

Technical Memoranda
issued by
Acoustics Research Laboratory
(F. V. Hunt, Director)
Harvard University
1947--1971

	D. T. Blackstock	Foreword
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TM1	A. A. Janszen	Simplified procedures for reciprocity calibration
TM2	C.A. Ewaskio	Electroacoustic phase shift in loudspeakers
TM3	G. J. Holton	Ultrasonic propagation in liquids under high pressures
TM4	Osman K. Mawardi	Sound propagation in horns. I Generalized solutions of Webster's horn theory
TM5	Osman K. Mawardi	On the propagation of sound waves in narrow conduits
TM6	Osman K. Mawardi	Measurement of acoustic impedance
TM7	R. L. Pritchard	Optimum directivity patterns for linear arrays
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TM9	F. G. Blake, Jr.	The tensile strength of liquids: A review of the literature
TM10	F. G. Miller	Development of the type 48-A power-level recorder
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TM12	F. G. Blake, Jr.	The onset of cavitation in liquids. I Cavitation threshold sound pressures in water as a function of temperature and hydrostatic pressure
TM13	Harold G. Elrod, Jr.	The propagation of small disturbances in boundary-layers of compressible fluids
TM14	Osman K. Mawardi	Sound propagation in horns II. Throat impedance of finite horns

TM15	F. V. Hunt, R. L. Pritchard, and A. A. Janszen	The coaxial electrostatic transducer
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TM17	A. A. Janszen R. L. Pritchard, and F. V. Hunt	Electrostatic loudspeakers
TM18	James J. Faran, Jr.	Apparatus for the measurement of the scattering of sound
TM19	Preston W. Smith, Jr.	Apparatus and technique for sound velocity measurements
TM20	Frank G. Miller	Stylus-groove relations in phonograph records
TM21	Robert L. Pritchard	Directivity of acoustic linear point arrays
TM22	James J. Faran, Jr.	Sound scattering by solid cylinders and spheres
TM23	Robert Hills, Jr.	Synthesis of directivity patterns of acoustic line sources
TM24	Miguel C. Junger	Sound scattering and radiation from thin elastic shells
TM25	Murray D. Rosenberg	Pulsations and growth of gas-filled bubbles in sound fields
TM26	Murray D. Rosenberg	Gaseous-type cavitation in liquids
TM27	James J. Faran, Jr. and Robert Hills, Jr.	Correlators for signal reception
TM28	James J. Faran, Jr. and Robert Hills, Jr.	The application of correlation techniques to acoustic receiving receiving systems
TM29	Preston W. Smith, Jr.	Computation of the velocity of sound in gases
TM30	Preston W. Smith, Jr.	Measurement of the velocity of sound in gases
TM31	James J. Faran, Jr. and Robert Hills, Jr.	Wide-band directivity of receiving arrays
TM32	Harold Levine	On the theory of sound reflection in an open-ended cylindrical tube
TM33	Theodore J. Schultz	An acoustic wattmeter
TM34	Miguel C. Junger	Theory and design of an end-fire directive sound source

TM35	Theodore J. Schultz	A miniature condenser microphone employing a flexible diaphragm controlled by air stiffness
TM36	John V. Bouyoucos	Self-excited hydrodynamic oscillators
TM37	Victor C. Anderson	The Deltic correlator
TM38	Hugh G. Flynn	Collapse of a transient cavity in a compressible liquid Part I: An approximate solution
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TM49	Robert A. Walkling	Dynamic measurement of the hardness of plastics
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TM52	H. G. Flynn	Cavitation dynamics. II. Free pulsations and models for cavitation bubbles
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TM55	Robert W. Pyle, Jr.	Solid torsional horns

TM56	Harry A. Schenck	ZYP— An automatic impedance and admittance plotter
TM57	James E. Barger	Thresholds of acoustic cavitation in water
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TM59	Harry A. Schenck	Bilaminar ceramic flexural vibrators
TM60	Stephen H. Burns	Finite-amplitude traveling waves with boundary dissipation
TM61	Lawrence A. Crum and Anthony I. Eller	The motion of bubbles in a stationary sound field
TM62	Robert E. Apfel	Vapor cavity formation in liquids
TM63	James V. White	The stylus-groove interaction in phonograph playback
TM64	F. V. Hunt	Signal-rate processing for transit detection 1. Experimental test equipment for a time-scaled model
TM65	Nai-chyuan Yen	Subharmonic generation in acoustic systems
Final Report	F. V. Hunt	N5ori-76 (Project Order 10) [NR 384-903]
Final Report	F. V. Hunt	Final Report: 1946-1970

FOREWORD

Like many other scientists whose professional lives were interrupted, and shaped, by World War II, Frederick Vinton Hunt—Ted to his colleagues and friends—had a three-part career: prewar, wartime, and postwar. In Hunt's case all three periods were spent at the same institution, Harvard University. Prior to 1941 he established himself as a researcher, inventor, and teacher. Of his seven doctoral students who began their work during this period, three—Leo Beranek, Maa Dah You, and Robert Watson—finished before the US entered the war; the other four, their education having been interrupted, graduated in 1946 or 1947. When hostilities became imminent, Hunt set aside his academic activities and founded and directed the Harvard Underwater Sound Laboratory (HUSL). Immediately after the war HUSL was disbanded, and Hunt returned to academic pursuits. This marked the beginning of the third phase of his career, a partial result of which is the collection of Technical Memoranda that make up this publication.

So successful had HUSL been in solving problems of critical interest to the Navy that it was ready in 1946 to support the basic research in acoustics that Hunt proposed on his return to academia. The administrative unit created at Harvard for the new research was the Acoustics Research Laboratory in the Division of Engineering and Applied Physics. Hunt's plan was for the research to be carried out primarily as thesis topics by doctoral students, rather than as projects done by full-time research staff. Later, postdoctoral fellows, most of whom were home grown, were added. The description of the proposed research was by today's standards amazingly general: "research in the field of acoustics including problems arising in the generation, propagation and study of airborne sounds and sounds in liquids and solids with a view to greater emphasis on fundamental studies of the physical factors underlying acoustical phenomena, including such of the following problems as are deemed by the contractor to be desirable..." There followed a list of diverse problems whose only common denominator was acoustics. Hunt's proposal was in marked contrast to today's highly specialized and mission-driven academic research statements. The Office of Naval Research (ONR) bought the idea and provided reliable and continued support of Hunt's laboratory until 1971, one year after Hunt retired.



Back row: David T. Blackstock, V. Carlton Maley, Wilfred J. Remillard, G. Kirby Miller, William P. Raney
Front row: Harry A. Schenck, Carl D. Lowenstein, Wayne M. Wright, Robert A. Walkling, Robert W. Pyle, Jr.
Seated: Frederick V. Hunt

During the 25-year period of ONR support, 30 doctorates were completed; about half the recipients stayed on for one to four years as postdoctoral fellows. Another eight postdocs came from other universities. The picture above is a snapshot of Acoustics Research Laboratory people in 1960, taken in Hunt's office.

The Harvard Acoustics Research Laboratory research results were disseminated formally by means of reports called technical memoranda (TMs). These are the 61 reports that constitute this publication (although the numbering is 1 to 65, Nos. 16, 51, 53, and 54 were never issued). Also included is Hunt's Final Report. Journal publication was of course strongly encouraged as well, and Enclosures E in the Final Report lists the relevant abstracts and articles. About half the TMs are doctoral theses in report form though some incorporate substantial additions. Most of the other half represent output by the postdoctoral fellows. Having an unusually broad range for a single research group, the topics represented by the TMs fall mainly in the following categories: radiation, propagation, and scattering; bubbles and cavitation; acoustical instruments; electroacoustic transducers; and properties of solids, liquids, and gases. In the framework of

the present JASA editorial responsibilities, the topics fit under general linear acoustics, nonlinear acoustics, underwater sound, ultrasonics and physical acoustics, transduction, instrumentation, applied acoustics, and acoustical signal processing.

To return to the present, why publish a set of reports that are now 35-60 years old? The distribution of the reports was primarily to individuals and universities at that time active in acoustics. Good collections therefore developed at certain universities. However, times have changed. New acoustics programs have developed that have no access to the reports. At the same time, the old collections have been discarded as libraries have been sorely pressed for space to accommodate new materials. As a result availability of the reports is now extremely limited. An anecdote makes the point. Recently a graduate student at a university having a major acoustics program badly needed access to one of the TMs to get construction details of a device, details not contained in any journal article. The student tried the university library, which at one time had had an excellent collection of the Harvard TMs, only to learn that the collection had been discarded ten years ago to make room for more recent publications. The present publication will make the entire collection of Harvard Acoustics Laboratory TMs widely available.

I'm sure I speak for all Hunt's students in expressing appreciation to the Acoustical Society of America for undertaking the task of publishing the "Harvard TMs," particularly to ASA Editor-in-Chief Allan Pierce, who came up with the idea. Thanks are also due to Ronald A. Roy, Boston University, who made the lion's share of the TMs available from Robert E. Apfel's collection, and to Alan O. Sykes, ONR alumnus, who found a way to obtain eight TMs that were once thought to be unobtainable.

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