sir Francis Bacon could have been the illegitimate son of the queen, allegations now shared by others.

As far as the work done at Riverbank on the Baconian codes, Jane Miller expressed a viewpoint different from the Friedmans in the *Herald* on August 6, 1939; the article was entitled "Shakespeare Mystery Key in Fabyan Books":

> Who wrote Shakespeare? This question of the literary world has had as many answers as there are Shakespearean authorities. Some claim it was Francis Bacon, who they are sure was the illegitimate son of Queen Elizabeth and heir to the English throne. Others say the plays were not the work of any one man. And a few scholars will even give credit to William Shakespeare himself.
>
> Col. George Fabyan, multi-millionaire cotton broker, spent fifty years of his life and a fortune endeavoring to solve this question. He collected an unequaled library of first and only editions of Elizabethan authors. His agents scoured the world buying rare code books which he used to decipher the works of Shakespeare. Just as the colonel was on the verge of solving this controversial issue, death put an end to his work.
>
> Shakespearean authorities in Chicago yesterday voiced a demand that the work to which Col. Fabyan gave his life should not stop with his death. His famous library was left in the will of his widow, Mrs. Nelle Fabyan, to the Congressional Library in Washington. Thus Shakespearean scholars feel, the government is in a position to fulfill Fabyan's ambition and settle once and for all the question of who wrote the plays of Shakespeare.
>
> Of his library, Miss Adele Cumming, secretary to Mrs. Fabyan and coexecutor of the estate, said: "Even in his boyhood the colonel was very interested in ciphers. They became a ruling hobby with him and he spent a tremendous amount of money collecting rare old cipher books. In his collection are several originals of code deciphering books from the fourteenth century.

As the colonel's interest in ciphers grew, he took up the famous dispute about who wrote the plays of Shakespeare. In 1916, his enthusiasm involved him in a lawsuit with Colonel William N. Selig, one of the first motion picture magnates.

Selig argued that Fabyan's contention that Bacon wrote the works accred-

ited to Shakespeare was keeping the movie public away from his epic on the life of Shakespeare. The victory went to Fabyan when Judge Richard S. Tuthill of the Cook County Circuit Court ruled that Fabyan's findings conclusively proved that Bacon was the author of Shakespeare's plays. However, so much pressure was put on Tuthill by the other county judges that he was later forced to recant his decision.

Throughout the years, the Bacon-Shakespeare controversy cost the colonel more than $500,000. Of his research, Cora Jensen, secretary of the laboratory at Riverbank said,

> Although the colonel first believed that Shakespeare's plays were the product of Francis Bacon, by the application of Bacon's bi-lateral cipher to the books of Elizabethan authors such as Shakespeare, Bacon, Marlowe and Spenser, he became convinced the writings of that period were the work of the Rosicrucian Society. ... This society controlled all the printing of that period. The colonel believed that everything printed under their auspices had an underlying meaning known only to those who could decipher the code.
>
> Col. Fabyan's interest in ciphers led him into further fields. Through their mutual hobby he met Dr. Wallace Sabine, acoustics authority of Harvard University. To help Dr. Sabine in his work the colonel built in 1918 an acoustical laboratory on his estate. Dr. Sabine died before he could make use of the fine collection of instruments and the laboratory was turned over to Dr. Paul E. Sabine, a cousin of the Harvard professor, who is still in charge.

Supporting the colonel's later theory regarding the Rosicrucian Society was an April 14, 1989 PBS television program entitled *Frontline: The Shakespeare Mystery.* The viewpoints of notable British and American writers, historians, scholars, and researchers that strong doubts exist that William Shakespeare wrote the plays attributed to him. Although Sir Francis Bacon was included as a candidate for authorship, the program indicated Edward de Vere, the seventeenth Earl of Oxford was a more likely choice. Near the end of the program, the commentator stated that because some of the theories presented were based on circumstantial evidence, the mystery still remains.

On August 7, 1989 a descendant of the earl, Lord Charles Buford, further supported the claims made on the television show in an article written by Bentley Boyd and printed in the Chicago *Tribune.* In addition to repeating much of the evidence presented on the PBS program, other accounts of Lord Buford's efforts to prove that the earl wrote the Shakespeare plays were cited. Lord Buford was a guest of a retired trader from the Chicago Board of Trade who had provided some financial support to the Shakespeare–Earl of Oxford project and whose hobby was also trying to prove that Shakespeare did not write the plays.

What perhaps was most intriguing about the colonel's theory was that in the opinion of some experts, both on the television show and those quoted in the articles cited earlier, more than one person had to be involved in the

Shakespeare writings. Essentially what they deduced, as highlighted in the television program, was similar to the argument expressed by Mark Twain. Mark Twain had realized how significant it was for him to have participated as a river boater to describe accurately life on the Mississippi. It was because of this realization that he questioned Shakespeare's authenticity. Mark Twain realized that besides experiencing the various changes in the landscape and the presence of many hazards along the Mississippi River as described in his writings, his learning of the unique language and terminology used by the captains and crews of the Mississippi River boats required a long time of personal exposure. Thus, to achieve the high degree of expertise and knowledge of all the various disciplines and verbiage described in all the plays and sonnets of Shakespeare in the short time span that they were written would have been impossible for any one individual to accomplish. George Bernard Shaw expressed similar views as well.

In January 1991 I received correspondence from Ian Taylor, a writer affiliated with TFE Publishing in Toronto, Canada. Taylor had written an article, "Francis Bacon and the Scientific Method," that appeared in the Winter 1989 Creation Science Association of Ontario *F.E.A.T.U.R.E.* Taylor referenced historian James Spedding's 1861 seven-volume work on the life of Francis Bacon as the orthodox account. Taylor went on to say, "However, other researchers since that date have unearthed more material and the mystery surrounding Bacon's life and silent years has slowly been revealed. It is a remarkable story."

What followed was yet another account that supported Colonel Fabyan's claim that Bacon was the son of Elizabeth I. Taylor's article states that Francis Bacon was born to Elizabeth in 1561. The father was Lord Robert Dudley, who, at the time, was married to someone else. Eventually, Taylor contends, Lord Dudley and the queen were secretly wed, and Francis Bacon was a legitimate heir to the throne. Because of Elizabeth's virgin-queen image, however, and the political climate of the times, she was never allowed to acknowledge Francis Bacon as her rightful heir.

As for Riverbank's involvement with the Shakespeare project, when the colonel died, so did his project. Perhaps the answer lies somewhere in the collection of the colonel's books and notes, now somewhere in Washington. The unanswered question is why, after all the other cutbacks in his projects at Riverbank because of the Depression, Elizabeth Gallup's passing, and the Friedmans's strong disbelief in Gallup's and the colonel's theory, would Colonel Fabyan continue to spend money on the Shakespeare project? Did he find some new evidence later in his vast collection of books. Some believe he did, especially when he changed the focus from Bacon to the Rosicrucian Society.

As far as linking architectural acoustics to Shakespeare, well that's a piece of cake. Obviously, most of you are aware of the Shakespearean phrase, "To

be or not to be — that is the question." Well, in acoustical terms, one way to state this phrase is, "Two dB to no dB, that is the question. Can you hear?" Obviously, a modern Shakespeare — or whoever wrote the plays — I am not. (However, acousticians will say that my pun has acoustical merit, because many theoretical accounts state that it takes a difference of three decibels before humans can detect a change in sound intensity.)

A Colonel Fabyan Story Regarding Bacon Documents

This is a story that may never be published: In 1994 Mr. Frederic R. (Robin) Sherwood of Victoria, British Columbia visited Riverbank and told a fascinating story about Colonel Fabyan and Dr. Orville W. Owen of Detroit that he was still researching and planned to publish in the very near future. The story involved some unusual events that resulted from the Baconian ciphers, including a trip to England, where a river was diverted in search of some of Sir Francis Bacon's documents. As promised, I did not include the story in this book but I am referencing it here because on September 3, 1995, Mr. Sherwood passed away and perhaps someone else may want to follow up on it.

The Sabine Family

The following material expands on the information and stories already presented about various members of the Sabine family.

The Sabine Roots

One question that I am often asked is, What was the relationship between Wallace and Paul Sabine? The most common answer is distant cousins. Another answer is that they shared the same great-grandfather.

However, after spending hours in various libraries throughout the country, I found some interesting facts about the family roots that didn't agree with what others had written. How delighted I was to find out later that my findings were correct, even though, had I had the information earlier, it would have saved me a lot of time and concern.

In January 1990, Paul Ballard Sabine, Paul Sabine's grandson, delivered some files of his father, Hale Johnson Sabine. One file contained documentation of what Hale Sabine designated as the "Sabine Roots." Most rewarding was the fact that his account corresponded with my research on the subject matter as well as provided some additional maiden names. What was most gratifying to find in these files was additional information that eliminated a dilemma encountered early in the research.

The Wallace Sabine biography and other related documents that followed stated that Professor Sabine was a descendant of Sabines of French Huguenot origin. When researching the family tree, I had difficulties in finding the French connection. Fortunately, Hale Sabine's file provided more in-

sight on the subject. In the file, Hale had a copy of his letter dated April 6, 1979. Apparently, copies were either sent or intended for six immediate family members and various cousins. In the letter, Hale Sabine had the following to say regarding his family roots:

> You might be interested in the attached article on the Sabine roots in England before our first American ancestor William Sabine came to Rehoboth, Mass. in 1643. This seems to dispel pretty conclusively the longstanding belief in the family that we are descended from French Huguenots taking refuge in England. Instead, the line seems to be all English for quite a way back, although the exact lineage prior to William is subject to speculation in the article. It's interesting that the name had many spelling variations including the *E* on the end.

The article Hale referenced is entitled "The Surname Sabin(e), Its Origin and Development, From Circa 1200," by William Henry Waldo Sabine of London, England, reprinted from the New England Historical and Genealogical Register. From our research, some help from Hale Sabine, and this article, the Sabine family tree in America appears to be as follows:

William Sabin (no *e*) came to America in 1643. He lived in Rehoboth, Massachusetts, and fathered twenty children. He died in 1687. One of his sons, Benjamin, was born in 1646. Benjamin Sabin was first married to Sarah Polly in 1625, and they also lived in Rehoboth. They moved to Roxbury, Connecticut, in 1675. In 1676, they moved to Woodstock, Connecticut, until 1705, when they moved to Pomfret. Sarah died, and Benjamin remarried in 1678 to Sarah Parker. They had a son in 1681 named Nehemiah (1), (the bracketed numbers are added throughout to avoid confusion). Nehemiah Sabin (1) married Eliz Boyden; while living in Medfield, Massachusetts, they had five children. The fifth child, Nehemiah (2), was born September 9, 1713. Nehemiah Sabin (2) married Ruth Cooper in 1735. They had three children; the last born in 1741 they named Nehemiah (3). Nehemiah Sabin (3) married Mary Rice in 1763. They had eight children. One son they named Nehemiah Sabin (4); another son they named Elijah Sabin. Elijah Sabin was born on September 10, 1776. He became a Methodist clergyman who married and had a son, Lorenzo, born on February 28, 1803. It was Lorenzo who later changed the family name to Sabine when he became the Honorable Lorenzo Sabine, a lawyer in Boston.

Nehemiah (4) was the link to both Wallace and Paul Sabine. He was their great-grandfather. Nehemiah (4) was a pioneer preacher who moved to the Darby Plains in central Ohio. He had eleven children. Two of his children were the brothers John Fletcher Sabine and Charles Fletcher Sabine. John, Wallace's grandfather, moved to Marysville, Ohio, and was elected county auditor and married Euphemia Clement. They had a son, Hylas, on July 5, 1829. Hylas would later graduate from the Harvard Law School. Before becoming a state railroad commissioner, a state senator, and a delegate to the Republican convention, Hylas was a farmer and editor-publisher of the

Union Press and had established the town of Richwood, Ohio. Hylas married Anna Ware on October 8, 1857. She was the daughter of Jacob Reed Ware and the former Almira Wallace. They had two children Annie (Tottie) Sabine and Wallace Clement Sabine (June 13, 1868), nicknamed Tinto.

At the age of thirty-two, Wallace married Jane Downs Kelly (August 22, 1900), a physician. They had two daughters, Janet (October 23, 1903) and Ruth (July 8, 1906). Ruth died at the age of sixteen and Janet eventually married Frederick T. Ley. They had a daughter, also named Janet (2) Wallace (1925). Janet (2) married Colonel Fred Bess; he changed his name to Ley. Another account of the Janet Ley (1 & 2) story follows this segment.

The Paul Earls Sabine branch of the Sabine tree is still growing. Charles Fletcher Sabine, Paul's grandfather, married Diana Stoddard, and they had two sons, Charles Jr., Paul's father, and Lorenzo, Paul's uncle. Charles Jr. followed in his father's and grandfather's (Nehemiah 4) footsteps by joining the clergy. He was a circuit Methodist preacher in the southern Illinois area. Charles Jr. married Rebecca McLeod, and they had three sons: Paul Earls Sabine, Ralph Stoddard Sabine, and John Randal Sabine. Paul, at the age of twenty-seven, married Mabel Johnson on December 27, 1906 and they would have two sons. Paul's younger son, Richard Wallace Sabine, born February 17, 1916, would marry Sarabelle Kesseler on April 29, 1939. They had two sons: John David Sabine, born November 4, 1942, and Richard Bruce Sabine, born October 10, 1947. Paul's older son, Hale Johnson Sabine, born October 23, 1909, married Majorie Alice Ballard on September 19, 1936. They had two sons: Paul Ballard Sabine, born October 22, 1938, and Charles Pruden Sabine, born June 4, 1941. Mabel Sabine died September 29, 1929. On April 16, 1938 Paul married Cornelia Corron Manley.

Janet Sabine Ley and Leo Beranek

An interesting account of the everlasting attempt to fill in the missing gaps of the Wallace Sabine legacy again comes from the renowned acoustician and Wallace Sabine historian, Leo L. Beranek. While Leo was reviewing the Riverbank files of Wallace Sabine in 1979, he received information that a Mrs. Frederic Alexander Ley (Janet) was alive and well in Philadelphia. The anticipation of interviewing Janet Sabine and filling in the Wallace Sabine gaps fulfilled a dream that Leo never thought possible. As it turned out, however, Leo's dream remained just that. He had found that Frederic Ley had remarried after his first wife (Janet Sabine) died, and by coincidence, his second wife was also named Janet. It was the latter about whom Leo had been informed. Consequently, Leo was not able to come up with any new information regarding Wallace Sabine other than Ley (pronounced "Lie") and Janet Sabine did have a daughter who they named Janet Wallace. However, Leo was told that she, too, had passed away. As it turned out this was not the case.

In 1986 Leo's quest for more information about Wallace Sabine was par-

tially fulfilled. This time he was informed that a Mrs. Janet Ley of Williamstown, Massachusetts had contributed to the Boston Symphony Orchestra fundraising drive and that she had mentioned that her grandfather was involved with the acoustics of the Boston Music Hall. Leo visited Mrs. Ley (61) and found that she possessed some material regarding Wallace Sabine that was given to her by her mother Janet (1) Wallace Ley. Although most of the material involved the documents used in the Wallace C. Sabine biography written by William Dana Orcutt, Leo was able to come up with a few new finds. Leo mentioned that Janet (2) Wallace Ley said that her grandparents pronounced Sabine as Say-bine, not Say-bin.

Leo had to explain away my puzzled look over the granddaughter's name, "Mrs. Janet Ley." Leo stated, "It's simple; her husband changed his name to Ley when they were married." Throughout the years I have known him, Leo Beranek often demonstrated an extraordinary ability to quickly resolve a dilemma by asking the appropriate questions. Sometimes, as was the case in researching the life of Wallace Sabine, Leo either had to resort to deductive or inductive reasoning to reach certain conclusions. Then, later, when new information was obtained, these conclusions were proven most accurate. Many new findings mentioned in the preceding chapters confirmed some of Leo Beranek's earlier published conclusions. Although Leo Beranek and I coauthored one article for the *Journal of the Acoustical Society of America* and jointly gave a presentation at a national ASA and local Boston chapter meeting, our professional paths rarely cross. Occasionally, because we both are members of the ASA History and Archives Committee and on the committee that organized the Sabine Centennial celebration, we do see each other at various ASA meetings. Most of our discussions through the years have occurred by mail or on the telephone and have typically centered on the Sabines. I owe Leo much gratitude for his guidance and inspiration involving the Sabine files located here at Riverbank. Most assuredly, without his support, the data in those files for all intent and purposes would never have been compiled.

A Wallace Sabine Reference Book

In 1990 I stumbled on a book in the files that had Wallace Sabine's signature on the inside cover. The book might have been one of the professor's reference books. The book is *Sound and Music, An Elementary Treatise on the Physical Constitution of Musical Sounds and Harmony,* by Sedley Taylor, M.A., former fellow of Trinity College, Cambridge. Third edition. London: MacMillan and Co. 1896.

Cornelia Sabine

I remember how surprised I was in 1980 to find out that Cornelia Sabine was alive and well in Colorado. I telephoned her and, in short order, made some

dumb comment about how alert and responsive she was to my questions. Cornelia Sabine stated, "I suspect that, although your comment is complimentary in intent, you are undoubtedly equating my age to what Paul would have been if he were still alive (101), rather than my present age of 70. You see, I was 28 years old when I married Paul, who was 59."

I remembered at the time how I wanted to crawl under my desk and die. Many years later on the way to an ASA meeting in California, I stopped off in Colorado Springs to give her a copy of the first draft of this book. As expected, she was indeed most proper, polite, and charming. I recalled how awed I was by her astute sharpness and comprehension of everything we discussed. I automatically became unsettled and remember thinking: Please God, let this day pass without me saying anything stupid. Cornelia Sabine sensed my uneasiness in being there and knew I had strong feelings about not being a professional writer, a murderer of the English language, and having a why-me attitude in regard to writing a book about the Sabines. Somehow, Cornelia turned the entire situation around; by the time I was ready to leave, I was feeling, as they say, good all over. I recall thinking how inspiring and wonderful the day turned out. By day's end, I wished I could have stayed in Colorado Springs a while longer. Although we both agreed that the book definitely required professional editing, I realized that Cornelia Sabine appreciated all my research efforts. In 1990, on her eightieth birthday, she visited Riverbank.

Cornelia Sabine was instrumental in getting this book edited; unfortunately, the book never reached the level of editing she desired. Cornelia Sabine felt that the book should be divided into three parts or three books about the colonel, Paul Sabine (Riverbank past), and Riverbank today.

Paul Sabine's Hearing Problem

While visiting Cornelia Sabine, she mentioned, "You know Paul had a void in his hearing at the very high frequencies." Just that one simple statement by Cornelia resolved a problem that had driven Riverbank personnel crazy for years. The problem was why on earth was 4000 cps (cycles per second) used rather than 4096 cps that would have been in line with the C-octave bands used at the time. The test frequencies in the 1930s were 128, 256, 512, 1024, 2048, and 4000 cps. The answer is now obvious: Paul couldn't hear it. Cornelia's comment clarified a statement made by Paul in a letter to Augustus Pohlman. Paul stated, "Since you realize my measurement problem above 4000 cps ... ." At the time I first read Paul's comment, I did not relate what he said to his hearing but rather to testing difficulties associated with perhaps either room instrumentation, humidity, or temperature.

What made the entire situation even stranger was that the other labs used the same frequencies. Obviously, Paul Sabine had some influence. By the way, today's test frequencies also include 4000 Hz in the 1/3-octave band.

Riverbank Laboratories

A clarification and technical update of my explanation of the merits of the Wallace Sabine test chamber (Room 0) follows: To head off anyone likely to pounce on a generalization, it should be pointed out that theoretically or acoustically speaking, any room, including the Wallace Sabine Riverbank test chamber, has what is commonly referred to as its own inherent acoustical characteristics (vibrations).

Besides room volume, surface area, and shape, an acoustical test room must meet a multitude of criteria, many of which are frequency related. A test room's fundamental frequency, critical frequency, resonant frequency, and the ever-popular normal or natural frequencies are all taken into consideration when determining the acoustical properties of a test room. Then there are other frequency-related requirements that center on a test room's modal distribution or modes of vibration which include spatial distribution and averaging characteristics. Traveling waves, axial waves, oblique waves, tangent waves, standing waves, and seismic waves should all be accounted for. Then, of course, one cannot forget situations involving diffuse fields, near fields, corner and edge effects as well as peaks, dips, nodes, and — perish the thought — voids. Diffusivity, diffraction, deflectors, and rotating vanes are also theoretical areas of concern involving standard deviation and 95 percent confidence limit measurement requirements. Of course, the room's barriers (walls, floor, and ceiling) offer potential problems associated with transverse, flexural, and shear waves, which must be considered because each could limit the rooms transmission loss capabilities. You also can not forget possible flanking paths or isolation characteristics to achieve acceptable ambient sound pressure levels. After all this, provisions for stringent air change, temperature, and humidity requirements are also needed to precisely define a set of measurements.

Because various acoustical test standards will address one or more problems, a laboratory must satisfy all these requirements. If they do, then and only then, can one claim to have a good acoustical test chamber. Given these parameters, the Wallace Clement Sabine Chamber (Room 0) at Riverbank is a very good test chamber. Perhaps former Riverbank manager Frank Tyzzer said it best:

> The very live and highly reverberant test chamber designed by Wallace Sabine limits quite extensively any inherent or exterior structural vibrations that could reflect false information in conjunction with whatever sound absorption, sound power or sound pressure measurements are being conducted.

The Test Chamber, Past and Present

The only differences in the test chamber today from what Paul Sabine used in 1929 — other than, of course, the rotating vanes, the equipment and instru-

mentation — are the temperature and humidity conditions. Paul Sabine maintained a ten degree variance in temperature in the testing chamber — from fifty-eight to sixty-eight degrees — an admirable mark of consistency, considering the type of room-conditioning equipment available in 1929. Today, with better environmental controls, Riverbank holds the room temperature at plus or minus two degrees and the humidity plus or minus two percent.

Another slight modification is the increased room voltages. When Riverbank had to provide 440-volt service within the chamber, it was necessary to have a feed-line hole drilled through the test chamber walls. A Geneva contractor was called in for a quote and he brushed the task off as a simple job and stated a price accordingly. The next day his worker showed up and started drilling the hole. It was amazing how he managed to pick the precise location of a matrix junction for the spring steel. After two days and many drill bits, the contractor returned and stated that although his company definitely could use the work, please do him a favor by never calling him again to drill a hole in the test room walls. Now, whenever we call that contractor to do work on other things, he always quotes us an hourly rate.

The Wallace Sabine Riverbank Organ Pipes

On July 30, 1991 Riverbank employee, Brian Hornig, and student summer helper, Laron Hafenrichter of the University of Illinois were cleaning out a mountain of used insulation in the warehouse when they noticed some metal pipes. The pipes were all in a one-stack (smaller inside the larger) configuration. Brian informed me that they might have stumbled on the organ pipes that are in one of the pictures in the museum. I checked and found that the pipes were indeed the Sabine pipes. They are now in the museum.

Elmer and Elmira

In August 1941, a letter from a client asked Paul if he was going to introduce Elmer (the name given to the dummy head used for hearing tests) to Charlie McCarthy. Paul replied that he had asked Elmer how would he feel about meeting Charlie McCarthy and that without batting an eye, Elmer said, "I think that guy talks too damn much."

For one reason or another, besides their use in hearing aid tests, Elmer and his lady friend, Elmira (another dummy head), have been used throughout the years for various pranks. Each head was mounted on a pole and stand that placed the head at about a four-foot height. Both had painted faces and, on occasion, were dressed up and placed at various strategic locations throughout the laboratory. One favorite location for Elmer was in a room that doubles as a utility sink area and the ladies powder room. Because of the L-shaped design of the room, Elmer was placed in such a way that he usually wasn't noticed by the occupant until the unsuspecting person had locked the door and was seated on the toilet. The sudden awareness of what appeared to

be a man dressed in a tuxedo leering at the occupant usually resulted in a scream or a hysterical "Will you guys quit it!"

Unfortunately, Elmer met his end at IITRI. Being used for an acoustical project, he was left unattended and was accidentally knocked over by a fork lift and crushed, a most gruesome ending for a pioneer in acoustical testing. Only Elmer's picture remains and hangs proudly next to a picture of the love of his life, Elmira, in the Riverbank museum.

Every once in a while, we receive a call from someone researching early hearing tests. The caller asks if they can speak to Elmer or Elmira, and usually a lengthy explanation results.

On one occasion, Elmer and Elmira were referred to in a paper presented at an ASA meeting by a student of a nearby college as two Riverbank scientists who were quite involved with hearing aid studies during the pioneering days. Immediately, heads turned toward me with those typical facial expressions that express knowledge of an error — smirks, grins, and head shaking. I merely acknowledged their awareness with a shrug of my shoulders. I then remembered trying to guess who would be the one to tell the young speaker during the question-and-answer period afterward because historically, there are those who enjoy any opportunity to demonstrate their scientific wisdom. Oddly enough, without the respective inputs the meetings would be far less entertaining and definitely less informative.

In 1991 Elmira was used by an acoustical consultant for a field test. Fortunately, she was in style. Prior to the project, Riverbank employee Peter E. Straus had taken Elmira home, and he and his family spruced her up. Once again, Elmira stands proud in the Riverbank museum.

The Tuning Fork Facility

The Riverbank tuning fork remains today the finest of its kind in the world. What was originally the colonel's garage is now a beehive of activity and is designated as Riverbank Laboratories Inc., owned and managed by Richard A. Schlindwein. Schlindwein and his staff are responsible for the manufacture of a variety of tuning forks as well as their recently introduced choir chimes. The business is flourishing with a worldwide list of customers primarily involved in the medical, electronic equipment, music, and teaching professions. Riverbank Laboratories Inc. is an independent operation not associated with IIT Research Institute's Riverbank Acoustical Laboratory.

RAL-IITRI Past and Present Employees

The following is a list of past and present Riverbank, IIT Research Institute (IITRI), Armour Research Foundation (ARF) employee-acousticians or administrators who provided services for acoustical related activities and whose names appear in the Riverbank files. The IITRI main files were never researched, therefore acousticians and their administrators whose names

were not in the Riverbank files are not listed. The letter designations after each name are defined as follows: A, acoustician; D, Director; LD, laboratory designer; M, manager; O, owner; P, president; S, secretary; and SP, supervisor.

Abbe, Fred (A)
Ancell, James (A)
Bellsford, Dorothy (S)
Benson, Robert (A)
Bonvallet, George (A)
Burkhard, Mahlon (A)
Callaway, Daniel (A)
Cumming, Adele (S)
Dawson, Raymond (A)
Eisenhour, Bert (LD)
Fabyan, George (O)
Fieth, Kenneth (A)
Fitzgerald, James (A)
Hall, Harry (A)
Hedeen, Robert (A)
Homans, Brian (A)
Howard, Robert (A)
Hrdina, Donald J. (A)
Huntley, Ralph (A, M)
Johnson, Kenneth (A, M)
Jones, Kenneth (A)
Joyce, Richard (A)
Kerfoot, Robert (A)
Kranz, Fred (A)
Lawre, W. E. (A)
Lowe, Michael (A)
Lubman, David (A)
McKee, Keith (D)
Morrison, David (D, P)
Mundy, Arline (S)
Olson, Elmer (A)
Perrone, Diane (A, S)
Potter, S. M. (A, SP)
Purcell, Ernest (A)
Ramer, Luther (A, M)
Richards, Roy (A)
Sabine, Hale (A)
Sabine, Wallace (A, LD)
Schechter, Howard (A)
Schulman, Steve (A)
Schwartzbart, H. (A)
Siekman, Bill (A, M)
Alcorn, Robert (A)
Anderson, Albin (A)
Benson, James (A)
Bishop, D. E. (A)
Bulet, Richard (A)
Caccavari, Cosmo (A)
Collings, Nick (A)
Davis, Donald (A)
Dorring, Karin T. (S)
English, John (D)
Fieldhouse, Irwin (D)
Firestone, Floyd (A)
Graneth, John (D)
Hardy, Howard (A, SP)
Hewitt, F. G. (A)
Hornig, Brian (A)
Howes, Maurice (D)
Hruska, Gail (A)
Jensen, Cora (S)
Johnson, Larry (A)
Jones, Randy (A)
Karplus, Henry (A)
Kopec, John (A, SP, M)
Krowzack, Frank (A)
Leedy, Hal (D)
Lowry, William (A)
McAuliffe, D. R. (A)
Mintz, F. (A)
Moschandreas, Demetrios (D)
Norman, Renny (A, M)
Pernet, David F. (A)
Pohlman, Augustus (A)
Prusa, James (A)
Raelson, Verner J. (A)
Reiffel, Leonard (D)
Ronk, Don (A)
Sabine, Paul (A, M)
Sanders, Guy J. (A, SP)
Schramm, Scott (A, M)
Schultz, Elmer (D)
Scott, John (P)
Simmilink, Andrew (A)

Sperry, William (A, M)	Stapleton, Robert (A)
Straus, Peter (A)	Swenson, John (A)
Tinberg, Elizabeth (S)	Tung, Vincent (A)
Tyzzer, Franklin (A, M, LD)	Valela, Richard (A)
Valentino, Anthony (D, VP)	Viergutz, Owen (A, M)
Victor, Dean (A)	Vogt, Arthur (M)
Warren, Robert (D)	Whymark, Roy (A)
Wilkomer, R. (A)	Williams, Don (A)
Winchotke, Horst (A)	Wright, Nobert (A)
Zedonis, David (A)	Zedonis, Donald (A)

Riverbank Management Designations

The Riverbank director designation remained after Paul Sabine's retirement in 1947. Although the ARF, renamed in 1962 the IIT Research Institute (IITRI), took over the facility and had a different title structure involving president, vice president, director, manager, supervisor, and so on, the duties of a director entailed a much wider spectrum of research endeavors. The title of the individual in charge of the Riverbank operations changed from director to manager to acoustical liaison engineer to chief of acoustical testing to supervisor and back to manager as it is currently.

A list of the individuals responsible for day-to-day operations, with their pertinent years bracketed and their respective titles follows. In some cases both the on-site RAL and the IITRI-Chicago person responsible are included, with the latest title first.

George Fabyan	1918–1936	RAL Owner-President
Wallace Clement Sabine	1918–1919	RAL Director Designee-Designer
Paul Earls Sabine	1919–1947	RAL Director-Dean
Luther Ramer	1947–1953	RAL Director-Physicist
Ralph Huntley	1953–1963	RAL Director-Manager-Supervisor
Frank Tyzzer	1963–1966	RAL Director-Manager-Physicist
William Siekman	1966–1972	RAL Director-Manager Research Engineer
Kenneth Johnson	1972–1974	IITRI Assistant Research Director
Renny Norman	1974–1981	IITRI Manager-RAL Manager
Owen Viergutz	1982–1984	IITRI Manager
Scott Schramm	1985	IITRI Manager
Arthur Vogt	1985–1993	IITRI Manager-IITRI Supervisor
John Kopec	1974–1996	RAL Manager-Supervisor Chief Liaison Engineer

Note: At various times between 1972 and 1982, Keith McKee, doubled as IITRI director and RAL manager and filled in as the corporate person responsible for RAL operations until a new manager could be found. There were a few other times in Riverbank's history that either Haldon Leedy, Irwin Fieldhouse, and John Granath did likewise.

Riverbank Secretaries

What appeared to be a simple task at first — establishing who were the secretaries during the various periods of the Riverbank story — turned into a major undertaking. Much of the early correspondence came out on stationery with just the word Riverbank, which involved the entire estate, or on Fabyan Bliss Corporation letterhead. Then, in 1923, the name Riverbank was incorporated and covered both the tuning fork and acoustical laboratories. When the colonel died in 1936, the Riverbank trustees also required secretarial services. In 1947, RAL became a separate identity under ARF (later IITRI). And, until the 1950s, various Riverbank secretaries provided services for any one or more of the three facilities.

One of our best sources was Elizabeth Tinberg, who left Riverbank in 1953. At the time of her departure, she was providing secretarial services for the trustees, the tuning fork facility, and the acoustical laboratory. Before leaving she trained her replacement, but she was not able to recall the trainee's name, only that the trainee did not stay long. The names of Anna M. Van Haelst and Miss Paterson appear in the files, and perhaps one of them was the trainee.

The succession of secretaries since the 1920s for the Riverbank trustees, Riverbank Laboratories Inc., and the Riverbank Acoustical Laboratories appears to be as follows: At first, Belle Cumming handled much of the colonel's secretarial needs. Then, when the scientific activities picked up, Cora Jensen was brought in. Cora and Belle shared the secretarial duties for all the scientific operations, including the code work, greenhouses, and so on. When Cora Jensen retired in the early 1940s Elizabeth Tinberg was hired. Besides being Paul Sabine's and later Luke Ramer's secretary, Tinberg took on the additional secretarial chores for Riverbank Inc. and was, for a time, the only Riverbank secretary, particularly after Belle Cumming's death in an auto-train accident. Tinberg remained until 1953, and although the name of the woman she trained is uncertain, Darlene Lund took over the secretarial tasks for the Riverbank trustees and the tuning fork operations and she was followed by Marjorie Hahn. Eventually, Lois Williams replaced Marjorie. In 1987, Lois died and was replaced by Deborah (Debbie) Franklin. In 1992, Mariam Schlindwein took over the secretarial duties for the tuning fork operations.

In 1953 Arline Mundy started. She was hired by ARF/IITRI on a part-time basis as secretary for RAL. Arline became secretary for Ralph Huntley followed by managers Frank Tyzzer, William (Bill) Siekman, Howard Johnson, Renny Norman, Keith McKee, and Owen Viergutz. Arline remained until 1982 when she retired as Mrs. Riverbank. Before leaving she trained her replacement, Diane (Haase) Perrone. Diane was secretary for RAL managers / supervisors Owen Viergutz, Scott Schramm, Arthur Vogt, and yours truly.

Later, Diane became interested in the testing portion of RAL operations

and became the first female to be accredited by the Department of Commerce's National Voluntary Laboratory Accreditation Program (NVLAP) Department to do acoustical testing. Because of her involvement in acoustical testing, Diane relinquished her secretarial duties to Karin Tallroth Dorring who was hired in March 1990. Karin was previously employed by the Geneva Chamber of Commerce.

There have been a series of secretarial romances at Riverbank, Inc. and RAL (IITRI). Cora Jensen married RAL Manager Frank Tyzzer, Majorie Hahn married RAL Manager Bill Siekman. Lois Williams was married to RAL employee (Mr. Riverbank) Don Williams, and Diane (Haase) Perrone is married to Riverbank Inc.'s former foreman, Jerry Perrone.

Riverbank Personnel: Past and Present

The following material expands on the information and stories already given about the Riverbank employees.

Elizabeth Tinberg

After leaving Riverbank, Elizabeth Tinberg remained in Geneva, Illinois, until she passed away on August 13, 1992. She was involved with church and community activities. She did a lot of Swedish-to-English or vice versa translation. In a previous discussion with her about Belle Cumming, Tinberg recalled that the woman (Mrs. Harriet Fowler) driving the car when she and Miss Cumming were hit by a train at the Geneva crossing was a former American Red Cross nurse-driver assigned to General George Patton's army. Many Genevans thought how ironic that Belle Cumming survived driving during the war but soon after returning was killed in an auto accident in Geneva. I remembered thinking at the time that what makes the story even more ironic is that General George Patton also survived the war to be killed afterward in an auto accident near a small town.

Arline Mundy

In late 1982, after thirty years of service, Mrs. Riverbank, Arline Mundy, retired. She was a favorite of many Riverbank clients. Arline was one of those individuals who could type faster than the typewriter could respond. While typing, she loved to whistle. One day while at my desk, I found that I was having quite a difficult time humming along with her rendition of As Time Goes By. Suddenly, I realized the problem and mentioned to Don Williams who was seated at his desk, "Hey Don — did you realize that Arline whistles off key?" Slowly Don turned and while looking over the top of his glasses said, "For almost thirty years, I been putting up with that *&%$# whistle. Why do you think I do most of my writing in the control room?"

Arline's voice, however, has become something of an acoustical reference.

In Riverbank's acoustic test data exists a graph of two male voices and one female voice reading street names (station stops) as a subway train approaches the station platform. Well, that was my doing for a project to develop an adequate speaker system for subway stations. Because I had noticed that our voices peaked at different third-octave bands, I taped the voices of Arline, Don, and mine for the experiment. The end result showed that the noise of the subway trains completely masked Don's voice and my voice, but Arline's voice could still be understood by the individuals standing on the platform.

When Arline retired, one of her gifts was a buzzer sound box. Before our new paging system was installed, each employee was paged by a code of shorts or longs or a combination of both buzzes. When an incoming telephone call occurred, we could all hear the ring, and it became automatic to pause to hear who would be paged. After a tolerable time, if no buzz occurred, we would proceed with our work. Because Arline was so popular with our clients, she often would pass the time of day with them and there could be a long delay between the telephone ring and the paging buzz. Often was the case that just when you reached the top of a ladder or headed into a no-phone area, your paging buzz would sound. How we hated that buzzer. When we commented to Arline about the length of time between the telephone rings and the page buzzes she would say, "You don't expect me to be rude with our clients do you?" Like I said, we sure hated that buzzer.

Today Arline and her husband Bill have become world travelers and have given much of their time showing pictures or talking about their travels to senior citizen groups. The Christmas displays at Arline's home are annual classics that on occasion make the local newspapers.

Lois Williams

On January 20, 1987 Lois Williams passed away. Secretary to Riverbank Inc. for many years, she suddenly succumbed to a cancer that had been detected only ten months earlier but thought to have been held in check. As with other great Riverbank women, her passing brought grief and sadness to the staff of both laboratories.

Lois just wasn't around any longer to accompany Don on all those trips they had planned to do together in their newly purchased mobile home

Ralph Huntley Interview

Many that once were in control of Riverbank were interviewed to gather information about Riverbank's past and the Sabines. During such an interview, former Riverbank Manager Ralph Huntley mentioned that he was a physics student at Harvard while Professor Wallace Sabine was there. Instantly, Ralph was slammed with a deluge of questions concerning his confrontations, experiences, and associations with the renowned professor. The onslaught of questions came to an abrupt halt after it was realized that Ralph

wasn't given time to respond to the first question. Ralph took a deep breath and in his deliberate and direct manner stated, "Young man, I deeply appreciate your overwhelming enthusiasm, but you must fully realize that at the time, Professor Wallace Sabine was the Dean of the Harvard Physics Department, and I was but a lowly freshman; thus, any general discussion between us, as was the case, was most unlikely."

After leaving Riverbank, Ralph Huntley went on to help develop the Cedar Knolls Acoustical Laboratory. He later retired in Florida. On October 20, 1995 at the age of 95, Ralph Huntley passed away.

Roger Ames

Although Roger was unaware of it at the time, his observance of the Riverbank tuning fork operation that day involving Nelle Fabyan and the foreman, as noted in Chapter 3, was a preview of where he would be some fifteen years later and would remain until he retired in 1986. Like Don Williams, Roger Ames is called on from time to time to do specific tasks at Riverbank. In 1987, Roger returned to run the tuning fork operation when the regular manager was laid up. Through the years as a Riverbank Inc. employee, Roger worked for Bert Eisenhour senior and junior, as well as the current manager, Richard Schlindwein, and is credited with inventing the Ames tube.

Carl A. Anderson and the Choralcelo

In 1980 Don Williams received a letter from former Riverbank employee, Carl A. Anderson, explaining the merits of the controversial Riverbank instrument, the choralcelo. Other accounts referred to the choralcelo as the Bacon levitation device, but Anderson attributes the instrument to Wallace Sabine in an article that appeared in *Voxcatoe,* in July 1980:

> "Choralcelo" is the name of a musical instrument not commonly found in a dictionary, and is slowly being lost in the encyclopedia. Having the unique pleasure of seeing and hearing such a rare instrument some years ago, here is a brief description.
>
> Basically, the console resembles a theater pipe organ console, with 2 manuals and about 32 tabs. The mechanics of the system includes a bank of approximately 48 signal motor generators of various sizes. All motors are of the synchronous type. The generators are of different frequencies corresponding to the orchestra pitch of the musical scale. When a key is played, the selected frequency from a generator is relayed to an electromagnet on the musical instrument selected by the top tab. Most of the instruments are of the string type, violin, piano, harp, cello, etc. The excited electromagnet then set the selected string in vibration producing the tone of that particular instrument. Other component parts included drums, marimba, etc. By vibrating strings electromagnetically, the musical tones are void of the hammer and pluck sounds.
>
> The Choralcelo musical instrument seen and heard was presumably invented by the late Prof. Wallace C. Sabine, Acoustical Physicist of Harvard U. and was

installed in the early 1900s in the Riverbank Acoustical Lab, Geneva Ill. The lab was owned by Col. George Fabyan. The Choralcelo was dismantled in the early 1940s shortly after the death of Col. Fabyan.

Peter E. Straus

Peter Edward Straus came to the lab in 1984 as a part-time employee. On April 1, 1985 he became a permanent and full-time Riverbank employee. Don Williams took him under his wing as his replacement so that he could retire. Peter not only fulfilled the rigorous demands of doing maintenance and testing but became Riverbank's computer whiz. Strangely, in the early days, Paul E. Sabine would initial the tests P.E.S. One day in 1990, a client called and asked, "Just how old is Pete anyway? I recently saw some 1930s Riverbank data with his initials on it. I surely thought he was much younger than that when I met him."

Another story involving Peter happened just about the time a TV mini-series entitled, *Rich Man, Poor Man* was aired. It starred the actor Peter Strauss. A woman from IITRI's Publicity Department called and asked, "From time to time I understand that noted individuals come to Riverbank, is that true?"

Feeling a little devilish, I responded, "Oh sure. In fact right now in the control room are Peter Straus, Jerry Lewis, and Michael Jackson." That was true, but I somehow failed to mention that Pete was not the actor, and the other two were the actual names of two individuals representing RAL clients. Anyway, there was a pause on her end; then she said, "You're kidding, aren't you?"

Just then Don Williams walked in, and I said, "Hey, guess what? Do you know the country and western singer Don Williams?" "Yes," she replied. "Well, it's your lucky day. Don Williams just walked in." I then went on, "Hi, Mr. Williams. Say! I'm sure you know who's standing in the control room. Will you please introduce yourself and inform the young lady on the line who those gentlemen are?" Don picked up on my ploy and responded with, "Hello, this is Don Williams. To whom do I have the pleasure of speaking?" After explaining who she was, Don said, "Well let me see, oh yes, I see Pete Straus, Michael Jackson and Jerry Lewis. Apparently they are looking at some sound data or something. Well, I'm somewhat in a rush. It's been a pleasure. Here's Johnny." He handed the phone back to me, and after listening to a whole bunch of chatter between the young woman and the people near her, I realized that to prevent a mass exodus from IITRI Chicago to Riverbank, I'd better explain.

For some reason, she never called me again about who's at Riverbank. Heck, I only told her the truth. I just don't understand why she would be suspect about what I might say — do you?

Roy Richards

Roy Richards started at Riverbank in 1946. Later, Roy would become part of Towne, Richards, and Chaudiere, consultants in sound and vibration in Seattle, Washington. Roy contributed material and information that he had on file for use in these writings, and in fact, one of his more recent letters, dated February 25, 1988, mentioned, "Acoustic Levitation has finally arrived — some 70 years after Colonel Fabyan's machine. See pages 496–501 in the February 1988 *ASA Journal.* Of course, it only takes SPL's of 160 dB to achieve it."

Roy Richards provided copies of material that he felt might provide additional input. Included, was a page from the July 1949 issue of *The Scientific Monthly* that was sent to Roy from Paul Sabine, which read:

PSEUDO-SONNETS FOR SENESCENT SCIENTISTS

I

Why must the poet always tune his lyre
To sing of lovers' griefs, of passion's glow;
Why must his song be laden with desire
Or in a minor mode be filled with woe?
Must mossy banks and softly rippling streams
Or daring deeds or melancholy death
Run full the gamut of the poets' themes
And claim the voicings of the poets' breath?
Soft moonlight filtering through the whispering leaves,
Fair swaying daffodils on river's brim,
The vines that clamber over thatched caves,
Ice crystals sparkling on the birch tree's limbs;
The smoke that, through the frosty twilight air,
Suggests the comforts of the toiler's cot —
All these the humble poet sings with care.
These are the counters of the poet's thought.

II

This lurid world of transient loveliness
Awakes the poet's soul to lyric song,
But Nature in her sphinxlike quietness
Serenely weaves enchantment yet more strong
And stirs the strivings of the questioning mind.
For he who seeks the wherefore and the why,
Not satisfied with Beauty, looks behind
Its surface where still deeper meanings lie.
On him fair Nature smiles or frowns in vain,
For, manlike, quite regardless of her mood,
He knows, alike in either joy or pain,
She's always eager to be understood.

So, not beguiled by her soft blandishments,
He would disclose what Nature would conceal.
With eager questions of experiment
He seeks her cherished secrets to reveal.

III

With oh what cunning skill and patient care
He fashions scientific traps designed
To catch elusive Nature unaware
And make her captive to his ruthless mind.
With meters, balances and microscope
He tries to pierce the center of her thought.
"By measurement to know" — this is his hope
That Truth in nets of numbers may be caught.
In terms of matter, motion, time, and space,
Electrons, atoms, molecules, and force,
He bravely seeks her tortuous ways to trace,
And mathematically to plot her course
He catalogues her uniformities
And proudly nominates them "Nature's Laws,"
Neglecting her vexatious vagaries;
He'll not allow effect without cause.

IV

Persistently he questions, till, forsooth,
Discouraged with the never-ending quest.
He wonders: "Does she always speak the truth?
Let Nature take her course, I'll take a rest."
Surprised, that for the time she's not pursued,
Dame Nature drops her mask of seeming guile,
Turns to her weary son in melting mood,
Bestows the favor of her rarest smile.
"You must not take me for a simpleton
And, fretful, charge that you have been misled.
I answer truly but, my foolish one,
My answers still must be interpreted.
I'm but the outer aspect of your mind.
Consider well. Though I admit 'tis true
I give half answers, yet you still must find
The other half, my dauntless son, in you."

Renewed, still eager, but a whit less bold
Humbly he feels new truths within him stir.
His colleagues smile. "He's growing old.
Our scientist has turned philosopher."

Paul E. Sabine
1109 North Weber St.
Colorado Springs, Colorado.

Signed with the handwritten words, "To my good friend, Roy Richards from P.E.S."

RAL Staff Award

In September 1989, RAL staff members Brian Hornig, John Kopec, Diane Perrone, and Peter Straus received the IITRI President's Award for meritorious achievements. Besides an individualized congratulatory letter sent to each of us from then IITRI president, David L. Morrison, the interoffice memorandum announcing the awards stated the following: "Superior performance and industrial revenue growth through teamwork on acoustical testing." During the awards luncheon, Morrison introduced the staff by stating, "When IITRI visitors are asked, of all the IITRI facilities, which impressed you the most? The answer at the top of the list is Riverbank." In 1994 John Kopec received the award. In 1996, the RAL staff, now consisting of Karin Dorring, Peter Straus, Dean Victor, and John Kopec, were once again recipients of this award. Thus John Kopec became the first IITRI employee to receive this award three times.

Geneva, Illinois

Today, Geneva, Illinois and Riverbank complement each other very well.

Geneva is one of the most pleasant places located within the Chicago and vicinity portion of the state map or, as noted elsewhere, within the hypothetical commuter boundaries of Chicago.

Through the years, Geneva has managed to maintain its heritage and traditional ways. Noticeably serene, quaint, and picturesque, Geneva is in great demand by those hoping to find a place of residence in this highly regarded, respectable Fox Valley area.

Every summer Geneva hosts one of the state's more enjoyable happenings, "Swedish Days." Visitors from far and near make their annual trek to this gala event. For an entire week, bargain prices, unusual items, and great food are offered. As well as a myriad of festival-related events, there are contests, sights, parades, and other forms of entertainment. It is a delight for young and old alike. In 1985, Geneva celebrated its sesquicentennial with Jerry Perrone (senior) as the grand marshal.

Throughout the year, Geneva is a favorite place for many of Riverbank's clients. Clients often return for more testing accompanied by business associates, friends, and family they persuaded to come along just to see the place. Besides their tests, usually the first order of the day is a Riverbank tour. Around noon, off they go to their respective favorite restaurant. After periodically checking on their tests, it's off to the various specialty shops located throughout Geneva.

Some of Geneva's shops are designed in the Swedish tradition where a house serves as private residence (home) and/or as a place of business. For

example, The Little Traveler, when approached, appears to be just one very large house containing many rooms. After entering, the patron soon observes that each room contains a specific category of items. Many items fall in the rare or unique category and the prices range accordingly. If one proceeds through each room and follows the same process at the next shop and so on ... and so on, the hours spent shopping add up quickly.

On returning to the lab, the clients and their quests usually bombard the staff with questions and favorable comments regarding the many places they visited or heard about. When departing, many express how much they enjoyed coming here and how both Geneva and Riverbank offer their own one-of-a-kind uniqueness in their respective areas. Because these same visitors express their views of what they saw to others, in time, they create more business. Thus, the Fabyan legend continues to grow, which might be good for business too. In any case, the colonel is still involved with the goings-on at Riverbank and in Geneva. Thank you, colonel wherever you are.

ASA History

One only has to attend an ASA meeting and play musical chairs as you jump from one session to another to fulfill your personal and professional needs. The tremendous scope of topics being covered is unbelievable. Oftentimes it is difficult to choose between concurrent sessions covering related topics of interest. On some occasions, joint sessions are scheduled to avoid such hassles. However, it becomes an individual challenge to fulfill one's own itinerary at the meetings. Other conflicts increase the challenge even more, such as technical committee meetings; technical demonstrations; various tours; special sessions; plenary sessions; commemorative sessions; award sessions; luncheons; product displays; and, of course, meetings with those within your own particular categories of interest.

The ASA meetings are acoustical spectaculars that occur twice a year in various parts of the country. While each location has representatives of the society who put meetings together under the auspices of the national ASA officers and executive council, each of the local area's contingents, in trying to outdo one another, has continually improved the quality and quantity of each successive ASA meeting.

ASA Meetings Past and Present

The ASA meetings through the years were similar to prestigious social gatherings, especially when it came to the attire, which in the beginning was fairly formal. The meetings had an air of refinement, almost snobbish in character. Today, however, the dress code at the meetings has changed considerably. The elders maintain traditional attire but some of the new bloods are creating

a more relaxed and casual atmosphere. For those in between, that is, those who appreciate the tradition but enjoy and prefer the casual attire, there is the problem of deciding which sessions are definitely suit and tie; which are sports coat and tie; which are no tie sessions; and, for the more daring, which are the decorated T-shirt and sweatshirt sessions. The only reason the issue of ASA attire is brought up is that whenever the discussion centers on the transition of the meetings through the years, the most obvious change as observed by the old-timers is the dress.

JASA

The Journal of the Acoustical Society of America (JASA) is another example of the conflict between holding with tradition and moving toward something more indicative of today. It is often asked is why the journal does not ever print more practical material or, at least, a joke, a cartoon, or silly pictures, anything other than the highly technical, academic- and mathematic-oriented text that has been part of JASA since its beginning.

The same question was put to long-time ASA Fellow Leo L. Beranek. Leo, who is a master of brevity, replied that actually an editor of *JASA* tried it once. He included a poem that offended some members and a picture of me, then president of the ASA "shooting the stars," that is, the photo was so captioned and showed me drinking from an elevated beer bottle at an ASA picnic.

Shortly thereafter then Editor Floyd Firestone dutifully, some say under pressure, turned in his resignation. It wasn't until many years later, when honored with a medal, did Firestone, also a former ASA fellow and president, ever return to an ASA meeting.

ASA History and Archives Committee

Fortunately, there are some within the ASA that are making certain that the history of the various acoustical disciplines will be documented. In 1988, the ASA formed the Committee on Archives and History. The original members were William J. Cavanaugh, chairman; Leo L. Beranek; Malcolm J. Crocker; Allen L. Cudworth; Betty H. Goodfriend; Carleen M. Hutchins; and John W. Kopec. The ex-officio members were ASA President W. Dixon Ward, ASA Vice-President Eric E. Unger, JASA Editor-in-Chief Daniel W. Martin, ASA Treasurer Robert T. Beyer, and ASA Secretary Murray Strasberg. In 1990, I became the chairman of the committee.

From the first two meetings in 1988, it was decided that this newly formed committee would first compile an inventory of the location and types of archival and historical material of interest to the society and then develop strategies for maintaining a meaningful historical collection for the multi-dimensional discipline of acoustics. For example, RAL is the location for the museum on architectural acoustics.

Final Recognition of Colonel Fabyan's Pioneering Efforts in Cryptology

In 1993 the National Security Council officially recognized Colonel George Fabyan for his pioneering efforts in cryptanalysis and cryptology training during World War I. The events leading to this award started in 1991 when I responded to a letter of inquiry from Louis Kruh, an editor for *Cryptologia,* a quarterly journal devoted to cryptology. After a few follow-up telephone conversations, Kruh decided that it would be best if he came to Riverbank to see what I, as well as what others in the Fox Valley area, had about the colonel and codes. When Kruh arrived, I gave him a tour of the laboratory and our museum. While we were in the museum, I surprised him with some letters and artifacts I had stored on codes and Colonel Fabyan. Kruh commented on the incredible significance that the letters and artifacts meant to the history of cryptology. He provided me with a most fascinating and incredible account of each item. Shortly after, Kruh began contacting various individuals at the National Security Agency (NSA). About one year later, I received a letter from Vice-Admiral J. M. McConnell, the director of the NSA:

> According to information brought to our attention by Mr. Louis Krush of Merrick, New York, you hold letters from the Secretary of State and others, applauding the service of Colonel George Fabyan and his Riverbank staff at the advent of World War I. Attention was drawn especially to the November 1917 letter from Colonel Van Deman, the "father of military intelligence," which contained these words: "The services you have rendered are not to be estimated in terms of money, and it is a source of regret to me that I am wholly unable to devise a method by which the sense of obligation, by the Intelligence Section in particular, may be fittingly evidence." The subject carefully avoided in the letter was that of cryptanalysis and cryptologic training, now among the responsibilities of this federal agency. Noting that the seventy-fifth anniversary year coincided with the fortieth anniversary of this agency, Mr. Kruh suggested that we might undertake to afford recognition to the memory of Colonel Fabyan and his Riverbank staff.
>
> We are therefore delighted to convey to you, as curator of the Riverbank historical collection and memorabilia, a plaque recognizing these volunteer citizen-cryptologists of 1917 and their assistance to the government at a time of critical need. I trust that you will find an appropriate place to display it, and will bring this belated recognition to the attention of the various organizations and friends of the Fabyans and Riverbank.

The plaque that accompanied the letter reads as follows:

> National Security Agency
> United States of America
>
> TO THE MEMORY OF GEORGE FABYAN FROM A GRATEFUL GOVERNMENT
>
> In recognition of the voluntary and confidential service rendered by Colonel Fabyan and his Riverbank Laboratories in the sensitive areas of cryptanalysis

and cryptologic training during a critical time of national need on the eve of America's entry into World War I.

Presented to mark the seventy-fifth anniversary by the National Security Agency, United States Department of Defense, 1917-1992.

I am very proud of the fact that responding to Kruh's letter, which was originally sent to someone else and later passed on to me, turned out even better than I had hoped. At the time, all I wanted was recognition of the colonel's contribution to cryptology by an authority on the subject. Fortunately, I provided enough information to persuade Kruh to come to Riverbank. We, at Riverbank, as well as many others in the Geneva, Illinois, area are grateful to Louis Kruh. Were it not for him, the colonel would not have received rightful recognition for his achievements in cryptography. To learn more about the award, obtain a copy of the October 1993 *Cryptologia.* Kruh provides in-depth coverage. In the same issue, Kruh wrote "Reviews and Things Cryptologic," which includes an update about Sir Francis Bacon.

Closing Comments

Originally started in 1978, the story of the Sabines at Riverbank was put on a shelf, so to speak, because of the discovery of twelve Wallace Sabine notebooks in the Riverbank library followed by my discovery of the professor's files in a closet. Details of the notebooks were documented by Leo Beranek. Originally, I had compiled the files (in total) in a nonpublished paper which was accepted by the Harvard Archives. Later, Leo Beranek and I authored and published an article for *JASA* covering the highlights of these files. In 1980, I returned to writing the story of the three Sabines and Colonel Fabyan and continued the arduous task of researching information about all four of them.

Through the years many distinguished ASA members have assisted me in various areas centered on architectural acoustics. I often tried to convince myself that researching the files was no problem but I realized that putting it into a publishable format really was not my forté. However, members of the ASA urged me on with the understanding that it would be easier if *I* compiled the information because I had access to the files; afterward, others could polish it up. Accordingly I continued, although at times I felt that I had a strong case for professional harassment against those who urged me on. Yet when all is said and done, I am honored to say that regardless of limitations in writing technique, this document is dedicated to all those ASA members who are concerned about the history of architectural acoustics. I do hope this book does justice to the Sabines, architectural acoustics, Riverbank, and the ASA.

– John W. Kopec

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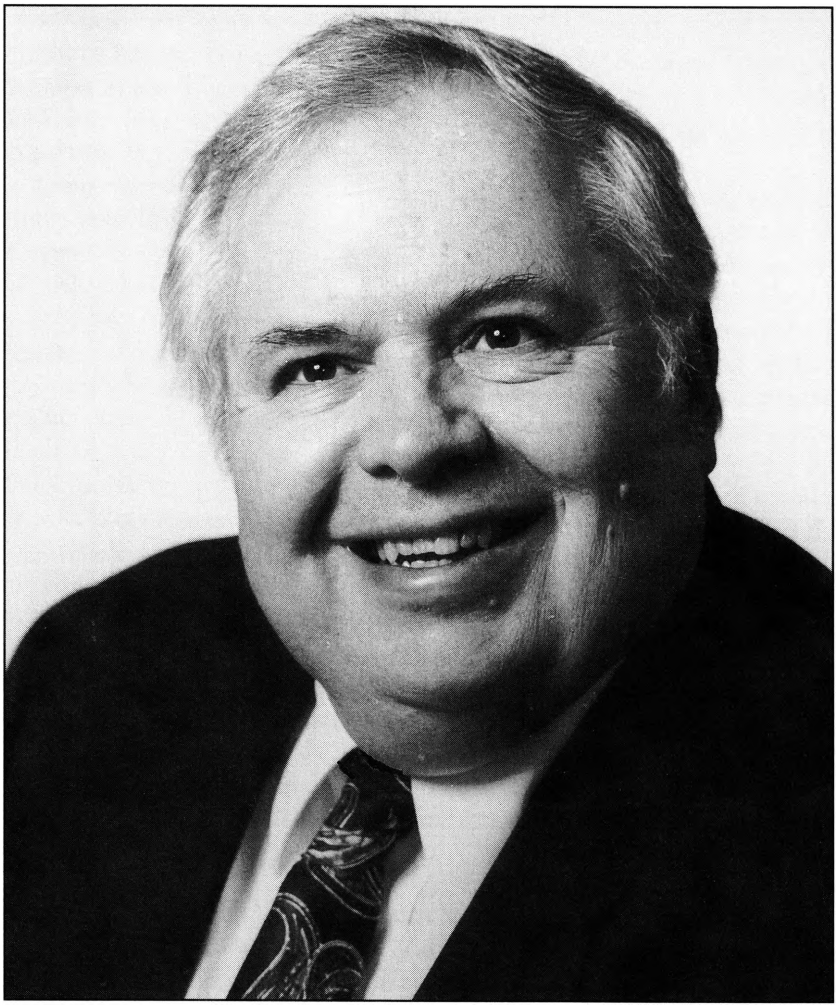
Riverbank files dating from 1900 to 1995 provided a considerable amount of information used in this book. The files are labelled as Wallace Sabine (1900-1918), Paul Sabine (1919-1947), Luther Ramer (1947-1953), Ralph Huntley (1953-1963), and Frank Tyzzer (1963-1966). There are also many Riverbank files involving individuals who were involved with either the IIT Research Institute (IITRI, 1963-1995), Armour Research Foundation (ARF, 1936-1962), and Riverbank Acoustical Laboratories (RAL, 1918-1995). Most of the latter are filed by name.



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John Kopec was born and raised in Chicago. After serving four years in the U.S. Air Force, he attended Chicago City College and the Illinois Institute of Technology (IIT). An employee of the IIT Research Institute (IITRI) since 1961, he manages IITRI's Riverbank Acoustical Laboratories in Geneva, Illinois. Kopec recently received IITRI's *Commitment to Excellence Award* for the third time—the first IITRI employee to achieve that honor. He is a Fellow in the Acoustical Society of America (ASA), a member of the Canadian Acoustical Society (CAS), the American Society of Testing and Materials (ASTM), and the New York Academy of Sciences.

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