

INDUSTRIAL DEAFNESS

Hearing Testing and Noise Measurement

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Preface

The increase in industrial noise and a greater appreciation of deafness in general during recent years have focused attention upon industrial deafness, which is the loss in hearing that results from exposure to intense noise.

Emphasis on the medicolegal aspect of this condition has furthermore introduced a number of challenging problems that noisy industries must meet and resolve. Such industries need to consider:

1. How to achieve a better understanding of and a clearer perspective on all aspects of industrial deafness as it affects employees and management.
2. How to determine whether a noise problem exists, and if so, what steps are necessary to establish a practical and effective conservation-of-hearing program.
3. How to train industrial personnel to perform reliable and valid hearing tests.

Considerable material has been published in the medical and acoustical literature in reference to these problems, but there has been no one volume that could be said to cover all phases of industrial deafness or to serve as a guide in solving the many problems now facing industry.

This book attempts to fill these needs and concerns itself with all aspects of noise measurement and audiometric testing. It is intentionally fundamental and is directed not to the acoustical expert but to industrial executives, industrial

physicians, hearing testers, otologists, nurses, industrial hygienists, and engineers. It is hoped that this book will make it possible for individuals with no previous experience in hearing testing or acoustics to acquire sufficient basic information and technique to perform measurements. Comparatively few bibliographic references are included because of the nature of the text, and the author and contributors have forsworn footnotes. At the end of the book, however, is included a bibliography of recommended articles published in the medical and acoustical literature.

Part I is intended to provide an over-all perspective of the various problems relating to noise and deafness. It covers the elementary physics of sound, how we hear, the causes of deafness, the medicolegal aspects of occupational deafness, and the basic problems involved in developing a conservation-of-hearing program. Certain complicated concepts, particularly in the chapter on The Physics of Sound, have been simplified. Efforts have been made to avoid equations and complex explanations as well as equivocal opinions throughout the book.

Part II is somewhat more technical and is intended for safety engineers, hygienists, and technicians concerned with noise measurements. It describes how to make noise measurements and how to use the necessary equipment. It also discusses damage-risk criteria relating noise and deafness, the principles of noise control, and the factors to be considered in making a room suitable for audiometric testing.

Part III is devoted to all aspects of hearing testing and is intended to serve as a guide and reference manual for industrial hearing testers. The directions for performing reliable and valid hearing tests are presented in a simple, step-by-step, practical manner so that they can be used for training personnel. The need for critical appraisal of testing techniques and extensive training under supervision is emphasized. This section also describes methods of record-keeping and the details to be considered in organizing a conservation-of-hearing program; it also discusses auditory fatigue, ma-

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lingering, and presbycusis. The roles of the industrial physician and otologist are presented in detail, and the principles of audiogram interpretation are demonstrated.

In order to make the book as comprehensive as possible, the author has invited several specialists to provide certain chapters so that the reader may have the benefit of the most authoritative information available. For these contributions the author wishes to express his appreciation to Charles Williams, Robert Roop, Robert Goldman, and John Zapp. To William Heimback and William Gross of the Westinghouse Corporation for their suggestions on industrial relations and the responsibilities of the engineer, and to Dr. H. Menduke for his criticism of the material on presbycusis, the author extends his appreciation.

The author also expresses gratitude to a number of colleagues and friends whose sustained interest, criticisms, suggestions, and encouragement have made this book possible: particularly to Drs. Frederick T. Hill, George M. Coates, and Frederick T. Harbert, and to those who comprise the faculty for the special course in Industrial Audiology given at Colby College, where Dr. Hill is director of the course. The different perspectives, ideas, and methods in this book have been influenced to some degree by these men at Colby, among whom are Drs. Walter Rosenblith, Hallowell Davis, Aram Glorig, Wayne Rudmose, Charles Williams, Kenneth Stevens, John Zapp, Jerome Cox, Ira Hirsh, and Stewart Nash.

For the opportunity to conduct a conservation-of-hearing program in a large industry for the past seven years, and by so doing to obtain additional field experience, the author thanks Dr. C. D. Stull, industrial physician.

The author also wishes to express his sincerest appreciation to Dale Phalen for his invaluable editorial assistance; and for continued patience in deciphering his handwriting during countless hours of typing and retyping, he is most grateful to his secretary, Nisa Delli-Pizzi.

Joseph Sataloff

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A suggested partial list of available publications in the fields of noise measurement and hearing.

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An Annotated Bibliography on Noise, Its Measurement, Effect, and Control, Industrial Hygiene Foundation of America, Inc., Mellon Institute, Pittsburgh, 1955.

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- Sound Level Meters for Measurement of Noise and Other Sounds*, Z-24-3, American Standards Association, New York, 1944.

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- Cox, I. R., Jr.: "How Quiet Must It Be to Measure Normal Hearing," *Noise Control*, vol. 1, #1, January, 1955.
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- Hirsh, I. J.: *The Measurement of Hearing*, McGraw-Hill Book Company, Inc., New York, 1952.
- Watson, L. A., and T. Tolan: *Hearing Tests and Hearing Instruments*, The Williams & Wilkins Company, Baltimore, 1949.

Visual Aids

The following films may be used to supplement much of the material in this book. Both motion pictures and filmstrips are included, the character of each being identified by the self-explanatory abbreviations "MP" and "FS." Immediately following this identification is the name of the primary distributor of the film and the year it was produced. Abbreviations are identified in the list of sources at the end of the bibliography. In many instances, the films can be borrowed or rented from local or state 16-mm film libraries. A nationwide list of these local sources is given in *A Directory of 3300 16mm Film Libraries*, available from the Superintendent of Documents, Government Printing Office, Washington 25. Unless otherwise indicated, the motion pictures are 16-mm sound black-and-white films and the filmstrips are 35-mm black-and-white and silent. The length of the motion pictures is given in minutes (min), that of the filmstrips in frames (fr).

For additional films, users should examine the latest annual editions and supplements of *Educational Film Guide* and *Filmstrip Guide*, published by the H. W. Wilson Co., New York 52. The *Guides*, standard reference books, are available in most school, college, and public libraries.

A Clinic on Deafness (MP; Med Film, 1946; 33 min color). Presents the known theories and the physiology of hearing, diagnostic methods to determine hearing range, and medical and surgical therapeutic methods. Prepared by Samuel J. Kopetsky, M.D., and Ralph Almour, M.D.

Doctor in Industry (MP; GM, 1946; 60 min). Dramatized photoplay featuring the life and struggles of a young doctor in the pioneer days of industrial medicine.

Ears and Hearing (MP; EBF, 1950; 11 min). Describes the physiology of the human ear; portrays how the parts of the ear function; and explains the common causes of impaired hearing. Correlated filmstrip, 70 fr, also available.

Fundamentals of Acoustics (MP; EBF, 1952; 11 min). Explains velocity of sound, refraction, range of hearing, lowering intensity, attenuation in air, eliminating high and low frequencies, reverberation and focusing of sound.

The Inner Ear (MP; Doho, 1951; 35 min color). Cinematographic study of the anatomy, physiology, and pathology of the inner ear. Prepared by H. G. Kobrak, M.D. Recommended by the American Medical Association for showing to otologists, audiologists, acoustic physicists, physiologists, and experimental psychologists who are interested in problems of hearing.

Life Begins Again (MP; West Elec, 1939; 15 min). Shows the dangers of defective hearing, the procedure of a hearing test, and the use of a hearing aid. Explains the purpose of the audiometer testing program.

How the Ear Functions (MP; KB, 1940; 11 min). Outlines the structure and function of the human ear; explains the nature of sound waves; and describes the functions of the tympanic membrane, ossicles of ear bones, and other parts of the ear.

Medical Aspects of High Intensity Sound (MP series; USN, 1956). Three films describing the nature of noise, psychologic and physiologic hazards of noise, particularly those made by jet aircraft, acoustic trauma, detection of hearing losses, and the relative effectiveness of ear protection devices. Subtitles and running times of the three films are:

General Effects (20 min)

Prevention of Hearing Losses (19 min)

Ear Defense (21 min)

Nose, Throat, and Ears (MP; McGraw, 1947; 10 min).

Shows the functions and structures of the nose, throat, and ears; and recommended procedures for their care. Follow-up filmstrip, 28 fr, also available.

Principles of Ultrasonics (MP; BIS, 1955; 15 min). Demonstration of the relation and range of sonic and ultrasonic waves; and the detection, properties, and uses of ultrasonic waves.

Quiet Please (MP; Celotex, 1950; 20 min color). Explains the principles of the physics of sound and the methods of controlling noise in all types of buildings.

Right to Hear (MP; Iowa, 1942; 31 min color). Demonstrates the techniques of group and individual hearing tests, medical follow-up procedures, and educational readjustments.

The Search: Johns Hopkins University: Deafness in Children (MP; YAF, 1955; 25 min). Explains a new approach to the diagnosis and cure of deafness based upon the theory that there is rarely a total loss of hearing. Produced by the Columbia Broadcasting System for television.

The Search: University of California at Los Angeles: Noise and Health (MP; YAF, 1956; 25 min). Describes the effect of noise on the health of people. Explains that sound can shatter various substances, and shows how it reacts in a "live" room and a "dead" room. Explains how the problem of noise is being combatted. Produced by the Columbia Broadcasting System for television.

Sound (MP; EPS, 1939; 9 min). Explains sound waves passing through the air with varying intensities, and the effects of vibrations with other objects.

Sound Waves (MP; UWF, 1951; 15 min). Establishes the principle that vibrations produce sound waves; analyzes the phenomena of wave motion, wavelength, and frequency; and illustrates the speed of sound in air, in water, and in solids.

Sound Waves and Their Sources (MP; EBF, 1950; 10 min). Identifies the three major sources of sound—vibrating columns of air, vibrating surfaces, and vibrating strings; explains the meaning of loudness, pitch, and quality; and shows

how the vocal mechanism functions as a vibrating column of air.

Submarine Noise Reduction: Bearings, Care in Installation (MP; USN, 1955; 19 min). Shows methods used by the U.S. Navy in reducing bearing noise and vibration in the battery vent blower. A specialized film of interest primarily as a method of effecting noise reduction.

To Hear Again (MP; USA, 1947; 37 min). Explains and shows examples of the U.S. Army's aural rehabilitation program—testing, treatment, and social rehabilitation; the use of hearing aids and lip reading; and stories of several patients. Primarily for patient orientation.

Vibratory Motions and Waves (MP; EPS, 1939; 20 min). Defines and explains damped, undamped, stationary, and propating waves; wavelength, phase, crest, trough, nodes, antinodes, condensation, and rarefaction; and transverse and longitudinal waves.

World of Sound (MP; TFC, 1946; 10 min). Explains the importance of sound, the effect of sound waves on the eardrum, and the operation of various types of hearing aids. Produced by Columbia Pictures Corp.

You Can Hear Again (MP; USVA, 1949; 30 min). Dramatized story of a veteran who finally recognizes his defective hearing and, through the aural rehabilitation program of the Veterans Administration, learns to compensate for his hearing difficulty and to lead a normal life.

Your Ear and Noise (MP; Acad Opth and Oto, 1950; 12 min color). Describes the relation of problems of noise with the functions of the ear. Shows methods of noise measurement in industry, noise control through ear defender, and noise control procedures. Stresses preemployment and routine periodic audiometer tests of employees working among hazardous noise levels. Produced by Howard P. House, M.D., and Douglas Wheeler, Ph.D., for the Subcommittee on Noise in Industry of the Committee of Conservation of Hearing of the Academy of Ophthalmology and Otorhinolaryngology.

LIST OF FILM SOURCES

- Acad Opth and Oto—American Academy of Ophthalmology and Otolaryngology, Subcommittee on Noise in Industry, 111 N. Bonnie Brae St., Los Angeles 26
- BIS—British Information Services, 30 Rockefeller Plaza, New York 20
- Celotex—Celotex Corporation, 120 S. La Salle St., Chicago 3
- Doho—Doho Chemical Corporation, 100 Varick St., New York 13
- EBF—Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
- EPS—Edited Pictures System, 165 W. 46th St., New York 19
- GM—General Motors Corp., 3044 W. Grand Blvd., Detroit 2, and 405 Montgomery St., San Francisco 4
- Iowa U—State University of Iowa, Bureau of Visual Instruction, Iowa City, Iowa
- KB—Knowledge Builders, Floral Park, N. Y.
- McGraw—McGraw-Hill Book Co., Text-Film Dept., 330 W. 42nd St., New York 36
- Med Film—Medical Film Guild, 167 W. 57th St., New York 19
- TFC—Teaching Film Custodians, Inc., 25 W. 43rd St., New York 36
- USA—U.S. Department of the Army, Washington 25
- USN—U.S. Department of the Navy, Washington 25
- USVA—U.S. Veterans Administration, Washington 25
- UWF—United World Films, Inc., 1445 Park Ave., New York 29
- West Elec—Western Electric Co., Motion Picture Bureau, 195 Broadway, New York 7
- YAF—Young America Films, Inc., 18 E. 41st St., New York 17
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