

## *Preface to Second Edition*

Interest in the telemetry course has remained, and thus it has been continued and expanded. Following the Boston presentation, it was given at the Royal College of Surgeons in London, England from June 26–28, 1968. It was next given for the University of California at San Diego from June 25–28, 1969. As a final activity that generated considerable enthusiasm and seemed to bring the whole topic “down to reality,” a laboratory session was instituted. Each participant was given a set of small components, and each succeeded in building a physiological monitoring transmitter in a short length of soda straw. With this start, it seemed easier for the participants to proceed with the immediate use of these techniques in their own areas of research. The lectures, exhibit, and laboratory were presented in Canberra, Australia in February, 1970, under the joint sponsorship of the Australian National University and the University of New England (New South Wales). Since the demand persists, it is presently scheduled to be given next in September 1970, at the American Museum of Natural History in New York.

In the first edition, many of the circuits employed transistor types whose number was preceded with the letters FK, denoting a standard transistor in a small package. The manufacturer has since discontinued this packaging, but none of the circuits are thus rendered obsolete. At any time equivalent transistors are available in small packages, and the reader is advised to inquire of manufacturers what equivalent types are available at the time of use. Indeed, transistors are being continuously improved at reduced cost, and thus it is expected that the original circuits can serve not only as examples of useful configurations, but may actually function under more difficult conditions.

As indicated previously, a steadily increasing number of investigators are using these methods and writing about them. A supplementary reading list may prove valuable to some, and thus a list of approximately 1,400 items has been added. This list is not to be considered as complete, but rather a random sampling of the literature. Some of the items were suggested by I. Ball, R. Barwick, P. Fullagar, C. Henssge, H. Hornicke, and J. Schladweiler.

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The recent studies on the fetus are being aided by a grant from the John A. Hartford Foundation, New York. The satellite oriented studies are aided by National Aeronautics and Space Administration grants, especially NGr 22-004-024.

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Boston, Massachusetts  
February, 1970

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Though some early research had been done by using procedures that might be termed bio-medical telemetry, the radio version has received the most attention during the last decade, especially since junction transistors have become available. Despite a 1962 conference at the American Museum of Natural History in New York devoted exclusively to these matters, many scientists were not using these methods, not because they had rejected them but because they were unaware of their existence or potential. On the other hand, in certain groups a sudden interest in biotelemetry brought about great confusion, and two government agencies complained that some investigators who had requested research funds did not understand the methods they were proposing to adopt.

Thus it seemed essential that someone produce a course of instruction to explain to the scientific community the advantages, procedures, and limitations of these methods. It seemed clear that reports at the usual scientific symposia, although important, were somewhat overlapping and would not serve this particular function of instruction.

To meet this need an intensive course for biologists, physicians, and engineers was organized. My lectures lasted for three full days and the associated exhibit gave the participants some experience with equipment. The interactions between participants of various disciplines seemed to stimulate the engineers to learn biological and medical needs and procedures, whereas the biologists and physicians learned something of the most modern techniques and scientific approaches to the analysis or interpretation and design of experiments. Radio techniques were emphasized, for I felt that it was a simplification to go to systems that employed telephone lines.

The first presentation in May 1965 in San Francisco was sponsored by the University of California; approximately 150 scientists, engineers, and physicians participated. The next presentation in March 1966 was sponsored by the University of California in cooperation with the American Institute of Biological Sciences. The enrollment and the diversity of the participants was significantly larger. Again, special interest was shown in the exhibit in which both apparatus and live animals demonstrated telemetry in progress. It seemed essential that the third presentation be extended to four days and this took place in August 1966 in Washington, D.C.,

under the sponsorship of the Smithsonian Institution, also in cooperation with the American Institute of Biological Sciences. Attendance numbered 250. I gave the lectures and the exhibit was manned by several of my students and staff—in particular, Barbara Dengler, George Rubissow, Ernest Woods, Sam McGinnis, and Charles Brown. A new feature was a simultaneous display of large-scale telemetry at the National Zoo. The next presentation is scheduled at Boston University, September 27–30, 1967, and a European presentation has been planned, probably in London in cooperation with the International Institute for Medical Electronics and Biological Engineering.

This book contains, essentially, this last set of lectures and should prove useful in future courses. Introductory electronics material is included for the benefit of the biologist, and some elementary biomedical material will give engineers an impression of the problems. Some biologists may find those aspects of transducers and electronics summarized in the early chapters helpful, even if they decide not to telemeter their information. The more detailed knowledge of each group should allow them to use this book as a point of departure.

Metric units are employed except for some lengths for which English units give a more convenient impression of the tolerances to which a system was built, or where standard materials or data tables are not so specified.

In the last few years interest in this field has burgeoned. It is no longer practical to prepare a complete list of references. In many cases it has proved convenient to take examples from work at Berkeley, which often involved my students. Thus much of the material is original; however, many excellent research workers throughout the world have contributed to this field.

In connection with the original research in this book several acknowledgments should be made. One relatively early development took place while I was on sabbatical in Sweden on a Guggenheim Fellowship. Both before and after this period parts of the research were supported by the Berkeley and San Francisco campuses of the University of California. Recently, many advances have been made, thanks to grant NSG-600 of the National Aeronautics and Space Administration.

Many people have assisted in the studies reported here. Special mention should be made of Barbara Dengler, George Rubissow, Sam Toy, Ernest Woods, Fred Jenkinson, and Harvey Fishman. Others are mentioned in the text, but I should like also to acknowledge the early help of John Carbone, Raymond Watten, Don Buckla, Elaine Ross, and Mark Bohrod.

*R. Stuart Mackay*