Book Reviews

The Life and Work of Bell

Bell. Alexander Graham Bell and the Conquest of Solitude. ROBERT V. BRUCE. Little, Brown, Boston, 1973. xii, 564 pp., illus. $12.50.

Bruce has written the first fully documented biography of Alexander Graham Bell (1847–1922). Gilbert H. Grosvenor, Bell's son-in-law, opened the Bell papers to Bruce and entrusted him with "writing the long-postponed biography." The result is a lengthy portrayal of a man gifted with intelligence, imagination, and energy pursuing a wide range of interests.

Bell was the son of an Edinburgh, Scotland, teacher of elocution who gained an international reputation for a system of phonetic symbols indicating the position and action of the vocal organs used in making sounds. This system, called "visible speech," was learned well by the son and later adapted by him to teach the deaf to speak. In Scotland and in England, Bell served as his father's assistant, audited courses in anatomy and physiology at the University of Edinburgh and University College, London, and taught elocution at private academies. After the family moved to Brantford, Ontario, in 1870, the son was asked to teach his father's system of "visible speech" to the deaf and the teachers of the deaf in Boston. In 1873 he was appointed professor of speech at the recently founded Boston University. Among his pupils in Boston was a young deaf girl, Mabel Hubbard, whom he married in 1877, after he had developed the telephone.

Accounts of Bell's invention of the telephone often overlook his mastery of vocal physiology and the mechanics of speech and stress his lack of the scientific knowledge of electricity that one would have expected on the part of the inventor of the telephone. This point of view is reinforced by the often-repeated anecdote in which Bell tells the venerable Joseph Henry of his lack of the electrical knowledge he needed for his undertaking and Henry replies, "Get it!" Bell, however, might well have said the same thing to an electrician aspiring to invent a telephone who confessed an inadequate knowledge of acoustics. Because the telephone has been characterized as an electrical invention, other accounts have misconstrued the process of inventing it. Bruce's emphasis upon Bell as a student of speech makes it clear that the science of sound was as important as—perhaps more important than—that of electricity in the invention of the telephone.

Bell, as Bruce stresses, was led to the telephone by his pursuit of a harmonic telegraph, the concept for which arose from his interest, starting at age 19, in synthesizing complex vowel sounds with tuning forks and from his learning, about that time, of Hermann von Helmholtz's experiments in which he sounded vowels using a combination of harmonically related electrically vibrated tuning forks. Bell, who could pitch his voice to sound piano strings selectively by resonant vibration, then thought of using electrically vibrated tuning forks as switches in electrical circuits that would pulsate with electrical currents of specific frequencies according to the natural frequency of the forks. Resonant piano wires would then, he believed, vibrate sympathetically and selectively, if the pulsating currents energized electromagnets influencing the piano wires. Similarly, Bell reasoned, tuned telegraph signals could be simultaneously transmitted and separately received, which was the essence of what would later be called a harmonic telegraph.

From 1872 to 1875, Bell, spurred on by the knowledge that telegraph companies paid well for multiplex systems, as they had for Thomas Edison's non-harmonic quadruplex, which sent four messages simultaneously over the same circuit, attempted to build a harmonic-type multiplex telegraph. As Bruce clearly establishes, the harmonic telegraph was Bell's principal concern as he carried on inventing part time while working as a teacher of speech. The telephone concept was then stumbled upon because Bell was not only well grounded in acoustics but observant and imaginative as well. Experimenting in Boston on 2 June 1875 with his invaluable assistant, machinist and instrument maker Thomas Watson, Bell noted in attempting to fix a malfunctioning vibrating-reed receiver that the magnetized reed, when manually plucked, induced currents in the coil of wire constituting its electromagnet and that these currents, transmitted into the next room, vibrated the reed of a similarly constructed transmitter. Bell realized that these currents were not the simple pulsating currents of a make-and-break arrangement but the undulating waves of electromagnetic induction carrying complex wave forms like those of the human voice. Recognizing the importance of his observation, he followed its implications until, in the spring of 1876, he transmitted audible speech with his telephone system. It took a year because his teaching was demanding, his financial supporter, business adviser, and soon-to-be father-in-law, Gardiner Hubbard, saw all the commercial gain in the harmonic telegraph, and because Bell, being a non-electrician, had to tinker his way to practical electrical devices.

It seems likely that Bruce's narrative account of Bell's invention of the telephone will—with its shadings and emphasis—be the definitive one. Bruce's treatment of rival telephone inventors is less convincing, however, simply because he labels them in such an offhand fashion—Daniel Drawbaugh, the "charlatan," Antonio Meucci, the "innocent," and Elisha Gray, whose "bitterness" caused him "to lash out [at Bell] one last time" (pp. 278–279). Zenas Wilber, the patent examiner who testified that he had revealed Gray's liquid-variable transmitter to Bell, who then included it in his patent, was, according to Bruce, "probably liquored up or bribed" (p. 278). All this may be true, but it strikes a discordant note.

Bruce tells us much more about Bell than is encompassed by the invention of the telephone. After developing the essentials of a practical system, Bell left the marketing and engineering to others. He then pursued the inclinations of his restless and powerful imagination, which was stimulated by the needs of the deaf (he founded the American Association for the Promotion of the Teaching of Speech to the Deaf), the regularities of nature (he sought the genetic patterns of deafness in humans and carried out experiments in sheep breeding), and the adventures of technology (he aided both Samuel Pierpont Langley and Glenn Curtiss in their work on mechanical flight). Bell himself had some bold ideas about tetrahedral kites and tetrahedral structures. Bell enjoyed the

friendship of scientists and generously supported their worthy endeavors, such as the *National Geographic Magazine* and *Science*. In 1882, Bell and his father-in-law began the subsidization and reorganization of *Science*, which had been supported earlier by Thomas Edison. They expended at least $80,000 before the American Association for the Advancement of Science provided a subsidy and in 1900 designated the publication as its official journal.

Bruce gives almost half of his well-written and carefully organized biography over to the years "after the telephone." Some readers who come to the book interested primarily in the telephone and the inventor may feel that they are told more than they need to know about other matters. Yet this emphasis upon other aspects should caution textbook writers and others against regarding Bell as a typical inventor of a typical invention that will serve as the basis for generalizations about these subjects. Bell, fully delineated by Bruce, cannot be forced into a Procrustean bed with other leading American inventors of his time, such as Thomas Edison, Elisha Gray, and Elmer Sperry. He was, to offer a distinction, a professor of elocution; they were professional inventors. Also, Bell took out only 30 patents; Edison had more than a thousand. Bruce's scholarly and broadly conceived biography will, it is to be hoped, encourage other biographers to enrich our knowledge of the varieties and subtleties of invention and inventors.

THOMAS PARKE HUGHES
Institute of Technology,
Southern Methodist University,
Dallas, Texas

Galaxy

The Milky Way. An Elusive Road for Science. STANLEY L. JAKI. Science History (Neale Watson Academic) Publications, New York, 1973. x, 352 pp., illus. $14.95.

Early peoples invariably have seen in it the mirror of themselves: to Egyptians, it was wheat spread by Isis; to Incas, golden star dust; to Eskimos, a band of snow; to Bushmen, campfire ashes; to Arabs, a river; to Polynesians, a cloud-eating shark; to Teutons, the way to Valhalla; to Iroquois, the path to Ponemah; to Christians, the road to Rome. The modern astronomer may find the Milky Way less poetic, but it is no less fascinating to him, for it is the visual manifestation of the system of roughly a hundred billion stars to which our sun belongs. The drama of the topic, not to mention the problems it has raised for science, makes the lack of detailed histories of Milky Way research surprising and lamentable. With this book, Jaki attempts to fill that void. The scholarly result is compelling yet disappointing, compendious yet deficient.

The book traces Milky Way studies from Aristotle to Bondi, with one chapter each devoted principally to the Greeks, the Middle Ages, Copernicus, Galileo, Newton, Wright, Herschel, 19th-century cosmology, and early-20th-century breakthroughs. Every chapter is followed by over 100 footnotes; and although the body of the text does not contain illustrations, 24 arresting plates, reproduced from obscure sources, are grouped at the end of the book. But, ironically, this tome on the beautifully photogenic Milky Way does not include a single photograph, historic or modern, of its subject. The index is strictly to persons' names; the reader can easily find entries for Duns Scotus or Pontano yet nothing for distance scale or interstellar absorption.

The strengths of the book are numerous and important, among them being consistently literate prose, extensive research, and frequently perspicacious observations. Jaki has investigated scores of ancient books. The result is unquestionably the most detailed study ever published of pre-Wrightian theories of the Milky Way. The first half of the book is a tour de force on the history of galactic research: it probes Aristotle's theories; uncovers delightfully perceptive astronomical reasoning during the Middle Ages; reveals a baffling lack of interest in or awareness of the scientific significance of the Milky Way on the part of early Copernicans, Galileo, and even Newton; and analyzes the independent yet overlapping discoveries made within a generation by Kant, Lambert, Wright, and Herschel.

But in the latter half, especially the final two chapters, there are significant weaknesses. As a minor point, Jaki, who earlier wrote the intriguing work *The Paradox of Olbers' Paradox*, seems preoccupied with this historic question of why the night sky is dark. *The Milky Way*'s 18 references to Olbers do not make it clear that the actual physical resolution of the paradox is independent of our galaxy; Jaki seems to overestimate its historic significance in Milky Way studies, and today it is a problem strictly of extragalactic cosmology. Also, Jaki uses the term "Milky Way" with unsettling inconsistency, implying meanings ranging from the whitish band on the celestial sphere to general star fields to the entire galaxy.

There are a few errors of fact, but not an exorbitant number for such a detailed treatise. One of them arises from Jaki's misreading of a journal article. In a paragraph on large radial velocities of spirals (p. 290), he claims that Curtis was so perplexed around 1920 by these velocities that he was almost ready to abandon the island universe theory. Actually, in the article to which Jaki is referring, Curtis made that statement about van Maanen's findings of high transverse velocities, not recessional; indeed, the large red shifts found by V. M. Slipher strongly corroborated the island universe theory, as E. Hertzsprung insightfully realized as early as 1914.

But another type of flaw is also present that can be instructive because it demonstrates differences between private and public science plus the desirability of using archival materials in historical research. Jaki's study of published sources—ancient monographs and early journal articles—is impressively thorough. But of his over 1000 footnotes only a handful are to original documents such as unpublished workbooks, manuscripts, diaries, and letters; likewise, there are scant references to the few research articles by other modern authors in which analyses of original sources have been reported.

For the early periods, frequently the only extant materials are secondary sources; however, for the post-Herschelian era and especially the early 20th century, many original documents remain. Although they generally are uncataloged and scattered in diverse observatories, libraries, and attics, the pursuit of them is worthwhile, for they often reveal a richer and more nearly accurate history than do the articles intended for public consumption.

Some examples: Jaki claims (p. 308) that E. Hubble "carefully avoided seeing an evolutionary process" in his classification scheme for nongalactic nebulae, whereas a 1923 letter (now at the Lowell Observatory) from Hubble to V. M. Slipher, in which Hubble wrote, "I have been trying to construct a classification of non-galactic nebulae analogous to Jeans' evolution se-