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George A. Campbell, 1870-1954

The passing of Dr. George Ashley Campbell November 10, 1954, marks the close of an era that has seen the communication art grow from infancy to robust manhood.

The problems of telephone transmission were little understood when

George Campbell, a young mathematical physicist joined the American Bell Telephone Company (later American Telephone and Telegraph Company) in 1897. He had just returned from four years of study at various universities in Paris, Vienna, and Göttingen, having received his B.S. degree in 1891 from Massachusetts Institute of Technology, A.B. from Harvard, 1892, and M.A. in 1893 from the same institution. In these early years at American Bell, he also continued his studies at Harvard, where in 1901, he received the Ph.D. degree.

Familiar with the work of Rayleigh and Heaviside, Campbell's first undertaking was to find some method of mitigating the attenuation of voice currents in telephone lines, which theretofore, produced a barrier against telephone communication over very long distances. Heaviside had shown that inductance, if properly applied in a long telephone circuit, should diminish rather than increase the attenutation. Campbell followed this suggestion and developed a theory of "loading," but there occurred one of those rare coincidences in the history of science of two independent investigators arriving at substantially the same result at the same time. Without knowing that, at Columbia University, Professor M. I. Pupin was studying the same problem, Campbell applied for a patent at about the same time as Pupin. After final adjudication under the technical rules of the patent law, the basic patent was awarded to Pupin, on the ground of priority of conception. As Dr. F. B. Jewett so aptly said, "It should be mentioned, however, that Campbell's analysis of the problem — actually more detailed than Pupin's — led him to formulate rules for the design of loading coils and their spacing, which were, from the very beginning, the only ones employed in this country. By this one piece of work performed within a relatively short time after his employment in the Bell Company, Campbell demonstrated his unique ability at mathematical physics, as well as his knack for stating conclusions in a form that the development engineer could use in practical applications."

As a consequence of his work on loaded lines — indeed, almost as a part of it — Dr. Campbell arrived at the idea of an electric wave filter. By a suitable network of coils and capacitors, he was able to produce a device that would allow a preferred band of frequencies to pass through it — such as those of the human voice, for example — while discriminating markedly against frequencies above and below the desired band. This development was first used in so-called "carrier" systems over long distance open-wire lines, which increased by several fold the number of telephone circuits carried by them. The principle became of even greater importance when much wider bands of frequencies were employed in the coaxial cable and in the newer forms of radio transmission designed to transmit, over the same electrical path, either many hundreds of telephone conversations, or several television programs. It will also be used in the new transatlantic telephone cable.

As the effectiveness of telephone instruments increased and the length of circuits grew, "crosstalk," the tendency for conversation in one circuit to be heard in another, became an obstacle to telephone advance. Earlier workers had shown that this crosstalk was a complex effect resulting partly from electromagnetic induction and partly from electrostatic induction. Campbell turned his attention to this problem between 1903 and 1907, and showed that crosstalk between two circuits depends to a considerable extent, and particularly for loaded circuits, on the direct capacitance between the wires of the two circuits. He termed this function the "Direct Capacity Unbalance." This work led not only to mathematical formulae, but to the development of measuring apparatus which was destined to play a great part in future telephone developments. In this period he produced his well-known shielded balance for the accurate measurement of electrical constants at telephone frequencies. This contributed greatly to the development of cables to replace open-wire lines. Out of it also grew the whole shielding technique applied today in innumerable ways in the high-frequency art.

Closely associated with his work on filters and line balance were problems concerning telephone repeater circuits. Early in telephone development, various experimenters and inventors had proposed circuits to accomplish two-way telephony, and from this prior work had come two fundamental repeater circuits, one in which a single repeating element amplifies messages reaching it from both directions, and one that includes two amplifier elements, one assigned to each direction of transmission. In the first, two sections of line, as nearly identical as possible, are balanced against each other as opposite arms of a bridge. In the second, each incoming section of line is balanced against an artificial line or network, thus permitting, as Campbell's analysis showed, a greater inherent flexibility as well as a greater stability. Campbell's studies closely formulated the stability limits of the circuits, and in addition, led to the use of the "four-wire circuit" as a logical extension of the one-way paths in the second type repeater, each extended path containing as many one-way amplifiers and line sections as desired. Although when it was proposed in 1912 it was looked upon as having little practical application, its later wide use at both voice frequencies and in the carrier art, shows it to be an example of a technical advance that could not be employed until a complex art had caught up with it.

As a mathematician, he was interested not only in solving problems, but also in the logical relations of mathematics itself; perhaps his most significant contribution in this field was in the table of Fourier Integrals for practical applications in the study of transients and other non-periodic phenomena.

In this brief review of Dr. Campbell's work, mention can be made of only a few of his many contributions. Those that have been chosen are representative of his more outstanding contributions to electrical communication. His career was highly productive of discoveries, inventions, and patents. His achievements entitle him beyond question to rank first among his generation of theoretical workers in electrical communication. In recognition of his distinguished contributions, he was awarded the Medal of Honor of the Institute of Radio Engineers in 1936, the Elliott Cresson Gold Medal of the Franklin Institute in 1939, and the Edison Medal of the American Institute of Electrical Engineers in 1940.

At the time of his retirement, he was a member of the American Mathematical Society, American Mathematical Association, American Physical Society, The American Association of Physics Teachers, American Academy of Arts and Sciences, and the Harvard Engineering Society. He was also a Fellow of the American Institute of Electrical Engineers and of the American Association for the Advancement of Science. In appreciation of Dr. Campbell's long and distinguished service and of his fundamental contributions to the development of electrical communication, his technical papers were collected and published by the American Telephone and Telegraph Company, in a bound volume entitled "Collected Papers of George A. Campbell" (1937).

Though Campbell's achievements are now best known by his personal mathematical contributions, he contributed to the advance of telephony in another way that should not be forgotten. He it was who hired Frank B. Jewett and Edwin Colpitts, and others, whose ability and training fitted them for leadership in the application of scientific knowledge and methods to the practical problems of telephony.

He was a gentle and retiring man, but to those who knew him best he was a lovable companion who sought, not fame or high position, but understanding. His interest in the technical problems of telephony continued to the end of a long and active life. Out of his work came useful and readily available mathematical tools for those who followed him, but more importantly, a spirit of inquiry that left its enduring imprint on the character of the Bell Telephone System as we know it today.