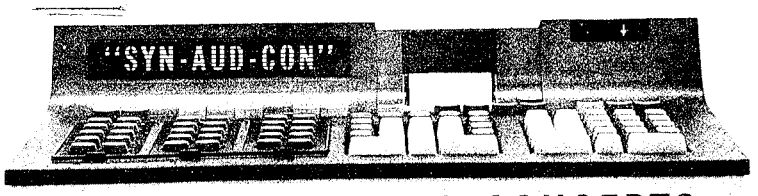


newsletter

SYNERGETIC AUDIO CONCEPTS

P.O. BOX 1134, TUSTIN, CALIFORNIA 92680

VOLUME 3, NUMBER 1
October, 1975

SYNERGETIC
Working together; co-operating; co-operative

SYNERGISM
Co-operative action of discrete agencies such that the total effect is greater than the sum of the two effects taken independently.

EXCHANGE OF IDEAS

I met a man with a dollar
We exchanged dollars
I still had a dollar

I met a man with an idea
We exchanged ideas
Now we each had two ideas

TABLE OF CONTENTS

VOLUME 3, NO. 1

PAGE

A SHIFT IN EMPHASIS

As our list of graduates grows, thanks to all of you who help spread the "word of mouth" news about the value and benefit of Syn-Aud-Con classes, we find that our input from graduates has significantly increased in both quality and quantity.

This flood of marvelous material has led us into an experiment with the Fall Newsletter. This time we are shortening the Newsletter but expanding the data that could have been put in the Newsletter into extra Tech Topics. Therefore, the information package you receive this time is larger, high quality, and we hope, more useful.

Many exciting changes are in the making in our industry, not the least of which is you, the Syn-Aud-Con graduate, trained, technically capable, and ready to deal with the advanced techniques necessary to the successful applications of advanced products.

MASH NOTES

While all graduates recognize and appreciate the fact that Syn-Aud-Con Sponsors, by helping share the costs of Syn-Aud-Con classes, have made it possible to hold attendance fees within reasonable limits, they are not always aware of the tremendous moral support such Sponsors lend us. The letter from "Bud" Morris, Vice President, UREI, sent to their distribution, is an example of the caliber of support our Sponsors give to all of our goals. These Sponsors help financially, provide the new products you need, contribute engineering insights and techniques, and are a very vital part of the Syn-Aud-Con team. Best of all, they are highly responsive to your input.

Dear UREI Dealer:

Enclosed is a brochure and 1975-76 schedule for Syn-Aud-Con Sound System Seminars.

Many of you will already be familiar with Syn-Aud-Con, and may have participated in one or more of these stimulating and rewarding training sessions. If not, and if your activities include or could include sound system design and installation, we suggest you strongly consider enrolling in the next Seminar in your area.

Don Davis is a skilled instructor whose enthusiasm, open-mindedness and continuing quest for new knowledge is contagious. He brings to his well-planned and expertly conducted sessions a distinguished record of success and experience in his field. Add to this the open exchange of ideas and expertise contributed by the attendees, plus the hands-on experiments with actual professional measurement and sound equipment and it becomes a learning experience you will always remember and profit by.

UREI is proud to have been one of the first sponsors of Syn-Aud-Con Seminars, and continues to monetarily support Don's endeavors to bring professional training in Sound System Design within the reach of all who seek it.

Very truly yours,

UREI

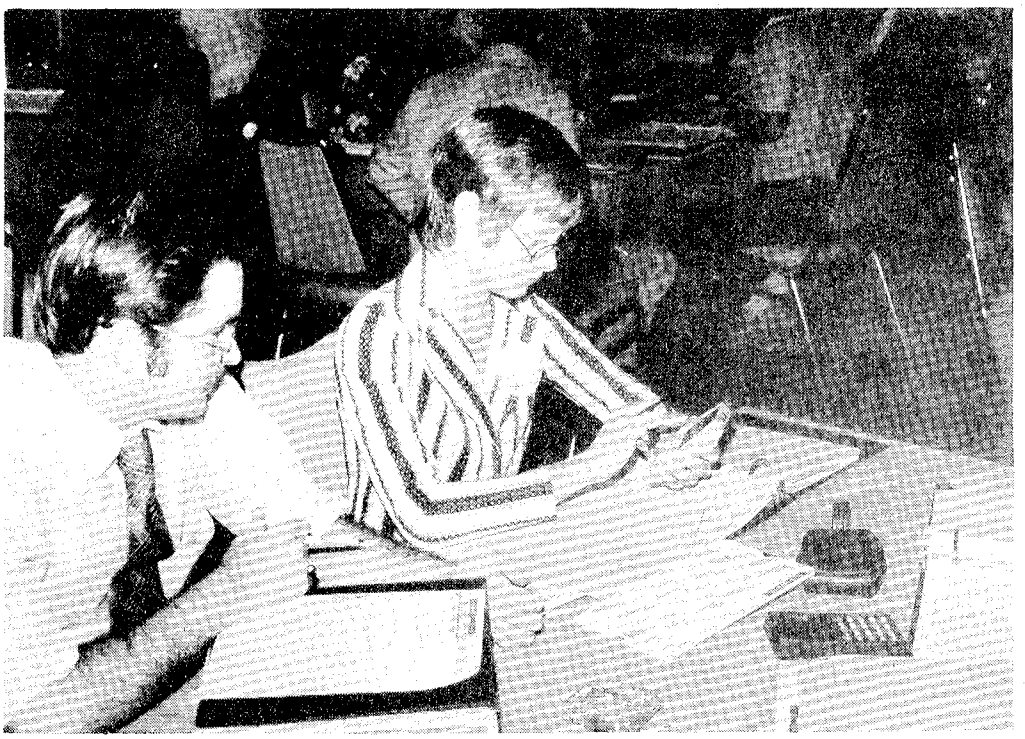
DeWitt F. Morris
Vice President

SESCOM COMMUNICATES

Sescom's Frank Miller takes close communication with his customers seriously enough to provide them with an 800 telephone. Sescom has installed a toll-free number for ordering and information. Their number is 800-421-1828. For California residents, Sescom will accept collect calls. Call for either Frank Miller or Eric Davis for information on this most useful line of products, their application and modification. Many of our graduates have found that this is the prime source for those special "black" boxes (only in Sescom blue).

ANOTHER ANSWER TO CALCULATORS??

Steve James, Los Angeles class 1973,4,&5, has a very pleasant alternative to the HP 21. His wife, Janie, (see picture) majored in mathematics.



Janie attended Syn-Aud-Con's 1975 Los Angeles class and did a majority of the problems in her head to *check* to see if the calculator was accurate. Unfortunately, the HP 21's are more readily available!

LUBELL LABORATORY'S "COLORN"

Alan Lubell, 1974 Pittsburgh class graduate and designer-manufacturer of the highest quality underwater loudspeakers presently available recently visited us at our Indiana farm to demonstrate his "Colorn".

What Lubell has done is to horn load a well-designed sound column which we have nicknamed the "Colorn". A separate data sheet from Lubell Laboratories is included in this Newsletter mailing. Our subjective reaction to the Colorn, formed by listening to it ¼ mile away across a large pasture, was that it projected sound with remarkable clarity (the talker's voice sounded as if he were standing right at my elbow).

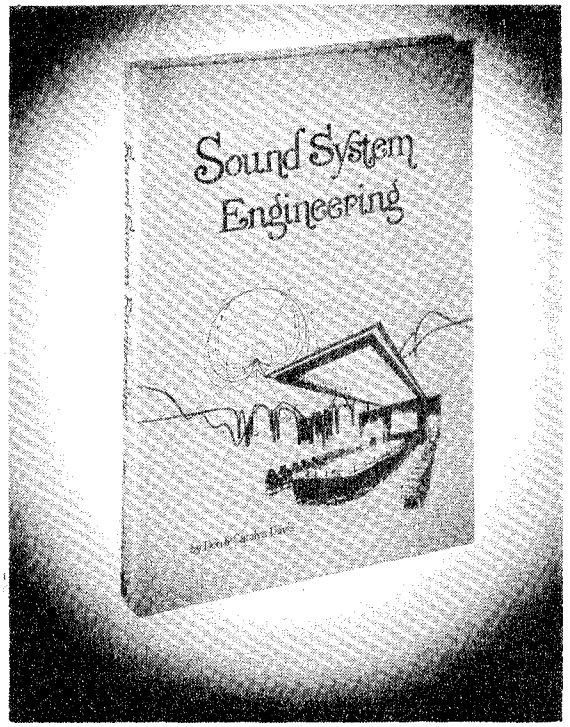
SHURE SM 82 MICROPHONE

Incidentally, we used the new Shure SM82 microphone *directly* into one of Shure's SR105A power amplifiers. This is a very high quality single microphone system at a surprisingly low cost. Two total controls for an unskilled operator to cope with -- On-Off and Volume.

The Shure SM 82 microphone not only includes the necessary gain but has an extremely clever compressor-limitor for the excessively loud talker. These three components: Shure SM 82, Shure SR 105A, and Lubell #4536 "Colorn" would be all that was needed in a great number of applications.

SOUND SYSTEM ENGINEERING TEXTBOOK PUBLISHED

Howard W. Sams has published *SOUND SYSTEM ENGINEERING* by Don and Carolyn Davis. When someone asked Carolyn, "and Carolyn?" she said, "Yes, Don was a great help to me."



A 295-page book, it features the original Syn-Aud-Con manual data plus all relevant Tech Topics and Newsletter data until about the 1st of this year. The book contains 11 chapters and 11 appendixes. Each page contains approximately twice the material of a page in the original manual.

One appendix contains all the "Useful Equations in Sound Engineering Work", and another is on the "Directivity of Instruments and Devices" and gives examples of Q and C_L for all basic types of loudspeaker systems.

Fully indexed and heavily illustrated, it is now being used in Syn-Aud-Con classes (first used in the Indianapolis class in September). Graduates attending Update classes will receive a copy as part of the class material. Graduates not attending an Update class at this time but wishing to obtain a copy of *SOUND SYSTEM ENGINEERING* may order the book from Howard W. Sams, 4300 W. 62nd St., Indianapolis, Indiana 46206.

The price is $19.95 plus 45¢ for postage and handling. Include sales tax where applicable.

AUDIO CYCLOPEDIA TO BE REVISED

A new staff of editors has been given the responsibility and task of updating the *AUDIO CYCLOPEDIA* published by Howard W. Sams Co., Inc. Editor in Chief is Don Davis, and associate editors are: Glen Ballou of Southington, Conn., a Syn-Aud-Con representative; Mel Sprinkle of Kensington, Md., a nationally known consultant and Syn-Aud-Con graduate; and Glen Osborne of Seabrook, Texas, a close associate of the late Howard Tremaine, the original author of the *AUDIO CYCLOPEDIA*.

We know from experience in the Syn-Aud-Con classes that many graduates own and use *AUDIO CYCLOPEDIA's*. Those graduates helping us improve the *CYCLOPEDIA* by sending in

1. Corrections to errors
2. New product techniques, or methods that should be included in the *CYCLOPEDIA*
3. Any improvements, expansions or useful modifications of present data in the *CYCLOPEDIA*

will be acknowledged as contributors to the *CYCLOPEDIA* in a special acknowledgement section. We hope many of you will be among those recognized in the next edition of the *CYCLOPEDIA*.

WHO TO CONTACT AT A SYN-AUD-CON SPONSOR

We get a fair number of phone calls asking who they should talk to at one of our Syn-Aud-Con Sponsors. So, we polled the companies, asking them, and receiving the following information:

UNITED RECORDING ELECTRONIC INDUSTRIES (UREI)
11922 Valerio St.
North Hollywood, CA 91605
Tel: (213) 764-1500 Telex: 65-1389

Contacts: Sales: D. F. Morris, Ray Combs, Claire Reinstein
Engineering: Brad Plunkett, V. P. Engineering - all products
Juergen Wahl, Sonipulse specialist
John Groper, Mod One Console specialist

SUNN MUSICAL EQUIPMENT COMPANY
Amburn Industrial Park
Tualatin, Oregon 97062
Tel: (503) 638-6551

Contacts: Bob Emmerich, President
Larry Lynn, V.P. of Sales/Marketing
Dick MacLeod, V.P. Research & Development
Doug Brown, Director of Sales-Pro Audio

SHURE BROTHERS CO, INC.
222 Hartrey Ave
Evanston, Illinois 60204
Tel: (312) 679-5830

Contacts: Ken Reichel, Sales Engineering Manager
John Phelan, Product Coordinator
Jerry Quest, Product Coordinator
Roger Ponto, National Sales Manager

GENERAL RADIO
300 Baker St.
Concord, Mass 01742
Tel: 617-369-8770

Contact: Call the district office nearest you for most information.

EMILAR CORP
4372 East La Palma Ave
Anaheim, CA 92807
Tel: (714) 993-7821

Contact: Algis Renkus

(Emilar derives its names from the 3 principal members of the firm: M(EM) for Manny Mohageri, who manufacturers their products; L(IL) for Harold Lindsay, who has spear-headed their development; and R(AR) for Jonus Renkus, who designed the original driver. (Algis is his son)

SESCOM, INC
P O Box 590
Gardena, CA 90247
TOLL FREE NUMBER FOR ORDERING AND INFORMATION 800-421-1828

Contact: Frank Miller, President
Eric Davis, Engineering

(If you have ever wondered why all Sescom products are blue, look at president, Frank Miller. Have you ever seen him dressed in anything other than blue? It's his favorite color.)

HP 65 APPLICATION PACS

Application Pacs for the HP 65 now number eleven. Syn-Aud-Con has purchased five of these application pacs, Math Pac 1, and 2, Stat. Pac 1, EE Pac 1, Finance Pac 1.

Our initial usage of these reveals that as useful as the pre-recorded cards is the book that comes with each Pac explaining the equations and the programming. These books along with your HP 65 constitute a unique self-teacher in mathematics. Other application Pacs presently available: Aviation Pac 1, Navigation Pac 1, Stress Analysis Pac 1, Chemical Engineering Pac 1, Medical Pac 1, Surveying Pac 1. These application Pacs cost $45 each. We have also found that HP application books for their HP calculators (except 65) are exceptionally useful. They cost $10 each.

HP 65 & HP 55 OWNERS

HP 65 Owners

Cam MacCardell, Show Sound, NY
Floyd Cooper, Cooper & Reiber, PA
Sydney Stegall, Custom Sound, GA
Frank Supak, Hollywood Bowl, CA
Bruce Hatch, Sound Gensis, CA
Henry Ranson, student, TX
Ed Fredericks, Gray Sound & Comm, PA
Claude Venet, Venet Enterp. England
Steve Hodge, Texas A&M, TX
Robert Torkelson, AIA, Torkelson & Assoc., Wisc.
Ed Rehm, Nordine Group, Ill.
Burt Boettcher, Ken Com Eng., Wisc.
John M. Odum Jr., Music Mart, KY
Robert Davidheiser, B&D Elect. PA
Garry Matthews, Sound Eng. Ser. Ohio

HP 55 Owners

Richard Jamieson, Jamieson & Assoc. Minn.
Robert Irvin, Photo Spec., CA
Ed Lethert, Northwest Sound Service, Minn.
Robert Torkelson, AIA, Torkelson & Assoc. Wisconsin
William Pohts, Penn. State, PA
Harold Flaxman, Detroit Public Sch. Mich.

HP 9820 Owners

Tom McCarthy, North Star Sound, Minn.
Kring Herbert, Ostegaard Assoc. N.J.
James Glass, Beardsley & Beardsley, NY

HP 9830 Owners

Cam MacCardell, Show Sound, NY

Many of these graduates have very sophisticated programs and are willing to share in exchange for other programs. Use your Graduate List to get names and addresses if you want to correspond.

THE MAN FROM OSHA

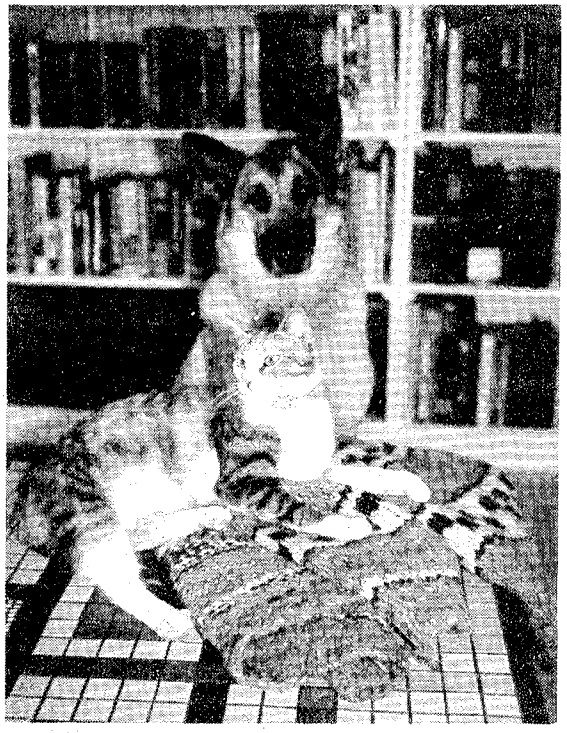
Quoting from MAN AND MANAGER, "He's tough! He can come into your place without advance notice and inspect for safety and health conditions. And, whether its a plant, an office, a store, or whatever, the new law requires that you must permit such a survey -- on the spot. Passed in 1970, the Federal Occupational Safety & Health Act is now moving into high gear. Federal inspectors have uncovered violations in 3 out of every 4 places visited thus far -- and penalties have been steep. In the first 19 months, OSHA inspectors conducted 52,034 inspections. They turned up 167,352 violations -- carrying penalties of approximately $4 million."

TECH TOPIC VOLUME 2, NUMBER 4 CORRECTION

As many of you noticed, we failed to include in the July mailing the update material for Tech Topic Vol. 2, Number 4, supplied by Mel Sprinkle and Ed Lethert for Bill Kessler's article, *"Vector Impedance Determinations with a Simple Electronic Voltmeter."* Everyone who had class before the May 1975 Los Angeles class should replace Page 3 with the enclosed Page 3.

NEW MEMBER OF THE SYN-AUD-CON TEAM

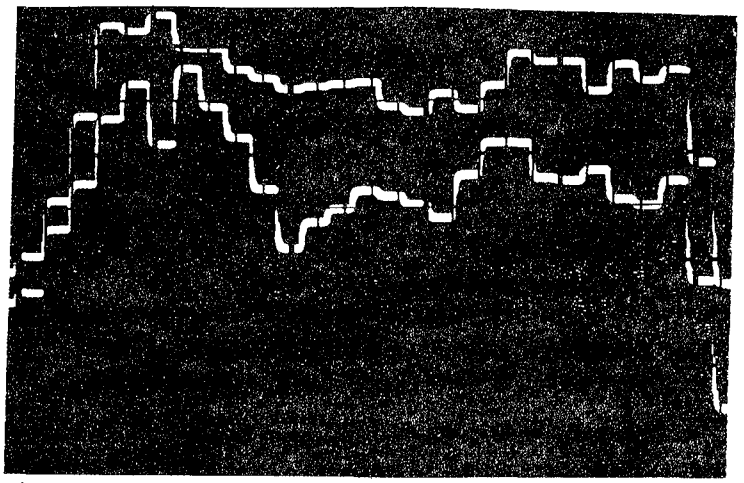
Judy, our German Shepard, has a new assistant and companion. Punch, a stray kitten that came to us, travels with us now and "attends" classes.



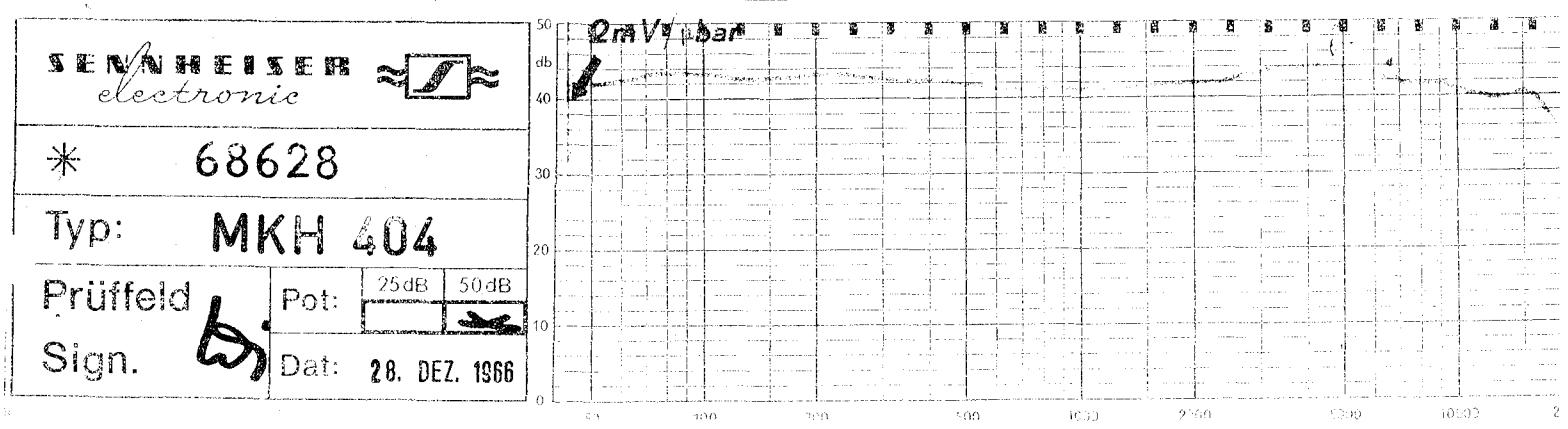
Punch and Judy

Punch with Helen Range (who runs things in Tustin)

FREQUENCY RESPONSE OF AN 8 YEAR OLD MICROPHONE

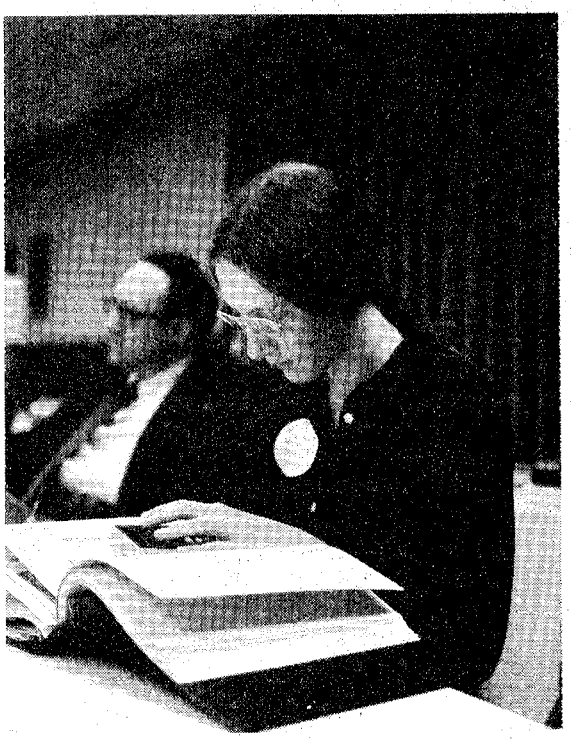


The Sennheiser 404 is an 8 year old microphone. The real time analyzer photo confirms what Tom Maydeck's ears (Ambassador College, Los Angeles class 1975) were telling him -- that the mic no longer met its original excellent specs. The heavy bass at 100 Hz muddied the drums.



SYN-AUD-CON'S YOUNGEST GRADUATE IS A GAL!

Pye Clark, 14 years old, is Syn-Aud-Con's youngest graduate to date. Pye attended the 1975 Syracuse class in August. Pye is a ham radio operator and helps her father, Phil Clark, operate one of the most competent commerical sound contractorships in the United States, Diversified Concepts, Inc.



Pye Clark is a musician who can combine technical training with a good ear in the process of being a real audio professional.

RENTAL TEST EQUIPMENT

Garry Matthews in the 1975 Indianapolis class sent us a catalog from General Electric, "Instrument Rental Catalog". The catalog is a 50 page collection of just about every instrument you are likely to ever need. And if they don't have what you need, they will get it for you. Rentals are reasonable, for example, a GR 1523 high speed graphic level recorder with the 1523-P3 stepped 1/3 octave analyzer rents for $590 a month. That's less than 10% of the new instrument. To obtain a copy of the catalog, write

General Electric Co.
Instrumentation & Control Service
Quick-Rent Instruments
Building 28, Room 450
1 River Rd.
Schenectady, New York 12345

There are dozens are rental centers in the US. The catalog will show the one nearest you.

Another useful instrument catalog is from Continental Leasing Company. Continental rents, leases, sells and services test equipment and offers excellent reconditioned equipment at real savings. They also have several offices, but write 175 Middlesex Turnpike, Bedford, Mass. 01730 for a catalog.

SOUND SYSTEM SURVEY FORM

Burt Boettcher, Chicago class 1973 & 74, sent us the following, "The Acoustic Environment Analysis Summary and the Sound System Parameters forms are some I have recently made up and used with fantastic success. The customers are really impressed with an engineering approach to their problems and are willing to spend money. One of the first church jobs we bid this way ended up with our getting the order even though we were twice as high as our competitor." (The Sound System Parameter is reproduced below)

SOUND SYSTEM PARAMETERS

* Fixed Acoustic Conditions

1- Ambient Noise (A) _____ (B) _____ (C) _____

2- Average Absorption Coefficient _____

3- Reverberation Time _____

4- Audience Capacity _____

5- Distance Between Talker & Farthest Listener _____

6- Distance Between Loudspeaker and Farthest Listener _____

7- Distance Between Loudspeakers and talker _____

8- Distance between Talker and Microphone _____

9- Equivalent Acoustic Distance _____

10- Critical Distance (Voice) _____

11- Critical Distance (Speaker, Q of ____) _____

12- Needed Acoustic Gain _____

13- Minimum Q of Speaker _____

* Sound System Performance

		( ) Existing	(.) Proposed
14-	Potential Acoustic Gain		
15-	Polar Distribution		
16-	Frequency Response		
17-	Dynamic Range		
18-	Q of Speaker		
19-	Microphone Working Distance		

* Based on 2 KHZ, 1/2 Audience, 1 Microphone
(C(Calculated) (M(Measured)

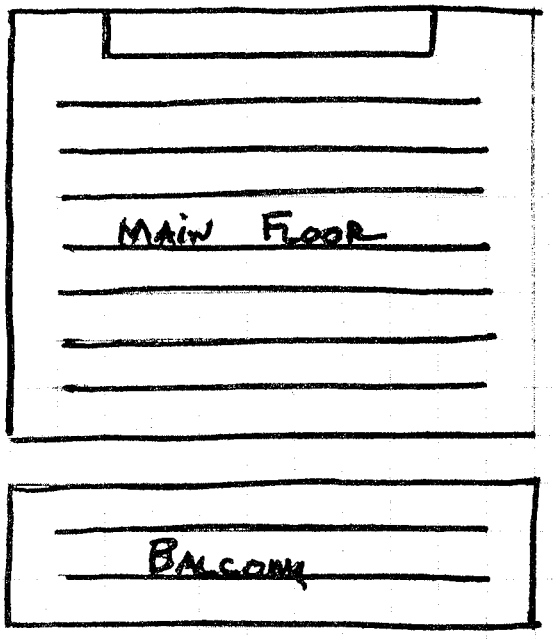
PROJECT _____

LOCATION _____

DATE _____ TIME _____

DEMONSTRATION SOUND SYSTEM QUESTIONNAIRE

Dave Edmonds, Sound and Communications, Inc., Jackson, Miss., Atlanta 1973, Orlando 1974 classes, gave us his very effective Questionnaire that he prepared for the church congregation to fill out at the church service in which he has provided a demonstration sound system. A few of the things that has made it successful for him is that it is short, the location of the listener is marked on a drawing of the church so that any trouble spots can be pinpointed, and third, the questionnaire is in the hands of the participant during the service rather than waiting until after the service to ask it to be filled out. The main advantage to having the participant mark his location in the church is, if only one or two mark a certain area as having unsatisfactory sound, they are able to assume that the individual probably has a hearing problem or a personal reason for marking the system as inadequate.



1. On the floorplan above, mark your approximate seating position.
2. I could hear and understand the sermon: _____well, _____satisfactory. _____unsatisfactory.
3. The demonstration sound system is ____better than, _____about equal to_____worse than the existing sound system.
4. Remarks:_____

_____

_____

_____

On your way out of the Sanctuary after the service, please deposit the Questionnaire in the boxes provided at the exits. Thank you for your cooperation.

"CHOOSING HEARING PROTECTORS"

The special reprint mailed with this Newsletter, "Choosing Hearing Protectors" by Richard E. Campbell, Consulting Engineer, was made available to us by the David Clark Co. It is especially interesting to the audio engineer. While the article cites the hazards of shooting firearms without ear protectors, it gives you the starting point for researching other impulse measurements, should you be called upon to conduct such tests yourself.

The range of duration of Peak Sound Pressure Levels (PSPL) are from 1.5 to 3.0 milliseconds for firearms. For example, a Winchester Model 70 .458 magnum rifle produces a PSPL of 174.7 dB at the left ear for 2.5 milliseconds. Typical earmuff attenuation is about 30 dB, leaving a PSPL at the ear of 144.7 dB. No wonder our ears ring!

One interesting aspect of these measurements is the problem of finding a microphone system with a transient response that allows the measurement of such high amplitudes of short duration with repeatable accuracy.

DEFINING CRITICAL DISTANCE

Critical distance in terms of the Hopkins-Stryker equations has meant "that distance at which the direct sound and *the reverberant sound field are equal in level.*" This implies that the room is sufficiently "live" to allow the establishment of a truly uniform reverberant sound field (i.e. $RT_{60} \cong 1.6$ seconds). It was not meant to depict some accidental coincidence where some *discrete sound reflection* was equal to the direct sound. Thus as rooms become acoustically "deader" D_C really has no meaning because there is no steady reverberant field as such but simply a series of large areas where the direct sound is *slightly* below the *reflected* sound.

Reverberant sound has a relatively stable level anywhere beyond D_C. Reflected sound will have a varying level with increasing distance beyond where D_C should have been. Perhaps we need a new term for these differing sound fields:

1. Reverberant sound field (remains constant in level beyond D_C)
2. Reflected sound field (does not remain constant beyond D_C)
3. Free sound field (no reflections.)

FINDING THE SHUNT RESISTOR VALUE

In the Syn-Aud-Con manual there is a variation of the familiar two parallel resistor equations:

$$R_T = \frac{R_L \times R_D}{R_L - R_D}$$

Where: R_T is the value of the terminating resistor

R_D is the desired impedance

R_L is the measured impedance to be shunted by R_T in order to obtain the desired impedance

This equation was derived from

$$R_D = \frac{R_L \times R_T}{R_L + R_T}$$

John Maus, Dallas class 1974 and 1975, pointed out that going back to the original parallel resistance equation, rather than the special case of two parallel resistors allows an even simpler derivation to be obtained:

$$\frac{1}{\frac{1}{R_L} + \frac{1}{R_T}} = R_D \quad \text{or} \quad \frac{1}{R_L} + \frac{1}{R_T} = \frac{1}{R_D} \quad \text{therefore,} \quad \frac{1}{R_D} - \frac{1}{R_L} = \frac{1}{R_T}$$

which is very quick on any of today's calculators using the reciprocal, $\frac{1}{x}$, key.

COMPLEX ARITHMETIC

With the advent of the HP 21 at $125, vector mathematics becomes a simple task through the use of the "to polar" and "to rectangular" keys included on the keyboard. For instance, the blue key is the shift key (SK) which allows access to the second function a regular key can perform which is marked on the front edge of the key in blue. To solve

3+j4 for the polar form we would do: 4,↑,3,SK,→P

which would give us the magnitude. Pressing x⇄y would give the angle. Pressing x⇄y again (to put the angle back in the y register) we can then go back to the rectangular form by SK,→R with 3 appearing in the x register and by pressing x⇄y we see that j4 is in the y register.

If we had been given $5\angle 126.87$, we would then do

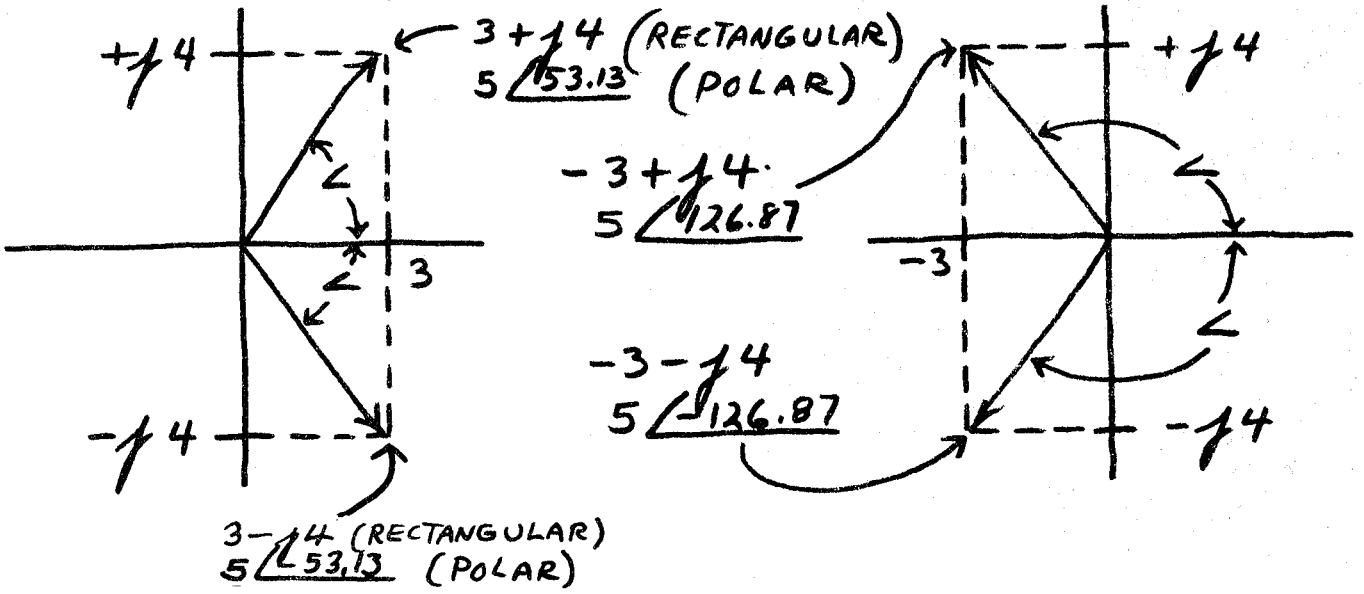
126.87, chS, ↑,5,SK,→R, and we would read -3 in the x register and by pressing x⇄y we would find -j4 in the y register.

The figure illustrates addition, subraction, multiplication and division of complex numbers. For example:

(3+j4)(3-j4) = 4,↑,3,SK,→P,4,chS,↑,3,SK,→P,x⇄y, R↓,x,STO,R↓,x⇄y,+,RCL,SK,→R,x⇄y

for 25 + j o

The HP 21 is a very powerful machine and you only have to compare it with the otherwise very excellent machines offered in algebraic format but without vector keys to realize its value to the audio engineer.



Add and Subtract Vectors by Converting to the Rectangular Form

$$\begin{array}{r} 3+j4 \\ +(3-j4) \\ \hline 6 \end{array} \qquad\qquad \begin{array}{r} 3+j4 \\ -(3-j4) \\ \hline j8 \end{array}$$

Multiply and Divide Vectors by Converting to the Polar Form

$$(3+j4)(3-j4) = \begin{array}{l} 5\angle 53.13 \\ 5\angle -53.13 \\ \hline 25\angle 0 \end{array} = 25 \qquad \text{(multiply magnitudes add angles)}$$

$$\frac{3+j4}{3-j4} = \frac{5}{5}\ \frac{\angle 53.13}{\angle -53.13} = 1\angle 106.26 = 0.28+j.96 \qquad \text{(divide magnitudes, subtract angles)}$$

AN EASIER WAY TO FIND CRITICAL DISTANCE, D_C

Many of our equations rely on obtaining $\bar{a}$ in a space in order to find D_C. The problem with this approach is the danger of intermixing the three major systems of obtaining $\bar{a}$ without the proper corrections:

Sabine	Norris-Eyring	Hopkins-Stryker
$\bar{a} = \frac{0.049V}{S(RT_{60}}$	$\bar{a} = 1 - e^{-\left(\frac{0.049V}{S(RT_{60}}\right)}$	$\bar{a} = \frac{1}{1+\left(\frac{S(RT_{60})}{0.049V}\right)}$

Now, $\bar{a}$ should range only from 0 to 1.0. When obtained by the Sabine method (and this is how the acoustical material association does obtain it), it can range up to >4.0. If by some other method you were able to actually obtain the *true* $\bar{a}$, then placing it into the expression $-\ln(1-\bar{a})$, you reconvert it back to the Sabine $\bar{a}$ and can again use the Sabine equation (this is all the Norris-Eyring equation is for). Obviously, using the acoustical material assoc. $\bar{a}$ in the Norris-Eyring equation is incorrect. A further complication arises when the room constant, R, is introduced.

Consider a room where the reverberation time is, for example, 3.0 secs. If we have measured this time it is then an actual fact. Therefore, all three of the following equations must come out at 3.0 secs:

$$\frac{0.049V}{Sa} = 3.0 \text{ secs.}; \qquad \frac{0.049V}{-S\ln(1-\bar{a})} = 3.0; \qquad \frac{0.049V}{R} = 3.0$$

Since the volume, V, and surface area, S, will remain a constant, then only the $\bar{a}$ value can change to accommodate the fact that the reverberation time of the room is 3.0 secs. If, for example, we found the $\bar{a}$ using Sabine, we would have to convert such an $\bar{a}_S$ to the $\bar{a}_R$ form for use in the Hopkins-Stryker equations, including critical distance.

Considering these facts leads us to a better way of finding D_C in an existing room:

$$D_C = 0.03121\sqrt{\frac{QV}{RT_{60}}}$$

This equation leaves us only with the measured fact and saves us the additional chore of measuring the internal boundary surface area. The attached equations show all forms of these new relationships:

Variations on Critical Distance, D_C, Equations

1. $D_C = 0.03121\sqrt{\frac{QVM}{RT_{60}(n+1)}}$
2. $Q = \frac{(D_C)^2 RT_{60}(n+1)}{(0.03121)^2\ VM}$
3. $RT_{60} = \frac{(0.03121)^2 QVM}{(D_C)^2(n+1)}$
4. $V = \frac{(D_C)^2 RT_{60}(n+1)}{(0.03121)^2 QM}$
5. $(n+1) = \frac{(0.03121)^2 QMV}{(D_C)^2 RT_{60}}$
6. $M = \frac{(n+1)(D_C)^2 RT_{60}}{(0.03121)^2 QV}$

Where: D_C is the critical distance in ft.

Q is the directivity factor (dimensionless)

V is the total internal volume in $ft.^3$

RT_{60} is the reverberation time in secs.

(n+1) is the number of loudspeaker groups providing reverberant sound (one group only providing direct sound)

M is any modifiers that increase D_C

WHY THE HOPKINS-STRYKER EQUATIONS WERE DERIVED

The original use intended for the Hopkins-Stryker equations as exploited by Beranek was

$$\text{dB-SPL} = \text{dB-PWL} + 10 \log \left[\frac{Q}{4\pi(D_X)^2} + \frac{4}{R}\right]$$

and

$$\text{dB-PWL} = \text{dB-}\overline{\text{SPL}} - 10 \log \left[\frac{Q}{4\pi(D_X)^2} + \frac{4}{R}\right]$$

(where metric dimensions are used)

In the equations above, the portion of the expression

$10 \log \left[\frac{Q}{4\pi(D_X)} + \frac{4}{R}\right]$ adjusts for the level change with distance indoors.

The equation was designed to approach zero value when a D_X of 0.282 and a $Q = 1$ were used. When $D_X > 0.282$, the equation generates negative values and when $D_X < 0.282$ it generates positive values, providing a $Q = 1$ is used.

Changing Q accomplishes the same result as changing the D_X value that will approach zero. Therefore, if Q is increased by four times, then the D_X value that will produce zero in the equation doubles. To an impartial observer in the front of a sound source raising the Q will measure *as if* the source were moved closer to him by the amount of 10 log Q increase (new Q - old Q) or D_i of Higher Q - D_i of original Q.

Still another way of exploring the same relationships is to solve for D_X when $\Delta D_X = 0$ and the $Q = 4$:

$$D_X = \sqrt{\frac{Q}{4\pi\left[10^{\left(\frac{\Delta Dx}{10}\right)} - \frac{4}{R}\right]}}$$

or

$$D_X = \sqrt{\frac{4}{4\pi(10^0 - \frac{4}{10}}} = 0.564^* \qquad ^*0.564 = 2(0.282)$$

Critical Distance Derivations of Reverberant Level

1. Reverberant field level independent of Q. PWL determines reverberant level

   $$\text{Reverb level} = \text{dB-PWL} - 20 \log \frac{0.141\sqrt{R}}{0.925'}$$ (dimensions in English ft. units)

   $$= \text{dB-PWL} - 20 \log \frac{0.141\sqrt{R}}{0.282m}$$ (dimensions in metric units. dB-PWL in both cases // 10^{-12} watt)

   (0.925' = 0.282m)

   $$\text{DIRECT LEVEL} = \text{Reverb level} + 20 \log \frac{0.141\sqrt{R}}{\text{x dist.}} + 10 \log Q$$

2. Raising Q allows PWL to be lowered for same direct level. If *only* Q is raised and PWL stays the same, then reverb. level stays the same but ratio of direct-to-reverberant sound improves for any given distance.

CONVERTING SEMILOG DECADES

Converting semilog decades

If you already know this, raise your hand. Semilog graph paper, though it's calibrated in decades of 1.0, can **be easily converted to span a new set of decades by multiplying the log values by a constant.** Thus, if you want to display a plot of audio response covering, say, 20 Hz to 20 kHz, don't reach for the four-cycle semilog paper; three-cycle paper will do the job. Simply multiply the abscissa values by 20, and you'll have **a much neater, more precise display of your data.**

CONVERTING THE HOPKINS-STRYKER EQUATION TO A POSITIVE NUMBER

There are several very important facets of the Hopkins-Stryker equations that can be profitably discussed. First of all, each distance, D_X, must be associated with the same Q in all calculations. There is a tendency as a user gets familiar with this equation to put Q in for the talker and another Q in for the loudspeaker. This will *NOT* yield the correct answer. When Q's are varied in this equation, the relative numbers obtained vary also because changing the Q changes the apparent starting distances from which the relative attenuation is being calculated. Therefore, all distances that are to be compared *must* be calculated for the same Q.

If ΔD_X is desired as a positive number for a majority of the cases (or for use in a Sinclair calculator which can't do the normal form of the equation), then

$$\Delta D_X = 10 \log \left(\frac{1}{\left(\frac{Q}{4\pi (D_X)^2} + \frac{4}{R} \right)} \right)$$

and its inverse becomes:

$$D_X = \sqrt{\frac{Q}{4\pi \left[\frac{1}{10^{\frac{\Delta D_X}{10}}} - \frac{4}{R} \right]}}$$

The Hopkins Stryker equation is a very useful tool so long as the user recognizes that in rooms with RT_{60}s below approx. 1.6 secs, true critical distances are not obtained.

EULER'S THEOREM

Ocassionally, in the course of using the handheld calculators, a graduate will inquire as to where the Napierian base e came from. Napierian logarithms are also called natural or hyperbolic logarithms. On the HP 21 the Napierian base keys are ln and e^x

$$\frac{a}{c} = e^n; \quad \ln \frac{a}{c} = n$$

The base e = 2.71828182845904523536'''' and is an unending irrational number like π.

The famous mathematician Euler found that the identity between exponential and trignometric functions was defined by

$$e^{ix} = \cos x + i \sin x$$

where cos x and sin x are done with the calculator in the "radian" mode.

It can thus be seen that the Napierian base e is the "natural" base much of our present mathematical system is based upon. Felix Klein remarked about Euler's Theorem "All analysis is centered here." Every symbol has its history -- the principal whole numbers 0 and 1; the chief mathematical relations + and =; π the discovery of Hippocrates; i the sign for the "impossible"square root of minus one; and e the base of Napierian logarithms.

Euler's Theorem

$$e^{i\pi} + 1 = 0 \qquad i = j$$

$$e^{ix} = \cos x + i \sin x \quad \text{(trig. functions in radians)}$$

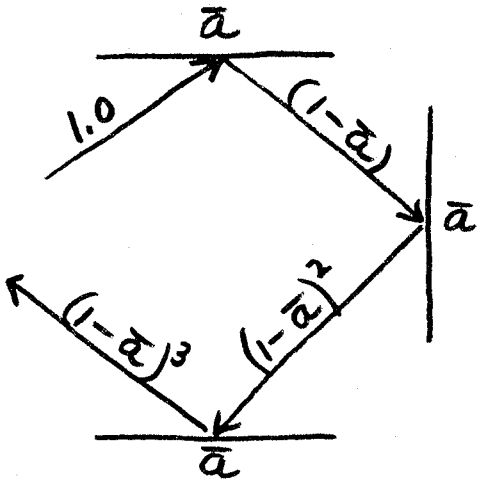
(exponential) (trignometric)

$$e^{i\pi} = \cos \pi + i \sin \pi$$

$$e^{i\pi} = -1 + 0 = -1$$

$$e^{i\pi} = -1 + 1 = 0$$

DERIVATION OF THE NORRIS-EYRING REVERBERATION EQUATION



TOTAL NUMBER OF REFLECTIONS (m) UNTIL THE SOUND ENERGY IS REDUCED TO $\frac{1}{1{,}000{,}000}$ TH OF ITS ORIGINAL VALUE (-60dB) WOULD BE:

$$(1-\bar{a})^m = 0.000001$$

$$m = \frac{\ln 0.000001}{\ln(1-\bar{a})}$$

MEAN FREE PATH (M.F.P.) THE AVERAGE DISTANCE THE SOUND TRAVELS BETWEEN REFLECTIONS EQUALS:

$$M.F.P. = \frac{4V}{S}$$

THE NUMBER OF REFLECTIONS PER SECOND EQUALS:

$$R.P.S. = \frac{\text{VELOCITY OF SOUND}}{M.F.P.}$$

AND THE REVERBERATION TIME (RT_{60}) EQUALS:

$$RT_{60} = \frac{m}{R.P.S.}$$

THEREFORE:

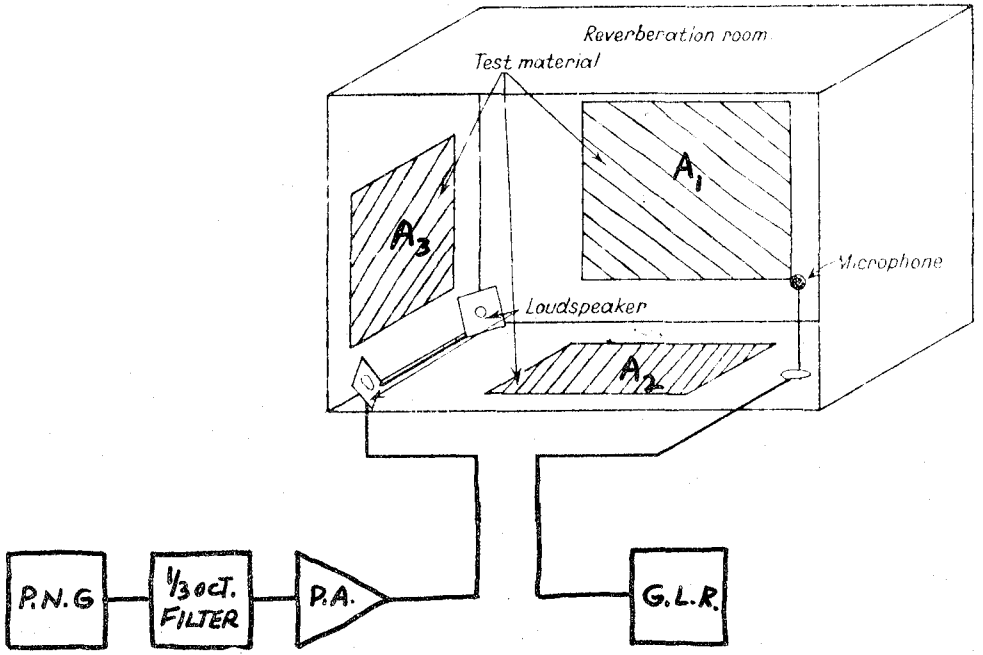
$$RT_{60} = \frac{\frac{\ln 0.000001}{\ln(1-\bar{a})}}{\frac{1130'/\text{SEC}}{\frac{4V}{S}}} = \frac{4\ln 0.000001\, V}{S\ln(1-\bar{a})1130} = \frac{0.049V}{-S\ln(1-\bar{a})}$$

USING A REVERBERATION CHAMBER TO CALCULATE $\bar{a}$

Assume a small (20'x20'x20') chamber of hard tiled surfaces with diffusion (splayed walls) and a reverberation time empty of 9.0 seconds. This room's volume equals 8,000 ft^3 and its boundary surface area equals 2,400 ft^2. According to Sabine's equation (the one normally used) the average absorption coefficient of this chamber is:

$$\bar{a} = \frac{0.049V}{S(RT_{60})} = \frac{0.049(8000)}{2,300(9.0)} = 0.018$$

Let's now introduce 75 ft^2 of an acoustic material to be tested for its absorption coefficient. We will distribute this material equally on three surfaces as shown below. We again measure the reverberation time of the room and we now find it to be 6.5 seconds.



Other Useful Forms of Formula

$$S_M = \left(\frac{0.049V}{a}\right)\left(\frac{1}{T_M} - \frac{1}{T_E}\right)$$

$$T_M = \frac{1}{\left(\frac{S_M a}{.049V}\right) + \left(\frac{1}{T_E}\right)}$$

$$T_E = \frac{1}{\left(\frac{1}{T_M}\right) - \left(\frac{S_M a}{.049V}\right)}$$

$$V = \frac{Sa}{.049\left(\frac{1}{T_M} - \frac{1}{T_E}\right)}$$

$$a = \frac{0.049V}{(A_1 + A_2 + A_3)}\left(\frac{1}{T_M} - \frac{1}{T_E}\right)$$

Where:

a is the absorption coefficient of the test material

V is the internal volume of the test room in ft^3

$(A_1 + A_2 + A_3) = S_M = 75\ ft^2$ is the total surface are of the test material

T_M is the measured RT_{60} of the test room with test material installed as shown

T_E is the measured RT_{60} of the test room empty

Total $S\bar{a}$ is $S\bar{a}$ empty + Sa of test sample

Sample Case

$V = 8,000\ ft^3$; $S = 2,400\ ft^2$

$$a = \frac{0.049(8000)}{75}\left(\frac{1}{6.5} - \frac{1}{9.0}\right) = 0.223$$; this is proven by

$$RT_{60} = \frac{0.049 \times 8000}{2400 \times 0.018 + 75 \times .223} = 6.5 \text{ seconds}$$

GALILEO GALILEI REFUTED AGAIN?

Quad Loudspeakers, a product of The Acoustical Manufacturing Co., Ltd. has brought back that propular belief of the dark ages: that light objects fall slower than heavy objects. The text from the ad: *FEATHERS AND THINGS Take a diaphragm from a QUAD electrostatic loudspeaker. Let it fall and you can count up to ten before it reaches the ground. Try to do this with a cone from a moving coil speaker and you'll need a high speed computer to do the counting. Remember all that stuff at school about kinetic energy? How heavy things are hard to start and hard to stop? That's why a QUAD loudspeaker responds immediately to every nuance in the music. It's obvious when you think of it. It's even more obvious when you hear it.*

Yes, we remember "all that stuff at school about kinetic energy" plus a few things about air resistance. Ads of this type have a way of reminding us that facts still get burned at the stake.

BOOKS OF INTEREST

ACOUSTICS, ARCHITECTURAL THEORY AND PRACTICE, Acoustical and Board Products Association, 6th Edition, 1975. (Formerly: Acoustical & Insulating Materials Assoc.) 205 West Touhy Ave, Park Ridge, Illinois 60068. You may order this extremely useful manual for $1.00 from AIMA.

PASSIVE EQUALIZER DESIGN DATA by Ralph Townsley, Chief Engineer at WBAA, Purdue University, published by Tab Books. This book was mentioned in Newsletter # 2, with the following recommendation, "The portion of the book in Chapter I, entitled, "Measurements for Determining Required Equalization Curve," is the most concise, accurate and detailed explanation on the subject I have found in the literature. If you think you know how to measure frequency response this book is for you. The remainder of the book is an excellent source of equalizer design methods and data." $19.95

(If you are looking for a source to buy Tab Books, Phil Clark at Diversified Concepts, 3929 New Seneca Turnpike, Marcellus, New York 13108 has Tab Books in stock.)

SOUND SYSTEM ENGINEERING by Don and Carolyn Davis. Howard W. Sams, Inc. 4300 W 62nd St., Indianapolis, Indiana 46206. $19.95 (See Page 4 for a "review".)

CLASSIFIED

FOR SALE: Hewlett Packard 5451A Fourier Analyzer with 16K Core computer. Rockland Dual Channel anti aliasing filter, high speed photo reader, TTY, digital plotter, software and operation manuals.
Robin M. Towne and Associates, Inc., 105 N.E. 56th St., Seattle, WA 98105
(206) 523-3350 Attn: Stan Champ

FOR SALE: Tape Recorder, Magnecord Model 1024-Rack mountable - perfect condition - write for complete specifications. Price: $595.00
Stephen M. Freeman, 18 University Hgts., Hopkinsville, KY 42240

WANTED: Hewlett Packard Calculator type 9830A fitted with Option 275, Option 270, and Option 274. In addition, the peripherals (thermal printer). Eddie Veale, Farringdon House, St. Albans Rd. East, Hatfield, Hertfordshire AL10 OET, England