

## Reviews and Abstracts



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### BOOK REVIEW

BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION edited by John M. Osepchuk, IEEE Press, 1983, 608 pages, member price \$47.95.

### INTRODUCTION

This IEEE Press book is a collection of about 100 papers on the physical, biological, medical, health, and safety-standards aspects of RF/microwave biological effects. It consists of reprints of papers written by engineers, physicists, and medical and biological professionals. There are seven sections, each compiled by an associate editor who has written a short overview, with its own list of references covering significant papers not reprinted in the book. The book was prepared by some members of the IEEE Committee on Man and Radiation (COMAR). All of the associate editors were on the Committee. While the title uses the term "electromagnetic radiation," this book only considers the RF portion of the EM spectrum.

A critical point that is made in the foreword of the book is the fact that while the book has a publication date of 1983, almost all materials were incorporated in the text in 1979, so the articles in the book are somewhat dated. In this rapidly-changing field, a delay of five years can seriously affect the relevance of this kind of a book. An attempt was made to solve this problem by breaking the book into sections, and having each section's associate editor incorporate an updated summary/bibliography of the literature on that section's subtopic, emphasizing more recent developments. This was only partially effective, as will be mentioned later.

### Section I: QUANTITATION OF ELECTROMAGNETIC FIELDS IN BIOLOGICAL SYSTEMS by A. W. Guy

This section provides a good but somewhat incomplete coverage of RF/microwave dosimetry (measurement and theoretical prediction of fields inside biological bodies) via several "overview" papers, and several original works on theoretical and experimental dosimetry. The lack of authoritative overview papers on the important experimental tools for modern dosimetry weakens this section. These tools are the non-perturbing temperature probe, electric and magnetic field survey instruments, and the implantable E-field probe. While one short paper by Bowman is presented on the design of one particular temperature probe, the state of the art, as it now exists, is not covered adequately for any of these tools. Well-written overview papers such as those on thermometry (Cetas, Med. Phys. 5, 1978), on survey instruments (Aslan, IEEE IM-21, 1972) and on implantable E-field probes (Bassen,



Radio Science (6S) 1979), should have been included or at least cited in the section's summary/bibliography.

Persons interested in the state-of-the-art of EM biological-effects measurements should read the comprehensive book from the National Council on Radiation Protection (NCRP Report 67, Washington, DC, 1981) on radiofrequency electromagnetic fields, properties, quantities and units, and biophysical interaction and measurements. This NCRP book can provide important contemporary material on the state of the art of EM bioeffects dosimetry.

### Section II: BIOPHYSICAL CHEMICAL BASIS OF RF FIELD INTERACTIONS by J. W. Frazer

This section covers the complex and interdisciplinary area of the biophysical interaction of RF energy with molecular, cellular, and biological microsystems. Frazer concludes that most effects of RF and microwave radiation in biological systems seem adequately explained as a direct response to a temperature rise. This is a questionable conclusion in light of many recent findings and theories. In situations where the temperature dependence is carefully controlled, nonthermal, quantum-mechanical explanations are necessary, as in the work by Olcerst, quoted by Frazer. Persons interested in this subject should read the publication by Olcerst, et al. (Radiation Research 82, 2, 1980). Also, the excellent collection of papers on mechanisms of interaction entitled "Biological Effects of Nonionizing Radiation," edited by K. H. Illinger (American Chemical Society symposium series No. 157, Washington, DC, 1981) should be read by anyone delving into this subject. It is surprising that in the review paper by Frazer, no mention is made of the Frohlich theory, nor is any of K. H. Illinger's work quoted. An interesting inclusion in this section is a collection of papers entitled "Summaries of Selected Papers from USSR Academy of Sciences." It represents a school of thought on RF bioeffects that believes that effects are induced by levels of RF radiation that are considered insignificant by a majority of Western scientists in this field.

One important new area of RF biophysical interaction was not included in this section. Research on the basis of interactions of pulsed, extremely low frequency (ELF) magnetic fields and pulse-modulated RF fields with biological tissues has become a very active area in the past five years. Of key importance in this area is the concept of electro-chemical information transfer and the interference of electromagnetic fields with this process. Actually, the basic papers on this subject of Basset et al., Chiabrera et al., Pilla et al., span the period from late sixties to the present, and as such should have been cited. Those interested in this subject should read some or all of the following:

- Pilla A. A., J. Biol. Physics 11, 51, 1983  
 Pilla A. A., Advances in Chemistry Series 188, 126, 1980  
 Pilla A. A., in Mechanism of Growth Control, R. D. Becher ed., C. C. Thomas, Springfield  
 Beltrame et al., Alta Frequenza 49, 101, 1980  
 Bassett, C. A. et al., Annals of the N.Y. Academy of Sciences 238, (1974) (242-262).

Section III: EFFECTS OF RADIO FIELDS ON THE CENTRAL NERVOUS SYSTEM AND BEHAVIOR by D. R. Justesen

The associate editor's overview of radiofrequency effects on the central nervous system and behavior is a well-written, concise presentation of most of the available information. Despite some obvious oversights, such as the lack of mention of microwave-drug interactions on behavior, this section's summary/bibliography covers most of the important topic areas and can serve as a starting point for those who wish to pursue specific areas more thoroughly.

The eight papers following this overview do not serve to fully represent the present state of the art on the central nervous system and behavioral effects of RF. For example, two of the eight papers deal with the subject of the "microwave hearing effect." It should be noted that recently, this phenomenon has been shown to be associated with thermoelastic pressure waves generated in the ear, and thus appears to represent a purely mechanical effect, rather than a direct CNS interaction, as was previously assumed. Another paper deals with dosimetric considerations in two RF exposure systems. While these latter three papers are interesting, one must question the wisdom of including many marginally-related papers in a section on central nervous system and behavioral effects. Because of the delay in the publication of this book, a significant portion of the CNS/behavioral papers presented in it were published in the early 1970's. Although such material may have served as a basis for subsequent work, today it is primarily of historical interest. It does not adequately represent the most current information in this critical area of research, nor does it reflect the current state of knowledge of the central nervous system and behavioral effects of RF.

Section IV: PATHOPHYSIOLOGIC ASPECTS OF MICROWAVE/RADIOFREQUENCY ENERGY EXPOSURE by S. M. Michaelson

This section deals with the harmful whole-body effects of RF energy. This is a vast area, so it is almost impossible to select a few papers and obtain an adequate collection. The brief introduction by S. M. Michaelson consists almost exclusively of caveats concerning the proper design and execution of experiments, and would apply to any area of biomedical research. One is left with the impression that very few, if any solid data on RF/MW bioeffects are available. This associate editor even states that in the appended bibliography, papers were included which "do not meet the criteria of sound scientific publications." It would be desirable for the associate editor to substantiate his opinion that "most of the experimental data support the concept that the effects of microwave exposure are primarily if not only, a response to hyperthermia or altered thermal gradients in the body." We noted that the conclusion of one of the reprints (Imig et al.) in this book is that in experiments on testicular degeneration "damage may result in part from factors other than heat." The important aspect of thermoregulatory responses is represented by a paper of peripheral vasodilation in the squirrel monkey by Adair, while the paper by Ely et

al. has only historical interest. Recent papers by Way et al. (Bioelectromagnetics 2, 341, 1981) and Spiegel et al. (Bioelectromagnetics 1, 253, 1980) should be read for a more complete coverage of this area. To fully appreciate the subject, the papers on cataracts in this section should be supplemented by reading the excellent review of microwave cataractogenesis by Cleary (Proc. IEEE, 68, 49, 1980). In conclusion, this section contains a collection of papers of mixed quality and relevance, which do not provide a coherent representation of the present state of knowledge on the pathophysiologic aspects of RF energy.

Section V: MEDICAL APPLICATIONS OF ELECTROMAGNETIC FIELDS by O. P. Gandhi

This section includes papers on the classical medical application of RF fields - diathermy (the therapeutic heating of the musculature, tendons, etc. for physical therapy), and papers on most of the new, important areas such as Nuclear Magnetic Resonance (NMR) imaging (which may soon challenge the most sophisticated, computerized X-ray imaging modalities such as Computerized Tomography (CT), and RF hyperthermia for the treatment of cancer. Most of the areas of medical applications of RF are discussed adequately, but the coverage of the rapidly changing field of cancer hyperthermia does not present a comprehensive overview of the state-of-the-art of hyperthermia applicators. Those interested in the subject should read Kantor (J. Microwave Power 16 (2) 1981).

One significant flaw in this section is the lack of almost any mention of the subject of bone and wound healing that is induced through the application of strong, pulsed magnetic fields or pulse-modulated RF carrier signals. Recently a new technical society was formed (Biological Repair and Growth Society) to cover this area. Also, the book gives no indication that there has been a steady history of clinical practice in which Basset and others have been active for over twenty years. Many thousands of patients suffering from bone fractures that would not heal normally have been successfully treated by physicians with long-term, pulsed magnetic fields. In light of this, the Food and Drug Administration has recently approved one bone-healing device as being clinically safe and effective. Therefore, the lack of any mention of such interactions of EM fields with biological systems is a significant oversight in this and the other sections of the book. A reference to the papers by Basset et al. and Becker et al. (see section II) should have been made, and at least one reprint included in this section.

Section VI: SAFETY STANDARDS by J. M. Osepchuk

This section contains papers dealing with personnel exposure standards and guidelines, and the physical basis for such standards. A paper that covers the prevalent personnel exposure and product-emission standards in 1980 by S. Michaelson was included. It is brief and somewhat incomplete. We assume that this paper was included as an up-to-the-minute summary of the status of RF safety standards at the time of publication of the book (since it was reproduced directly from a typed and photocopied, rather than typeset, manuscript). Because of its "timeliness" it has a rough physical appearance and is difficult to read, with the tops of virtually each character clipped off. Papers on the occupational exposure of personnel, and standards for control of such exposures, were not included in this book. A paper, such as one by Conover (Proc. IEEE 68(1), 1980) or other knowledge-

able regulatory agency professionals should have been included in this section's summary/bibliography.

Section VII: INTERFERENCE EFFECTS: ELECTROMAGNETIC COMPATIBILITY OF CARDIAC PACEMAKERS by J. C. Mitchell

Electronic cardiac pacemakers are the only medical devices covered in this section on interference effects. Mr. Mitchell and his group at the U.S. Air Force School of Aerospace Medicine are world experts in the area of pacemaker interference. Although this paper represented the state of the art at the time of its publication, effects on the new generation of "programmable" pacemakers were not mentioned. These new devices actually contain radiofrequency receivers or other means to obtain instructions for their operational adjustment after implantation in the patient, and can be susceptible to certain kinds of RF interference. A shortcoming of this section on RF interference in biomedical systems is the lack of any attempt to cover any other medical-device EM-interference problems, such as interference with critical, life-support and monitoring devices. The FDA's Bureau of Medical Devices (now part of CDRH) published a proposed final draft standard on electromagnetic compatibility for medical devices several years ago. This document (Medical Device Standard MDS 201 0004, 1979) should be read by anyone who is concerned with RF interference effects on medical electronics.

CONCLUSIONS

This book and its collection of papers provides relatively good, but somewhat outdated, coverage of the engineering and physical aspects of RF fields and their interaction with biological systems, plus the biomedical applications of electromagnetic fields. The coverage of the "biological" areas of this subject (the biophysical, pathological, and behavioral/central nervous system effects of EM fields) lacks a discussion of some of the most important scientific information on this subject, including the important area of pulsed-magnetic and RF field biological effects, their biophysical basis, and medical application to bone and wound healing. An overall view of this book is that it provides an extensive but incomplete set of references for this complex, controversial, and rapidly-changing field. Due to the changes that have occurred since this book went to press, it does not provide a complete overview of the present state of knowledge in this area.

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## Distinguished Achievement Award Announced

The Administrative Committee of the Antenna and Propagation Society has authorized a new award, the Distinguished Achievement Award. This award may be given to recognize an individual member of AP-S for outstanding technical achievement and meritorious service to our society.

The first award will be made in 1985 if a suitable candidate can be identified. Contact the AP-S Awards and Fellows Committee Chairwoman for nomination forms:

Professor I. C. Peden  
Department of Electrical Engineering FT-10  
University of Washington  
Seattle, WA 98195  
(206) 543-8025

The deadline date for receipt of completed nomination forms is October 1, 1984.

## Winners of the IEEE Centennial Medal

The following members of the Antennas and Propagation Society have been awarded IEEE Centennial medals. Those marked with an asterisk were awarded medals by the Society, and were honored at the banquet of the International AP-S Symposium in Boston on June 28, 1984. The other members listed received their medals from other IEEE societies, or regional entities, such as Sections.

S P APPLEBAUM*	JAMES STEWART HILL
S L BAILEY	TIMOTHY A HOSTETLER
R BARTNIKAS	A. ISHIMARU*
D M BOLLE	VIJAY K. JAIN
H G BOOKER*	E C JORDAN
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