Preface to the German Edition

It is the task of telecommunications engineering to gather up whatever is to be communicated, to process it, and to transmit it across space and time. A typical example of this task is to bring about in a person an auditory perception that originated at another place and time, perhaps as it was experienced by another person. At the end of the telecommunications chain signals must be generated whose result is that the listener hears what is intended.

If an attempt is to be made to create the auditory illusion that the listener is present at the point of origin of the transmission and directly experiencing the original auditory events, then the directions and distances of what is heard must correspond as closely as possible to those at the point of origin. This requirement has led an increasing number of telecommunications engineers to become interested in the spatial attributes of auditory perceptions and in the signals that accompany these attributes, which is to say in what we shall call "spatial hearing."

Interest in spatial hearing is interdisciplinary. Important contributions to research on the subject have come from fields as diverse as psychology, psychophysics, physiology, and medicine on the one hand, and engineering, physics, and musical analysis on the other.

The first of these groups consists of fields that, from the outset, concern themselves with the human being as a consciously perceiving being. The differences between psychology, psychophysics, and physiology in this regard are, after all, only methodological. Psychology and psychophysics attempt to draw conclusions from externally observable behavior about the internal processes of the human being before, during, and after auditory experiences; physiology deals with these internal processes through direct observation. Medicine uses both methods but is especially concerned with abnormal processes and with distinguishing them from normal ones. There is special interest in spatial hearing in the fields of otology and audiology.

The second group consists of fields in which the person perceiving the auditory event is seen as the last link of a transmission chain, that is, as the recipient of the information. Among the branches of engi-

neering, telecommunications takes the greatest note of, and makes the greatest use of, the phenomenon of spatial hearing, though applications occur also in the technologies of measurement and of noise control. When applied to design problems in architectural acoustics, physics runs up against the problem that the quality of the "acoustics" of a room must ultimately be determined according to human judgments. Musical analysis, finally, is interested in the relationship between the spatial ambience created during the performance of a work and the artistic impression obtained in subsequent reproduction. It should be apparent to anyone who listens to music that contemporary composers—of popular as well as "serious" music—make increasing use of spatial effects as an artistic element.

Because of this diversity of sources of interest, knowledge about spatial hearing is widely dispersed and not readily accessible to a specialist in any particular field. The few works that contain detailed summaries (indicated by asterisks in the bibliography) are of limited scope, and their perspectives are those of one particular field.

The present study attempts to bring together the currently known fundamentals of spatial hearing and to explain them clearly enough so that readers will gain at least a preliminary overview of the subject. The numerous source notes and bibliographical references in the text are intended to provide easy access to the more detailed literature on specific problems. The number of relevant works is, however, enormous, and some of these are not readily accessible. A complete bibliography is therefore impossible.

This monograph is based primarily on literature in the fields of psychology, psychophysics, otology and audiology, telecommunications, and physics. Although physiological details are not explained, the material presented here will nonetheless be of interest to the physiologist, who is faced with the especially difficult task of bringing the results of behavioral studies into line with knowledge about physiological processes. Also, details of electroacoustic transmission systems are not discussed, since there are already a good number of surveys of works in this field. Reference is made to these in the text where appropriate.

Research in spatial hearing is based for the most part on auditory experiments using human subjects. At least for engineers and physicists, it is unusual for data to be available only by way of the descriptions by subjects being tested. Often descriptions by several subjects, based

on identical experimental conditions, will differ considerably from one another. In order to arrive at quantitative results despite these problems, psychology and psychophysics have developed special "psychometric" methods of measurement. A brief explanation of these techniques, and of the models upon which they are based, is given in the first chapter.

The first chapter also includes a few remarks on test signals and on sound fields. These will be familiar to physicists and engineers, but the remarks may make it easier for other readers to understand the physical and acoustical context of spatial hearing.

The human being has two ears. The acoustic signals presented to the two ears are by far the most important physical parameters of spatial hearing. It would be appropriate to discuss spatial hearing in terms of these signals alone, thus making possible an organization of the text based on the categories of signal theory. However, experimental results are currently available only for certain classes of ear input signals: mostly for ones that occur in a free sound field or in enclosed spaces. For this reason the present study preserves the traditional classification according to the number of sources of sound. This choice has the advantage of conforming to common practice.

I have had an opportunity to do both theoretical and experimental work in the field of spatial hearing for a number of years at the Institute of Electrical Telecommunications Engineering of the Rheinisch Westfälische Technische Hochschule Aachen. I wish to express sincere appreciation to my honored teacher, the Director of the Institute for many years, Prof. Dr.-Ing. V. Aschoff, who has given strong support to my work and who encouraged me to compile it in the present form.

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Aachen
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