George C. Maling, Jr.

Special Session
8 September 2014

10:00 AM to 12:20 PM

Co chairs: William W. Lang and Eric J. W. Wood

In Honor of GEORGE C. MALING, JR.

Monday, September 8, 2014

10:00 AM Rio Vista I Room

William W. Lang, Co-chair
Noise Control Foundation, Poughkeepsie, NY

Eric J. W. Wood, Co-chair
Acentech Incorporated, Cambridge, MA

10:00
Chair's Introduction: George Maling's major contributions to noise control engineering

10:10
George Maling's contributions to acoustics and noise control at International Business Machines Corporation

William W. Lang, Noise Control Foundation, and Matthew A. Nobile, Poughkeepsie, N.Y.

10:30
George Maling's contributions to the founding and development of the Institute of Noise Control Engineering of the USA (INCE/USA)

Eric W. Wood, Acentech, Cambridge, MA

10:50
George Maling's contributions to the publication program of INCE/USA including the newsletter and *Noise/News International*

James K. Thompson, NIOSH - Office of Mine Safety and Health Research, Pittsburgh, PA

11:10
George Maling's many contributions to America's standards program and to international standardization in noise control engineering

Robert D. Hellweg, Jr., Hellweg Acoustics, Wellesley, MA

11:30
George Maling's contributions to the development of both the NOISE-CON and INTER-NOISE series of annual noise control engineering conferences

Joseph M. Cuschieri, Lockheed Martin, Boca Raton, FL

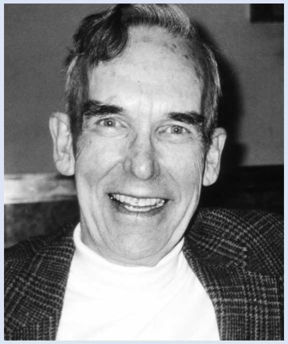
11:50
George's enormous contributions to the *Technology for a Quieter America* Program for the U.S. National Academy of Engineering

Proctor P. Reid, National Academy of Engineering, Washington, D.C.

12:10
Norah Maling behind-the-scenes with George's fifty-year effort to establish noise control as an engineering profession

Norah Maling, Harpswell, ME

Please join us in honoring a man who has contributed so much to
INCE/USA and the Noise Control Engineering Profession!!



Slide, Words, and Handout by Bill Lang
for George Maling

Special Session to Honor George Maling

- Introduction and greetings
- George’s education & background before IBM
- George’s interest in signal processing
- OSHA noise problem in New Jersey
- All-nighter in the IBM Board room
- Friendship with Jim Cooley
- Beginnings of digital signal processing
- “What is the Fast Fourier Transform?”
- Inestimable benefit to the world

Special Session to Honor George Maling

Ladies and gentlemen, it is a pleasure to welcome you to this special session to honor George for his many accomplishments in the field of noise control engineering. The handout is from the archives of the National Academy of Engineering to which George was elected a member in 1998. I have selected three examples from his long and illustrious career to illustrate a few of his many accomplishments.

He entered the field in 1954 as a graduate student; and in 1963, when he completed his PhD under Uno Ingard, he had five academic degrees—four from MIT and his Bachelor's degree from Bowdoin College. After consulting for IBM for several years, he became a full-timer in 1965 and was the specialist for the corporation available to consult on problems related to product noise control on all four continents. But his duties were principally directed at the design and product development of low-noise business machines for the Poughkeepsie acoustics laboratory.

My first example of his corporate responsibilities were when he was called to an IBM plant in New Jersey manufacturing punch cards for the IT industry. OSHA inspectors found the twenty card manufacturing presses to be over the OSHA noise limit for operator exposure and threatened to close down the plant until a plan was in place for reducing the operator exposure. The local management told George that two years previous they were working on this problem, had a noise enclosure for each press designed, but the operators had them removed as they were interfering with card production. The covers were scrapped. George told management to find one. After a mad scramble, a scrap cover was located on a farmer's field in Indiana; and IBM had it shipped back to New Jersey. The problem with reinstalling the cover was that the farmer had used it as a chicken coop, and it was full of chicken poop. But the plant was rescued from closing when George had the chicken poop removed, the cover re-installed on one press, and the OSHA inspector approved his plan to lower the noise levels of all the presses in the New Jersey card plant. The day was saved with the best analog equipment available in 1967.

There was not much signal processing in this field trip, but George's interest in signal processing was developing, but it was in its infancy. How primitive it was is illustrated by a request by the IBM Executive Vice President for Innovation to demonstrate to the IBM Board of Directors how the field was developing. George, with two engineers and a station wagon full of the best analog equipment then available in 1967, was told he could set up the demonstration in the Board room starting at 5 p.m. for the next day's Board meeting. He worked all night to set up the demonstration with local difficulties; there was not even a 110-volt AC outlet in the room. The demo consisted of an IBM type-bar typewriter at one end of the room and a large meter at the other end of the room with three areas marked. The left sector was marked with a capital I, the middle sector with a capital B, and th right sector with a capital M. With the best analog equipment and microphone in front of the meter, the operator would type an I; and the needle on the meter would swing up to the I sector; with B it would swing up to B; and with M it would swing up to M—all without wires and the rudiments of signal processing. After working all night and getting the demonstration to work flawlessly by 7 a.m., George was confronted at 8 a.m. by the IBM Vice President in charge of arranging the Board meeting for the IBM directors that would convene at 9 a.m. "What's all this stuff?" he asked George. "It's a demo for the Board requested to be set up by the Executive Vice President for Innovation." Without even bothering to look at the demonstration, the IBM VP coordinating the meeting told George that the Board members would be unable to understand the demonstration and told him to get it out of there. By 9 a.m. the room was clean, and George and his helpers had all the equipment back in the station wagon headed back to Poughkeepsie.

But George's interest in signal processing and the impending evolution of digital signal processing was undismayed. He struck up a friendship with Jim Cooley, an IBM researcher who had developed an algorithm for digital signal processing with John Tukey of Bell Telephone Laboratories. George immediately grasped that this algorithm might be what was needed to move the world from analog signal processing to digital signal processing. Working with Jim and other collaborators from BTL and MIT, he organized two symposia on the algorithm—one held in New York by the IEEE and the second in Boston by the ASA. By the end of 1967 the algorithm had caught fire, not only for the processing of noise signals but for all electronic signals transmitted through the air or on wires. IEEE top management was astounded at this developent and requested that George and his collaborators immediately prepare a paper for the proceedings of the IEEE entitled “What is the Fast Fourier Transform?” Every electronic device on your desk or in your pocket today incorporates the FFT or its modern equivalent. What started out as a new technique for processing the noises audible to the ear in digital format was responsible for the explosion of interest in the FFT which has had inestimable benefit to the world.

I would now like to introduce my colleague, Matt Nobile of the IBM Poughkeepsie Acoustics Laboratory, who will present technical details of more of George’s outstanding engineering accomplishments.

Handout from the NAE Archives

George Maling is internationally recognized as a pioneer in the field of noise control engineering. Through his research, publications, and leadership beginning in 1954 when he entered the field of acoustics and noise control he has played a key role in establishing noise control engineering as an engineering discipline. He is recognized worldwide as an authority on the noise emitted by air-moving devices and on the noise emissions of discrete frequency sources. His apparatus for determining noise emissions of air-moving devices is now internationally standardized and is universally used for noise evaluations. His research on discrete frequency sources led to the development of international standards for sound power determinations for evaluating machinery noise emissions—standards now widely used within the European Union. With collaborators from IBM, Bell Laboratories, MIT, and other institutions, he wrote two seminal papers on the Fast Fourier Transform and digital filtering—techniques that have revolutionized signal processing and have had a major impact on the fields of electrical, mechanical, and noise control engineering. He was a pioneer in applying signal processing techniques to noise control engineering. He was widely recognized within IBM as the corporation's technical leader in noise control engineering. He established evaluation methods and noise limits essential for the design of low-noise emission products. As a founder of the Institute of Noise Control Engineering of the USA (INCE/USA) in 1971, he has been instrumental in making the field of noise control engineering a recognized engineering discipline, and he continues to provide exceptional leadership to the profession through his current work for the National Academy of Engineering as chair of the committee that wrote the "Technology for a Quieter America" report published by the National Academies.

Slides followed by words by Matt Nobile for George Maling

George Maling's Contributions to Acoustics and Noise Control at IBM

William W. Lang

Noise Control Foundation

Matthew A. Nobile

Hudson Valley Acoustics

The crew when Matt started at IBM

What I imagine George said to himself on his first day at IBM…

“Hmmm… OK, I see that IBM primarily deals with:”

1. **Air moving devices (fans and blowers)**
2. **Reverberation Rooms**
3. **Anechoic Chambers**
4. **Acoustical materials**
5. **Acoustical noise measurements**

“So, I guess I will just have to become an expert in all of these.”

Air Moving Devices (fans and blowers)

Reprinted from THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, Vol. 35, No. 10, 1556–1564, October, 1963

Dimensional Analysis of Blower Noise

GEORGE C. MALING, JR.*

Development Laboratory, International Business Machines Corporation, Poughkeepsie, New York
(Received 15 May 1963)

The acoustic power/cps radiated by a centrifugal blower may be written in the form $E=\rho c^2 D^3 F(\pi DN/c, Q/\pi D^3 N, f/N)$, where D is the impeller diameter, N is the impeller speed, Q is the volume flow rate, f is the frequency of the radiated sound, and ρ and c are the fluid density and speed of sound, respectively. The form of the function F has been determined from measurements on three small centrifugal blowers that are dimensionally similar. The power radiated above some lower cutoff frequency (f_a) may be written $PWL_{a-\infty} = 10\log D^2 M^4 + 10 \log k(s_a,\phi) + 170$ dB, where $s_a = f_a/N$, $\phi = Q/\pi D^3 N$, $k(s_a,\phi)$ is a function derived from the function F, and M is the tip-speed Mach number, $\pi DN/c$.

The results of the analysis are compared with the sound laws for fans.

INTRODUCTION

A NUMBER of attempts have been made[1–8] to measure the acoustic power radiated by centrifugal blowers, and to correlate that power with operating variables such as horsepower, speed, size, static pressure, volume flow, etc. The sound laws for fans do not provide a general description of the radiated power because they are applicable only when the blower point-of-rating remains constant. Moreover, the laws provide neither the absolute level nor the spectrum of blowers cannot always be predicted by using the sound laws.

In this paper, the measured sound-power levels are expressed in terms of dimensionless variables, and a relatively simple description of the radiated power is obtained which is more detailed than the description provided by the sound laws. All of the variables that influence the magnitude of the acoustic power radiated by a blower are grouped into dimensionless ratios by application of the Buckingham pi theorem. The form

Air Moving Devices (fans and blowers)

July 2, 1962 TR 00.890

CORRELATION OF BLOWER NOISE BY THE USE OF DIMENSIONAL ANALYSIS

G. C. Maling, Jr.

ABSTRACT

Measurements on three similar centrifugal blowers have confirmed the hypothesis that the acoustic power per cycle generated by a blower may be written in the form $E = \rho c^2 D^3 F(M, \phi, s)$. The form of the function (F) has been determined by experiment, and it is shown that the power output above some lower limiting frequency (f_a) may be written:

$$PWL = 10 \log D^2 M^4 + 10 \log \left[k(s_a)\, h(\phi) \right] + 170$$

where $k(s_a)$ and $h(\phi)$ are experimentally determined functions. The former is the integral of a spectrum function, and the latter depends on the operating point chosen. Sample calculations are presented.

The experimental data on blower noise presented in this report was obtained by using the 50-foot tunnel in the IBM Acoustics Laboratory, Poughkeepsie. The operating points of the blowers used in this series of experiments were chosen so that the data could be correlated using a

Air Moving Devices (fans and blowers)

ACOUSTICS LABORATORY
TECHNICAL NOTE 418-2

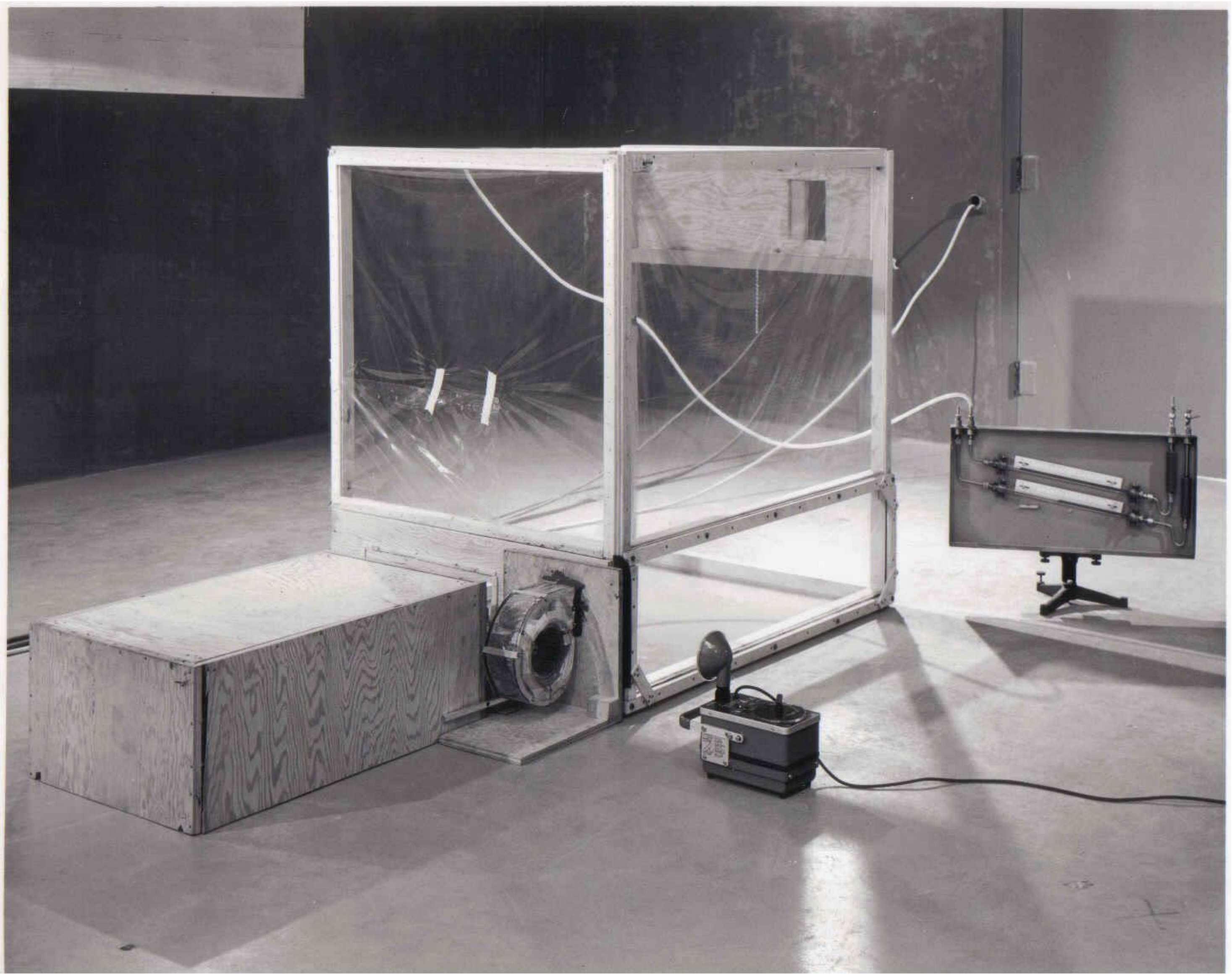
REVERBERATION CHAMBER MEASUREMENTS OF BLOWER NOISE

G. C. Maling, Jr.

INTERNATIONAL BUSINESS MACHINES CORPORATION
DATA SYSTEMS DIVISION
Poughkeepsie, New York

24 September 1964

Air Moving Devices (fans and blowers)



Air Moving Devices (fans and blowers)

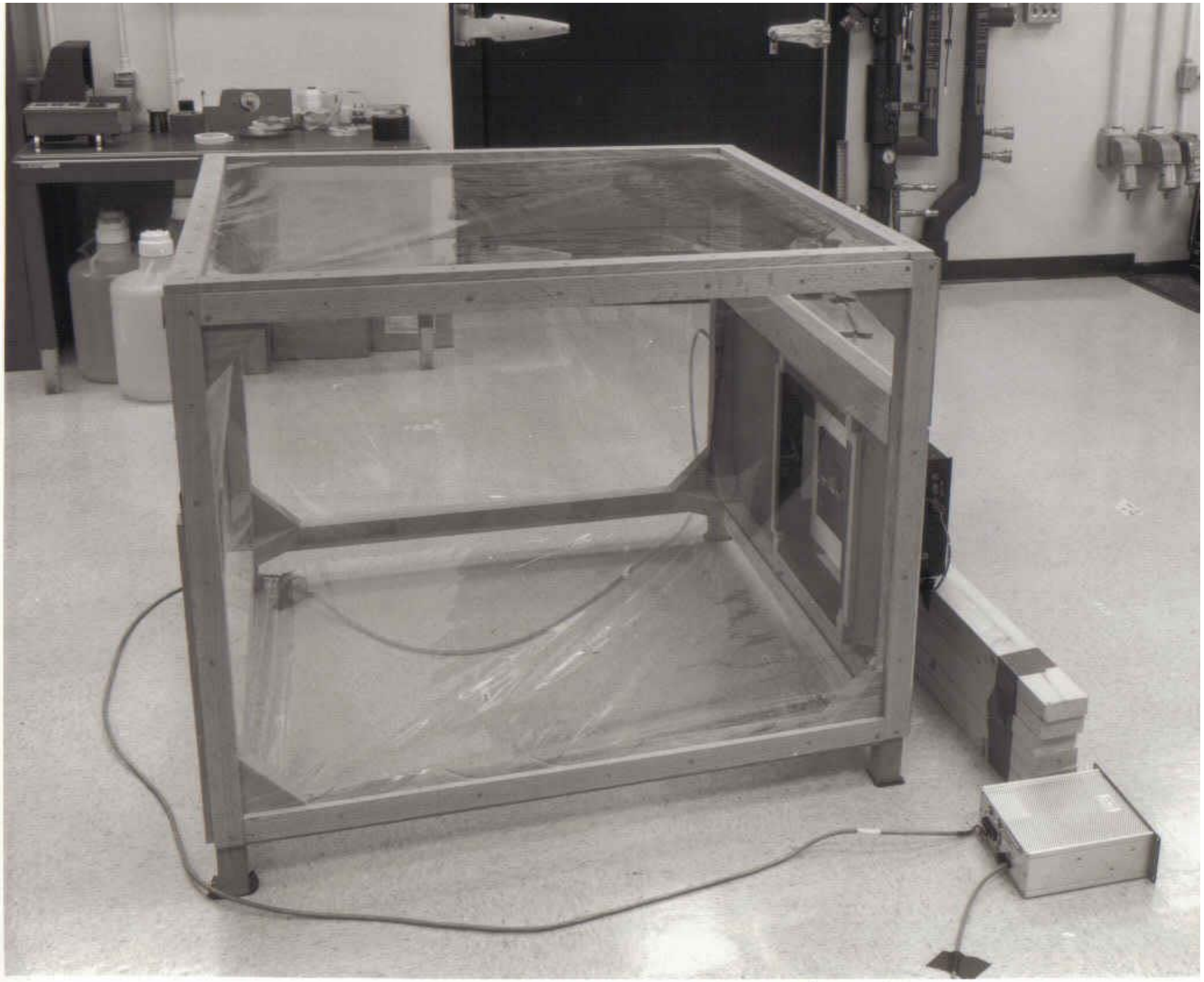


FIGURE 2

Air Moving Devices (fans and blowers)

INTERNATIONAL STANDARD

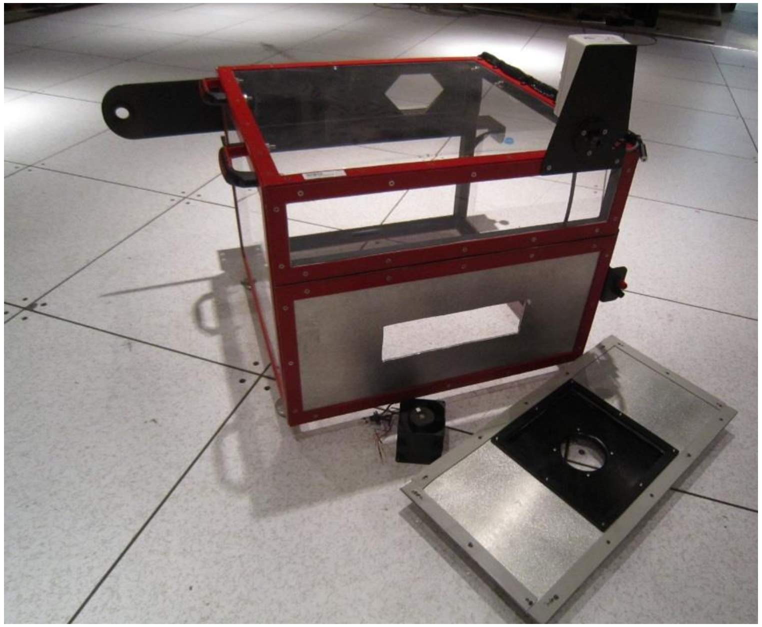
ISO 10302

First edition
1996-12-15

Acoustics — Method for the measurement of airborne noise emitted by small air-moving devices

Acoustique — Méthode de mesurage du bruit aérien émis par les petits équipements de ventilation

Air Moving Devices (fans and blowers)



Reverberation Rooms and Underlying Theory

Reprinted from THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, Vol. 42, No. 4, 859–865, October 1967

Calculation of the Acoustic Power Radiated by a Monopole in a Reverberation Chamber

G. C. MALING, JR.

International Business Machines Corporation, Poughkeepsie, New York 12602

The acoustic power W radiated by a harmonic monopole of strength Q located in a rectangular reverberation chamber has been calculated by using an eigenfunction expansion of the Green's function. An expression for the sound intensity valid for small normal admittance β has been integrated over the chamber surfaces to determine the power output. The results are within approximately ±2 dB of the results obtained by Waterhouse and Cook when the source is near one or more reflecting surfaces. At low frequencies, the ratio of W to the free-space output W_0 varies with source position within the chamber, and has been treated statistically. The space-averaged value of W/W_0 is generally less than unity, but values in the range 0.1–10.0 occur for particular values of frequency and β. The normalized standard deviation of W/W_0 lies in the range 0.3–0.4 for $\beta=0.05$, and increases as β decreases. The results are applicable to the choice of an optimum absorption characteristic for low-frequency pure-tone power-level measurements.

INTRODUCTION

As is well known, the acoustic power radiated by a sound source placed near reflecting surfaces is not the same as the power radiated in a free field. For example, if a point monopole is placed over a rigid reflecting plane, it can be shown that the acoustic-power output approaches a value that is 3 dB higher

coefficient R or a specified normal admittance β. Some typical geometrical configurations that have been studied include sources (monopole, dipole, quadrupole) over a plane, sources in a corner, sources between two parallel planes, and sources at the intersection of two planes. Most of these results may be obtained by image considerations, or by a method that involves the reflec-

Reverberation Rooms and Underlying Theory

J. Sound Vib. (1971) **16** (1), 79–87

7 3 . 3

COMPUTER STUDIES OF MODE-SPACING STATISTICS IN REVERBERATION ROOMS†

G. C. MALING, JR

International Business Machines Corporation, Systems Development Division, Poughkeepsie, New York, U.S.A.

(*Received* 10 *December* 1969)

Normal mode-spacing statistics have been computed in third-octave bands for 200 m³ reverberation chambers having dimension ratios in ranges that have previously been found to be satisfactory. The results are compared with those obtained by Sepmeyer using a different normalization procedure, and contour plots are presented that can be used to identify rooms having optimum dimension ratios.

1. INTRODUCTION

ars, several workers [1–7] have studied the problem of the distribution
encies in rectangular rooms. Although there are a number of techniques
d the mode distribution at high frequencies, at low frequencies most of
ıl importance have come from direct computation of the modal fre-
ıed that such computations are unnecessary in the design of a reverbera-
erberation room walls can be skewed, or diffusing vanes can be intro-
› change the mode structure. However, many reverberation rooms are
epipeds, and it is reasonable to expect that a room that has good mode
tisfactory, when diffusing vanes are added, than a room that has poor
, Ebbing [8] has shown that vanes are not completely effective in
ations in the radiation impedance "seen" by a source, and other
hown that an unusually high mode concentration near one frequency

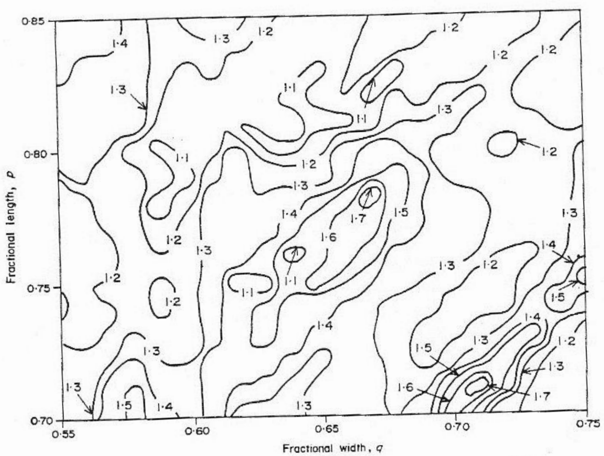


Figure 1. Contours of mean-square spacing index (I^2). Frequency range 30–90 Hz.

Reverberation Rooms and Underlying Theory

Reprinted from **IBM Journal of research and development**

Vol. 11 | No. 5 | September 1967

G. C. Maling, Jr.
K. S. Nordby

Reverberation Chamber Determination of the Acoustic Power of Pure-Tone Sources

Reverberation Rooms and Underlying Theory

Reprinted from: The Journal of the Acoustical Society of America

Reverberation-room qualification for determination of sound power of sources of discrete-frequency sound

Charles E. Ebbing
Carrier Corporation, Syracuse, New York 13201

George C. Maling Jr.
IBM Corporation, Poughkeepsie, New York 12602

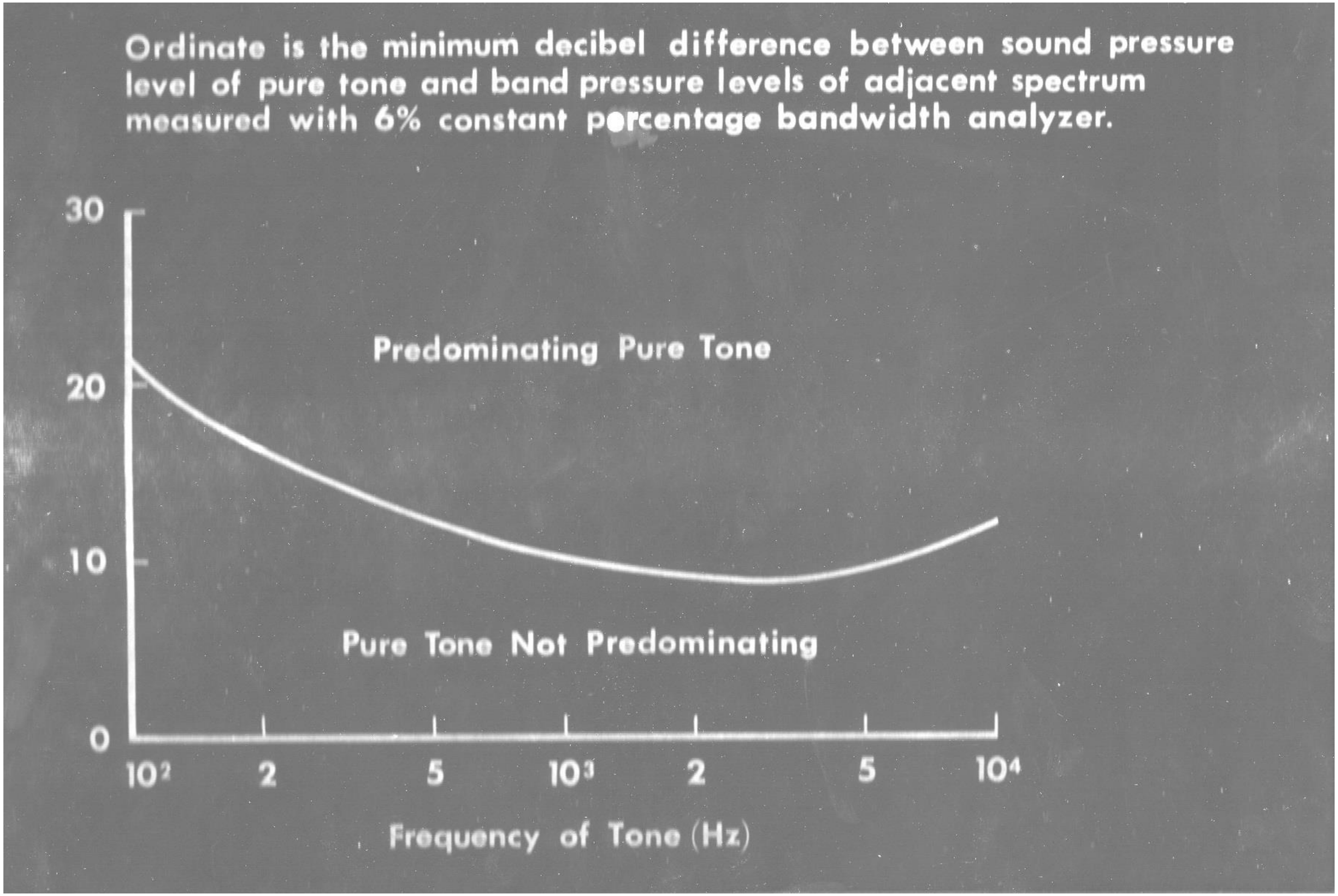
In practice, many sources of sound such as motors, pumps, fans, blowers, and transformers radiate sound having discrete frequency components. The reverberation room is a particularly convenient environment in which to determine the sound power produced by such sources provided that the measurement uncertainty can be reduced to an acceptable value. If the measurement uncertainty lies within standardized limits, the room is said to "qualify" for measurements on sources of discrete-frequency sound. The causes of the various uncertainties in the determination of sound power have been considered. It is shown that, in effect, the discrete-frequency room qualification procedure allows the measurement uncertainty to be estimated for a monopole-type sound source. The problems involved with discrete-frequency and swept-frequency qualification procedures are discussed, and experimental qualification data for several rooms with and without vanes and other accessories are presented. Methods of generating the frequencies necessary for the room qualification procedure are examined. From both theoretical and experimental studies it can be concluded that a major factor affecting the qualification of the reverberation room is the uncertainty in the measurement of the mean-square sound pressure throughout the room. This factor can be minimized by increasing the number of independent samples that one uses to estimate the mean-square pressure in the room, either by using a sufficiently long continuous microphone traverse or by using multiple microphones. At low frequencies (say, below 500 Hz in a 280-m^3 reverberation room) the variability of the sound-power output with source position (change in radiation impedance) is also a major source of the uncertainty of the sound-power estimate if the sampling of the sound field has been accomplished adequately.

Subject Classification: 7.5; 2.7, 2.8; 17.3.

INTRODUCTION

The advantages of using a reverberant room for determination of the sound-power output of sources radiating broad-band sound are well recognized. In practice, however, many noise sources radiate sound which is not entirely broad-band, but contains significant discrete-frequency components. In common the determination of the sound power produced by sources of discrete-frequency sound. However, in the last 15 years a better understanding of both the statistics of the pressure field in reverberation rooms and the variations in the radiation impedance of sources placed in a reflecting environment has made it practical, in some cases, to use a reverberation room for sound-power determination when the spectrum of the source

Subjective Response to Noise



Acoustical Materials

TR 00.2746
April 8, 1976

Composite Sound Absorbers

G.C. Maling, Jr.

IBM

Technical Report

Acoustical Materials

TR 00.2724
December 30, 1975

Measurement of High-Frequency
Sound Absorption Coefficients

George C. Maling, Jr.

IBM

Technical
Report

Acoustical Materials

IBM Confidential until December 31, 1981;
thereafter IBM Internal Use Only

Technical Report

TR 00.3081

December 30, 1980

Thin Porous Materials for Sound Absorption

George C. Maling, Jr.

Acoustical Materials

IBM Confidential until 31 December 1981
thereafter IBM Internal Use Only

Technical Report

TR 00.3060

June 18, 1980

Dual Channel Analysis

George C. Maling, Jr.

IBM
Poughkeepsie

Acoustical Measurements

calculation of the A-weighted level and noise ratings at integration times between 0.125 and 32 seconds. Transmission is at 134.5 bps and the application has been run on different computers at two remote sites.

"The Device Coupler has reduced overall turnaround time by eliminating tedious, error-prone manual recording and keying of input data and insuring its accuracy," reports Maling. "And, as users, we don't have to be concerned with software compatibility between the Device Coupler and the computers.

"We've also been able to increase the scope of our testing through the Device Coupler. With the Device Coupler, it is now possible to take much greater advantage of the performance built into our Real Time Analyzer."

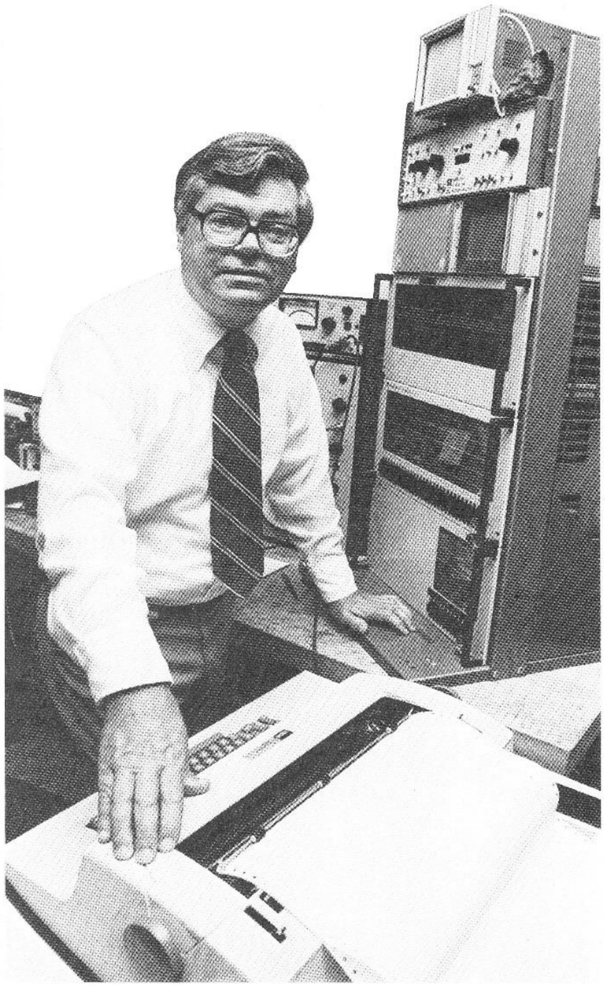
BENEFITS:
Specifically, the Device Coupler permits:

- More precise control of IBM's noise standards tests.
- Elimination of errors inherent in manual transcription and calculation of acoustical data.
- True computer and computer language independence.
- Linking acoustics data collection instrumentation to most computers.
- Gathering more acoustics data in a given time to attain better test results.
- Both the researcher and technician to make better utilization of their time.
- Ease of programming.

FUTURE APPLICATIONS EXPAND SCOPE

The availability of the Device Coupler has opened up a wider range of additional test applications for IBM acoustic labs. Among those currently under consideration are:

- Transmission of Fast Fourier Transform Analyzer readings to a remote computer. With the 7406's fast transmission rate, large volumes of data formerly impractical to collect can now be acquired.
- Voltage margin tests utilizing a programmable power supply and digital voltmeter. In this application, inputs will be changed and outputs monitored automatically under control of the application program.
- Addition of a digitally controlled frequency synthesizer which can produce test signals faster and more accurately than the audio oscillator in use today.
- Experimental analysis of normal incidence sound absorption coefficients of acoustic materials by having the application program select frequencies. Testing would be much faster and would permit automatic entry of data into a computer.
- Automatic cycling of temperature chambers with unattended collection of data on thermocouple functions.

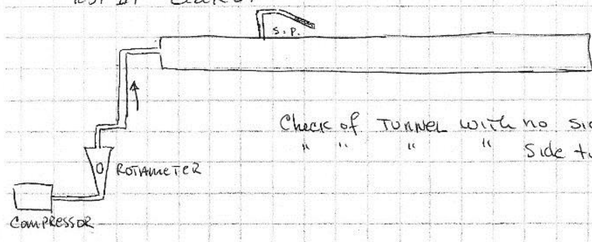


"One of the advantages of the Device Coupler is that it enables us to have easy access to a large-scale computer system which is located off-site," says Dr. George Maling. "The storage capabilities of a large system and freedom from maintenance and systems programming considerations make our system very useful for the day-to-day collection and processing of acoustical data. When one system is temporarily unavailable, another is only a telephone call away."

13. 3. 1961.

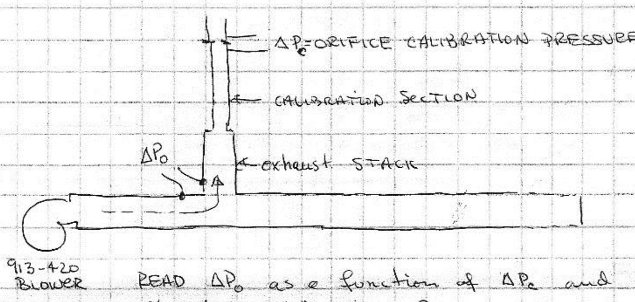
Tunnel Calibration

Test #1 Leaks:



Check of TUNNEL with no side tube 3 CFM Leak RATE @ 4½" H_2O
" " " " side tube in place 3 CFM " " @ 2½" H_2O

Test #2 - Calibration



READ ΔP_o as a function of ΔP_c and use calibration chart to determine Q (= Air flow in CFM) from ΔP_c

ΔP_o	ΔP_c	CFM
0.0025	0.055	55
0.0047	0.085	70
0.0068	0.12	82
0.009	0.15	94
0.012	0.18-.19	106-108
0.016	~~0.20~~ 0.22 (second check)	~~110~~ 115
0.02	0.28	132
0.025	0.33	142
0.03	0.39	155
0.04	0.49	172
0.05	0.64	196
0.06	0.76	213

ΔP_o	ΔP_c	CFM.
0.07	0.92	234
0.08	1.09	256
0.09	1.26	270

Cont. from P. 69

$$\frac{W}{W_0} = 8\pi\left(\frac{8}{V}\right)^2 \left\{ \int dx\,dy\,\Sigma\Sigma + \int\Sigma\Sigma\,dy\,dz + \int dx\,dz \right\}$$

Dimensional check $[dx\,dy] = L^2$ Sum has [ ] L^2 → double sum →

$8\pi\left(\frac{8}{V}\right)^2$ { } have L^6 (OK)

$\frac{1}{V^2}$ has dim $\frac{1}{L^6}$

Write down one double sum & integrate

$$\iint dx\,dy \sum_{l,m} \frac{\cos\frac{l\pi x}{L_x}\cos\frac{l\pi x_0}{L_x}\cos\frac{m\pi y}{L_y}\cos\frac{m\pi y_0}{L_y}\cos\frac{n\pi z_0}{L_z}}{D_0 - 2ik\beta\left\{\frac{\epsilon_L}{L_x} + \frac{\epsilon_m}{L_y} + \frac{\epsilon_N}{L_z}\right\}} \times$$ valid for $z=0$, $z = L_y$

$$\sum_{l,m} \frac{\cos\frac{l\pi x}{L_x}\cos\frac{l\pi x_0}{L_x}\cos\frac{m\pi y}{L_y}\cos\frac{m\pi y_0}{L_y}\cos\frac{n\pi z_0}{L_z}}{D_0 + 2ik\beta\left\{\frac{\epsilon_L}{L_x} + \frac{\epsilon_m}{L_y} + \frac{\epsilon_n}{L_z}\right\}}$$

$$= \int_0^{L_x}\int_0^{L_y} \frac{\cos^2\frac{l\pi x}{L_x}\cos^2\frac{l\pi x_0}{L_x}\cos^2\frac{m\pi y}{L_y}\cos^2\frac{m\pi y_0}{L_y}\cos^2\frac{n\pi z_0}{L_z}}{D_0^2 + 4k^2\beta^2\{\ \}^2}\,dx\,dy$$ Cross-terms cancel out.

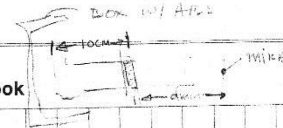
$$\int_0^{L_x}\cos^2\frac{l\pi x}{L_x}dx = \int_0^{L_x}\left\{\frac{1}{2} + \frac{1}{2}\cos\frac{2l\pi x}{L_x}\right\}dx = \frac{L_x}{2}$$

$$= \frac{L_x}{2}\frac{L_y}{2}\frac{\cos^2\frac{l\pi x_0}{L_x}\cos^2\frac{m\pi y_0}{L_y}\cos^2\frac{n\pi z_0}{L_z}}{D_0^2 + 4k^2\beta^2\{\ \}^2}$$

SURFACE AREA / 2

$$\frac{W}{W_0} = \frac{8\pi}{4}\left(\frac{8}{V}\right)^2\beta\left\{\frac{\cos^2\frac{l\pi x_0}{L_x}\cos^2\frac{m\pi y_0}{L_y}\cos^2\frac{n\pi z_0}{L_z}\left(L_xL_y + L_xL_z + L_yL_z\right)}{D_0^2 + 4k^2\beta^2\left\{\frac{\epsilon_L}{L_x} + \frac{\epsilon_m}{L_y} + \frac{\epsilon_n}{L_z}\right\}^2}\right.$$

$$\frac{W}{W_0} = \pi S\left(\frac{8}{V}\right)^2\beta\left\{\frac{\cos^2\frac{l\pi x_0}{L_x}\cos^2\frac{m\pi y_0}{L_y}\cos^2\frac{n\pi z_0}{L_z}}{\quad}\right\}$$



..O DATA ON 1/8" MAT'L (SEE BOOK # 63187, P.99. SAME SAMPLE.

	Ⓐ MAT'L W/ RIGID BACKING		Ⓑ NO MAT'L – OTHERWISE mm TUBE BEHIND PLACE FOR SAMPLE		Ⓒ TUBE + MAT'L IN PLACE	
	α	dmin	α	dmin		
..00	.085	8.5cm	.14	6.4	.29	6.2
..50	.155	6.8cm	.14	3.05	.65	2.0
..00	.100	5.25"	.235	10.7 also .18@0.0mm	.62	9.3
..00	.125	4.15"	.28	6.5	.45	5.7
..00	.06 ck ok	3.3	.32	3.00	.595	2.9
..0	.145	2.55	.47	.2	.76	4.4
..0	.155	2.00	.615	2.25	.595	2.3
..0	.165	.016	.75	3.1	.62	2.3
..0	.18	.012	.85	0.3	.795	1.85

M1 M2 M3

M320 JUL – M2 20 JULY

For impedance calc gives ~ series imp

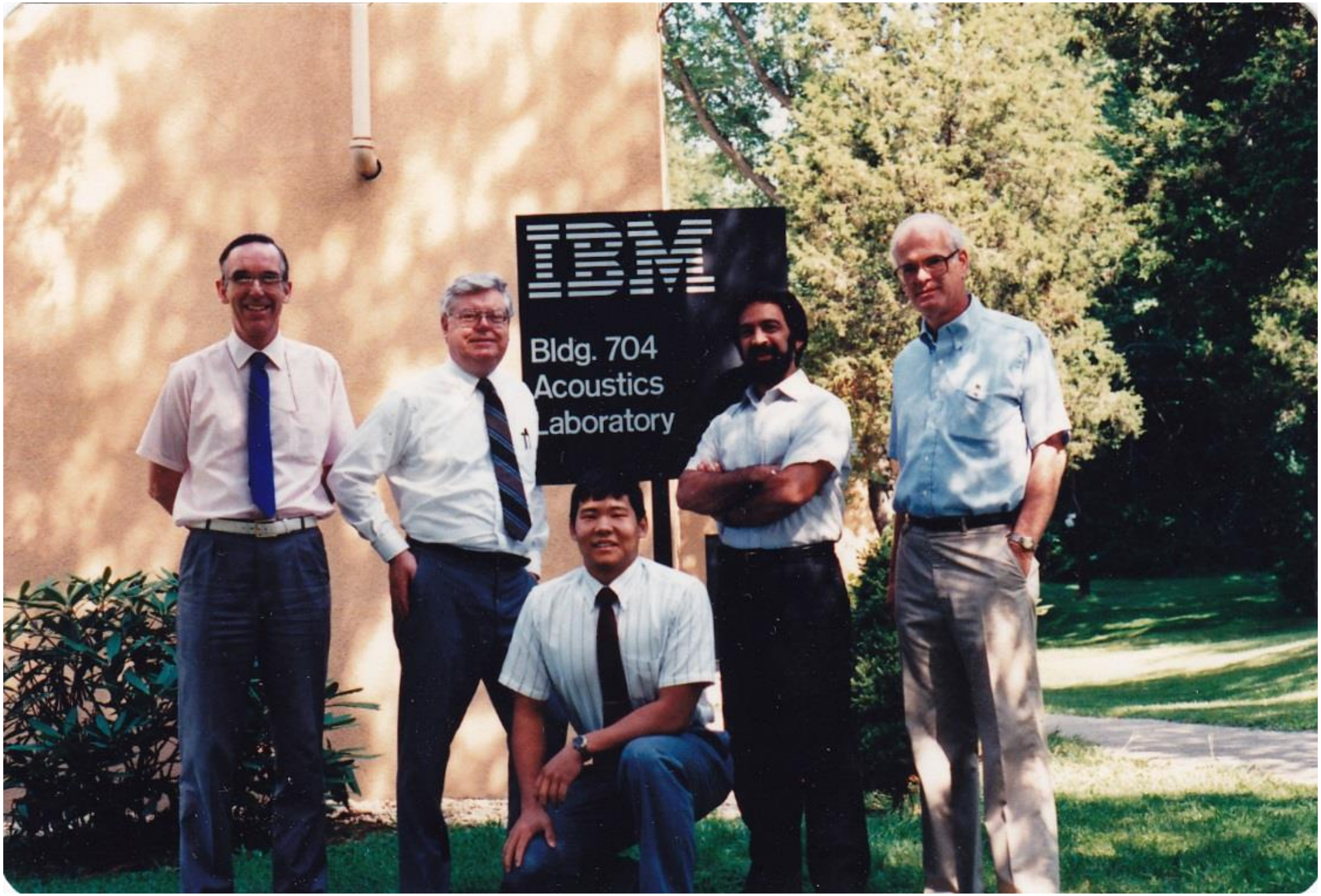
```
      ∇GO[⎕]∇

    ∇ GO
[1]   TMAT←((⍴FLST),7)⍴0
[2]   TEMP←(DATA)×0.001
[3]   L←1
[4]  LP:T2←FLST[L] ZZZ AD←ALPH[L],TEMP[L]
[5]   T3←GETB T2
[6]   TMAT[L;]←FLST[L],ALPH[L],TEMP[L],T2,T3
[7]   →LP×⍳(⍴FLST)≥L←L+1
[8]   FVEC⍕TMAT
    ∇

      ∇ZZZ[⎕]∇

    ∇ Z←F ZZZ AD
[1]   RMAG←(1-AD[1])*0.5
[2]   DEN←1+(RMAG*2)+2×RMAG×(2○2×AD[2]×K←○2×F÷344)
[3]   Z←((1-RMAG*2)÷DEN),(-2×RMAG×(1○2×AD[2]×K))÷DEN
    ∇

      ∇GETB[⎕]∇

    ∇ Z←GETB M
[1]   Z← 1 0 DV M
    ∇
```

PROGRAMMING FOR impedance Calculations

SEALS in gram

CONTINUE in PAC

George as Mentor



George as Mentor (with a sense of humor)

1986 AUG 20

FINAL EXAMINATION
FOR
M. A. NOBILE

1. The comparison method for determination of sound power uses the following equation:

$$W_S = W_R \cdot \frac{\overline{p_s^2}}{\overline{p_r^2}}$$

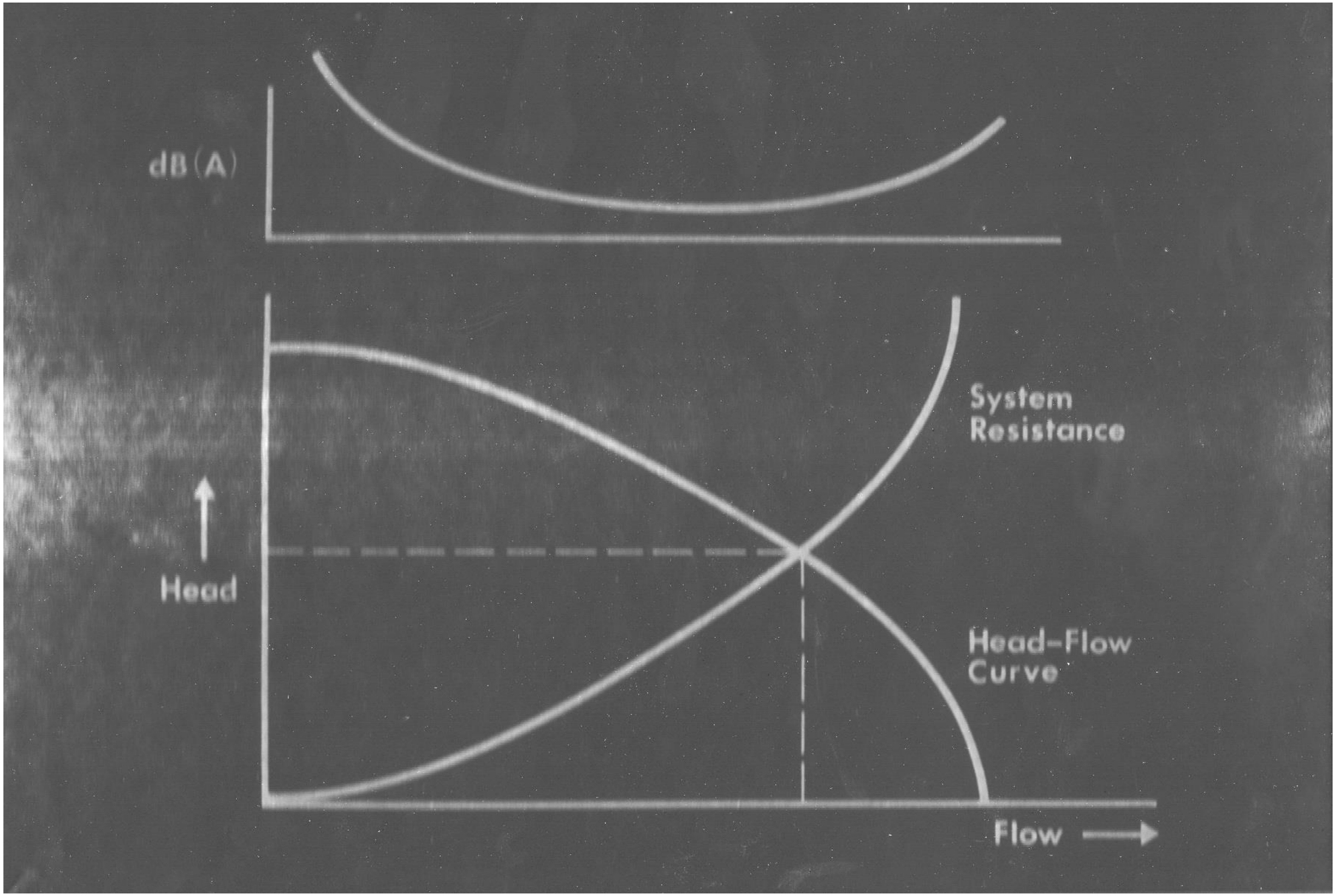
Where W_S = Power of the source under test
W_r = power of the reference source
$\overline{p_s^2}$ = mean square pressure on a measurement surface due to the source
$\overline{p_r^2}$ = mean square pressure on a measurement surface due to the reference source.

In a practical situation, the value of $\overline{p_r^2}$ depends on the position of the reference source. Suppose M source positions are used for the reference source and a set of values $\overline{p_{rj}^2}$ are obtained $j = 1, 2 \ldots M$

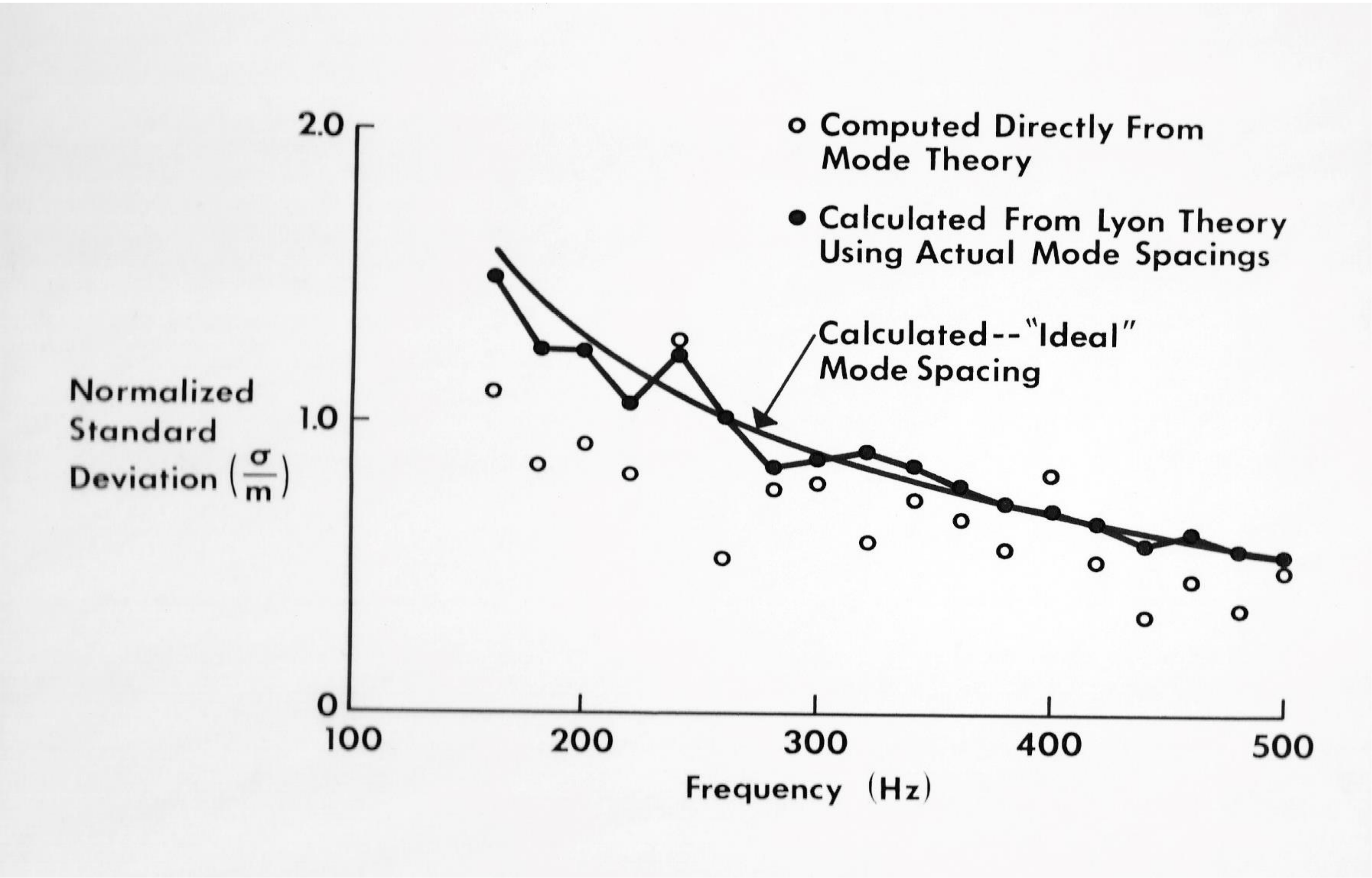
Derive an expression for the best estimate of the power output of the source. [redacted] [redacted]

Thanks for Your Attention

Extra Slides, not shown at conference (for George)


dB(A)
System
Resistance
Head
Head-Flow
Curve
Flow

Reverberation Rooms and Underlying Theory



Acoustical Measurements

Technical Report

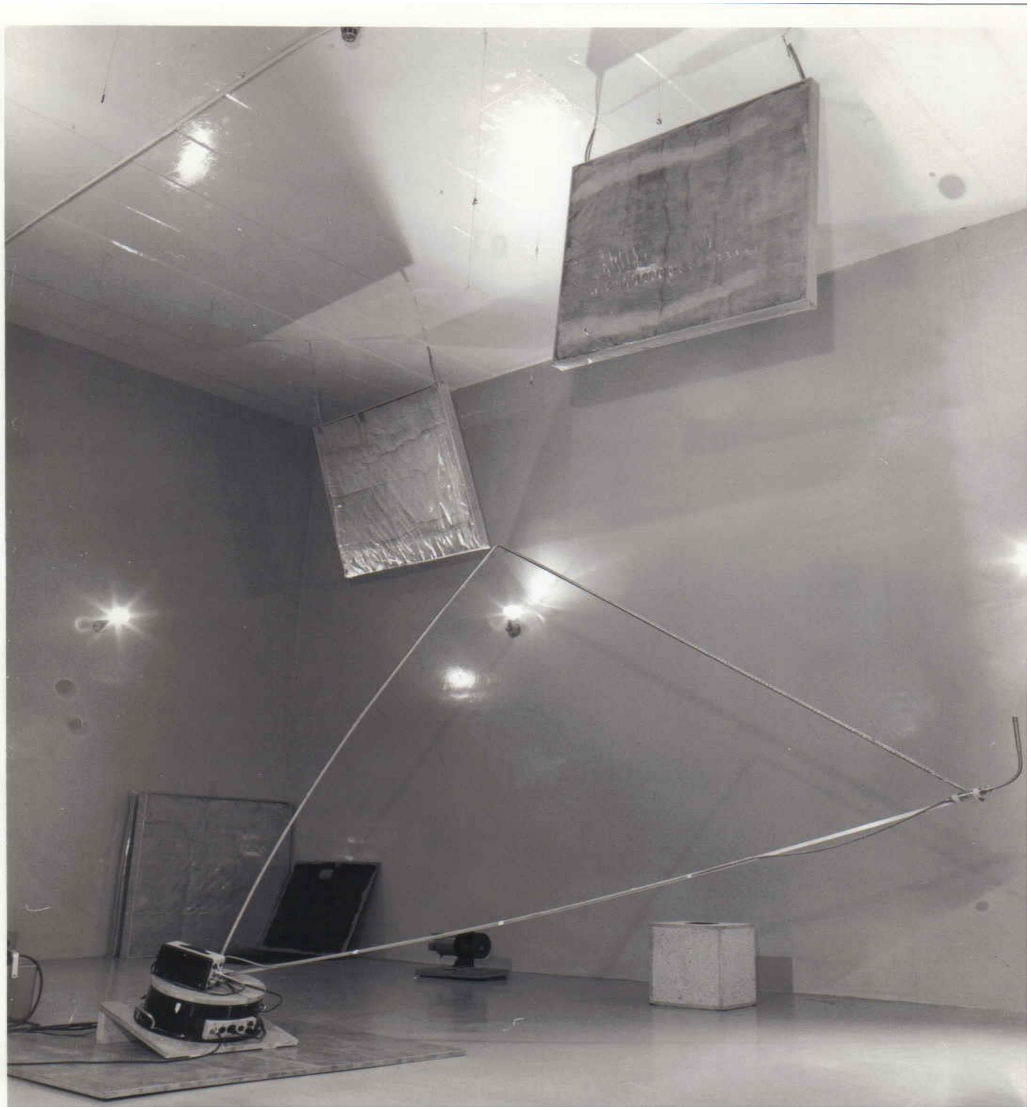
TR 00.2995
January 24, 1979

Determination of Sound Power Radiated by IBM Machines

G.C. Maling, Jr.
R.E. Wise

IBM
Poughkeepsie

Reverberation Rooms and Underlying Theory



Reverberation Rooms and Underlying Theory

Reprinted from: The Journal of the Acoustical Society of America

Guidelines for determination of the average sound power radiated by discrete-frequency sources in a reverberation room

George C. Maling, Jr.
Acoustics Laboratory, International Business Machines Corporation, Poughkeepsie, New York 12602
(Received 30 August 1971)

When a source of discrete-frequency sound is placed in a reverberation room, the sound-power output depends on the source position and frequency. In addition, the measured sound-pressure level depends on microphone position. In this paper, some experimental data are presented that are relevant to both the microphone path length required for an accurate determination of the space/time average mean-square pressure in the room, and the variations of sound-power output with source position in the room. Based on theoretical and experimental results, some guidelines are proposed for the determination of the sound-power radiated by discrete-frequency sources in a reverberation room.

Subject Classification: 7.6; 2.2; 7.7; 11.4.

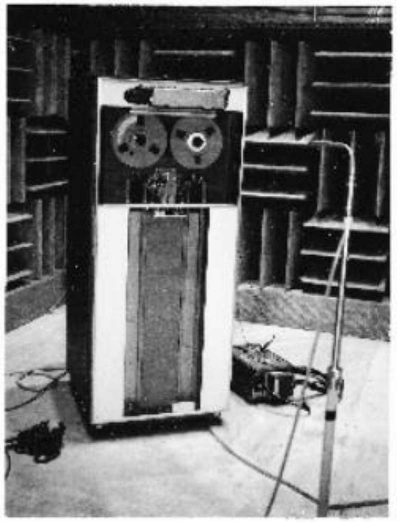
INTRODUCTION

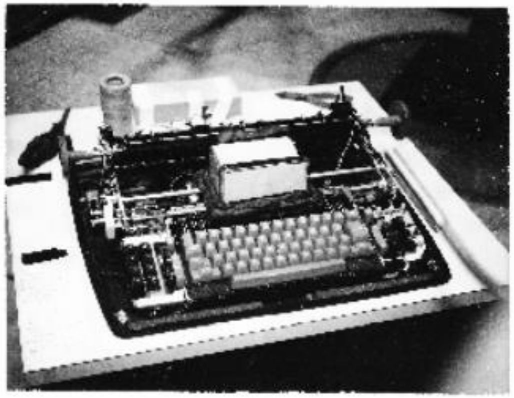
The purpose of this paper is to present some experimental results on determination of the sound power produced by a discrete-frequency source, using a reverberation room, and to suggest some guidelines that will lead to sound-power data having a given degree of accuracy. In ANS Standard S1.2-1962,[1] it is recommended that a reverberant environment *not* be used for the determination of the sound power produced by discrete-frequency sources in a reverberation room. However, many results obtained since that standard was published indicate that such measurements can be made provided that the effect of the environment on the measurements and on the source is understood. ANSI has therefore undertaken a revision[2] of this standard. There is also standardization activity in process on the inter-

Tichy,[10] Schultz,[11] and others.[12] If the sound field is produced by a single discrete-frequency tone, the spatial variance (normalized to unit mean) of the mean-square pressure is unity,[13] and the percent probability of the sample mean lying within some range of the true mean can be determined as a function of the number of uncorrelated sample points. For example, Waterhouse and Lubman[4] find that approximately 30 sample points are required to determine the mean-square pressure within ±1 dB with a probability of 80%. In many cases, it is impractical to use such a large number of discrete mircophone positions.

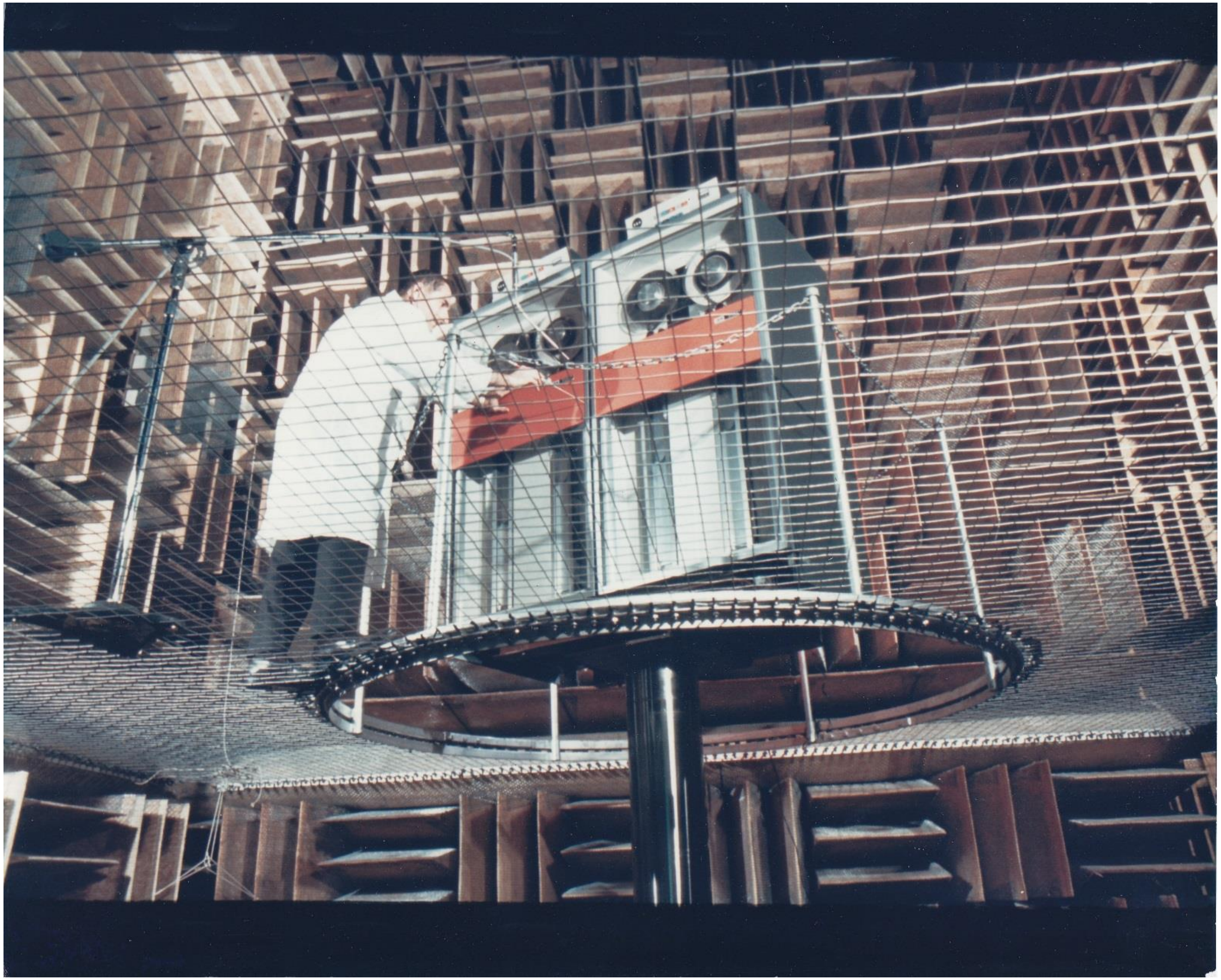
An alternative approach is to average (or integrate) the mean-square pressure continuously over a microphone path of sufficient length. Since points spaced more than one-half wavelength apart on such a

Acoustical Measurements





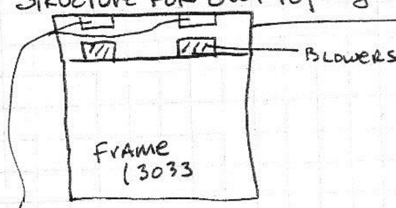
Acoustical Measurements



Acoustical Measurements

1980 MARCH 14

STRUCTURE FOR OVER TOPS OF BLOWERS IN FRAME



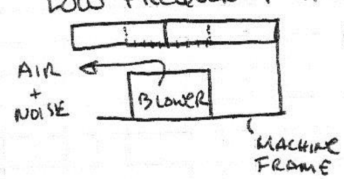
cover designed by Rew & Cliff Shelkovsky

TRAYS designed by GCM / cliff shelkovsky & Rew. HOLD 1 FT^2 OF ABSORBING MATERIAL. AIR GAP BETWEEN MICRO-POROUS PLASTIC OF 1" and 1 1/2". Tests by Mark Clark indicate good results - several dB of noise reduction achieved by trays. Controlling band for NR goes from 2000 to 500 indicating that HF absorption needed. To be calculated on an A-weighted basis using A-weighted spectra. Will probably show same trend.

INCREASED LOW FREQ ABSORPTION

DOTTED LINES THIS COULD BE OPEN, OR COULD BE A SLOT OR HOLE TO PROVIDE SOME RESONANT ABSORPTION

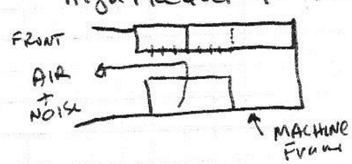
LOW FREQUENCY TRAY DESIGN



RED = POROUS MAT'L

BLACK = RIGID. This puts more air space behind mat'l which lowers the impedance making the POROUS MAT'L a better absorber.

High FREQUENCY - LOW FREQUENCY Design



RED = POROUS
BLACK = RIGID. THIS IS SPLIT ABSORBER. PORTION IN FRONT HAS SMALL (SAY 2.5CM AIR SPACE BEHIND - GOOD FOR High FREQ ABSORPTION. ~~BEHIND IS SMALLER SPACE~~ REAR ~~to~~ PORTION HAS LONGER DUCT WHICH PRODUCES MORE LOW FREQ ABSORPTION. ~~TH~~

Acoustical Measurements

DIGITAL DETERMINATION OF THIRD-OCTAVE AND FULL-OCTAVE SPECTRA OF ACOUSTICAL NOISE

BY

G. C. MALING, JR., W. T. MORREY, AND W. W. LANG

Reprinted from IEEE TRANSACTIONS
ON *AUDIO AND ELECTROACOUSTICS*
Volume AU-15, Number 2, June, 1967
pp. 98–104

Slide 1

I met George in 1982 when I first joined IBM in Poughkeepsie, and worked with him for 10 years in the Acoustics Lab before he retired. I can tell you this… those of you who know George in your various professional relationships and you know just what a kind, unselfish, honest person he is… well he was like that day in and day out even during the normal routine of his day job at IBM. George was always-approachable and his door was always open.

George taught me that it was possible to <u>like</u> doing technical work. It was <u>fun</u> to be challenged. We might be in the middle of measurements or experiments, and I'd ask a question or suggest something that may or may not have been directly related and he'd go "hmmm… let's go check that out." and we'd soon be doing some other experiment just out of his curiosity.

Slide 2

So here is the crew at the IBM Acoustics Lab when I started in 1982. That's Dave Yeager, Bill Lang, George, and Russ Wise. I still don't recognize this guy with all the black hair.

Slide 3

Now's here what I imagine George said to himself on his first day at IBM…

"Hmmm… OK, I see that IBM primarily deals with:"
Air moving devices (fans and blowers)
Reverberation Rooms
Anechoic Chambers
Acoustical materials
Acoustical noise measurements "So, I guess I will just have to become an expert in all of these."
And that's exactly what he did. And not only an expert, but a world leader in most of these.

The best way to summarize George's contribution to acoustics at IBM is to just highlight some of the projects he worked on, without the actual technical details.

Slide 4

Starting with Air Moving devices, there's no question that George became a world leader in this area while at IBM, starting way back in 1963 with his groundbreaking "Dimensional Analysis of Blower Noise" paper in which he expressed measured sound power levels in terms of dimensionless variables and came up with a better model to predict radiated sound power than the basic "fan laws" that existed up to then.

Slide 5

The work behind that paper was conducted at IBM in the early 60s when George was a consultant to IBM and continued after he joined the company, with the measurements of the sound power level of the blowers being done in the tunnel under the floor of the lab that Bill mentioned. Here's the internal IBM report from 1962 with the key equation and results.

Slide 6

OK, but forget the tunnel, why can't we just measure blower sound power level in the reverberation room, since IBM has such a nice one? Well, from this 1964 report we see that George figured out how to do this.

Slide 7

The main problem is that the radiated power depends on how the blower is loaded aerodynamically, so you needed a way to adjust the back pressure on the blower. But also, since the noise radiates from both the inlet of the blower and the outlet, whatever you did to adjust the back pressure had to allow the sound to freely radiate.

The result was George's ingenious "plastic box" shown here. The slider allows the static pressure to be varied, and the thin plastic is essentially transparent to the sound. An inclined manometer allows monitoring the pressure drop.

And… if you accidentally poke a hole in the plastic, no problem, just get some masking tape!

This was in 1965 or so, and as most of you know, 25 years later the world discovered George's plastic box and ran with it.

Slide 8

A standardized construction was agreed upon (with thin mylar replacing the plastic)…

Slide 9

And after INCE-USA published a technical report on it, the method became first an American National Standard and then an international standard and used exclusively today to measure the sound power level of small air moving devices.

Slide 10

Since computers and the associated cooling fans have gotten smaller over the years, we now have the so-called half-sized plenum, which can even be fully automated. And for this, we owe it all to George.

Slide 11

Now moving on to the Reverberation Room, itself, George figured if he were going to be taking measurements in this horrible modal environment, he'd better fully understand it. (and that he did).

The world's education began with another seminal paper of George's, "on the acoustic power radiated by a monopole in a reverberation chamber". Why is it different from the free field value, and how – perhaps through the use of optimal absorption – could we accurately measure it?

Slide 12

Well, of course a lot had to do with the modal density and mode spacing. Yes, you may think you understand all that now, but this was almost before computers! At best you had to work on a computer that you couldn't see and use FORTRAN to code the equations, and then go drive to pick up the output. So, a plot like this of the modal spacing parameter was not at all trivial back in the late 60s.

Slide 13

In fact, can we use the RR to measure the sound power level of discrete tones? Up to when George started this project in the mid-'60s, most people said "No." But if you really understood the reverberation room, George said "Yes." And this—using the reverb room to measure tonal sources—was another one of George's key contributions to acoustics at IBM, which again worked it's way into international standards.

Slide 14

In fact, most of us in this room are now benefitting from George's research. Because, once he concluded that yes, you could make measurements on tonal sources, he moved on to develop a method to qualify reverberation rooms ahead of time for testing such sources. And this method is still in the sound power standards today, essentially unchanged. In truth, a lot of us are cursing George for this, because the method is very tedious, but when all is said and done, we're thanking him.

54(4) 1973 935-949

And there were a few follow-up papers on how to determine the number of microphone positions and source positions for tonal sources… and these also became the methods in our standards that we all use, all springing from George's work at IBM.

53(4) 1973 1064-1069

Slide 15

George did a lot of work on the subjective response to noise and how IBM's customers would respond to its products. So… did you think all this recent work on prominent discrete tones that we have be seeing in the literature began about 15-20 years ago? No, here's George working on "predominating pure tones" about 50 years ago.

Slide 16

George did a lot of work at IBM on absorption and designing special absorbers for various IBM products…

in the mid 70s some work on composite sound absorbers, not only the theory (using T-networks and equivalent circuits) but also devising methods to measure the absorption, in this case he designed and constructed a square impedance tube

Slide 17

The measurement of high-frequency sound absorption coefficients. This, I believe, was done as part of a major effort in looking at the annoying high frequency tones that were coming from CRT displays, where, by the way, George became an IBM hero in solving that problem. His work also led to an international standard on how to <u>measure</u> high frequency noise to begin with. (and maybe we'll hear about that later).

Slide 18

And are you impressed by all the recent work and progress on micro-perforated materials that we are seeing at these conferences? Well, George was on top of that 35 years ago. “Thin porous materials for sound absorption” where he experimented with micro-perforated metals and plastics.

Slide 19

And as far as all the nice two-channel techniques that sprang up in the mid and late 80’s… well George was doing all that at IBM in the late 70’s, and here’s a pivotal report that showed how to use cross spectrum and transfer functions for source localization and reflection coefficients.

Slide 20

And what about interfacing acoustical instruments with a computer? When do you think that all started? Well, here’s George in 1977 with the all-new IBM 7406 Device Coupler that through a phone coupler allowed an instrument to communicate with a computer (and that would be a mainframe computer located in another building since this was well before the PC).

Slide 21

And here’s an entry from George’s first IBM Lab Notebook (we all had to use these back in the days)… It shows the blower measurement tunnel that Bill mentioned.

Slide 22

Or here’s an entry when he was working on the modal response in Reverb Rooms. Oh, … hey George, there’s an error in this denominator here.

Slide 23

And let me just show you this one to let you know that George was also an expert APL programmer… here’s some APL code.

Slide 24

Finally, let me say that George was a true mentor, totally unselfish with his time. We almost always had a summer intern at the lab (here is David Yao) that George would work with and help develop professionally.

Slide 25

But he was also a mentor for me, and he was a mentor with a sense of humor… He would give me “Final examinations” or pop quizzes when he thought there was something I should know or wanted me to check something he was working on. I sincerely missed this after you retired, George, and I know that IBM and other Corporate cultures today could greatly benefit from this kind of mentoring and the kind of leadership and integrity that you gave them. Thank You, George, and thanks for your attention.

Slides by Eric Wood for George Maling

Institute of Noise Control Engineering of the United States of America

INCE

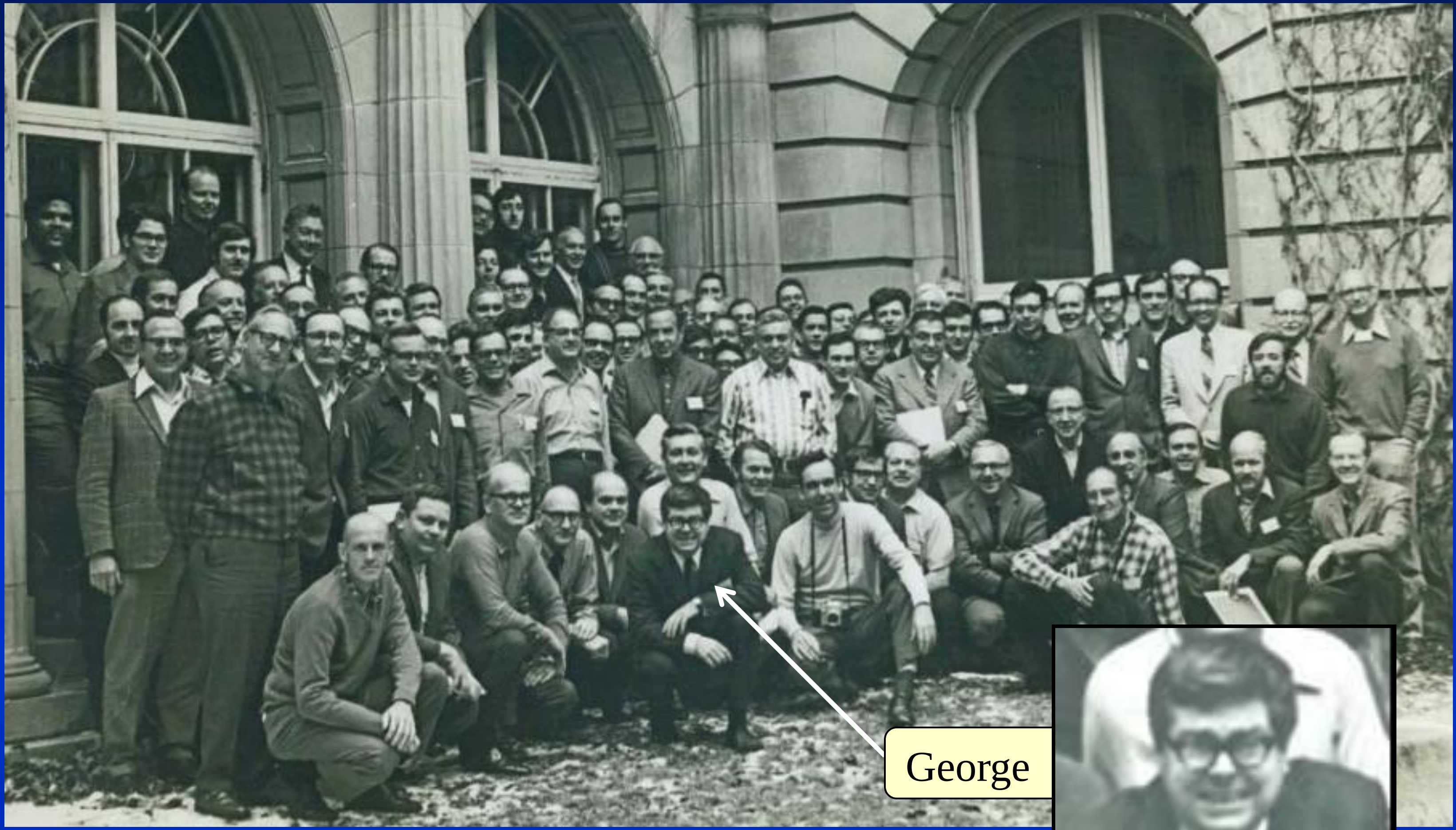
the premier noise control engineering institute

Honoring our colleague and friend George C. Maling, Jr.

Board of Directors First Meeting 1971 October 22 in Denver

Officers: Leo Beranek, Bill Lang, & George Maling

Directors: Pete Baade, Malcolm Crocker, Ken Eldred, Lew Goodfriend, Warren Kundert, Ken Oliphant, and Glenn Warnaka



Participants at the Arden House Meeting 1972 January 16-19

George and Norah at Arden House
INCE 20th Anniversary Celebration (1991)

•

They served as a magnet attracting 165 founding and pioneer members of INCE/USA.

Listed on the next two slides.

Pioneer Members

ALLEN, CLAYTON H.	ANCELL, JAMES E	ANGEVINE, OLIVER L.
BAADE, PETER K.	BAILEY, JAMES R.	BANNISTER, RONALD
BARGER, JAMES E.	BAUER, BENJAMIN	BENDER, ERICH
BERANEK, LEO L.	BIES, DAVID A.	BISHOP, DWIGHT E.
BLANCK, MICHAEL W.	BLAZIER, WARREN E. JR.	BOBBER, ROBERT J.
BOE, ROLLIN O.	BOLT, RICHARD	BONVALLET, GEORGE
BRUCE, ROBERT D.	CALLAWAY, VERNON E.	CAVANAUGH, WILLIAM J.
CHALUPNIK, JAMES D.	CHANAUD, ROBERT C.	COHEN, RAYMOND
CONNOR, WILLIAM K.	COPLEY, LAWRENCE G.	CROCKER, MALCOLM J.
CUDWORTH, ALLEN L.	CUMMINS, JIM R., JR.	DALY, EDWARD A.
DAVY, BRUCE A.	DRISCOLL, DANIEL A.	DUDA, JOHN F.
DYER, IRA	DYM, CLIVE E.	EBBING, CHARLES E.
ELDRED, KENNETH M.	ENGSTROM, JOHN R.	FEHR, ROBERT O.
FELDMAN, SAMUEL	FLYNN, DANIEL R.	GALES, ROBERT S.
GALLOWAY, WILLIAM J.	GOODFRIEND, LEWIS S.	GOODMAN, JEROME
GRAHAM, J. BARRIE	GRIFFIN, GLENN H.	GUINTER, JOHN M
HAAG, FRED U.	HALVORSEN, WILLIAM G.	HAMILTON, JAMES F.
HEMDAI,, JOHN E.	HEMOND, CONRAD J., JR.	HERBERT, R, KRING.
HICKLING, ROBERT	HILLIARD, JOHN K.	HILLQUIST, RALPH K.
HIRSCHORN, MARTIN	HIXSON, ELMER L.	HOLMER, CURTIS I.
HOOVER, ROBERT M.	HORNER, TOM	HUBBARD, HARVEY H.
IHDE, WILLIAM M.	INGARD, K. UNO	JOHNSON, JOHN C.
JUNGER, MIGUEL C.	KAMPERMAN, GEORGE W.	KERWIN, EDWARD M., JR.
KESSLER, FREDERICK M.	KINGSBURY, HOWARD F.	KIRSCHNER, FRANCIS
KLEINSCHMIDT, KLAUS	KLEPPER, DAVID L.	KODARAS, MICHAEL J.
KOENIG, ROBERT J.	KUNDERT, WARREN R.	LAMBERT, ROBERT F.
LANG, WILLIAM W.	LEASURE, WILLIAM A., JR.	LEPOR, MEYER

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Honoring our colleague and friend George C. Maling, Jr.

Pioneer Members

LOTZ, ROBERT	LOWE, ALBERT W.	LUBMAN, DAVID
MAGLIERI, DOMENIC J.	MAIDANIK, GIDEON	MALING, GEORGE C., JR.
MARLOTTE, GARY L.	MARSH, ALAN H.	MEDWIN, HERMAN
MEYER, ALVIN F., JR.	MEYERSON, NORMAN L.	MILLER, LAYMON N.
MILLER, THOMAS D.	MORGAN, WILLIAM R.	MORROW, CHARLES T.
MULL, HAROLD R.	MUSTER, DOUGLAS	NASH, ANTHONY
NORDBY, KNUT	NORTHWOOD, THOMAS D.	ODELL, ALBERT II.
OLIPHANT, KENWARD S.	PARRY, HUGH J.	PATEL, KRISHNA N.
PATTERSON, WILLIAM N.	PAULHUS, NORMAN "CHRIS" R	PEARSONS, KARL. S.
PEPPIN, RICHARD J.	PETERSON, ARNOLD P. G.	POTTER, STANNARD M.
POWELL, ALAN	PURCELL, JACK B.	REETHOF, GERHARD
RETTINGER, MICHAEL	RICHARDS, ROY E.	ROCKWELL, THOMAS H.
SALMON, VINCENT	SALTER, CHARLES M.	SCHMIDT, BELA
SCHULTZ, THEODORE J.	SEEBOLD, JAMES G.	SEPMEYER, LUDWIG W.
SESSLER, STEPHEN M.	SHAPIRO, NATHAN	SHARP, BEN H.
SHINER, ALLEN H.	SMITH, DONALD B.	SPERRY, WILLIAM O.
SUTHERLAND, LOUIS C.	SWING, JOHN W.	TANNER, ROBERT H.
TATGE, R. BRUCE	TEPLITZKY, ALLAN M.	THORNTON, WILLIAM R
TICHY, JIRI	TIMS, EUGENE F.	TYLER, JOHN M.
UNGAR, ERIC E.	VAN HOUTEN, JOHN J.	VATZ, IRVIN P.
VER, ISTVAN L.	VON GIERKE, HENNING E.	WADE, SAMUEL R.
WALKER, BRUCE E.	WARNAKA, GLENN	WEISS, MARVIN
WILSON, GEORGE P.	WINZER, GEORGE	WISE, RUSSELL E.
YERGES, LYLE F.	YOUNG, ROBERT W.	ZORUMSKI, WILLIAM E.

•

George Maling has contributed greatly to the vision, birth, and raising of the world's finest professional noise control engineering institute

INCE

Honoring our colleague and friend George C. Maling, Jr.

Service to our Institute Includes

Visionary

Incorporator and Founder (1971)

Executive Committee

Member for 43 years

President 1975

Vice President 1979 – 1981

Secretary 1972 - 1974

Director 1972 – 1977

Managing Director

Conference Chair and Proceedings Editor

Dozens of Papers and Articles During 7 Decades

Student Paper Prize Competition Chair

A Link to the National Academy of Engineering

Vice President Communications for I-INCE Founded in 1974

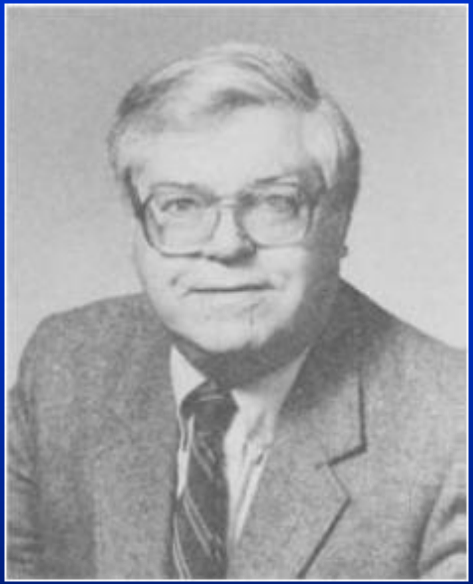
INTER-NOISE CONGRESSES

the largest international gathering of experts in noise control engineering each year

George served as the General Chair of:

INTER-NOISE 1980 in Miami, and

INTER-NOISE 1989 in Newport Beach



INCE Awards

Distinguished Noise Control Engineer Award

For pioneering leadership in establishing noise control as an engineering discipline, and for exceptional contributions to the development of international and national noise control practice and standards.

INCE Awards

INCE/USA Distinguished Service Medal

Without George and Norah, INCE/USA would not be the fine organization that it is today; they are the personification of altruism and we are fortunate that they have focused on making INCE/USA successful.

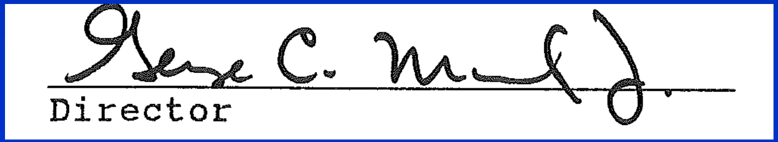
INCE Fellow Member

For service as Founder, Director, and Managing Director of INCE/USA, and Director and President of the INCE Foundation. For contributions to noise control engineering as a leader of the National Academy of Engineering Technology for a Quieter America program, managing editor of Noise News International, and international and national noise control practice and standards. And as the 2001 recipient of the INCE Distinguished Noise Control Engineer Award, and together with Norah Maling the 2009 INCE Distinguished Service Medal.

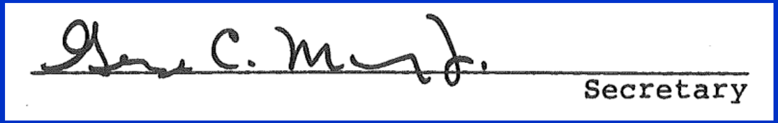
Service to the INCE Foundation

Founder and Incorporator (1993)

Director



Secretary



President

Editor of Annual Newsletter

It has been said that:

George Maling has provided the glue that has held the organization together over the years.

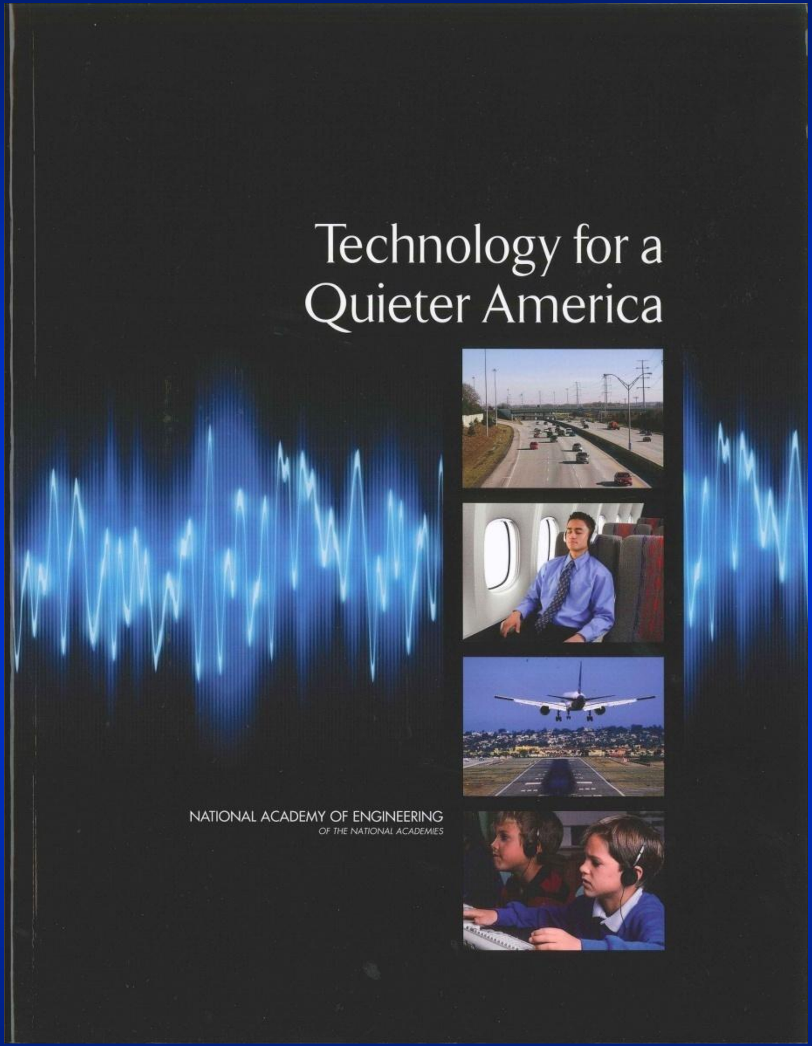
He has provided the backbone that has kept INCE a thriving organization since its founding.

INCE/USA History Document

The history of our Institute is provided in a document written by Bill Lang and is available without charge from our website on the page: About INCE

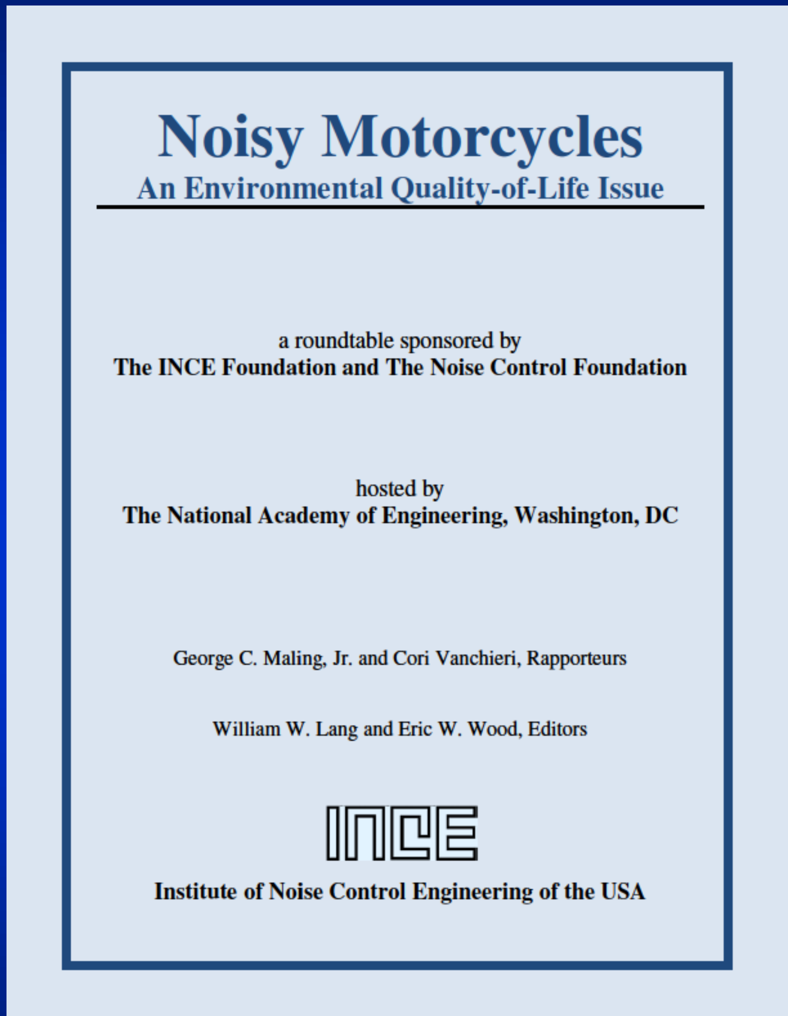
Let me know if you would like a paper copy.

Recent Publications



Published by the
National Academies
Press (2010)

Recent Publications



Noisy Motorcycles

An Environmental Quality-of-Life Issue

a roundtable sponsored by
The INCE Foundation and The Noise Control Foundation

hosted by
The National Academy of Engineering, Washington, DC

George C. Maling, Jr. and Cori Vanchieri, Rapporteurs

William W. Lang and Eric W. Wood, Editors

INCE

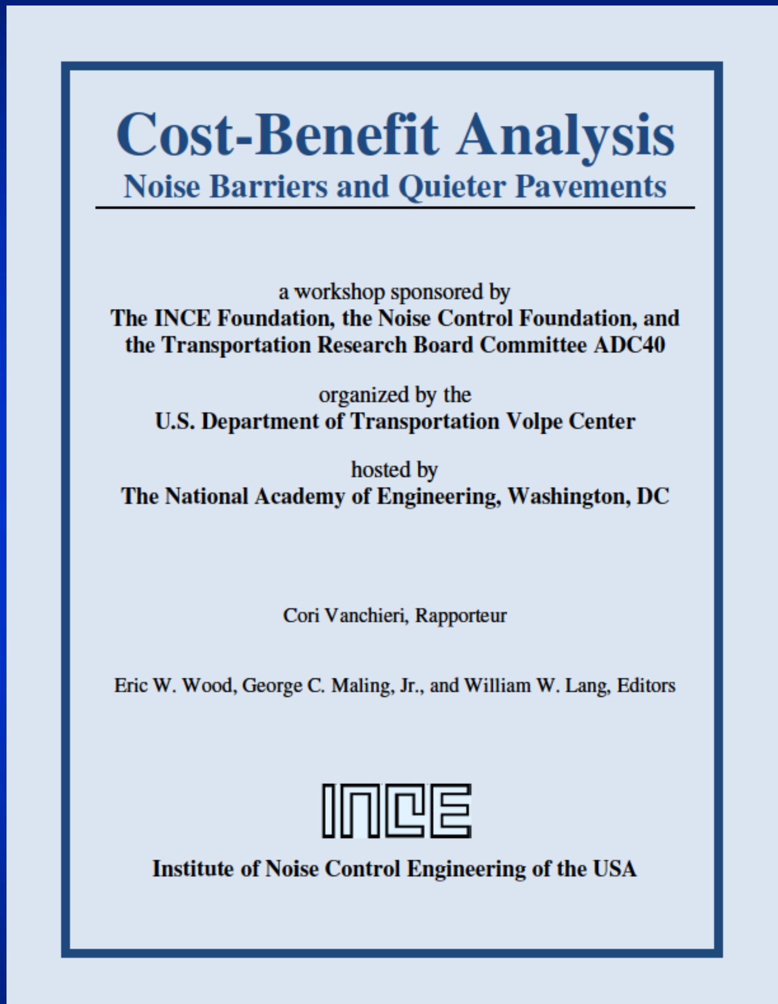
Institute of Noise Control Engineering of the USA

INCE/USA

Public Information

Document (2014)

Recent Publications



Cost-Benefit Analysis

Noise Barriers and Quieter Pavements

a workshop sponsored by
The INCE Foundation, the Noise Control Foundation, and the Transportation Research Board Committee ADC40

organized by the
U.S. Department of Transportation Volpe Center

hosted by
The National Academy of Engineering, Washington, DC

Cori Vanchieri, Rapporteur

Eric W. Wood, George C. Maling, Jr., and William W. Lang, Editors

INCE

Institute of Noise Control Engineering of the USA

INCE/USA

Public Information

Document (2014)

Honoring our colleague and friend George C. Maling, Jr.

Publication in Progress

Reducing Employee Noise Exposure in Manufacturing

Best Practices,
Innovative Techniques,
and the Workplace of the Future

INCE/USA

Public Information

Document

(in progress)

A Team Effort by George and Norah

Norah Maling has served as:

Membership Secretariat and the Office of Managing Director

She continues providing enormous ongoing support, understanding, and kindness.

Thank you Norah.

George and Norah at InterNoise 1989

Newport Beach

George and Norah at InterNoise 1992

Toronto

George and Norah at Dinner with Friends

Istanbul During InterNoise 2007

Honoring our colleague and friend George C. Maling, Jr.

Presidents Panel during NoiseCon 2011

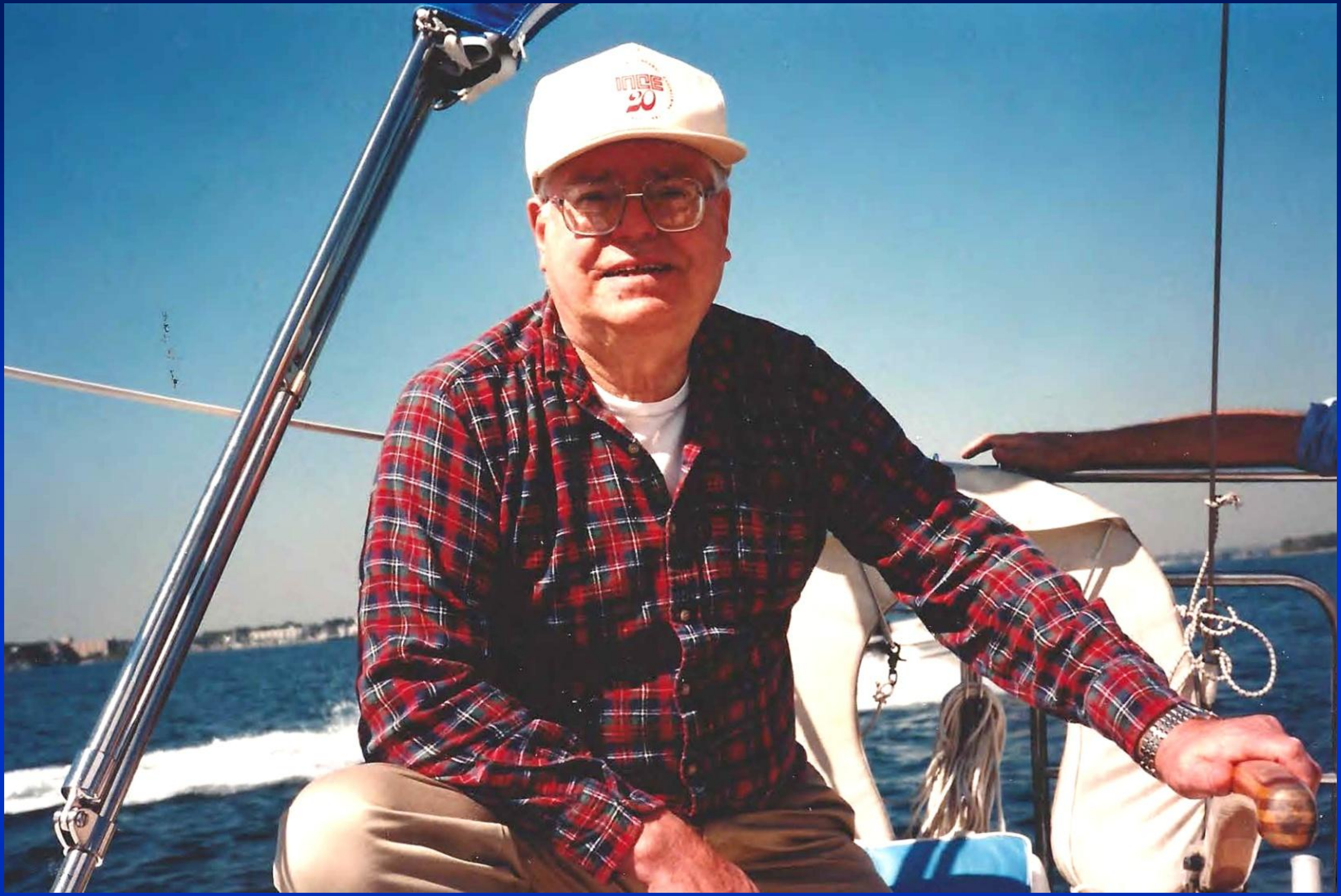
Views from the Corner Office

George and Norah at NoiseCon 2011

Portland, Oregon

Honoring our colleague and friend George C. Maling, Jr.

Images from the Maling Family Album



George and the INCE 20th Anniversary Hat

Sailing in the San Juan Islands

Son Jeff and Son-in-Law Greg

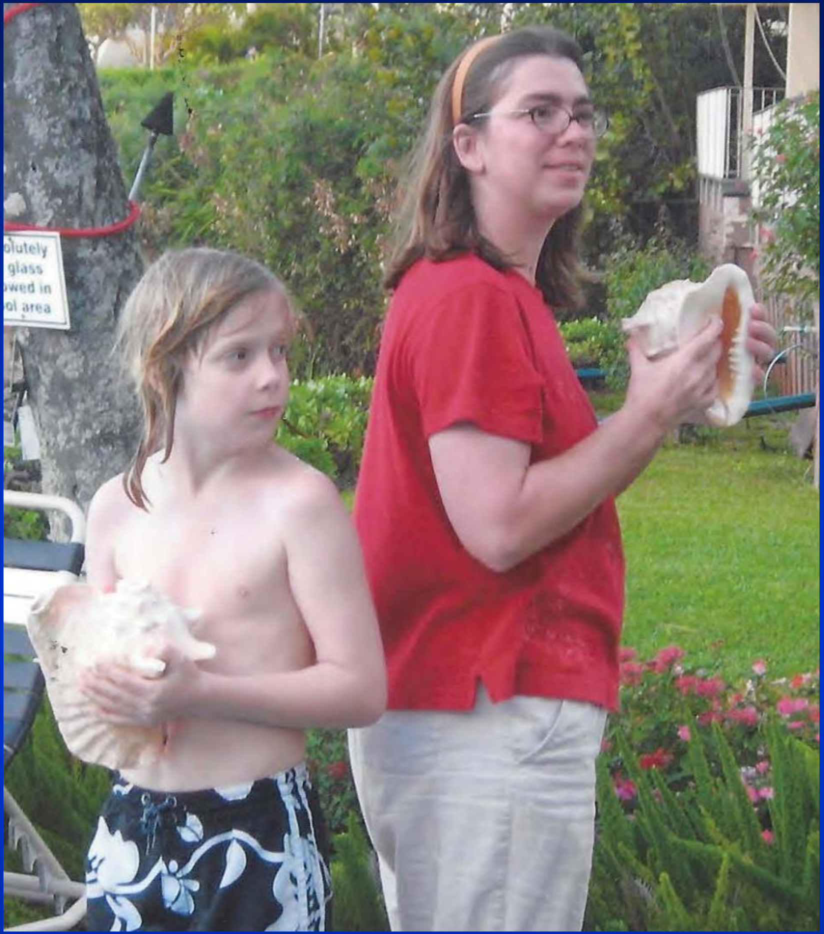
Home Away From Home – The Famous Family Tent
With Daughter Barbara and Grandson Andrew

George with Daughter Ellen in Washington, DC

Along Alamoosook Lake, Maine

With Daughter Barbara, Grandson Ian, Greg, and Grandson Andrew

Daughters Barbara and Ellen and Grandson Andrew along the Maine Shore



Daughter-in-Law Trish and Grandson Andrew
Conch Players

Maling Family Togetherness (July 2014)
With Grandchildren Ian, Cayen, and Aamycia

Honoring our colleague and friend George C. Maling, Jr.

George, thank you for your decades of support and contributions to the:

Noise Control Engineering Profession

Institute of Noise Control Engineering of the United States of America

INCE Foundation

And Thank You for Your Friendship

•

Norah, thank you for your

Support, Friendship,

And Sharing Lovely Family Photographs

IHonoring our colleague and friend George C. Maling, Jr.

Slides by Jim Thompson for George Maling
Not Available

Slides by Bob Hellweg for George Maling

Advancing the Technology and Practice of Noise Control Engineering

George Maling's many contributions to America's standards program and to international standardization in noise control engineering

Robert D. Hellweg, Jr.

Hellweg Acoustics and Epsilon Associates, Inc.

George Maling's Contributions to Standards used in Noise Control Engineering

Outline:

- Development of standards for the measurement of sound power levels
- Implementation of the use of FFTs and Digital signal processing
- Fan noise testing with the "Maling Box" – a fan plenum

Why is an employee at IBM interested in measurement standards?

- Measured product noise values are accurate
- Measurement techniques that are reliable, repeatable, and practical to implement
- Measured changes due to noise mitigation are not due to measurement variability.
- To predict product noise emissions during design before prototypes are available for testing

George Maling – Leadership in Standards Development Organizations

- Chair and Vice-chair
  - American National Standards Institute (ANSI) Standards Committee S1 (Acoustics) (which at that time included noise measurements).
- Individual Expert
  - ANSI Standards Committee S12 (Noise)

George Maling – Developing in Standards

- Significant contributor to the development of sound power measurement standards
  - Many presentations at conferences:
    - NOISE-CON
    - INTER-NOISE
    - ASA
  - Many papers published
    - *NCEJ*
    - *JASA*

1. Development of standards for the measurement of sound power levels – Reverberation Rooms

- Significant contributor to the development of Reverberation Room sound power measurement standards for products with discrete tones
  - "Guidelines for determination of the average sound power radiated by discrete-frequency sources in a reverberation room", *JASA* v53(4), 1973
- Developed a multi-tone technique for qualifying a reverberation rooms with Peter Baade
- Revised standards resulted in more accurate, practical and reliable procedures
  - ANSI S12.31 and S12.32 => S12.51
  - ISO 3741 and ISO 3742 => ISO 3741
- "Determination of Sound Power in Reverberant Rooms", *NCEJ* v25(2), 1985

Measurement of sound power levels – Hemi-anechoic rooms and High Frequency noise

- **Hemi-Anechoic Rooms**:
  - Developed an alternate source for qualifying hemi-anechoic rooms with Russell Wise and Mathew Nobile
- **Noise in the 16 kHz octave band**:
  - Helped develop procedures in both Reverberation Rooms and Hemi-Anechoic rooms with Gaunt, Woehrle, Yeager and others

2. Implementation of the Use of FFTs and Digital signal processing

IEEE Transactions on Audio and Electroacoustics, Issue 2, June 1967 "Special Issue on "Fast Fourier Tranform and its application to Digital filtering and spectral analysis" edited by William W. Lang

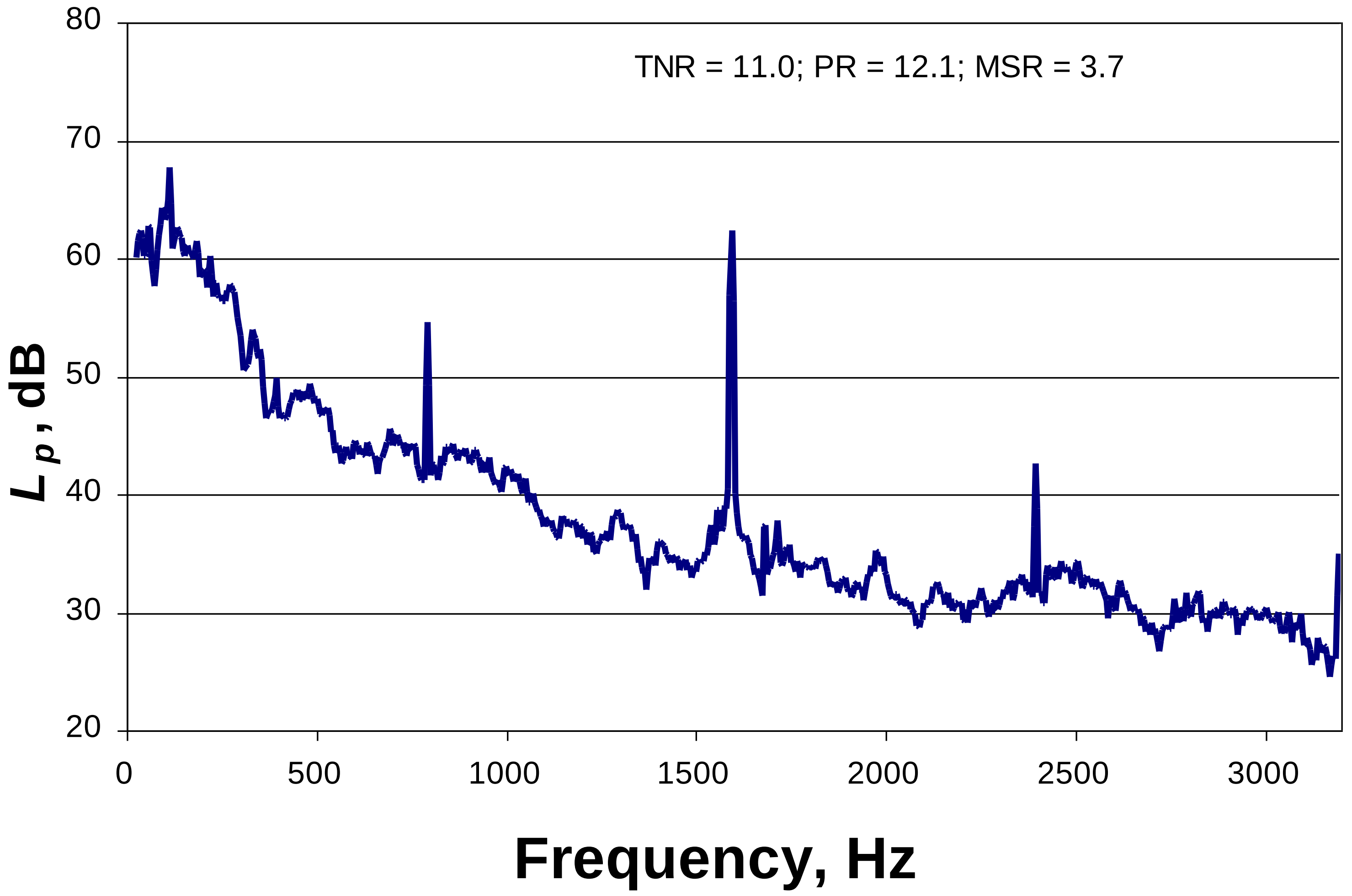
- "Digital determination of third-octave and full-octave spectra of acoustical noise" by Maling, G.C., Jr. ; Morrey, W. ; Lang, W.W.

- "What is the fast Fourier transform?" by Cochran, W.T. ; Cooley, James W. ; Favin, D.L. ; Helms, H.D. ; Kaenel, R. ; Lang, W.W. ; Maling, G.C., Jr. ; Nelson, D.E. ; Rader, C.M. ; Welch, Peter D.

Using FFT analysis in product noise control

- Identification of noise sources
- Evaluation of annoyance of sounds e.g., prominent discrete tone (PDT)
    - Example of computer noise with PDT.

Reference: Hellweg and Nobile, INTER-NOISE 2002



3. The Maling Box – for fan testing

His apparatus for determining noise emissions of air-moving devices is now internationally standardized and is widely used for noise evaluations and for product design.

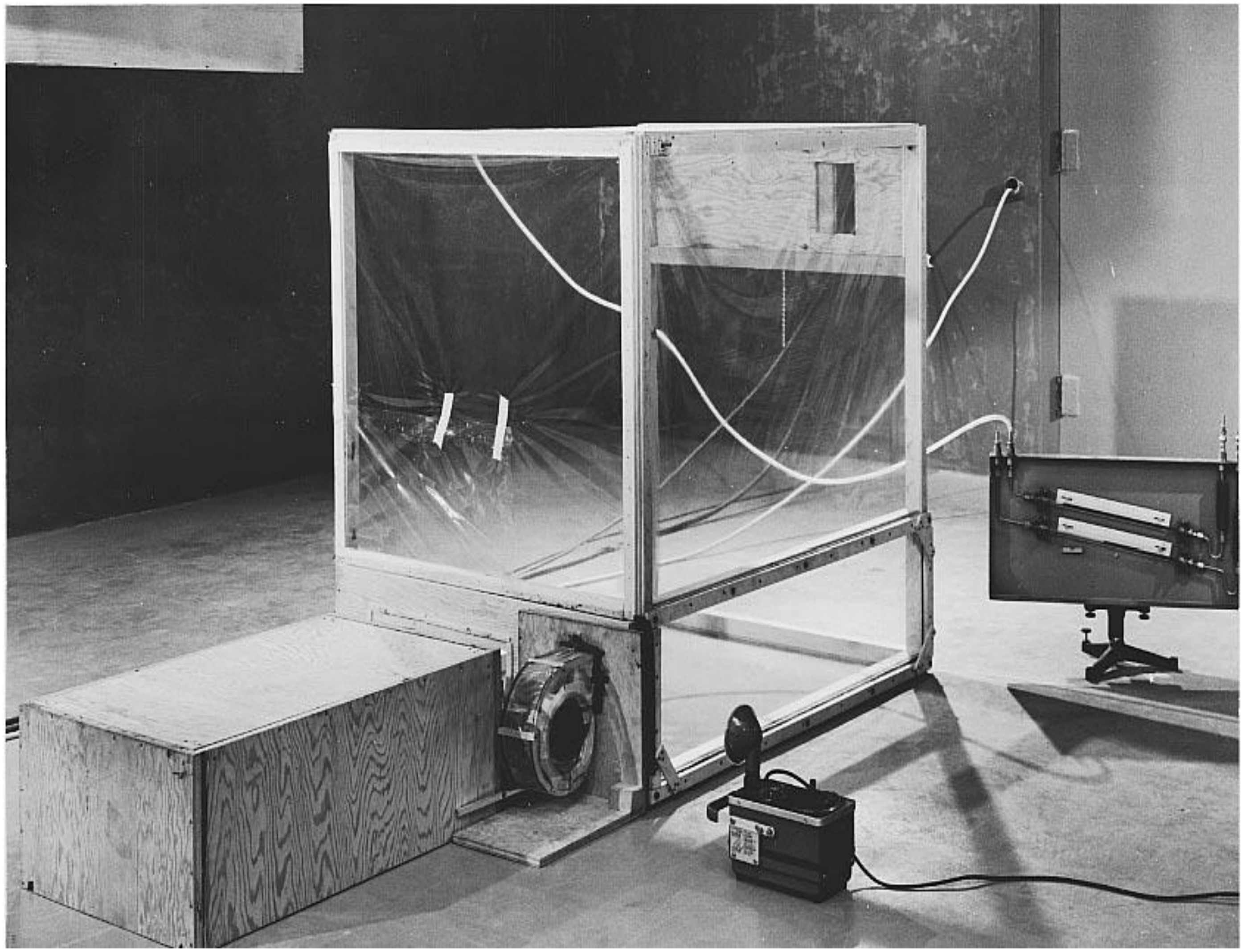
Problem defined:

- There was not a procedure for determining sound power levels from small fans installed in computers which could then be could be used to predict sound power levels from fans in products.
- Manufacturers' data were not useful
  - Sound pressure level tests with fans at free delivery 1 meter from the fan
  - Sound pressure level tests of fans in tubes with anechoic ends.

1963 - “plastic plenum” (c. 1963) at IBM

From NCEJ: Noise Control Eng. J. 42 (5), 1994 Sep–Oct

Fig. 4 – The “plastic plenum” (c. 1963) for measurements of the sound power level of small air-moving devices.



The Maling Box – for fan testing

The Solution: The plastic plenum box (aka "The Maling Box"):

- Support edges constructed of wood
- Thin plastic (mylar) sides that are acoustically "transparent".
- Fan mounted on "limp" front panel
- Rear sliding gate permitted adjustment of impedance on fan
- 1.2 m x 1.2 m x 0.9 m high
- Fans sound power level could be determined easily in a reverberation room at many operating points

Development of a fan plenum standard to measure airborne noise

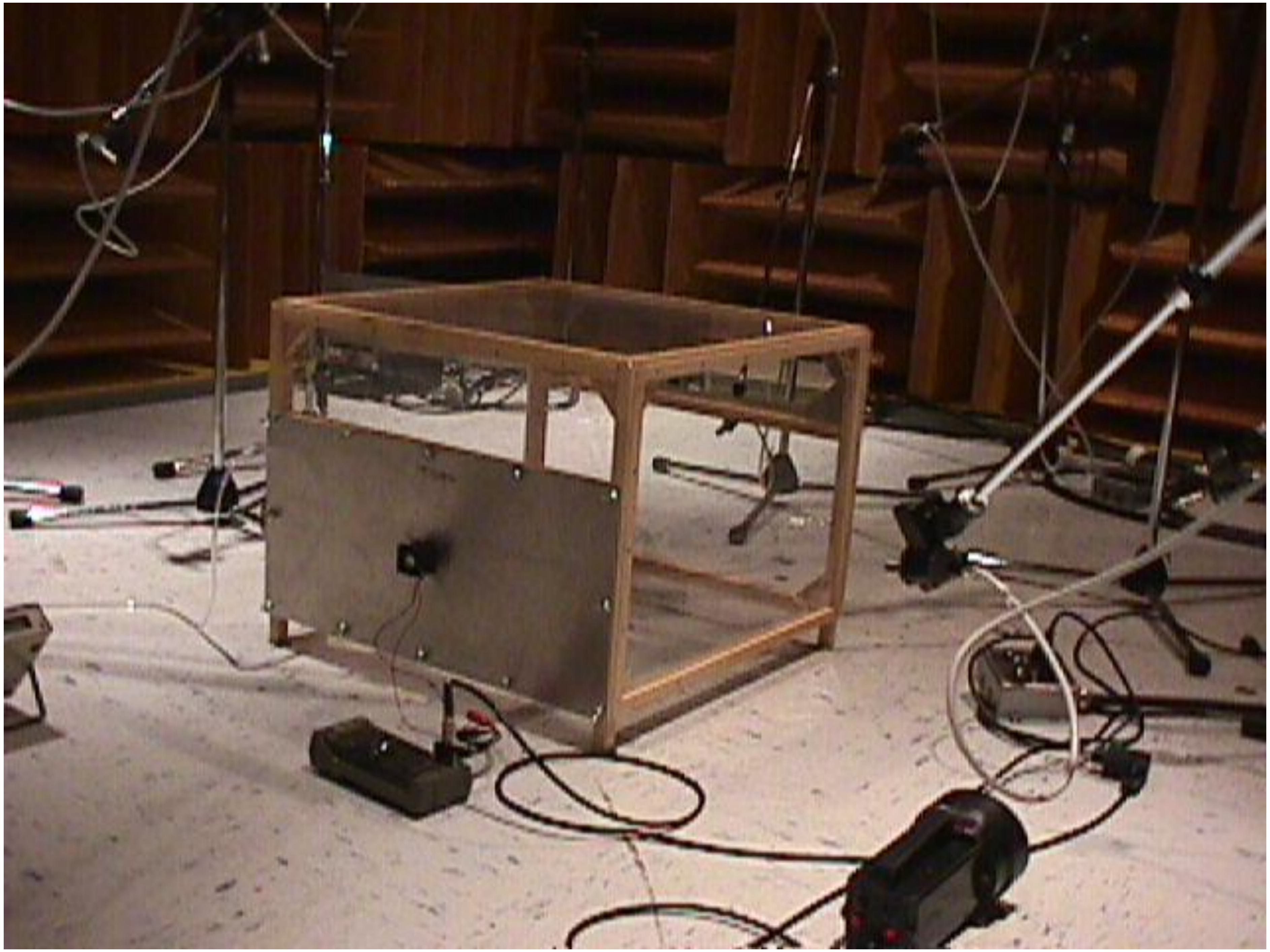
- INCE TG/CBE began development of a standard
- INCE Recommended Practice published in 1985
  - INCE RP 1-85
- INCE RP1-85 => ANSI S12.11 => ISO 10302
- Round Robin demonstrated precision (Lotz)
- Later revisions:
  - Full size => half size => quarter size

- INCE TG/CBE => development of standard to measure fan structure-borne noise

Fan Plenum for measuring <u>structure-borne noise</u>

- INCE TG/CBE began development of a standard
- Fan mounted on damped panels
- Accelerometers measure acceleration levels near fan mounting points
- INCE Recommended Practice published in 1996
  - INCE RP 1-96
- INCE RP 1-96 => ECMA 275 => ANSI S12.11/Part 2 => ISO 10302/Part 2
- Round Robin demonstrated precision (Hellweg, Pei and Wittig)

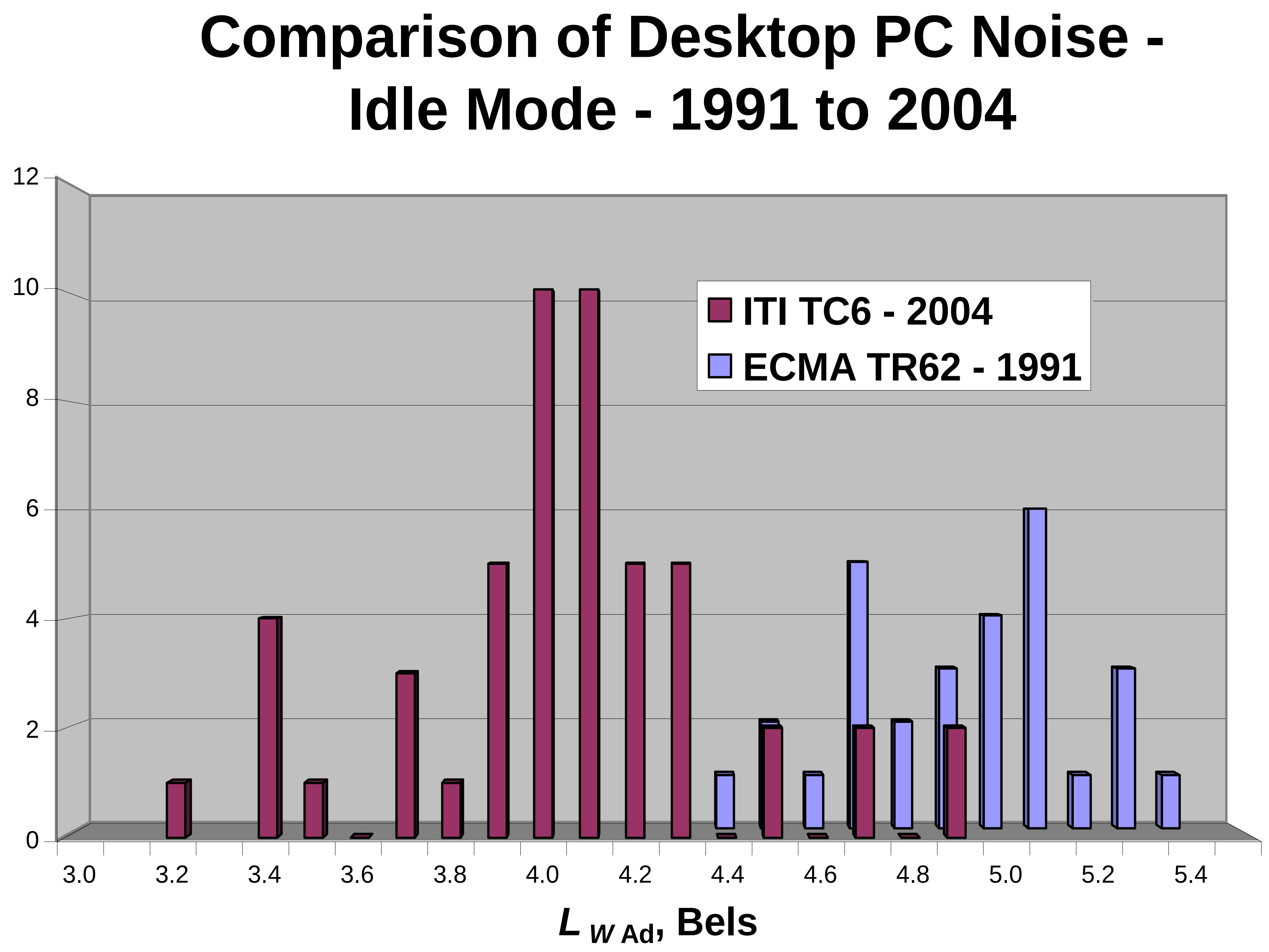
Half size plenum in Hemi-Anechoic Room



The Maling Box – for fan testing

- Results of fan testing can be used for:
  - Fan Specification
  - Product design
- Product sound emissions could be accurately predicted using L_W determined from plenum tests (Maling NCEJ 1986)
- Baugh and Nelson have each developed procedures for using fan plenum L_W data to optimize selection of fans in product design.
- "Historical developments in the control of noise generated by small air moving devices", by George C. Maling, *NCEJ*, v42(5), 1994

Maling Fan Plenum Box – Benefits?



International recognition of George Maling

1992 Acoustical Society of America (ASA) Silver Award:
Cited for: "… for outstanding leadership in noise control and in the development of widely used, internationally and nationally standardized methods for noise evaluations."

National Academy of Engineers (NAE) – Elected in 1998:
Citation: For noise-control engineering and the development of international and national noise standards.

2001 INCE Distinguished Noise Control Engineer Award:
Citation: For pioneering leadership in establishing noise control as an engineering discipline, and for exceptional contributions to the development of international and national noise control practice and *standards*.

**Thank you, George,
for your many contributions
in the development of standards
that support and benefit
noise control engineering.**

Slides by Joe Cuschieri for George Maling

GEORGE MALING'S CONTRIBUTIONS TO THE DEVELOPMENT OF BOTH THE NOISECON AND INTERNOISE SERIES OF ANNUAL NOISE CONTROL ENGINEERING CONFERENCES

Joe Cuschieri

Noise 2014

Ft. Lauderdale, Florida

- On 1970 May 17, I made notes on the proposed structure of the Institute of Noise Control Engineering. INCE would be a "non-profit, American engineering association for those professionally involved in the control of acoustical noise. It would be international in scope with an overseas membership and would publish an archival journal (there was no American archival journal exclusively devoted to noise control). This new association would emphasize the engineering aspects of the field, offer certification to qualified noise control engineers, **and sponsor an annual symposium with exhibits, state-of-the-art papers covering the entire field, a topical conference, in depth on one subject, and a tutorial course**." I also noted several reasons for the creation of an association with its own journal **and national meeting** …. To be successful in starting our own journal, we would need a **national meeting for the presentation of papers preceding their publication in the journa**l.

NOTES FROM BILL LANG

A new organization devoted to the control of environmental noise has been incorporated in Washington, DC. The Institute of Noise Control Engineering (INCE) is a non-profit technical society which ultimately may number among its members all professionals in this country who are concerned with the engineering aspects of noise control. Increasing public concern with noise problems has led to the formation of this new professional society. By certifying and registering noise control engineers, INCE will protect the interests of the public. Another primary objective of the Institute is to advance the technology of noise control engineering with particular emphasis on solving everyday noise problems. Formation of INCE was decided upon at a conference of noise specialists last January. **It is planned that the new organization will sponsor meetings and conferences to hear reports on the latest advances in noise control engineering and will publish one or more periodicals to document these activities**… Interest in noise is worldwide….

PRESS RELEASE JULY 1971

- **George Maling** has provided the glue that has held the organization (INCE/USA) together for over years
- In addition to serving as INCE Secretary, INCE President, and General Chairman of INTER-NOISE 80 and 89
- **George** has served continuously as Editor-in-Chief of NOISE/NEWS since he published the first issue in 1972
  - Why is this important?
- … with the publication of Issue No. 1 of NOISE/NEWS dated 1972 January-February. This issue featured a photo of Leo Beranek on the cover, a lead article that "INCE is Incorporated," photos from the ASA Conference on Noise Standards which had been held at Arden House during the period 1971 July 28-31, the program for the second Arden House workshop, and a Call for Papers for INTER-NOISE 72
- This led to InterNoise 72, the first held InterNoise in Washington Dc with Malcolm Crocker as the Congress President
- George was instrumental and critical in getting to this stage and the Start of the NoiseCon and InterNoise Series of Conferences and Congresses

READING FROM THE INFORMAL ACCOUNT OF EARLY YEARS BY WILLIAM W. LANG

- Right from the beginning of INCE/USA George Maling got involved in the organization of the NC Conferences
- George was involved in the Forming Arden House meetings and this translated to George's Leading the Administrative Organization of NoiseCon by INCE/USA
- This as expected also ending up with George being involved in the Administrative Organization of the INCE/USA hosted InterNoise Congresses
- Not to miss out, George had a significant helper – Nora, not that one wants to decrease George's Contributions, but everywhere one finds George, there would be Nora Maling not far behind.
- This state of affairs lasted for a good thirty years

NOISECON AND INTERNOISE BEHIND THE SCENES

- A successful NOISE-CON 77 was organized by Harvey Hubbard and George Maling at NASA Langley, Virginia. This was the first INCE/USA meeting since INTER-NOISE 72 which produced a significant surplus for the Institute thanks to the untiring efforts of volunteers.

NOISECON

- Send out Request for Proposal to Hotel and Conference Centers
- Review Responses to RFP and Down Select Venue
- Visit Selected Hotel/Conference Center to get First Hand information and identify which is best for INCE/USA
- Select Hotel/Conference Center and Negotiate Contract
- Sign Hotel/Conference Center Contract and Start Early planning
- Schedule Regular Site Visits to Hotel/Conference Center
- Coordinate with General Chair/President of meeting – but one always can rely on George to handle all the details
- Continues …..

TYPICAL ACTIVITIES AS ADMINISTRATIVE ORGANIZER PART I

- Collect and Combine the Conference Papers into a Proceedings with the Help of the Technical Chair
- Arrive Early for the Hotel pre-Con and make sure everything is ready to go
- Be on site to coordinate delegates bags and set up Registration Desk, etc.
- Daily meet with Hotel to review the day activities
- Close out with Hotel/Conference Center at the Completion of the Conference/Congress
- Sort out the meeting finances

Most Humans by this time are ready to take a vacation, Not George – He is ready to start all over again for the meeting in the coming year!

TYPICAL ACTIVITIES AS ADMINISTRATIVE ORGANIZER PART II

- **Now we need a “Big Wig” Management Company to do all that George and Nora Used to do!**

FURTHERMORE…

- Venue: Bahia Mar Hotel, Ft. Lauderdale Florida
- General Chair: Dave Yeager
- Technical Chair: Joe Cuschieri
- Secretariat: Susan Fish, Florida Atlantic University
- “George handled all the Organizing Logistics”
- Dave Yeager and I would tag along, but Really George did the heavy lifting

NOISE-CON 1994

- Venue: Marriott Marina, Ft. Lauderdale
- Co-Presidents: Dave Yeager/Joe Cuschieri
- Technical Chair: Stewart Glegg
- Secretariat: Susan Fish, Florida Atlantic University
- “George again handled all the Organizing Logistics”
- One interesting event leading to IN99 was during pre site visit by George and Nora.
  - IN99 was in December, and it was around September that Nora and George made the Site visit. The weekend they were in Ft. Lauderdale a hurricane was bearing on South Florida, I met George and Nora for Dinner one evening, and all through the evenings the lights at the hotel kept flickering. I drove home in driving rain and lost my car headlamp lenses.
  - George and Nora made it safe home and we had a successful Inter-Noise in December

INTER-NOISE 1999

- George as usual took care of most if not all of the arrangement
- However going one year before, InterNoise 1998 in New Zealand
  - I was not sure I would be traveling that far, but eventually I made it
  - George had already taken care of all the arrangement for the closing reception
  - George also had all the slides for the Invitation to InterNoise 1999 in Ft. Lauderdale
  - The day before the closing, On Tuesday, since I was the Co-President for the coming InterNoise, George hands me a deck of slides and asks me if I wanted to give the Invitation Speech – I agreed
  - I really enjoyed giving the Invitation and have to thank George for having everything prepared

INTERNOISE 1999

- **In 1993 INCE Changed its Structure and quoting from the President's Column of the December Issue of NNI, President at the Time was Bill Cavanaugh:**
- **"To create the office of the Managing Director of INCE/USA. It seems Clear that INCE/USA will need Professional management as it Grows and as the Dedicated all-Volunteer Founders of the Organization relinquish some of their duties"**
- **This was the start of some significant changes within INCE/USA and by the Beginning of the New Century (2001) George Started to play less of an Administrative Role in the Organization of NoiseCon and InterNoise (USA)**

TIME OF CHANGE

- George (and Nora) Continued to be the Administrative Face for INCE/USA at USA Conferences and USA Congresses till around the year 2001, when George indicated he is ready to “Retire”
- InterNoise 2002, held in Dearborn with Raj Singh as President for the first time had a non-volunteer Business Office and Executive Director responsible for the Administrative Organization of the Congress

THINGS CHANGED

THANK YOU GEORGE AND NORA

Slides by Proctor Reid for George Maling
Not available at this time

Slides by Norah Maling for George Maling
Not Available

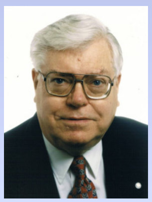
You are invited to attend the reception for George Maling and Proctor Reid on Sunday evening 7 September 2014 from 05:30 to 07:00 PM following the INCE/USA Board meeting

Accompanying persons are welcome

At the NoiseCon 2014 Conference Hotel: Westin Beach Resort & Spa, Fort Lauderdale

Proctor Reid is the program director at the National Academy of Engineering (NAE) who has been responsible and instrumental in supporting and guiding the program and report *Technology for a Quieter America*. He continues working with us on the TQA Follow-up initiatives that include the workshop and resulting report published by the National Academies Press, *Protecting National Park Soundscapes*. Two roundtables hosted by the NAE and the resulting INCE public information documents addressed: *Noisy Motorcycles – An Environmental Quality of Life Issue* and *Cost-Benefit Analysis for Noise Barriers and Quieter Pavements.* The most-recent workshop addressed *Innovative Techniques for Reducing Employee Noise Exposures.* A public information document for this workshop is well underway.

George Maling is a Founder of INCE/USA who has been active guiding and supporting the Institute for 43 years, currently is our Managing Director Emeritus, and was Chairperson for the Committee for Technology for a Quieter America, and was editor of *Noise News International.* George is an INCE/USA Fellow and Distinguished Noise Control Engineer. He received the INCE/USA Distinguished Service Medal in 2009. A Special Session in honor of George is scheduled for Monday morning 8 September 2014 from 09:00 AM to noon. Please consider attending.



<u>Please respond to let us know if:</u>

Yes, I plan to attend the reception Sunday evening
Yes, I will probably attend
Yes, will bring an accompanying person

No, unlikely
No, will not attend

We look forward to seeing you at the reception and special session,

Bill Lang and Eric Wood