Foreword

IN February 1971 a special issue of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES on Biological Effects of Microwaves was published under the editorship of Dr. J. Osepchuk. The issue contained a survey of existing knowledge and continuing research on the biological effects of microwaves. In his editorial, Dr. Osepchuk emphasized the lack of activity in the category of applications by noting that there were only three papers dealing with the subject. Of these three papers only one dealt directly with medical application, a paper by Zimmer, Ecker, and Popovic, on the use of microwaves in the treatment of tumors.

When asked by the Adminstrative Committee to be Guest Editor for this special issue, I accepted, mostly out of the conviction that biological hazards have overly dominated the literature during the past seven years. There has been a proliferation both of scientific and of popular publications that have focused on deleterious effects and health hazards of electromagnetic fields. Almost without exception, the news media and writers of the popular literature have emphasized harmful effects beyond all reckoning with the realities and limits of established knowledge. During these seven years while hazards have been grabbing the headlines and receiving most of the attention of governmental funding agencies and of working scientists, a smaller group of researchers have been making significant but less publicized progress in the area that was barely touched in the previous special issue. The use of electromagnetically induced hyperthermia as an adjunct in cancer treatment is now receiving increased attention from many specialists in engineering, biology, and medicine. As a result of the progress that has been made in this area and because the harmful effects of electromagnetic fields have received so much attention, I felt that this issue should be devoted to the important but less publicized role of Microwaves in Medicine, with Accent on the Application of Electromagnetic Waves to Cancer Treatment.

The use of heat in the treatment of cancer is believed to date back to 3000 B.C. (Baker *et al.*, this issue). Effectiveness of the treatment, however, requires a high degree of control and quantitation in the application of the heat, usually in combination with other forms of cancer therapy quantitation are dependent on the contributions and skills of workers in a wide range of disciplines from the physical sciences to the life sciences. It seems that the impetus by individuals from many disciplines who have worked together over the past few years on the problem of health hazards has now led to the required interdisciplinary communication and technology for a promising future in the use of electromagnetics in the treatment of cancer. Many, if not most, of the oncology research groups and clinics in the United States are now very much aware of recent progress in this area.

One of our colleagues, Dr. Curtis C. Johnson, who played a key role in providing leadership in organizing and directing the interdisciplinary research that has played no small part in this improved technology communication, was himself struck down by cancer this year. (See "In Remembrance of Curtis C. Johnson" following this "Foreword.") Let us hope that other engineers continue the good works begun by Curt and that they add their skills along with those of oncologists, radiologists, immunologists, and other biological scientists to insure that this new interest in the use of hyperthermia as an adjunct to cancer treatment will not dissolve, as in the past, as a result of the lack of quantitation and sound approaches for the controlled treatment of neoplasms. Let us hope that the new role of electromagnetics as a valuable tool in this ancient therapy be promptly developed and proven before excessively stringent federal regulations are generated by public fear—and before the existence of an incomplete and inconsistent base of scientific data on the health hazards of electromagnetic fields squelches the research and the clinical use of these new and promising therapeutic techniques.

Some of the papers in this issue were submitted as a result of special announcements to researchers in both physical and health sciences who have been actively engaged in research in this important problem area. Other papers originated from the special sessions on Applications to Cancer Treatment during the 1977 International Microwave Symposium, June 21–23, 1977, in San Diego, CA. Finally, a few of the papers were derived from those routinely submitted to this TRANSACTIONS.

The papers selected for this special issue include four on biological experiments that relate to treatment of tumors by electromagnetic fields. The first two papers of the series deal with the effects of electromagnetically induced heating, either alone or in combination with drugs, in inhibiting growth of experimental tumors in mice. The third paper discusses the combined effects of microwaves and ionizing radiation in delaying repair time of damaged cells. Finally, the last paper of the group compares the effects of microwave radiation, of convective hyperthermia, and of drugs on cancer-cell metabolism.

The increased emphasis on the development of suitable applicators for producing hyperthermia in tissues is demonstrated by the five papers on microwave applicators, including two for inducing hyperthermia in laboratory animals and three for inducing hyperthermia in human beings.

Finally, recent work on measurements and analysis in

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relation to the cancer problem as well as to other medical applications is reflected by the last eight papers. They include analyses of heating of cutaneous human tumors by 27-MHz short-wave diathermy, thermographic enhancement of tumor detection by microwave heating, studies of cell-suspension physiology through rapid measurement of dielectric properties, discussion of a possible definition for hyperthermic dose, analyses of the characteristics of the probes for measuring electric-field strength in biological tissues, analyses of the heating patterns in tissue models after exposure to loop and dipole antenna sources, and papers relating to theoretical and experimental studies on the interaction of millimeter waves with biological tissues.

The Editor wishes to thank each of the authors for submitting the manuscripts published in this issue and the other investigators whose works could not be included. The Editor owes special thanks to Lorraine Boyd whose tireless and skillful assistance made his task manageable. Special thanks go to the many reviewers of papers that were submitted for consideration in this special issue. Their help was essential not only in the selection of the best papers, but also for their many valuable suggestions to the authors for improving content. The Editor also wishes to express his appreciation to the people listed below for reviewing the manuscripts and providing the recommendations and constructive criticisms that led to the best choice of papers for inclusion in this special issue:

E. L. Alpen
P. W. Barber
A. H. Barrett
J. L. Bjorkstam
E. C. Burdette
F. L. Cain
R. L. Carpenter
D. R. Chambers
K. M. Chen
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S. F. Cleary
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J. W. Frazer
O. P. Gandhi
E. W. Gerner
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H. S. Ho
K. H. Illinger
A. Ishimaru
M. Iskander
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D. R. Justesen
G. Larson
J. F. Lehmann
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S. M. Neuder
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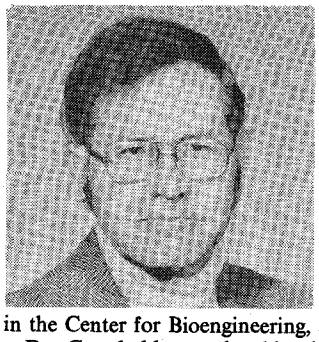
S. W. Rosenthal
H. P. Schwan
C. Süsskind
J. J. Wang
W. A. G. Voss.

ARTHUR W. GUY
Guest Editor



Arthur W. Guy (S'54–M'57–SM'74–F'77) was born in Helena, MT, December 10, 1928. He received the B.S. degree in 1955, the M.S. degree in 1957, and the Ph.D. degree in 1966, all in electrical engineering from the University of Washington, Seattle.

From 1947 to 1950, and from 1951 to 1952, he served in the U.S. Air Force as an Electronic Technician. Between 1957 and 1964 he was a Research Engineer in the Antenna Research Group, Boeing Aerospace Company, Seattle, WA. While there his field included research on broadband and microwave devices, surface wave antennas, propagation through anisotropic dielectrics, and antennas buried in lossy media. Between 1964 and 1966 he was employed by the Department of Electrical Engineering, University of Washington, Seattle, conducting research on VLF antennas buried in polar ice caps. At that time he also served as a consultant to the Department of Rehabilitation Medicine, doing work on problems associated with the effect of EM fields on living tissue. In 1966 he joined the University of Washington Medical School faculty and accepted his current position as Research Director in the Department of Rehabilitation Medicine. He is presently a Professor in that department, Adjunct Professor in the Department of Electrical Engineering, a member of the Core Faculty in the Center for Bioengineering, and is involved in teaching and research in the area of biological effects and medical applications of EM energy.

Dr. Guy holds memberships in Phi Beta Kappa, Tau Beta Pi, and Sigma Xi. He is also a member of the American Association for the Advancement of Science. He has positions on the IEEE Technical Committee on RF Radiation Socio-Technological Activity Committee on Man and Radiation (COMAR); the American National Standards Institute, Inc. (ANSI) C95 Committee, where he holds a chairmanship of the ANSI C95 Subcommittee IV; the National Council on Radiation Protection; Armed Forces-National Research Council Committee on Vision, Working Group 35; and Commission A., Radio Measurement Methods and Standards, International Scientific Radio Union (URSI), and Publicity Chairman. He serves as a Consultant to Battelle Pacific Northwest Laboratories; National Institute of Environmental Health Sciences on the USSR-US Health Cooperative Program; Physical Medicine Device Classification Panel, Electrotherapeutic Subcommittee, Food and Drug Administration; and National Research Council, Evaluation Panel for Electromagnetics Division, National Bureau of Standards. He is also a member of the editorial boards of the *Biophysical Journal* and the *Journal of Microwave Power*.