

# This Week's Citation Classic

**Budden K G.** *Radio waves in the ionosphere: the mathematical theory of the reflection of radio waves from stratified ionised layers.*  
Cambridge, England: Cambridge University Press, 1961. 542 p.  
[St. John's College, University of Cambridge, Cambridge, England]

The first half of this book is concerned with 'ray theory,' applicable to homogeneous or slowly varying media. The second half deals with 'full wave theory,' which is used when the ray theory approximations fail. It is applied to the processes of reflection, coupling between characteristic waves, and partial penetration. [The SC]<sup>®</sup> indicates that this book has been cited over 935 times since 1961.]

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"The radio group in the Cavendish Laboratory, Cambridge, England, was started by Sir Edward Appleton in 1920. I joined it in 1936, under J.A. Ratcliffe. Its research was aimed at elucidating the structure of the ionosphere by using radio waves emitted from the ground. Although I was at first doing experimental work on radio waves of very low frequency (VLF) (16 kHz), Ratcliffe always insisted that we should keep abreast of the theory and my interest in this was stimulated by H.G. Booker,<sup>1</sup> whose papers provided much material for this book. From about 1952 onward my research was concentrated entirely on the theory. The material was assembled in the period up to 1957. This was made possible by seminars, and discussions with members of the radio group and with frequent visitors to Cambridge, including workers from A.H. Waynick's group at Pennsylvania State University. The biggest step forward was when I was able to use the Cambridge computer EDSAC 1, which was largely designed by M.V. Wilkes. In the daytime it was nearly always undergoing engineering changes and maintenance, so we used to work on it at night. There I met many distinguished scientists

and we often had interesting discussions around 3 or 4 a.m., while we waited for our results to come out on the tape punch, and while our wives were sleepless at home wondering whether we were being electrocuted by the machine. The first EDSAC 1 program for calculating ionospheric reflection coefficients at VLF was written by D.R. Hartree, to whose memory *Radio Waves in the Ionosphere* is dedicated. He had a wide knowledge of theoretical techniques and could always be relied upon to help with problems. He was particularly encouraging about my first and most important paper on the ionospheric reflection of VLF radio waves.<sup>2</sup> The first draft of the book was written in Boulder, Colorado, in 1957, while I was with the National Bureau of Standards and the High Altitude Observatory, and it owes much to discussions with colleagues there.

"One of the most striking aspects of research in the Cavendish Laboratory was the importance that was attached to clear exposition when the work was written up for publication. Ratcliffe was supremely good at this himself as is shown by his own papers and books, particularly the book on magnetoionic theory,<sup>3</sup> and he taught us to follow the same tradition, which was said to have originated with Lord Rutherford. Our papers often had to be redrafted four or five times before they were considered ready for submission to a journal. I applied the same criteria to *Radio Waves in the Ionosphere*. The objective was to write a book that could be used and quickly understood, without the need for much auxiliary study, by engineers and physicists with little previous knowledge of the subject. If this objective was achieved, it may help to explain why this work has had so many citations.

"The book has been cited frequently in mathematical papers, for example, in the work of J. Heading. One of his recent papers<sup>4</sup> gives further references."

1. Booker H G. Propagation of wave-packets incident obliquely upon a stratified doubly refracting ionosphere. *Phil. Trans. Roy. Soc. London A* 237:411-51, 1939.
2. Budden K G. The numerical solution of differential equations governing reflexion of long radio waves from the ionosphere. *Proc. Roy. Soc. London A* 227:516-37, 1955.
3. Ratcliffe J A. *The magnetoionic theory and its applications to the ionosphere.* Cambridge, England: Cambridge University Press, 1959. 206 p.
4. Heading J. Properties of some generalized hypergeometric functions governing coupling at transition points. *J. Inst. Math. Appl.* 25:311-24, 1980.