where a vocabulary is developed before severe loss of hearing sets in, there is a gradual deterioration of the speech. In both cases visible speech in the forms described here should be of considerable help in speech training and rehabilitation. This has proven true in the case of the congenitally deaf engineer noted above. During the past year, his speech has improved considerably and can be understood quite well by the average person with whom he comes in contact. His work with the translator patterns, however, has emphasized the desirability of providing an indication of the voice pitch.

Unless the acoustically handicapped are able to control the pitch and the volume of the voice as well as the positions of the articulators, their speech will sound unnatural although it may be intelligible. The best ways to display pitch are still uncertain. One possibility is by means of a wave trace perhaps below the pattern; another by a fixed trace, in which the line intensity is varied in proportion to the fundamental frequency. The latter is simpler from an apparatus standpoint, but in a first experimental use seemed less acceptable as an indication.

There remains to be discussed, potential uses for these sound patterns in various fields of specialized acoustics for purposes of analysis and illustration. The foregoing discussion of speech patterns indicates in a general way the possibilities as applied to phonetics, philology, and speech correction and development, but the patterns have many uses for the visual interpretation of complex waves other than speech. Figs. 3 and 4 include a number of pictures of more or less familiar sounds that may illustrate better than speech the relationship between what we hear and what we would see in this form of visible interpretation. Sustained tones produce horizontal lines as in A of Fig. 3. The clicks of a hammer against a metal block contain brief spurts of energy spread over the whole frequency range, so that they appear as vertical lines in B of Fig. 3. Swinging the frequency of a variable oscillator up and down the scale results in the wavy line of C in the same figure.

The remaining patterns of Fig. 3 and those of Fig. 4 are described fairly well by the brief captions. For those interested in a more detailed examination of the time and frequency dimensions it should be added that in Fig. 3 (A to G inclusive and I and J) and in Fig. 4 (E to H inclusive) the length is approximately 9.4 seconds and the vertical scale includes a frequency range of zero (at the black base line) to 3,200 cycles per second at the top. In H of Fig. 3 and in the first four patterns of Fig. 4 (A to D inclusive) the length is approximately 4 seconds and the frequency scale is zero to 7,500 cycles per second.

The bird songs[1] pictured in Fig. 4 were originally selected for use as test material because they contain a wide variety of tone modulation without the complications appearing in sounds that are rich in harmonics. But these song patterns are obviously revealing and illustrate well the possibilities of sound portrayal. With such patterns as these it will be possible to analyze, compare, and classify the songs of birds, and, of even more importance, it will be possible to write about such studies with meaningful sound pictures that should enable others to understand the results. The same argument applies to an almost endless variety of inaudible as well as audible sounds of both natural and mechanical origin. Even such low frequency oscillations as those accompanying the beat of the heart may be recorded slowly and converted to the sound spectrogram form by high speed reproduction. Also frequencies beyond the upper range of the ear may be shifted to the audible range by well-known methods so that sound spectrograms may be made in a region where recording is less difficult.

In conclusion, it is well to point out that this is necessarily an incomplete story of the sound portrayal development. Nothing has been said about several important points: for example, use of a logarithmic frequency scale, and a frequency selection that corresponds more closely to the aural experience; and better amplitude representation by contours, color, and other means. Some interesting results have been obtained in developments along these lines but it seems best to reserve them for later discussion. Also, a great deal could be said about the need for a modernized alphabet in this age of speed when a rapid exchange of ideas and information is increasingly important, but this too had better be reserved for some later occasion.

Many members of the Bell Telephone Laboratories, including both engineers and those associated with the experimental training, have cooperated in this development work. All have displayed an enthusiastic interest and it is a pleasure to acknowledge their contributions.

OBITUARY

WALTER BRADFORD CANNON
1871–1945

A FEW months before his death Dr. Cannon's last book was published. It is called "The Way of an Investigator" and is an autobiography in the best sense, since it presents those aspects of his life which in long view he felt most useful to others. This book,

[1] These sound spectrograms were made from the Cornell Bird Song Records (Albert R. Brand Bird Song Foundation, Laboratory of Ornithology, Cornell University).

with other records such as the material in the small volume published in 1932 to commemorate his twenty-five years as a professor at Harvard, will provide details as to his many accomplishments and distinctions. Here it seems more appropriate to write of the man as so many of us knew him.

All that Dr. Cannon entered was vivified by his capacity for personal interest. Though critical of his own work he was integrated so deeply in all he did as to make impersonality, detachment of view, difficult for him. He worked for himself and through others with the intentness of an artist. His complete frankness and honesty were his safeguards against mistaken bias.

Dr. Cannon was so engrossed with his physiological problems and kept his own hands so deep in experimental work, that it became an unending wonder to many of us to realize how extensively he was active outside his research. For years he was the great effective liberal in the Harvard Medical School. He never refused service upon committee after committee. At the same time he never lost touch with general university activities in Cambridge. Resuscitation commissions of national scope, the American Medical Association, the wide-flung interests of the National Academy, the American Association for the Advancement of Science, the problems of cooperative aid to Russia, China, Spain and South America were but a few of his involvements. His participation in all these outside issues was no rubber-stamp contribution. I knew how great a service he rendered beyond the university, but until I had opportunity to examine his files of correspondence and notes, had no conception of the detail and systematic care each outside task received. There was, for example, almost a wheelbarrowful of letters, requests for grants in aid, analyses of policy, all annotated in his own hand and all expressing his careful attention to the affairs of the National Foundation for Infantile Paralysis, in which he was a member of the guiding committee.

When a great figure in our life is gone, we resort to artifices of varying type to describe the loss. There can be no one who requires certification of Dr. Cannon's place in the history of medical advance, through listing the distinctions that came to him. He valued these recognitions of service and originality, for he was a very human man. He was deeply touched by the celebration at the Harvard Medical School which commemorated his twenty-five years as a professor in the university. The exercises on this day began in the afternoon in Dr. Cannon's amphitheatre, Building C, where he had lectured to so many students. All that was said through afternoon and evening came from the hearts of distinguished pupils and co-workers.

Dr. Cannon liked people, all sorts of people, listened to what they said, was on their level instinctively, and was sustained by a sense of humor that never left him. It was part of a youthfulness of spirit which expressed itself so constantly in all his outlook upon life.

I remember so well my first intimate encounter with him, in Baltimore in 1916. He asked me to breakfast at the Maryland Club, and reinforced the breakfast with an offer to join his staff in Boston and so become committed to physiology in earnest. I remember how his enjoyment of the situation grew from his own experience, how he said, "Years ago the only thing in the world I wanted was a chance to work in physiology, and then Harvard University not only gave me the opportunity but actually paid me for it!" I came to the Harvard laboratory in 1916, after Dr. Cannon had finished his classical work upon the mechanical factors in digestion, the sea into which he and Dr. Bowditch had sailed while he was a medical student. To many, Dr. Cannon's reputation will rest chiefly upon these fortunate early experiments. But to all who knew his habit of mind, they merely pulled the trigger. Whether again he ever brought down such big game was in the fortune of the chase. He followed the leads set by his imagination, and out of early and characteristically acute observations upon the effects of emotional disturbances in cats under x-ray examination of intestinal movements, grew the large body of research upon the emergency function of the sympathetico-adrenal mechanism, and finally the search for the eventual chemical mediators of neuromuscular phenomena.

He had been fortunate in the possession of so rugged a physique (in all my early years with Dr. Cannon he loved to describe himself as "hearty!") as to be able to work his way through Harvard College and the Medical School, gaining a distinguished record in each case. He graduated in medicine in 1900, having published two classical papers upon gastro-intestinal movements as observed for the first time with the x-rays. But, characteristically, the young Dr. Cannon closed his medical school career with additional assets—an earned balance of seven hundred dollars, a wife and a trip to Europe for a bit of mountaineering!

Fifteen years ago, Dr. Cannon learned he was afflicted by one of the inexorable lymphomatous diseases, all so poorly understood and all so disastrous. His illness inevitably ate a little into his humor and his irrepressible good spirits, but not into his will to work, and only those nearest to him could realize a vestige of change.

Dr. Cannon was an artist in classical physiological technique. One has only to glance at the tracings which illustrate his articles to realize how capable he was with his hands. He used all sorts of tools

easily and effectively from early years, but always upon his own occasions. He was a beautiful surgical operator, a fact so evident in the nerve ablation experiments which distinguished his later career. He was better than a good sculptor. He rejoiced in this dexterity and relied upon it. Yet I remember how characteristically he spoke at lunch in the Brigham Hospital years ago. At the beginning of the Ford era he purchased a car, the first in a long series. These Fords had character. On cranking, they responded to a definite formula or balked aggressively. Each car was an object of affectionate regard by the entire Cannon family, but Dr. Cannon never learned the anatomy and physiology of the Ford as known to millions throughout the land. He had too many vivid interests to burden his consciousness with the idiosyncrasies of even the most worthy Ford, remarking characteristically that he relied upon the "Vis medicatrix Fordi!" to keep the current old faithful in motion!

It is our habit to seek for influences which start men of great accomplishments upon their careers. Usually such efforts result in highly artificial syntheses inappropriate to the man involved. At his twenty-fifth anniversary dinner, Dr. Cannon described himself as the grandson of Ludwig and the son of Bowditch. But no teachers really influenced him. He had his own "self-starter" which never failed to stir and stir in his agile brain. His spirits rose and fell as he saw himself progressing or baffled in the current research. What Dr. Cannon accomplished was all his own. No one else had the ideas, no one else labored painstakingly over pupils, giving ideas and counsel without thought for self. What he published came wholly from his brain. His other contribution, the researches of pupils scattered all over the world, will speak Dr. Cannon's obituary as he would wish. Questions being answered, never an end of questions! In the study of living processes something is always beyond the horizon. Indeed, our progress is devoted to pushing back the horizon so that as we gain knowledge we are never satisfied with our gains. Dr. Cannon enjoyed this struggle. He judged contemporaries and pupils by their ability to ask good questions. Amongst his files I have come upon one large folder labelled "Questions." Here, upon varied bits of paper but always in his legible hand, are scores of questions noted as they came to him, and usually without comment.

Peptic ulcer from simultaneous stimulation vagus and sympathetic?

Factors affecting the growth of hair?

Milk secretion as affected by fright, rats (hissing sound)?

Effect of secreted adrenalin on bronchioles in dog?

Unilateral effect of convulsants?

Catnip in relation to sex? Spayed cats?

Dr. Cannon was fortunate in that much of his life was spent in the Harvard Medical School while it was under the administrative direction of Dr. Edsall. These two men saw eye to eye in their desire to extend productive scholarship through every department of the school. They worked and died together, leaving an example of accomplishment their pupils will be hard set to equal.

CECIL K. DRINKER

DEATHS AND MEMORIALS

DR. JOHN CAMPBELL MERRIAM, from 1920 to 1938 president of the Carnegie Institution of Washington, died on October 30 at the age of seventy-six years.

THE death, at the age of seventy-six years, is announced of Robert Hagelstein, honorary curator of Myxomycetes at the New York Botanical Garden.

AT the annual Robert Kennedy Duncan Memorial Luncheon on October 29 the Robert Kennedy Duncan Club of Mellon Institute conferred honorary membership on Dr. Rufus Henry Fitzgerald, chancellor of the University of Pittsburgh. The club is in honor of the late Robert Kennedy Duncan, the originator of the industrial fellowship system; it is the center of the social and professional life in the institution.

SCIENTIFIC EVENTS

NUCLEAR PHYSICS AND CHEMISTRY AT HARVARD UNIVERSITY

RESEARCH in nuclear physics, the branch of science which helped develop the atomic bomb, will be made broader at Harvard University during the next five years. The Harvard Corporation has appropriated the sum of $425,000 for use of a committee on nuclear physics and chemistry during this period. Dean Paul H. Buck, provost of the university, will head the committee, members of which have not yet been announced.

Two other developments emphasize the university's interest in the atom and its possibilities in times of peace. The Harvard cyclotron, which did service with the Manhattan project of bomb development at Los Alamos, is to be returned to Cambridge for additional atom-smashing labors.

Three new associate professors of physics, all