THE SOUND ENGINEERING MAGAZINE

JANUARY 1981
$1.95

# db

A98105KUOWA325COMI1 0181 9999
KUOW RADIO
D S 50 UNIV OF WASH
325 COMMUNICATIONS BLDG
SEATTLE WA 98105

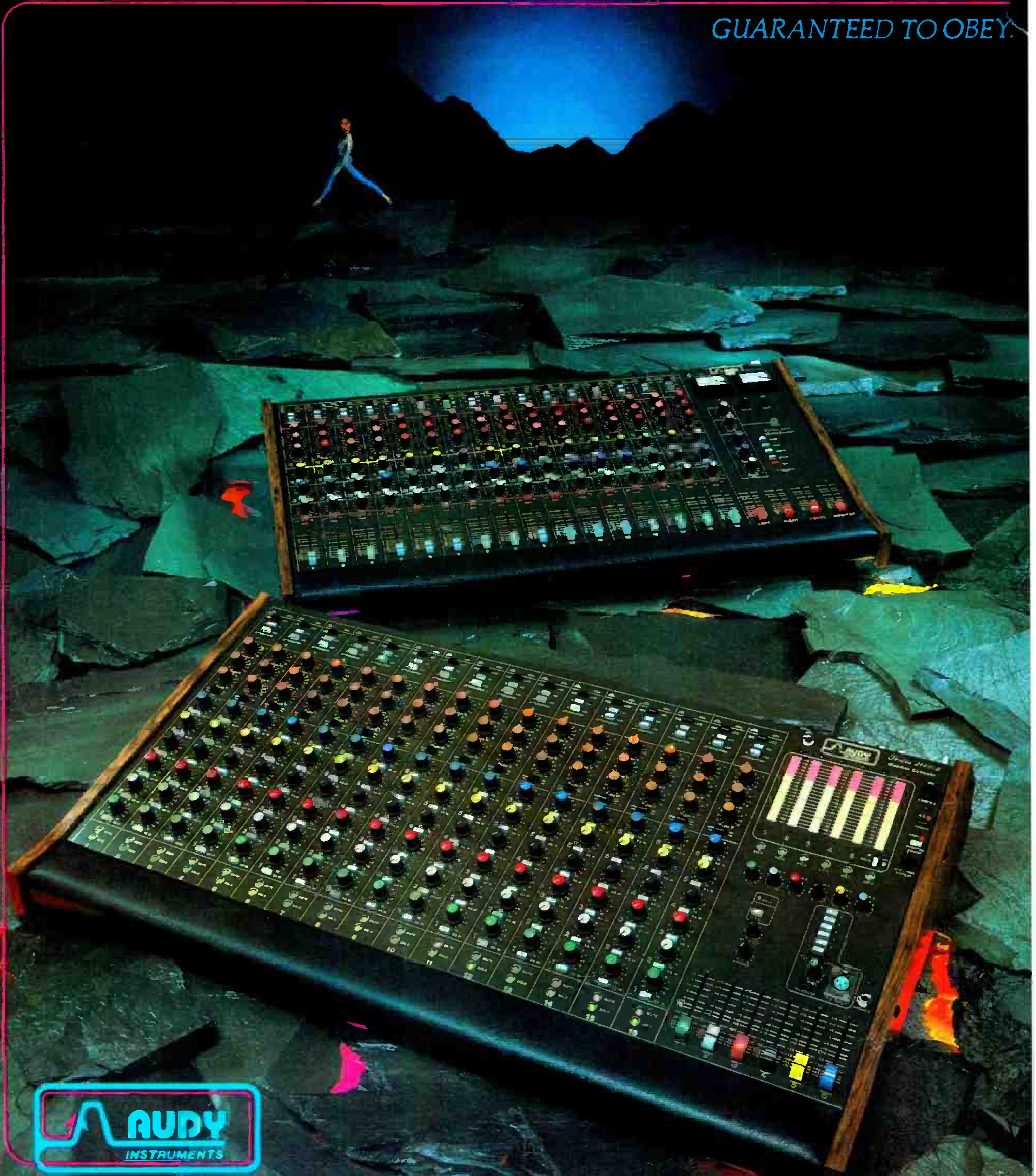
Of all the mixer manufacturers in the industry, why is Audy the only one to offer a full two year warranty? Simple. We can back it up.

We can state unequivocably that the Audy Series 2000 will obey whatever commands your performance requirements dictate.

Because Audy is more than a manufacturer. We're our own toughest customer. A professional concert sound company for top artists throughout North America, Audy conceived and designed the Series 2000 for one simple reason: no other mixer was good enough.

And thousands of concerts later, we're still convinced that the Series 2000 is the master of its class.

The Audy Series 2000 and Series 2000M monitor consoles. Command and they will obey. We guarantee it.




*For a free, full color brochure, write Audy Instruments, Inc., P.O. Box 2054, 35 Congress Street, Shetland Industrial Park, Salem, MA 01970. (617) 744-5320*

*Circle 10 on Reader Service Card*

**Larry Zide**
Publisher

**John M. Woram**
Editor

**Mark B. Waldstein**
Associate Editor

**Kathy Lee**
Advertising Production & Layout

**Carol Vitelli**
Classified Advertising

**Lydia Anderson**
Book Sales

**Eloise Beach**
Circulation Manager

**Bob Laurie**
Art Director

**Crescent Art Service**
Graphics

**Spartan Phototype Co.**
Typography

sales offices

**Karaban/Labiner Inc.**
**New York, New York 10036**
25 West 43rd Street
(212) 840-0660

**Chicago, Illinois 60601**
333 N. Michigan Ave.
(312) 236-6345

**Roy McDonald Associates, Inc.**
**Dallas, Texas 75207**
1949 Stemmons Freeway, Suite 670
(214) 742-2066

**Denver, Colorado Area**
**Englewood, Colorado 80112**
14 Inverness Dr. East, Bldg. 1—Penthouse
(303) 771-8181

**Houston, Texas 77036**
6901 Corporate Drive, Suite 210
(713) 988-5005

**Los Angeles Area**
**Glendale, California 91204**
424 West Colorado Street, Suite 201
(213) 244-8176

**Portland Area**
**Hillsboro, Oregon 97123**
510 South First
P.O. Box 696
(503) 640-2011

**San Francisco Area**
**Emeryville, California 94608**
265 Baybridge Office Plaza
5801 Christie Avenue
(415) 653-2122

**Sagamore Publishing Co., Inc.**
**New York**
**Plainview, NY 11803**
1120 Old Country Rd.
(516) 433-6530

ABOUT THE COVER

• Dr. Dale Warland, left, music director of the Dale Warland Singers, and Scott Rivard, chief engineer of Sound 80 Studios in Minneapolis, review earlier takes of a digital recording inside a Stark Mudge mobile unit. This is the third digital recording by the Dale Warland Singers, produced on the Augsburg Sound 80 label. The recording utilizes 3M's 4-track digital recorder.

# db

THE SOUND ENGINEERING MAGAZINE

**JANUARY 1981 NUMBER 15, VOLUME 1**

| | |
|---|---|
| EDITORIAL | 32 |
| A LOOK AT DIGITAL RECORDING TAPE<br>Del Eilers | 34 |
| THE MITSUBISHI PCM RECORDING FORMAT<br>Kunimaro Tanaka | 36 |
| HUMAN STRESS PROVOKED BY DIGITALIZED RECORDINGS<br>Dr. John Diamond | 41 |
| A db SPECIAL REPORT: A POST-SCRIPT ON DIGITAL STRESS | 44 |
| A GUIDE TO DIGITAL TAPE RECORDER SPECIFICATIONS | 46 |
| 1980 INDEX OF ARTICLES | 52 |
| LETTERS | 6 |
| DIGITAL AUDIO<br>Barry Blesser | 12 |
| THEORY AND PRACTICE<br>Norman H. Crowhurst | 20 |
| SOUND WITH IMAGES<br>Martin Dickstein | 24 |
| NEW LITERATURE | 27 |
| NEW PRODUCTS AND SERVICES | 28 |
| CLASSIFIED | 50 |
| PEOPLE, PLACES, HAPPENINGS | 56 |

db is listed in **Current Contents: Engineering and Technology**

db, the Sound Engineering Magazine (ISSN 0011-7145) is published monthly by Sagamore Publishing Company, Inc. Entire contents copyright © 1980 by Sagamore Publishing Co., 1120 Old Country Road, Plainview, L.I., N.Y. 11803. Telephone (516) 433-6530. db is published for those individuals and firms in professional audio-recording, broadcast, audio-visual, sound reinforcement, consultants, video recording, film sound, etc. Application should be made on the subscription form in the rear of each issue. Subscriptions are $12.00 per year ($24.00 per year outside U.S. Possessions and Mexico, $13.00 per year Canada) in U.S. funds. Single copies are $1.95 each. Editorial, Publishing and Sales Offices: 1120 Old Country Road, Plainview, New York 11803. Controlled circulation postage paid at Old Saybrook, Connecticut 06475

Rauland

**PURE PRO**

**audio design**

*introduces the remarkable*

**3535 LOG-8 Microphone Mixer**

with *Voice-Entree*™ option

Permits the activation and simultaneous use of multiple microphones without feedback and does the job automatically—no operator, no manual adjustments required...

***ASK FOR DESCRIPTIVE FOLDER***

**LOOK TO RAULAND FOR EVERYTHING IN PROFESSIONAL SOUND**

**Spectrum-Master Equalization** (Patented): Most complete line available. Includes 1/3- and 1-octave models, test set, and tunable notch filter.

**Spectrum-Master In-Wall Amplifiers:** Available in 35-watt, 60-watt, 100-watt outputs. Each with built-in 1-octave equalizer and D.R.E.

**Spectrum-Master Amplifiers:** Incomparable Model DX (5-year warranty) and TAX amplifiers, from 70 to 250 watts RMS to meet any professional audio requirement.

**Spectrum Series Speakers:** Professional quality two-way speaker systems embodying superior components in advanced system designs.

***WRITE FOR TECHNICAL BULLETINS***

Rauland *The Quality Name in Professional Audio*

**RAULAND-BORG CORPORATION**

**3535 W. Addison St., Dept. N., Chicago, Ill. 60618**

*Circle 31 on Reader Service Card*

# db Letters

## Dealing With Head Bumps

To The Editor:

Regarding *The Spars Survey*, November 1980, and *db Surveys the Survey*: It is pleasing to see a de facto standard arising for analog tape operation and alignment. Yet it appears that no studio has voiced how it deals with the low-frequency reproduce irregularities known as "head bumps" or "contour effect." One explanation I have heard of the cause of head bumps is that at long wavelengths a greater width of the head than just the gap becomes a transducer. Regardless of the cause of head bumps, multi-track (and two-track) tape recorders in my experience exhibit record playback responses varying as much as 4 dB in the low frequency end, depending on how well the reproduce head is designed. One machine I know has a rise near 30 Hz of 3½ dB on some tracks (resulting in a pinned vu meter), and a slight dip near the upper bass region. This is at 15 ips speed, and at 30 ips the rise moves to a higher frequency and or to a greater amplitude.

Many studios feel that 30 ips has a worse (weaker) bass response than 15 ips, when in reality what happens is that the response peak of the reproduce head falls at a high enough frequency to be within the effects of the reproduce low-frequency equalization adjustment. Instead of bringing this peak down to 0 vu, the alignment engineer might find it better to make a sweep frequency response of the low end up to about 250 hz, and then set the reproduce low-frequency control to a level that produces the *flattest average* low-end response. (He also should use some judgment based on listening experience, remembering that the ear reacts more to peaks in a response than to dips. Also, that a peak at 63 hz is more annoying than one at 31.5 hz.)

The key to this problem is that low-frequency equalization should be adjusted in record mode. No full-track or multi-track *spot frequency* test tape (even one compensated for fringing effect) is adequate to measure the head bumps, since they often reach their maximum or dip *between* the standard spot frequencies.

My suggestions to deal with this problem are as follows:

1) When the machine is first acquired, record a tape of the low-frequency response, with swept tones. Chart the acquired record playback response for each channel. (The assumption is made that the record equalization is correct. That is why no machine in my experience has any low-frequency adjustment in the record side.)

# Index of Advertisers

Ampex . . . . . . . . Cover III, 21
Audio-Technica . . . . . . . . . . 19
Audiotechniques . . . . . . . . . 27
Audy Instruments . . . . . Cover II
Bose . . . . . . . . . . . . . . 9
CBS Records . . . . . . . . . . . 31
Crown . . . . . . . . . . . 11, 42
Electro-Voice . . . . . . . . . . . 15
FSI . . . . . . . . . . . . . . . 45
Garner Industries . . . . . . . . 12
Inovonics . . . . . . . . . . . 10
Knowles Electronics . . . . . . . 14
Mike Shop . . . . . . . . . . . 16
R. K. Morrison Illust. Mats . . . 26
Rupert Neve . . . . . . . . Cover IV
Orban . . . . . . . . . . . . . 39
Pentagon Industries . . . . . . . 16
Polyline . . . . . . . . . . . . 24
Pro Audio Seattle . . . . . . . . 6
Rauland-Borg . . . . . . . . . . 6
Sescom . . . . . . . . . . . . . 24
Shure Brothers . . . . . . . . . 7
Soundcraftsmen . . . . . . . . . 23
Standard Tape Lab . . . . . . . . 38
3M . . . . . . . . . . . . . . . 29
Teac . . . . . . . . . . . . . . 25
Telex . . . . . . . . . . . . . 13
Telex Turner . . . . . . . . . . 8
Tentel . . . . . . . . . . . . . 43
UREI . . . . . . . . . . . . . . 33
Valley People . . . . . . . . . . 17
Waters Manufacturing . . . . . . 14
White Instruments . . . . . . . . 20

# Coming Next Month

• In February, **db Magazine** goes International. There's a story about an advanced new studio in Mexico, our man in Britain, John Borwick reports on the activities of the APRS, and Japan comes to California as we look at Yamaha's research center studio complex in Glendale. There will also be a report on the recently concluded (New York) AES Convention. And there will be more, coming in **db, The Sound Engineering Magazine.**

# fact: you can cut conference clutter—and improve the sound in the bargain!

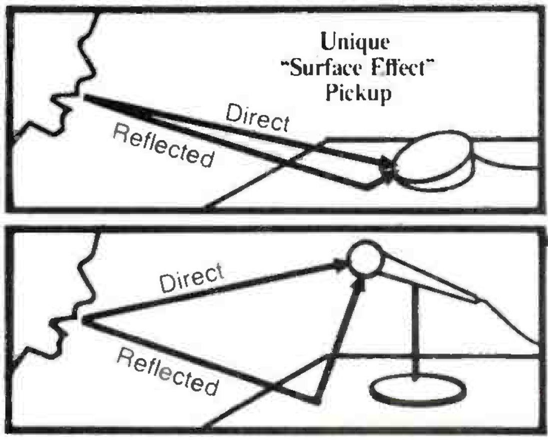
## What you can't see... lets you hear better!

Eliminate your conference room's "electronic jungle" with the new, inconspicuous Shure Lo-Profile™ SM18 unidirectional microphone designed to lie flat on the table. Distracting (and intimidating) chrome-plated hardware gives way to unobtrusive brown foam-encased units... even the brown cables blend into wood-finished table tops.

The Model SM18 is ideal for seminars, press conferences, speakers' platforms, and sales meetings.

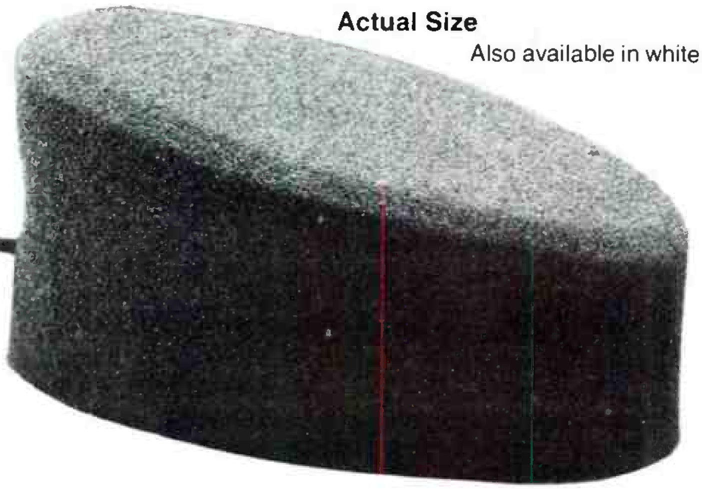
But appearance isn't the only advantage. A special "Surface Reflection Effect" configuration eliminates the unnatural hollow sound caused by reflected sounds bouncing off table surfaces. The Model SM18 picks up sound from the front while suppressing audience noise. It is especially engineered for voice range pickup. What you say is what the audience hears... period.

For full details, check with your firm's audio visual expert, your sound installer, or send for our new brochure (AL630).




**Actual Size**

Also available in white.



# The New SM18 LO-PROFILE™ microphone by

® SHURE ®

Shure Brothers Inc., 222 Hartrey Ave., Evanston, IL 60204

In Canada: A. C. Simmonds & Sons Limited

Outside the U.S. or Canada, write to Shure Brothers Inc., Attn: Dept. J6 for information on your local Shure distributor.

Manufacturers of high fidelity components, microphones, sound systems and related circuitry.

*Circle 28 on Reader Service Card*

# Desk Paging?

# Turner has More!

Turner desk paging microphones allow the audio professional more flexibility in choosing the right microphone for each installation. A minimum amount of electronic modification is required because Turner has engineered its products to meet virtually all applications. Twelve distinctly different microphones in two desk-top case styles. There is a quality Turner desk paging microphone with features to meet the following applications requirements:

**• Omnidirectional • Low Impedance • Normally Open Switching • Normally Closed Switching • High Impedance • Zone Paging • Cardioid • Noise Cancelling • Press-To-Talk • Lift-To-Talk • Amplified.**

And, that's only the beginning. Turner has 13 other paging microphones in gooseneck, handheld and wall mount versions, as well as a full line of sound reinforcement microphones. Turner *does* have more, and now, with the additional product development strength of Telex Communications, Inc. there will be even more to come.

**Quality Products for The Audio Professional**

TELEX TURNER

TELEX COMMUNICATIONS, INC.

9600 ALDRICH AVE SO., MINNEAPOLIS MN 55420 U.S.A.
EUROPE: 22, rue de la Legion-d Honneur 93200 St Denis, France

*Circle 23 on Reader Service Card*

2) Determine the *one* low-frequency (between approximately 63 hz and 125 hz) which, if adjusted to read 0 vu, will result in the flattest low-end response. Note that this frequency will probably be different for 15 and 30 ips.

3) Use *this* low-frequency as your standard low-end frequency test tone recorded at the head of all your tapes. A sweep response would be ideal, but probably takes up too much tape time.

4) When an out-of-house tape arrives, determine exactly what low-frequency test tone(s) is on that tape. If the tone coincides with your standard low-frequency tone, then adjust your reproduce equalization to read 0 vu. If the tone does not coincide, then first observe a chart of your known reproduce response and adjust the low-frequency equalization accordingly.

For example, if a tape comes with an 80 hz tone, and your machine should have a 1 dB dip at 80 hz for flat low end, then adjust the 80 hz to −1 vu.

I would like to see reactions from recording engineers regarding this recommended practice.

Bob Katz
Freelance Recording Engineer
New York City

**db replies:**

*Well, how about it readers? Let's hear some reactions.*

## On Test Tapes:

I appreciate the fine articles on test tapes in November's **db.** Referring to Mr. McKnight's article, "Jay McKnight and MRL," Mr. McKnight states, "Properly used, a calibration tape will last until it becomes so limp that you're sorry for it." Two paragraphs later he says, "In time, any calibration tape will begin to show poor results because of aging (through use)—" Which is correct?

Also, why, when we pay so much for test tapes must they:

1. Be sold without leader?
2. Be recorded so close to the front of the tape; why not a bit further down the reel?
3. Have so little raw tape on the end that they come off the machine almost immediately when the tone ends?
4. Why the difference, sometimes, in the 700 Hz reference tone at the beginning and the 1 kHz in the frequency run? We have had at least two Ampex test tapes with the 700 Hz reference tone about ½ db different from the 1 kHz tone. In these cases I don't believe it was the machines since the same results show on several machines.

Lewis Kanoy
Station Engineer, WFDD-FM


*"The Bose 802 speaker is so versatile that it can be used in applications from churches to performing arts centers to discos.*

*"The speaker is very compact and aesthetically pleasing. Architects find it especially appealing. Performers love it because of the sound. We love it because it's simple to install and it saves us money and time in installation.*

*"Our clients like it because it works and it's reliable. You can just turn it on and forget about it. The size and simplicity make it about the only system that's practical to demonstrate on site before we make a sale. We can just bring them in and set them up on stands. Once my clients hear the Bose 802, they don't want me to take it back to my shop.*

*"Using Bose has opened up new avenues of business for us. Bose has helped build our reputation to what it is today."*

Thank you, Jay.

It's also nice to know the 802 has a smooth frequency response that holds down feedback and reduces the need for extensive system equalization.

But we think reading what Jay Bridgewater has to say is more likely to make a Bose believer out of you. Consider the Bose Model 802 when you need speakers for a church, theater, night club or disco. It will give you the kind of performance and appearance that will make you a Bose believer.

**BOSE**

Better sound through research.

For the 802 Engineering Bulletin and a complete catalog of Bose Professional Products, send in the coupon below.

Bose Corporation, Dept. SE
The Mountain
Framingham, MA 01701

Please send me the 802 Engineering Bulletin and the complete Bose Professional Products Catalog, along with a list of your dealers and contractors.

Name: __________

Street: __________

City: ______ State: ____ Zip: ____

Tel: ( ) __________

Patent rights issued and pending

© Copyright 1979 Bose Corporation.

**Jay McKnight Replies:**

On the life of a Calibration Tape: Sorry that the two paragraphs seem to conflict. I meant to indicate that if a calibration tape has been carefully used, then by the time it is "so limp you're sorry for it," it will also "begin to show poor results because of aging (through use)," or vice versa.

On leaders: We have followed the recommendation of the standards ANSI S4.14 (1976)/EIA RS-434 for Magnetic Tape Records, which call for "an attached leader of non-magnetic material or an extension of the magnetic tape free from recording, at least one meter long extending beyond each end of the recorded portion of the tape." (IEC Publication 94 has a similar requirement.) The MRL extensions of unrecorded tape are approximately two meters at each end, which seemed to us a convenient length. We would like to hear from any other readers who feel that the two-meter leader is too short—how long you would like it to be?

On a separate leader: If we attach a separate leader to each end, it will add to our manufacturing cost (nothing is free!), and we feel that it does not add a commensurate value to the finished product. Furthermore, we find that different users leader our tapes according to their own needs, so our leadering would be redundant. Again, is there a large demand for a separate leader? Are you willing to pay another couple of dollars for it?

On the questions about level control on the 700 Hz and 1000 Hz tones on the Ampex Calibration Tapes: Only Ampex can answer these questions. I am forwarding Mr. Kanoy's letter and this reply to Mr. Stan Busby, who is manager of the Ampex audio engineering group, for his answer.

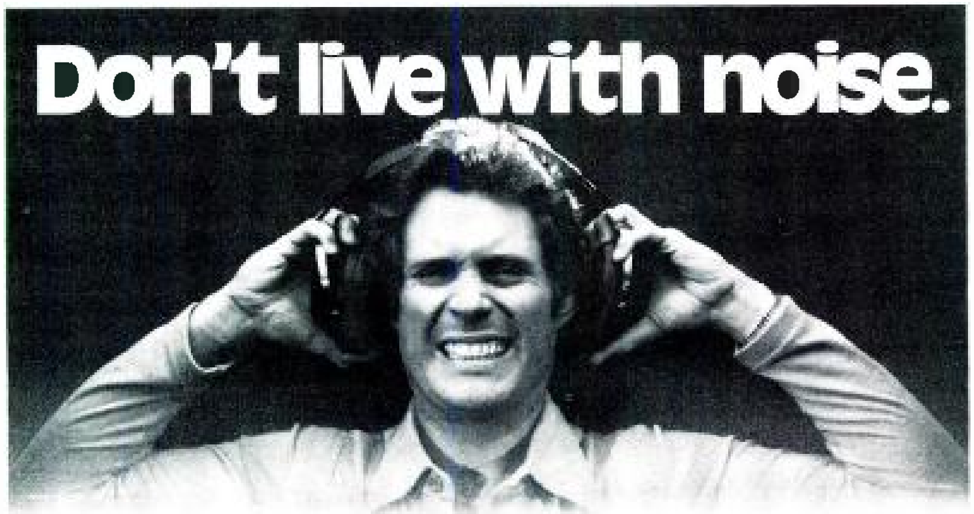
On Mr. Katz's comments on the *Spars Survey*, which relates to calibration tape usage for measuring and adjusting the reproducer's low-frequency response: Everything he says is absolutely true. Although what he says has been published many times before in technical articles (1, 2) and in manufacturers' instruction books (3...6) he is quite right that most users and technicians are still not aware of these facts. We inadvertently omitted this method from the instructions that accompany our Calibration Tapes, but we will add it in our next revisions. I would certainly be glad to see anything that Spars, **db Magazine,** and Mr. Katz can do to bring this matter to the attention of those who do the practical adjustment and operation of studio recorders.

JOHN G. (JAY) MCKNIGHT
President
Magnetic Reference Laboratory

**REFERENCES:**


1. J. G. McKnight, "Tape Reproducer Response Measurements with a Reproducer Test Tape," *J. Audio Eng. Soc.* Vol. 15, pp. 152-156, (1967 April). See "Frequencies on the Test Tape," and Figs. 4 and 5.
2. J. G. McKnight, "Low-Frequency Response Calibration of a Multitrack Magnetic Tape Recording and Reproducing System," *J. Audio Eng. Soc.* Vol. 26, pp. 202-208, (1978 April). Reprint available on request from MRL, 229 Polaris Ave., Mountain View, CA 94043.
3. Anon., "Ampex AG-440 and AG-445 Recorder and Reproducer, Operation and Maintenance Manual," Ampex Corp. Manual Number 4 890 301, (1969 and later revisions). See Sec. 4C.3.9, "Low Frequency Reproduce Equalization."
4. Anon., "Scully 280 B Series Recorders/Reproducers, Instruction and Maintenance Manual," Scully/Metrotech Div. of Dictaphone Corp., Cat. No. 200 612, (undated, about 1974). See Sec. 6.2.3 d.
5. Anon., "MCI JH-110A Professional Tape Recorder, Technical Manual," MCI Inc., (1976 and later dates). See Sec. 5.9.5 "Low Frequency Eq. Alignment Notes," and Sec. 5.9.11 "Reproduce—Low Frequency Adjustment."
6. Anon., "Ampex ATR-100 Series Recorder/Reproducer, Operation and Maintenance," Ampex Corp. Cat. No. 4 890 407-01 (1977). See Sec. 5-31 "Use of Alignment Tapes," last paragraph; Sec. 5-35 "Reproduce Equalization Adjustment," Sec. 5-36, Para. 12; and Sec. 5-45 "Record Alignment," Sec. 5-46, Para. 27.






The DYNEX Noise Suppressor helps get rid of electronic and environmental background noise without sacrificing program clarity.

Choose low-frequency, high-frequency or wideband noise suppression. As legitimate program energy in the suppressed band increases, suppression is progressively reduced. The result is a cleaner sound for broadcasting, location filming or studio recording and production.

You don't have to live with noise. Find out more about the DYNEX. Call or write us today. Model 241, DYNEX —$300.

**Inovonics Inc.**

503-B Vandell Way
Campbell, CA 95008

Telephone
(408) 374-8300

*Circle 33 on Reader Service Card*


TO THE EDITOR:

When Altec closed its microphone operation a few years ago, all the Altec mikes in the field became orphans. But somewhere in southern California there must be a former Altec employee or service shop with the capability to service relics such as the 21 D condenser mike. Does any db reader have information on where or to whom I can go for parts or service on the venerable 21 D? Responses desired by Bruce Mallion, 8 Elaine Road, Stoneham, Mass. 02180. Collect calls taken at (617) 899-3250.

BRUCE MALLION

**db replies:**

*How about it readers? Anybody out there able to help out an orphan?*

TO THE EDITOR:

I have recently become the proud owner of an old Ferrograph Super Seven ½-Track Tape Deck.

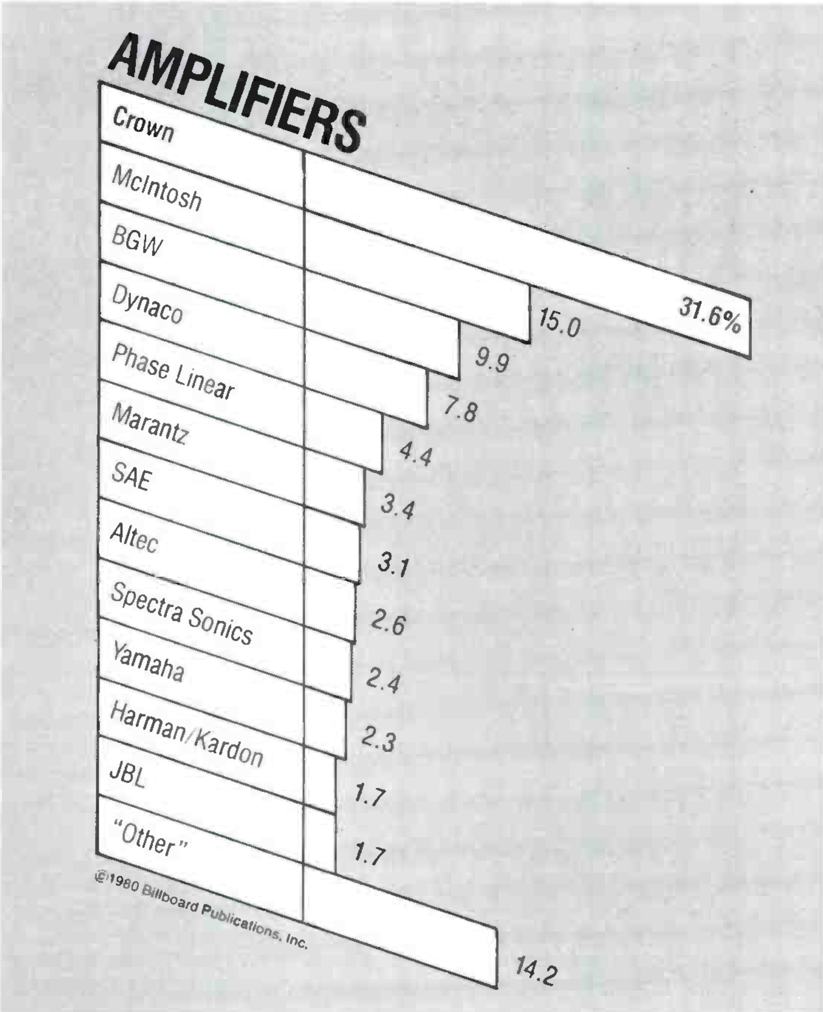
I would like to obtain service manuals for it, but I can't find the address of the manufacturer. Can you help me in this matter?

LEONARD BARISH

**db replies:**

*In order to obtain a service manual, contact Richard Chilvers of Neal Ferrograph at 652 Glenbrook Rd., Stamford, Conn. 06906.*

# THANKS!




The 1980-81 BILLBOARD International Recording Equipment and Studio Directory again identifies Crown, for the fourth year in a row, as the first choice of US studios for monitor amplifiers.

To all the many professionals in the recording industry who made that happen, we say a heartfelt thanks.

We think we build very good amps, but your opinion is the final test. You have tested them all, and you have selected Crown.

You have also been exposed over the last few years to a large amount of promotion which tried to convince you that "Brand X" or "Brand Y" was the choice of professionals. We think the BILLBOARD numbers present our case much better than we could have ourselves.

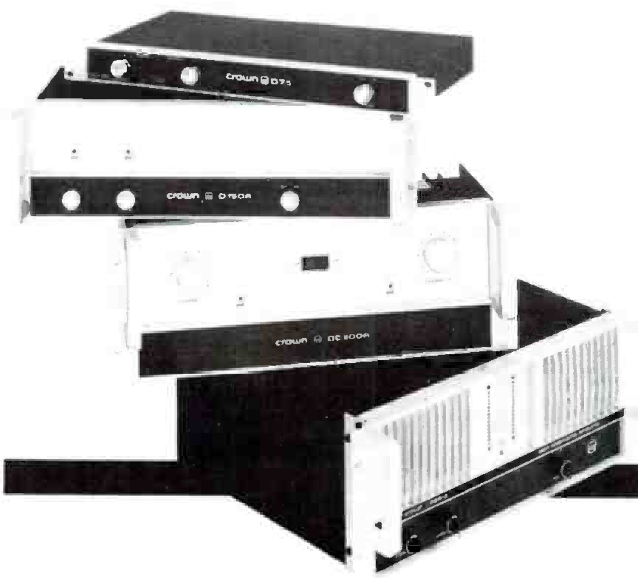
You also need to know that we do not intend to rest on our laurels. We intend to maintain this leadership, with new amplifiers that will make the Crown choice even easier for you.

Cordially,

Ken Woodcox
Western Regional Manager

Howard King
Eastern Regional Manager

James S. Beattie
General Sales Manager

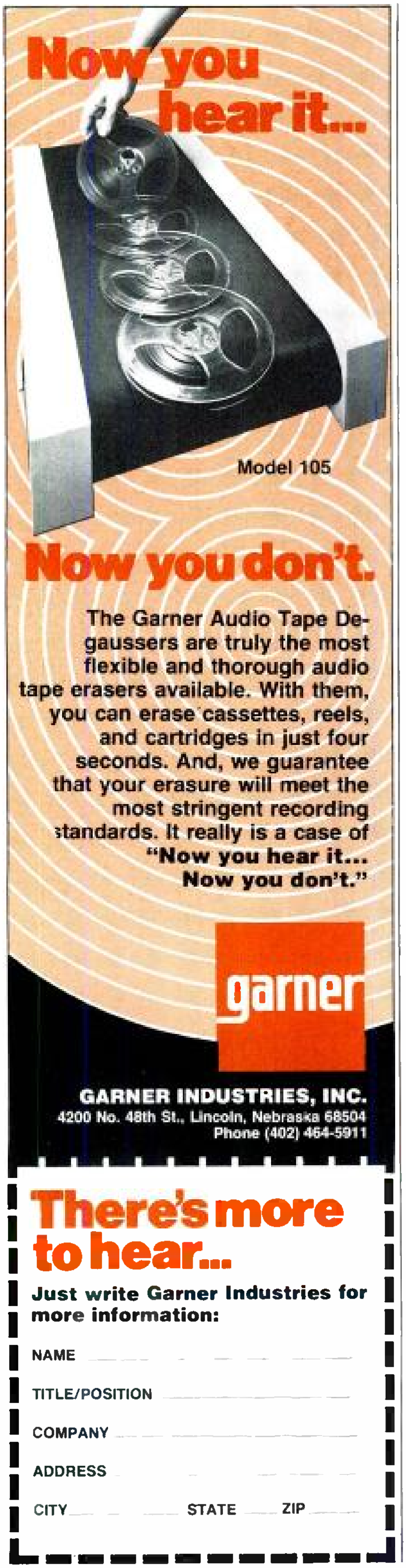


crown

1718 W. Mishawaka Rd., Elkhart, IN 46517.

*Innovation. High Technology. American. That's Crown.*

*Circle 19 on Reader Service Card*




*Circle 37 on Reader Service Card*



# Specifications, Part I

• Up to this point in our series on digital audio, we have been dealing with straightforward technical material. There has been nothing controversial, since the presentation was based on classical mathematics and physics. Now, just to change the mood, I would like to bring up a set of issues which will clearly generate some heat. How do we specify the requirements for a digital audio system? In the analog domain, the issue was usually moot since the audio engineer simply tried to do the best he could. Within the digital world, however, one can always do better if one wishes. If the dynamic range of a 15-bit converter is not enough, use a 16-bit device. If that is not sufficient, use 17 bits. The costs rise. One can rationalize by saying that the digital alternative is already much more expensive than the analog equivalent, and quality should not be sacrificed for a few more dollars. Moreover, the digital field is in its infancy and there is a strong wish not to lock the profession into a standard which it will regret in the future. These arguments lead to a specification confrontation which is beyond anything which we have seen before. The following are the kinds of questions which are being discussed intensively:

1. What sampling rate should be used in order to achieve what audio bandwidth? The European broadcast profession has adopted a 15 kHz bandwidth at a 32 kHz sampling frequency. The rest of the profession is considering 20 kHz or more, using a 44.1 kHz or 50 kHz sampling frequency.
2. How many bits in what format should be used in the conversion in order to achieve what dynamic range and S/N ratio? There is some drift to a 16-bit format, although some would use only 14 bits within the format. Others argue for 18 bits within certain equipment. The human hearing system can be shown to have 120 dB between threshold of detection and pain. Should we therefore aim at *20* bits? ($S/N = 20 \log 2^{20} = 120$ dB-**Ed.**)
3. What specifications should be adopted for the anti-alias and anti-image low-pass filters? These include: limit of passband; sharpness of cut-off; attenuation in stopband; ripple in passband; phase non-linearity, and temporal overshoot. How much is enough?

Before you get your blood pressure up about these questions, rest assured that I will not answer them directly. At best, I will only provide a very qualified answer. Rather than providing answers, I see my primary role as that of presenting a methodology for dealing with the questions. To begin any such discussion requires some kind of philosophic statement and an assertion about the validity of the scientific method. Although pure science is usually the domain of highly trained individuals, the basic ideas are rather simple.

There are three phases to an investigation of the specifications of a digital audio system: a) the original untestable assumptions, b) the methodology for conducting experiments based on the assumptions, and c) the rules for drawing limited conclusions from experiments. We will examine the scientific method in the context of digital audio.

## ASSUMPTIONS

The first and central assumption is that we define the metric of quality based on the *faithful reproduction of music-like* sound signals for *listening* pleasure. Furthermore, each of these special words


# Take a close look at what Tape Transports are going to be like in the '80s

**The all new Telex 3000 is here NOW!**

No industry has witnessed more technological improvements over the past few decades than our own. So, if you're looking for a tape transport for broadcast, studio or industry, it's important to choose a product with all the lastest industry innovations in one unit, the NEW Telex 3000. Write for exciting details about these features.

- Interchangeable head blocks
- A.Q.R. (Auto Cue Release)
- Differential electro-mechanical braking
- Spill-proof logic
- Motion sensing
- Tape counter
- 4 head capability
- Hyperbolic tape path
- Remote control capability
- Play only or record/play combinations
- Auto cue/rewind/cycle
- Dual speed
- Hysteresis drive motor
- Two torque spooling motors
- Quiet operation
- 120/240 volt operation
- Urethane pressure roller

Quality products for the audio professional

**TELEX**®

TELEX COMMUNICATIONS, INC.

9600 Aldrich Ave. So., Minneapolis, MN 55420 U.S.A.
Europe: 22, rue de la Légion-d'Honneur, 93200 St. Denis, France.

*Circle 38 on Reader Service Card*


Circle 13 on Reader Service Card


Circle 29 on Reader Service Card

has a second-level set of assumptions. Consider the word *music-like*. We would all agree that this rules out teletype codes in an FSK format. We would all agree that it includes music made from acoustical and electronic musical instruments. However, we must be careful in the next level of assumptions. Is a steady 18.2 kHz sinewave tone, lasting six seconds, a legal musical event? Notice that there is nothing in the question which concerns science. And, there may be some controversy about either a "yes" or "no" answer. Personally, I would not assume that it is a musical event, since it would not give me any pleasure listening to a music presentation which contained such a signal. Others might have different *tastes* and would consider this to be an important part of the music.

Let us consider another word from the central assumption: *listening*. Who will be doing the listening? We must be careful about how we select our "relevant" group of listeners. This could be defined as the "average" listener, the audiophile, the trained mixing engineer, or the slightly-deaf rock performer. The importance of this assumption can be illustrated by the following extreme cases. Suppose we define the listener as *the* person with the most sensitive hearing system. This would mean that if I could find one person who could hear 30 kHz, then all systems would need to reproduce this bandwidth to meet the reproduction assumption. To be even more absurd, we could require listening pleasure for cats, dogs and birds, since they may be members of the family. Anybody for a 50 kHz audio bandwidth? On the other hand, no one has demonstrated that anybody can hear the bandwidth limitation of 15 kHz, using music made by acoustic instruments. (See later discussions on experimental methods.)

The above is only a small sample of the implicit and explicit assumptions which must preceed any scientific question. Assumption systems involve matters of taste, marketing, specsmanship, nonsense and anything else you wish. Who could argue with the assertion that vibration at 1 Hz is pleasurable when reproducing a cannon shot in the 1812 overture? Blesser's Scientific rule No. 1: never argue with an untestable assumption, even if it appears to be the ravings of a lunatic.

I would like to use the history of FM broadcasting to illustrate the importance of assumptions. When FM was being invented, engineers maintained that there would be a significant improvement in signal-to-noise, compared to conventional AM broadcasting. They based this assertion on some prototypes which they had built in the laboratory. Several scientists, also working on FM broadcasting, had proved that there would be *no* improvement in signal-to-noise. They based their assertion on pure mathematics. The controversy raged for

# Electro-Voice's Greg Silsby talks about the Sentry 100 studio monitor


Production Studio, WRBR-FM, South Bend, Indiana.

In all the years I spent in broadcast and related studio production work, my greatest frustration was the fact that no manufacturer of loudspeaker systems seemed to know or care enough about the real needs of broadcasters to design a sensible monitor speaker system that was also sensibly priced.

Moving to the other side of the console presented a unique opportunity to change that and E-V was more than willing to listen. When I first described to Electro-Voice engineers what I knew the Sentry 100 had to be, I felt like the proverbial "kid in a candy store." I told them that size was critical. Because working space in the broadcast environment is often limited, the Sentry 100 had to fit in a standard 19" rack, and it had to fit *from the front, not the back*. However, the mounting hardware had to be a separate item so that broadcasters who don't want to rack mount it won't have to pay for the mounting.

The Sentry 100 also had to be very efficient as well as very accurate. It had to be designed so it could be driven to sound pressure levels a rock'n roll D.J. could be happy with by the low output available from a console's internal monitor amplifier.

In the next breath I told them the Sentry 100 had to have a tweeter that wouldn't go up in smoke the first time someone accidentally shifted into fast forward with the tape heads engaged and the monitor amp on. This meant high-frequency power handling capability on the order of five times that of conventional high frequency drivers.

Not only did it have to have a 3-dB-down point of 45 Hz, but the Sentry 100's response had to extend to 18,000 Hz with no more than a 3-dB variation.

And, since it's just not practical in the real world for the engineer to be directly on-axis of the tweeter, the Sentry 100 must have a uniform polar response. The engineer has to be able to hear exactly the same sound 30° off-axis as he does directly in front of the system.

Since I still had the floor, I decided to go all out and cover the nuisance items and other minor requirements that, when added together, amounted to a major improvement in functional monitor design. I wanted the Sentry 100 equipped with a high-frequency control that offered boost as well as cut, and it had to be mounted on the front of the loudspeaker where it not only could be seen but was accessible with the grille on or off.

I also didn't feel broadcasters should have to pay for form at the expense of function, so the walnut hi-fi cabinet was out. The Sentry 100 had to be attractive, but another furniture-styled cabinet with a fancy polyester or die-cut foam grille wasn't the answer to the broadcast industry's real needs.

And for a close I told E-V's engineers that a studio had to be able to purchase the Sentry 100 for essentially the same money as the current best-selling monitor system.

That was well over a year ago. Since that time I've spent many months listening critically to a parade of darn good prototypes, shaking my head and watching some of the world's best speaker engineers disappear back into the lab to tweak and tune. And, I spent a lot of time on airplanes heading for places like Los Angeles, Grand Rapids, Charlotte and New York City with black boxes under my arm testing our designs on the ears of broadcast engineers.

The year was both frustrating yet enjoyable, not just for me but for Ray Newman and the other E-V engineers who were working on this project. At this year's NAB show it all turned out to be worth it. The Sentry 100's official rollout was universally accepted, and the pair of Sentry 100's at the Electro-Voice booth was complemented by another 20 Sentry 100's used by other manufacturers exhibiting their own products at the show.

What it all boiled down to when I first started the project was that I knew that the Sentry 100's most important characteristic had to be *sonic integrity*. I knew that if I wasn't happy, you wouldn't be happy. I'm happy.

Market Development Manager,
Professional Markets

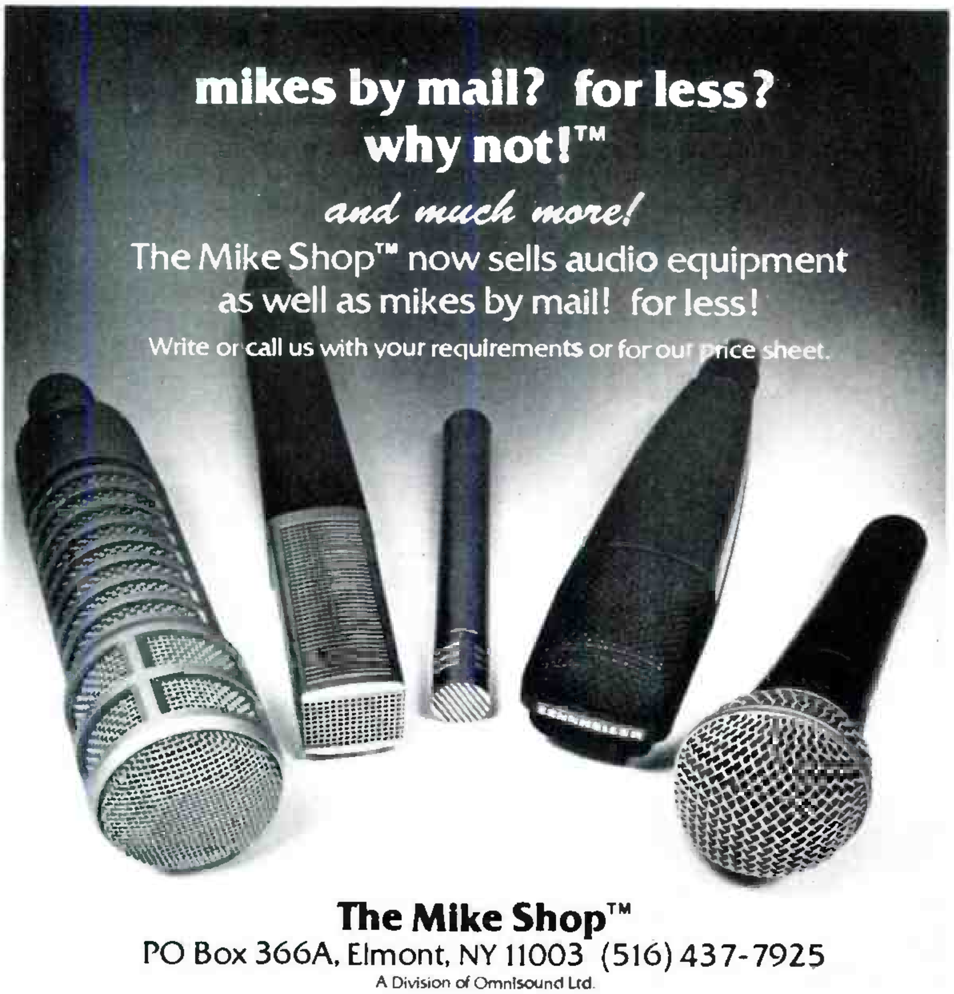
Electro-Voice®
a gulton company

600 Cecil Street, Buchanan, Michigan 49107

In Canada:
Electro-Voice, Div. of Gulton Industries (Canada) Ltd.,
345 Herbert St., Gananoque, Ontario K7G 2V1.

*Circle 39 on Reader Service Card*

*Circle 27 on Reader Service Card*



*Circle 22 on Reader Service Card*

several years, with each side claiming that they were clearly right. One group built a system which worked, and the other "proved" the reverse result. The mathematicians viewed the engineers as having violated the laws of nature with a version of the "perpetual motion machine." The resolution was very simple: both groups were right. The mathematicians had assumed that the FM modulation system would have the identical side-band bandwidth as the reference AM modulation system. Only the form of modulation was changed. The engineers had increased the bandwidth more than one order of magnitude. The differences were only a matter of assumptions. This leads to Blesser's Scientific Rule No. 2: when two or more smart people disagree in a conclusion, the basis of the disagreement will usually be found in the unspoken assumptions.

### METHOD

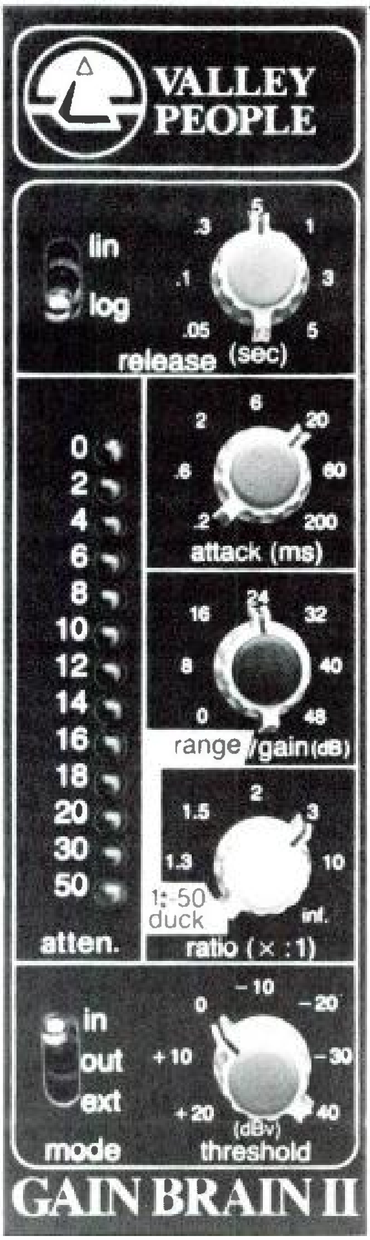
Having demonstrated the significance of the assumption system, we need to turn our attention to the method of conducting an experiment. If you run an experiment by saying the following to a subject: "This sample has a 15 kHz bandwidth, and the next has a 20 kHz bandwidth: which do you prefer?", the results will be nonsense. Honesty cannot be assumed since a subject has unconscious biases. He may think that he hears a difference when there is none. In psycho-acoustic testing, we must always run a *controlled double-blind* experiment.

By controlled, we mean that only one variable is manipulated at one time. If bandwidth is the variable under consideration, then the two sets of samples should differ only in that way. The noise, distortion, phase, reproduction equipment, test samples, subjects, etc. should all be as identical as is humanly possible. Let us illustrate an uncontrolled bandwidth experiment. A subject is given an unlabeled switch which bypasses a 15 kHz low-pass filter in one position and includes it in the other. He is asked if he can hear any difference. Since there is an extra set of circuits in one case, we might find that noise and distortion are higher in the filtered case. Hence, the difference which the subject might hear could be based on the spectral difference of the noise at lower frequencies. The noise at 10 kHz could have a strong influence on the *subjective* sense of bandwidth. In fact, the "low bandwidth" case might sound as if it had *more* bandwidth than the high bandwidth case. A good experimenter will ask subjects to describe the perceived difference. In the above hypothetical case, the experimenter would be warned that he had a problem if subjects judged the filtered samples as having more bandwidth than the unfiltered samples.

The list of variables to be controlled is very large. A carefully controlled experiment can be extremely difficult to perform since such variables as phase, noise, distortion and loudspeakers need to be measured and matched. A good scientific

# GAIN BRAIN II

# Now...a limiter/compressor and *ducker* that understands MUSIC



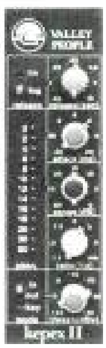

Strong words? We're prepared to back them up. Just listen to **GAIN BRAIN II** and you'll agree it's the only real advancement in dynamics control in nearly a decade.

**GAIN BRAIN II** is fundamentally different from any other limiter/compressor device, including our own Allison **GAIN BRAIN I.** The others struggle along with Peak and RMS detection methods that squash and flatten the life out of music, as if it were a laboratory test signal. **GAIN BRAIN II** treats music waveforms with greater respect and understanding. It does this by means of exclusive circuitry: Linear Integration Detection, Log Domain Processing, Peak Reversion Detector Correction, and the most transparent VCA ever created by man—namely our own EGC 101.

Sure, these are new words; we invented them. Just like we invented the technology that goes with them. Audibly effective technology that allows **GAIN BRAIN II** to solve the great limiter paradox: tight control vs. musical integrity.

**GAIN BRAIN II** can give you the *flattest VU meter output of any limiter/compressor device in existence*, while maintaining an *unheard of degree of integrity to the subtle dynamics of music and speech*. And it's a ducker, too.

And the **GAIN BRAIN II** phenomenon is just the beginning. Get your copy of our **GAIN BRAIN II** literature package. Once you've read it, you'll understand the full implications of our new technology. Better yet, get yourself a **GAIN BRAIN II.** Your ears will tell you all you need to know.



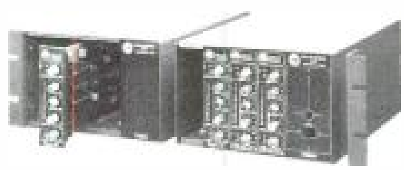

**KEPEX II** Our original KEPEX® is credited as the most successful signal processing device of the 70's. We're flattered by the imitators who widely advertise claims that they have "improved" on our design.

One fact remains: More studios buy KEPEX than *all* of the imitations combined, yet we seldom advertise the equipment. Does that tell you anything?

There does, however, exist a genuine "improved KEPEX". It's not a copy though, it's an original in its own right. We call it KEPEX II®. New technology from the ground up. New capabilities for the 80's: new controls, new functions, and best of all, dramatic new levels of audio transparency thanks to our EGC 101 VCA.

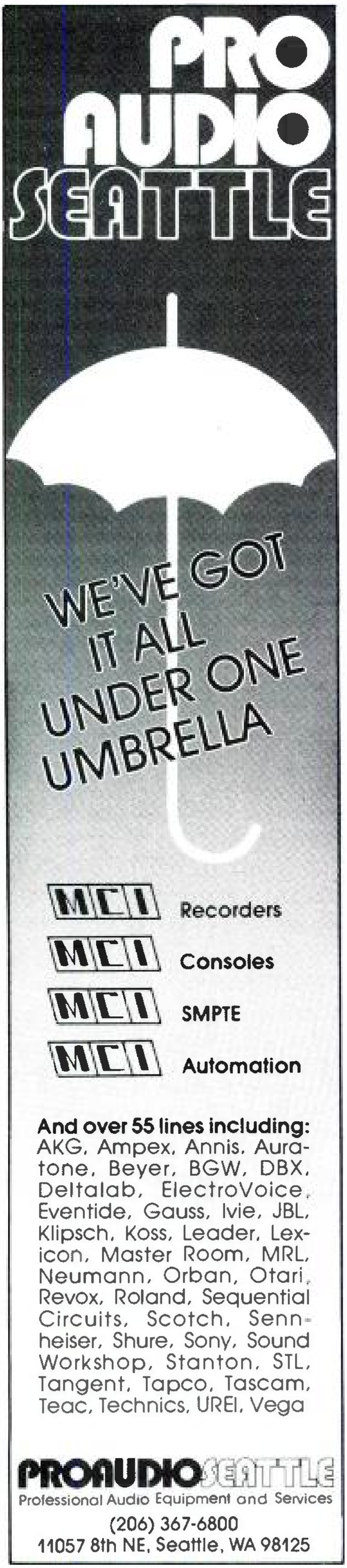
Today, more people buy KEPEX II than all of the others. Find out why this is true.

**Travelling Goodies** New for the 80's ... the TR-804 Processing package. It holds KEPEX II®, GAIN BRAIN II, and the host of unique processing equipment now under development at VALLEY PEOPLE. TR-804 combines all of the advantages of a portable "goodie box" for the freelance engineer/producer, with the benefits of multiple device rack mounting for the serious studio. Ample connections and powering assure its ability to accept future products.



VALLEY PEOPLE, INC.
a merger of ALLISON RESEARCH & VALLEY AUDIO
P.O. Box 40306/2820 Erica Place
Nashville, Tennessee 37204
615-383-4737
TELEX 558610 VAL PEOPLE NAS

*Circle 25 on Reader Service Card*



Circle 14 on Reader Service Card

paper will provide a section which lists all of the experiment details so that another scientist can check the validity of the experiment and, if he wishes, try to reproduce the results. Few scientists do a perfect job of controlling secondary variables.

We have just considered the case of a false-positive result in which a perceived difference could have been false due to an uncontrolled variable. A reverse situation is also possible: a false negative. Suppose we did an experiment in which we showed that there is no difference between 10 kHz and 15 kHz bandwidth. It might look reasonable in terms of controlled variables, but the experimenter might have neglected to determine if the music contained any signal above 10 kHz. Similarly, the loudspeakers might have been defective. A negative result must be examined in a different way than a positive result.

In one case, the difference was another variable; in the other case, the variable did not exist.

Double-blind is a term used to describe the situation where neither the subject nor the person conducting the experiment knows the truth value of the test signals. Hence, they are both blind. I often illustrate the importance of double-blind with the story of the farmer who had a horse that could understand English and answer questions correctly. The farmer would bring the horse to a disbeliever who would ask it a question. Since the horse could not talk, he would pick up his right foot whenever he heard the correct answer. The process would go as follows. Question: What is the capital of the United States? Presented Answers: New York (no foot), Boston (no foot), Washington (foot raised). The horse was a great marvel and nobody could prove that the horse did not understand. Was the horse for real? Everybody who had seen the horse was convinced that the horse understood the questions.

Eventually, someone noticed that sometimes the horse did not get the right answer when somebody else asked the questions. Careful investigation showed that the farmer leaned forward imperceptibly when the right answer was spoken. The horse perceived this even though the lean was negligible. In a double-blind experiment, the horse never got the right answer. Double-blind means that the horse, *and* the presenter of the questions were both blind to the correctness of the answers.

## CONCLUSIONS

In the scientific method, the conclusions must always be qualified with the assumptions and conditions of the experiment. A scientist would never say that nobody can hear music above 15 kHz, even if it were true. He could say that the following subjects, selected in the following way, could not hear the difference between the two cases created with the following equipment, when tested with the following samples and controlled in the following way. This is not a mumble-jumble cop-out, but a carefully stated conclusion consistent with the assumptions and experiments. As limited as the scientific method is, it is better than the random results which one gets from emotional bias, prejudice, stupidity and arrogance. Science does not cover the domain of untestable assumptions. A scientist can make whatever assumptions he wishes so long as he reports them along with the conclusions. Then, if you wish to ignore the results, you can do so by noting the differences in assumptions.

## SOFT-SCIENCE

A truly-pure scientific investigation into all the specifications required for digital audio would probably require 5 to 10 man-years of effort. Because of the time and expense, we need to find short-cuts, even if they are less reliable. Often, informal listening tests and controlled conditions can give useful results and insights. In this informal environment, however, we need to consider one additional phenomenon: a *weak* effect vs. a *strong* effect. A weak effect is a variable which is very difficult to perceive directly and often requires a statistical result. You may hear a difference more often than chance, even though the confidence in your judgements is low. With a strong effect, the variable is clear and can be described easily. Finding the best test material and test subjects can turn a weak effect into a strong effect.

Consider an investigation comparing two systems having a 60 dB S/N and an 85 dB S/N using a solo piano as a test sample and sound engineers as subjects. They would all hear the difference, describe the difference, and leave little doubt about the variable being considered. The effect is strong.

Consider the reverse case: two systems with 2, and 0.1 percent, harmonic distortion using popular music and untrained subjects. A carefully-controlled experiment might reveal a difference using fancy statistics. An informal test would probably give no results. The effect is weak.

The more difficulty one has in creating a strong effect, the more convinced one becomes that the phenomenon, if it exists, is weak. On this basis, I will make the following assertions:

a) 15 kHz bandwidth is generally adequate and anything beyond is a weak phenomenon, if it exists.
b) Phase linearity as created by complex low-pass filters is also a weak effect.
c) Ripple in the pass band of less than 0.2 dB is weak.
d) An S/N of more than 85-90 dB is more than adequate and additional requirements are only relevant for extremely rare cases.

Finally, beware of Blesser's Scientific Rule No. 3: Never say never because you can be proved wrong if one person comes up with one counter example. ■

# GO AHEAD. STOMP YOUR FEET!

# You've got an ATM Instrument Microphone System.

You're on stage to make music, not noise. But most microphones will respond to everything that hits them. Including noise coming through the mike stand. Except these new ATM microphone systems. Because each of these specially-designed instrument mikes includes a *very* effective shock mount and a windscreen.

Even if you're on a "bouncy" stage, you needn't tiptoe when an ATM microphone system is at work. Distracting noises are reduced... not amplified. Including floor resonances from speakers nearby. Or the clunks when you raise or lower the mike. All the audience hears is your chops.

But a great microphone system is not just a shock mount or a piece of foam. At the heart of our systems are three superb studio-quality microphones: a unidirectional dynamic, a unidirectional condenser and an omni condenser. Road tough? Of course. But with response specially tailored with uncanny accuracy for instrument reproduction.

With these ATM microphones a trumpet is bright, not strident. Trombone is dark but not murky. Reeds are full but not thick. And drums are crisp and clean, not fuzzy or thumpy. For two important reasons.

First, frequency response is smooth and peak-free and extends well beyond the limits of your instrument. So the balance between overtones and fundamental isn't distorted. And one part of your range isn't favored over another.

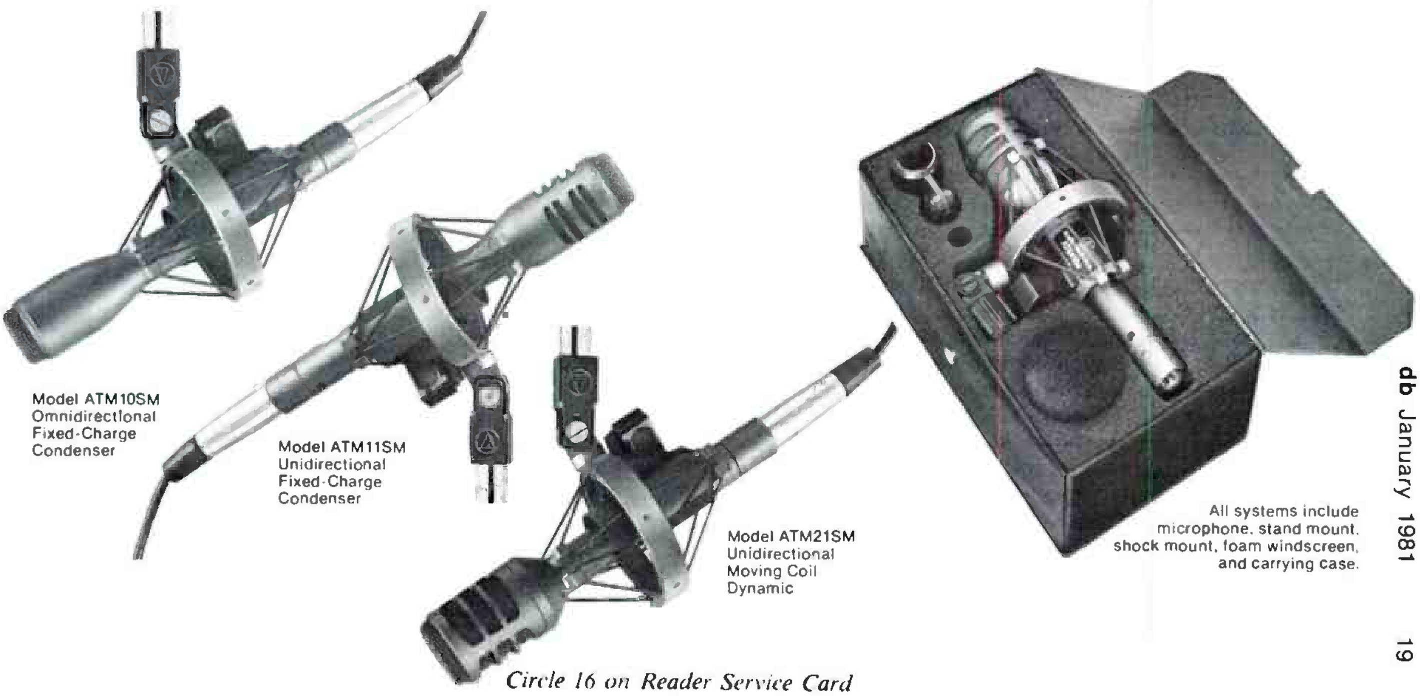
Second, and equally important is our wide dynamic range... designed to capture and amplify all of yours. It's almost impossible to overblow our ATM dynamic, for instance. And our electrets will handle up to 130 dB with ease. So your *fff* crescendo won't come out just *ff*.

Great sound and no distractions. The best possible way to start your sound system working *for* you. ATM Instrument Microphone Systems are waiting for you at leading pro music dealers everywhere. Kick up your heels!

AUDIO-TECHNICA U.S., INC., 1221 Commerce Drive, Dept. 11BD, Stow, Ohio 44224. In Canada: Audio Specialists, Inc., Montreal, P.Q.

**audio-technica**

*Great sound right from the start!*



Model ATM10SM Omnidirectional Fixed-Charge Condenser

Model ATM11SM Unidirectional Fixed-Charge Condenser

Model ATM21SM Unidirectional Moving Coil Dynamic

All systems include microphone, stand mount, shock mount, foam windscreen, and carrying case.

*Circle 16 on Reader Service Card*

NORMAN H. CROWHURST

# db Theory & Practice

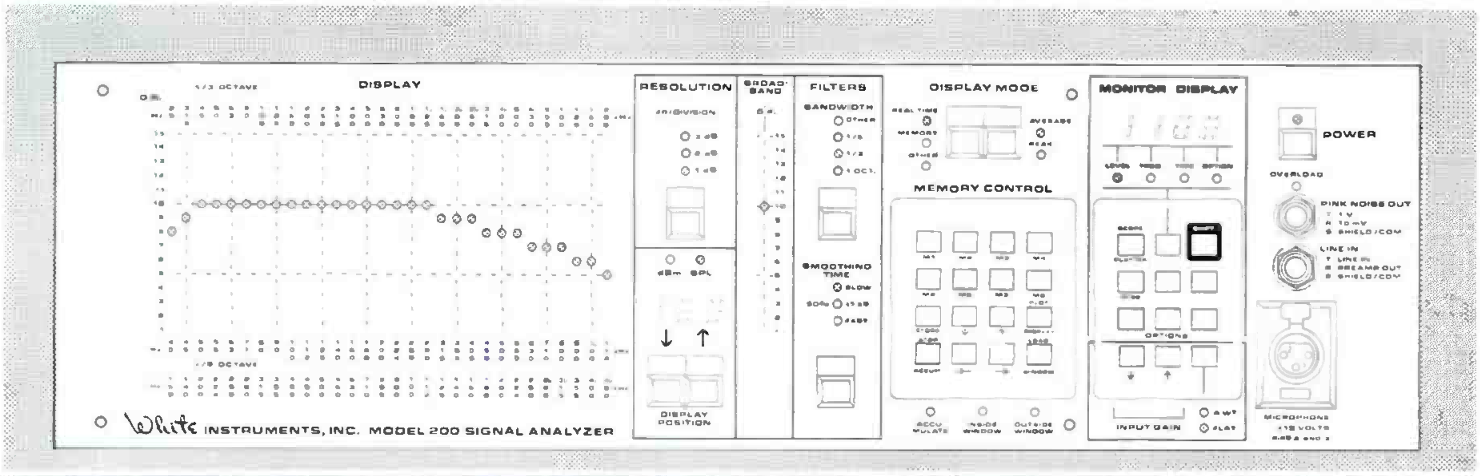
# People as Processors

• In recent articles, we have been trying to apply what the human hearing faculty—and other human faculties—can do to find ways of improving our technology. Now, let us reverse this process. Today we see advertisements for computers, or processors, that can "think," or that can "learn." This almost directly reverses a principle that has been one of our criticisms of today's educational system: that it merely trains human beings to do things that can be done much faster, more accurately, and more efficiently by a computer.

In the sense that most of today's population can "think" and "learn," perhaps those computer claims are right. If this really is true, we may yet live to see computers take over and make slaves of us all, as some science fiction stories have predicted. But those science fiction stories usually finish up by finding some respect in which the human computer is better than its manufactured counterpart, so that man finishes up on top, once more. Nonetheless, those stories make you think, or they should.

Perhaps the real difference is not in the power to think, or to learn, but in creativity. Readers of this magazine are familiar with sound and hearing. So familiar in fact, that we take them for granted, as do most human beings, excepting those who happen to have been denied the faculty of hearing. We don't realize what our hearing does for us every day. To the extent that this is true, we function like a man-made micro-processor: more sophisticated, maybe, but something that a future microprocessor will undoubtedly be able to do.

An example of this is the way we can


EXPANDABLE SYSTEM 200 SIGNAL ANALYZER

**MICROPROCESSOR CONTROL:**
Features and functions of the SYSTEM 200 SIGNAL ANALYZER are **Software Dependent**. Everything the analyzer now does, or will do in the future is the result of running a **Computer Program**, as opposed to being hard-wired to do the work. The SYSTEM 200 SIGNAL ANALYZER has a built in hedge against obsolescence, since its personality can be revised to accommodate the rapidly changing technology of our industry.

**MODULAR IN CONCEPT:**
Most of the SYSTEM 200 SIGNAL ANALYZER plugs together with connectors. The advantage of this architecture is that modules can be quickly extracted from the mainframe for service. Exchanging modules with the factory minimizes downtime and makes system updating **simple** and **inexpensive**.

**EXPANDABLE:**
The SYSTEM 200 SIGNAL ANALYZER'S mainframe contains **three** unused card slots. These positions are reserved for future options which will simply plug into the analyzer and expand its **capabilities**. Options presently in the **prototype** stage include: 1) **Load Into Memory** software allowing the user to load his own response into one of the analyzer's eight memories and then compare it in different ways with real time. 2) **Band Limited Noise Generator**, which will allow the user to excite a sound system only in the band-pass he wishes to study. 3) **Interface Port**, allowing the SYSTEM 200 SIGNAL ANALYZER to communicate with the outside world.

**INTERCHANGEABLE PLUG-IN FILTER SETS:**
**Filters** are the **heart** of a real time analyzer. The SYSTEM 200 SIGNAL ANALYZER'S filters are supplied on cards which can be quickly installed in the MAINFRAME. **Three** filter sets are currently available.

**200-01-00:** **30** three-pole **one-third octave** filters on I.S.O. centers from 25 Hz through 20 kHz meeting **A.N.S.I. S1.11, 1971, CLASS III. Switchable to . . .** **10** three-pole **octave band** filters on I.S.O. centers from 31.5 Hz through 16 kHz meeting **A.N.S.I. S1.11, 1971, CLASS II.**

**200-02-00:** **30** two-pole **one-sixth octave** filters on I.S.O. centers from 40 Hz through 1.12 kHz. This filter set matches the **one-sixth octave** sections of our **Models 4301** and **4303 Active Equalizers.**

**200-03-00:** **30** two-pole **one-sixth octave** filters on I.S.O. centers from 160 Hz through 4.5 kHz. This filter set matches the one-sixth octave sections of our **Models 4240, 4310** and **4311 Active Equalizers.**

The analyzer will accommodate the 200-01-00 filter set plus either the 200-02-00 or 200-03-00 filter set simultaneously. Conversion between the two one-sixth octave filter sets requires only two additional filter cards. Custom filter sets for unique applications can be discussed. The SYSTEM 200 SIGNAL ANALYZER need **never** become obsolete with changing spectrum resolution standards.

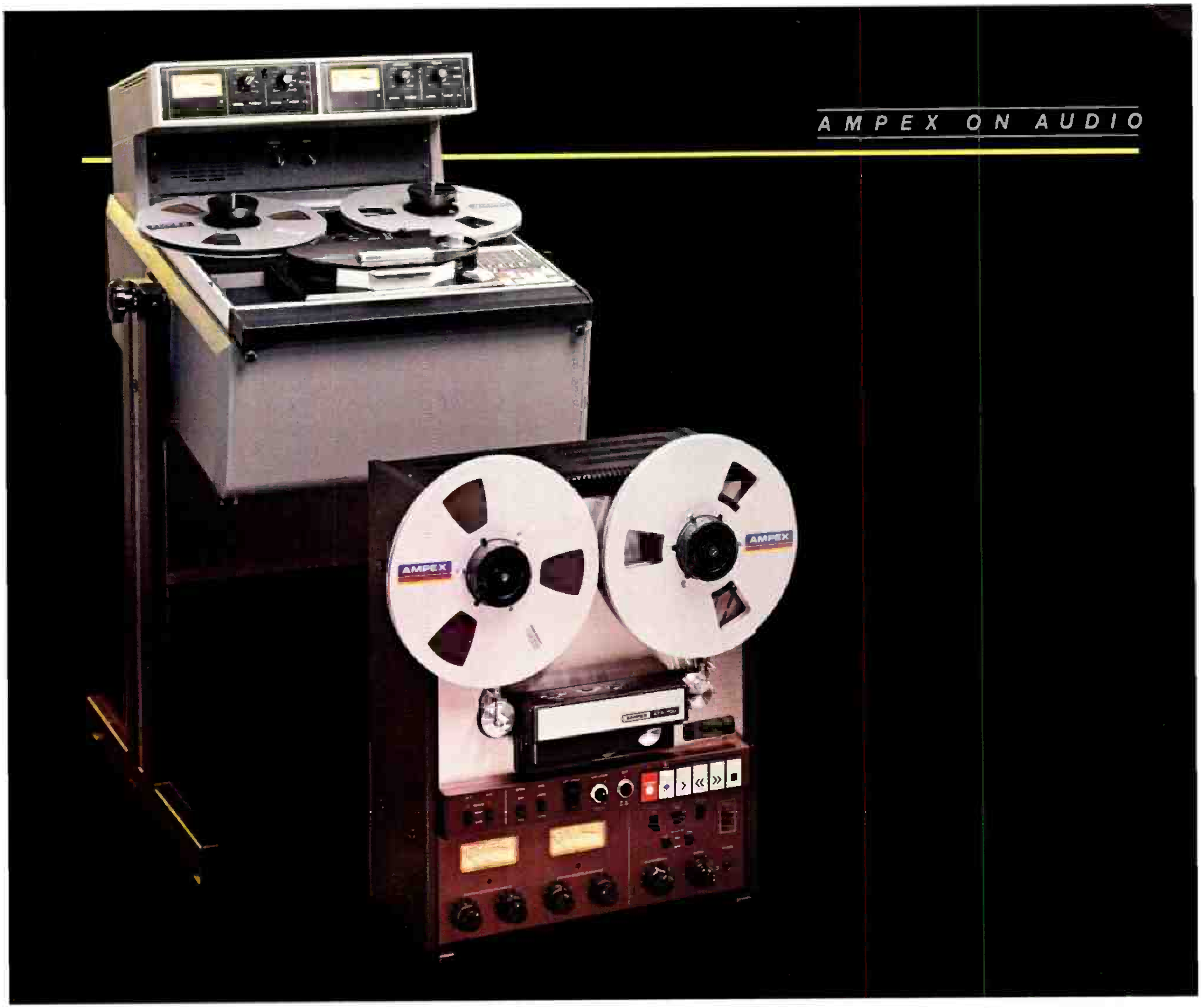
**8 EIGHT NONVOLATILE MEMORIES:**
The inclusion of **8 MEMORIES** in the basic SYSTEM 200 SIGNAL ANALYZER was not superfluous. They add considerable **speed and convenience** to the everyday use of the analyzer. When you turn off the power, a **nickel-cadmium** battery keeps the memories **alive** for future reference.

**3 SMOOTHING TIME CONSTANTS:**
The user can apply either **SLOW, 90% ± 1dB**, or **FAST** smoothing rectifiers to the filters via front panel control to provide optimum measurements in a given room situation.

**AVERAGE AND PEAK MODE PROCESSING:**
The SYSTEM 200 SIGNAL ANALYZER processes the incoming signal in **average** and **peak** modes **SIMULTANEOUSLY**. The user can switch between an average or peak display via front panel control—**free of transients or waiting for the filters to re-settle**. Memory functions are also executed in both modes. The user can display real time or memory data in both modes, at once, using a special **DUAL DISPLAY** feature.

**$T_{60}$ MEASUREMENTS:**
The SYSTEM 200 SIGNAL ANALYZER is programmed to simultaneously make **three $T_{60}$ EXTRAPOLATIONS** based 1) on the first 15 dB, 2) second 15 dB and 3) first 30 dB of incoming signal decay. Successive measurements can be **automatically averaged**. Measurements can be made through **any filter** installed in the mainframe, or broadband, using any combination of **average** or **peak** modes, and **slow** 90% ± 1dB, or **fast** smoothing time constants. Amplitude data in real time is available on the rear panel to drive a storage oscilloscope or a strip chart recorder.

White instruments, inc
P.O. BOX 698, AUSTIN, TX 78767
512/892-0752




# Technological Leadership. It's the Reason You Should Buy Ampex Audio.

Technological leadership. It's the reason you buy Ampex equipment. And it's the same reason you should buy Ampex audio products.

Our ATR series recorders, the ATR-100 and the ATR-700, for example, are ideal audio recorders for broadcasters. You'll discover impressive performance and dollar-saving reliability when you put these hard-working recorders to use in your broadcast operation.

***THE ATR-100. THE PROFESSIONAL.***

The ATR-100 is the standard of excellence in the audio recording industry. Its reputation for low distortion, low wow and flutter, and phase corrected equalization is unsurpassed.

For broadcasters, a cue amplifier and editing kit are available. Finding an edit point is as easy as turning the capstan knob.

***THE ATR-700. A RUGGED PERFORMER THAT'S ALSO PORTABLE.***

Our ATR-700 is a master performer. Perfect for those situations where quality is as important as efficient, trouble-free production. You'll find the ATR-700 to be a rugged performer for news and commercial assignments in the field, as well as a first class addition to your audio equipment in the studio.

You'll get standard features like important controls up front for easy operation, plug-in printed wiring assemblies for efficient service, and a built-in 4 in 2 out mixer.

*Circle 40 on Reader Service Card*

***WHEN YOU THINK AUDIO, THINK AMPEX.***

Ampex was there first. And we're still the leader. So, when you think audio for your broadcast operation, think Ampex audio.

Call your Ampex dealer today for the full Ampex audio story. In a competitive business, it pays to get the edge.

***GET THE AMPEX EDGE.***

**AMPEX**

Ampex Corporation
Audio-Video Systems Division
401 Broadway, Redwood City, CA
94063, 415/367-2011

Keep
db
in
sound
order!

**Special binders now available.**

All you regular **db** readers who, smartly enough, keep all your back issues, can now get our special binders to hold a whole year's worth of **db** magazines in neat order. No more torn-off covers, loose pages, mixed-up sequence. Twelve copies, January to December, can be maintained in proper order and good condition, so you can easily refer to any issue you need, any time, with no trouble.

**They look great, too!**

Made of fine quality royal blue vinyl, with a clear plastic pocket on the spine for indexing information, they make a handsome looking addition to your professional bookshelf.

Just $7.95 each, available in North America only. (Payable in U.S. currency drawn on U.S. banks.)

**Sagamore Publishing Co., Inc.**
1120 Old Country Road
Plainview, NY 11803

**YES!** Please send ______ **db** binders @ $7.95 each, plus applicable sales tax. Total amount enclosed $______

Name______

Company______

Address______

City______

State/Zip______

isolate one sound among the many that we hear at the same time. As a baby—an unlearned microprocessor—the human being finds sounds confusing, unless received one at a time. Some never grow out of that limitation, even as adults. They cannot hear what one person says if a lot of other people are talking at once.

It is much more difficult for a person with only one good ear to isolate sounds, but such separation can be made with practice. The ability to "turn down" unwanted sound, so you can hear what you are listening for, is definitely an acquired one; one that has to be learned. Some do, some don't. What is the difference?

A baby is born with all its "circuits"—its complex nerve and memory system. It has no inputs, unless it brings some from its life in the womb, as some contend. It is confused by all those inputs, visual and aural. But fairly quickly it starts coordinating those inputs. Sound and sight are coordinated so the baby can locate the source of a sound and look in that direction to identify it. Those capabilities are among the first phases of learning.

Does the baby have to think about learning that? Everyone is born with a brain. It listens and absorbs language until it can replicate that language and use it to ask questions. What is this? Why does that happen? Anyone who has had children knows the pattern. It is evidence of an active, inquiring mind.

Although at the outset, locating a source of sound involves setting up an optical search pattern, it quickly becomes a virtually automatic function. Later in life, the same person may learn to spot jet aircraft in the sky by a little more refined method. If he looks in the direction from which his earlier experience tells him the sound comes from, he will see nothing but blue sky. But now he listens for a few moments, to determine the direction in which the apparent source of sound is moving. Then he looks further ahead in the same direction, and his eyesight finds the aircraft.

What is happening is that the child's mind is doing a computation, based on the knowledge that sound takes much longer to travel the 30,000 feet from air to ground than light does, so the sound arrives from a direction where the plane was several seconds ago. He inverts this information, to project where the plane will be now.

We tend to think that if a sound is audible, we'll hear it. Yet we often don't. More accurately, our ears may pick it up, but our hearing faculty ignores it. How often does a mother say to her child, "You are not listening to me."? Is the child hearing her, but deliberately ignoring her?

If there is nothing wrong with his hearing, he undoubtedly can hear her. This she has probably verified by testing his hearing ability. Therefore, she concludes that he must be hearing her, but ignoring her. But is that true?

From a consideration of the objective factors, it is evident that the ear translates every sound picked up into a coded synthesis of frequencies, varying in amplitude, over the auditory nerve bundle. On the other end, the brain acts as a microprocessor to interpret all this "information."

It is also evident that this processing depends more on the way sounds change, than by their instantaneous frequency content. All of this is something that could, in theory, be duplicated by modern technology. However, the fact is that, related to the individual who owns the hearing faculty, this is an acquired capability. It has to be learned, either consciously or subconsciously.

The child's ability to ignore what his mother says to him is probably not consciously developed. But, if you are faced with trying to listen to a person on the other end of a telephone located in the middle of a sheet metal shop where a lot of hammering is going on, you will find conscious effort is necessary.

This becomes a question of modifying the masking effect measured by Fletcher and Munson. If a child is too absorbed in what is going on while watching his favorite TV show, to hear his mother say, "drink your milk," this is merely a matter of selective "hearing." His ears pick up both sounds, but his attention is on the TV program.

Once, visiting a company's sheet metal shop, we were in the manager's office, waiting for him to get off the phone. He hung it up and it rang again. He picked it up and handed it to me saying, "It's for you." I couldn't hear a thing in that earpiece, for the hammering going on around me. But obviously, he could. This provided me with the motivation to develop the same capability. And before long I did, to the point where the hammering no longer bothered me.

Obviously the hammering was at a higher level than the sound from the telephone earpiece. According to Fletcher and Munson's curves, the voice on the other end of the phone should have been completely inaudible. But careful training of my hearing, or listening faculty, enabled me to change the data in those curves, at least as far as my personal hearing was concerned. You must remember that all that data is *average*, taken over a fairly large number of subjects.

From that, you would consider that each person's native capability was more or less absolute, and that the variation was essentially between individuals. But, experiences like the above show that an individual's capability can change due to conscious, or perhaps in some cases, unconscious effort.

Most of the experiences we have discussed thus far would be in a category that could be built into a man-made microprocessor as a capability for learning. For the moment, we don't need to consider how we would program it to do that. But it would be possible to do so, because the human equivalent can do it, without conscious programming.

When conscious programming is involved, we are on the border line of creativity. Maybe learning to hear on the telephone in the middle of a noisy shop doesn't sound like a very creative endeavor, but it is something that does not come naturally, without conscious effort.

Now, consider the maestro who conducts his orchestra, and can hear the sour note played by a single violin, and identify the musician responsible. You couldn't do it (unless you had training equivalent to the maestro's), but he can. He may not have consciously trained his hearing to do that: he may have been much more interested in the music to which he was listening. But his creativity—the desire to produce an improved performance, and to identify flaws—is what promoted that ability.

The same can be true of an auto mechanic, who can listen to the sound of an engine running, and detect sounds that seem totally inaudible to you. He's not being creative; just doing his job. But that ability did involve creative effort on his part, at some time in the past.

Earlier, we mentioned the young child's inquiring mind. What is that? Why does this happen? An inquiring mind is the basis for creativity. We remember our school days, when we were discussing man's inventions. At the time we still had the inquiring mind that sought to "catch up" with all that was known, at that date. Railway trains were commonplace, jet aircraft were still in the future. We could not envision a time without trains, just as my son could not envision a world without jet aircraft. He came home from school one day to ask, "Why didn't the people who ran the pony express take a jet? It's much faster!"

Back in my own school days, discussing inventions, I remember thinking that everything that could be invented, already had been: they'd left nothing for me to invent! Yet today, if I look through an electronics catalog, there isn't an item in the whole thing that had been invented when I was a boy. (And some of them even had my name on the patent specs when they were invented.)

Such inventiveness involves creativity. How would you define that? Perhaps as conscious effort to move into the unknown. We did a lot of it. The first fully automated electrical power station; the first automated safety equipment for mines; the first automated language translation systems; some of the early electromedical developments, both diagnostic and therapeutic. Doing all those things, more or less at once, makes for a hectic life. So we developed a solution for the crunches that come with crash programs in systems design and development.

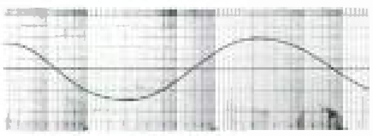
That was before World War II. It had an unexpected side advantage that gave the Allies the technological edge, when the Axis unleashed some technological surprises. We produced countermeasures in an incredibly short time. Long-term grounding in creativity paid off over the Prussian discipline of the Nazi establishment.

Since then, we've lost ground, although creative momentum has carried us a long way. Today that "know-how" is a rare commodity, and one that the establishment seems determined to extinguish. We found that puzzling at first. Creativity being the key to progress, and progressiveness serving to put the country that possesses it in the lead, why would anyone want to extinguish it?

That is an interesting question. Maybe it's not too closely linked with audio technology, but since audio people, as well as everyone else, are, or ought to be, concerned with progress, perhaps we should examine that next. The fact is, the answer is on your doorstep and mine. ■


PRO-EQUALIZER by Soundcraftsmen
MADE IN USA BY SOUNDCRAFTSMEN


SECTION A



ACTUAL SWEPT-FREQUENCY RESPONSE CHARTS SHOWING THE EXACT CURVES RESULTING WHEN CONTROLS ARE SET AS SHOWN IN PHOTO ABOVE.

SECTION B

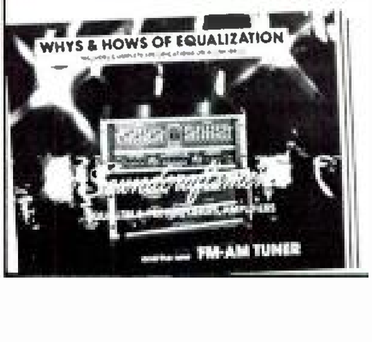
DESCRIPTION Exclusive Zero-Gain L.E.D.'s provide instantaneous in-out balancing convenience and optimum EQ performance. They are operated through a high precision Differential Comparator circuit with a read-out accuracy of 0.1dB, to provide true equalization with no change in the signal level being processed.

A filter Q of 2.0, combined with 3dB per octave slope and minimal phase shift, enables smooth reproduction of music without the sometimes harsh characteristic associated with a higher Q. A high Q can cause sharp dips between filters, sharp peaks at the filter centers, and pronounced phase shift.

Soundcraftsmen's expertise in the high fidelity field is combined with necessary shelving to improve speech and intelligibility, external loop, pre/post EQ capability for external loop and balanced input/output capability. This combination provides all of the advantages of high fidelity specifications plus the practical features necessary in professional, commercial, public address, and industrial fields of operation.

FEATURES: FREQUENCY ANALYZER TEST RECORD, with Reference Tones, Test Tones, all-band Pink Noise, and complete instructions, is included ... COMPUTONE CHARTS, for INSTANT-MEMORY Programming on full-size charts, for cut-out or marking of desired curves, are included ... L.E.D. INDICATION of unity gain within 0.1dB ... LINE INPUTS/OUTPUTS duplicated on front ... PRE-EQ (LOOP) inserts EQ either pre or post external Loop/Monitor . 600 OHM BALANCED or unbalanced operation.

Six Graphic EQ Models, 1/3 and 1 octave. **$249 to $550**

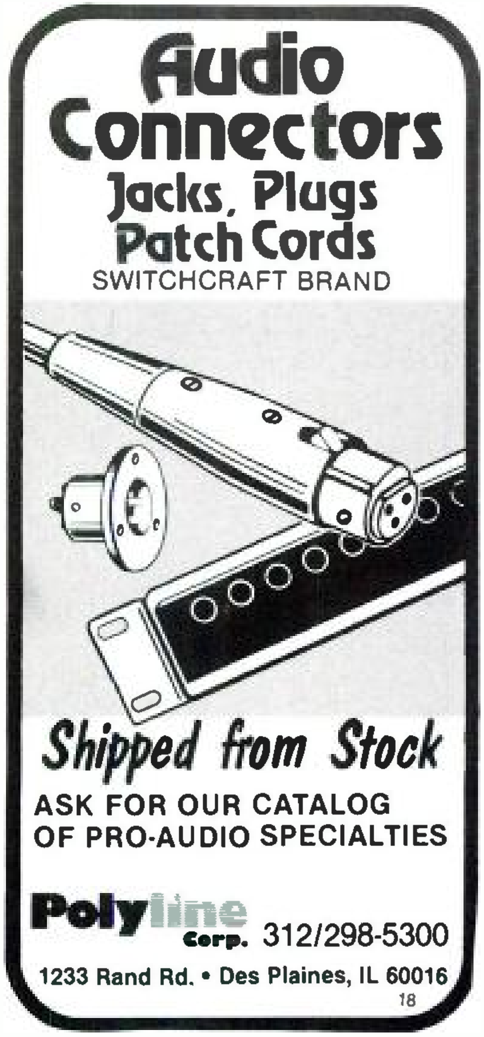



**FREE! 16-page Full-Color Brochure** *Includes TEST REPORTS, complete specifications, Class "H" amplifier ENGINEERING REPORT, EQ COMPARISON CHART, and the "WHY'S & HOW'S" of equalization—an easy-to-understand explanation of the relationship of acoustics to your environment. Also contains many unique IDEAS on "How the Soundcraftsmen Equalizer can measurably enhance your listening pleasures," "How typical room problems can be eliminated by Equalization," and a 10-POINT "DO-IT-YOURSELF" EQ evaluation checklist so you can FIND OUT FOR YOURSELF WHAT EQ CAN DO FOR YOU—SEND $6.00 FOR EQUALIZER-EVALUATION KIT 1-12" LP TEST RECORD, 1 SET OF COMPUTONE CHARTS, 1 COMPARISON CONNECTOR, 1 INSTRUCTION FOLDER*

SOUNDCRAFTSMEN INC., 2200 So Ritchey, Santa Ana, CA 92705 • (714) 556-6193 • CANADA: E.S. Gould Marketing, Montreal H4T 1E5

*Circle 30 on Reader Service Card*

*Circle 26 on Reader Service Card*



*Circle 24 on Reader Service Card*

MARTIN DICKSTEIN

# db Sound With Images

## Psychophysics

• Being involved in a research project can sometimes lead to a rediscovery of some of the basic thinking that went into the ideas that we use today as a matter of course. In this case, the subject under scrutiny is the matter of presentations—things like whether formal or informal, audio visual aids or not, flip chart vs. boards, form and content of material to be left-behind or taken-away (depending on where the meeting takes place), etc., and the who, what, when, where, and how of preparing for and making the presentation.

In reading some of the reference material being used, I became reacquainted with what happened in the past to bring us up to where we are now. Back then, the subject of psychophysics came into the picture. Today, you may hear some of the experts talk in terms of psychoacoustics, or why we hear as we do, and what the mind has to do with how we interpret what we hear. Some of this material may already be known to you (or some of you), but to many it may prove interesting food for thought. It may also be of interest that what was found through the years about one sensation (such as hearing), was also applicable to other sensations such as sight, touch, smell, and so on. How did they get to learn all this? Good question.

Back 130 years ago, a German physicist by the name of Gustav Theodor Fechner got to thinking about measuring the subjective sensations that had previously been considered unmeasurable. He recalled some experiments that had taken place about 30 years earlier. A German physiologist, Ernst Weber (not the Weber whose name is used in electrical flux theory—that was Wilhelm E. Weber, a German physicist) had found that when a person is subjected to two closely related stimuli, he (or she) could not detect the difference unless there was a fixed proportion between one and the other. Weber found that unless there was a 25 percent difference in the intensities of two sounds, the listener said that the two sounds were equal in intensity. To Weber, this was a "just noticeable difference." At this point, the subject could only say that one sensation was "less than" or "more than" the other, but there were no measurements made. To Fechner, if such measurements could be made, it would prove the unity of the material world and the spiritual. Fechner began his own experiments to set up an "exact science on the functional relations ... between body and mind."

Fechner used the "just noticeable difference" between two sensations as his measurements. (Today, they are called "jnd's.") He studied sound, light (brightness and color), and the lifting of weights. He himself ran over 24,000 tests with himself as the test subject in the lifting-of-weights experiments. He thought that jnd's could be added together to measure sensation variations through a complete spectrum. It took him 10 years, and then he published his "Elements of Psychophysics" (he also coined the word). He thought he had found the law which could be used to measure any sensation. He called it "Weber's Law," but it has been known as "Fechner's Law." The law, in essence, expresses the relation between stimulus and sensation—as stimuli are multiplied, sensations increase by addition. This meant that as the intensity of a sound was doubled, one step was added to the sensation of loudness. Mathematically, this meant that the sensation increases as the logarithm of the stimulus. He said that this same relation of sound and hearing could be applied to light and vision, and similarly to taste, touch, and smell.

Psychologists refused to accept the jnd as a valid unit of measurement of sensation. Much was written to try to destroy this theory, but the "law" was taught in schools, textbooks quoted it, and the theory hung on for about 70 years. Fechner was quoted as saying that "the Tower of Babel was never completed because the workers could not agree on how it should be built; my psychological edifice will stand because the workers will never agree on how it should be torn down."

Then, along came the real trouble

# The Tascam 16-Track System.

Chair not included.

# All this for the price of a 2-inch recorder.

If you don't need 2-inch compatibility or 24 tracks, you don't have to pay the price for expensive 2-inch hardware.

Instead, you can own the heart of a 16-track studio.

The Tascam Model 15 Mixer. 24-in 8-out 16-track monitor with a comprehensive cue system that can be fed simultaneously by 48 signals.

The Tascam 85-16 Recorder/Reproducer. A 1-inch transport with 16-track integral dbx.*

And the Tascam 35-2B Mastering Recorder. A 1/4-inch 2-track with integral dbx.

With this Tascam 16-track system, you'll get professional sound at an affordable price. And because it's all new equipment, you save even more with tax credit potentials.

Write to us today for the name of your nearest authorized Tascam dealer. He'll show you how a Tascam 16-track system can fit your studio needs and your budget.

**TASCAM**

TEAC Production Products Group

*dbx is a registered trademark of dbx inc.

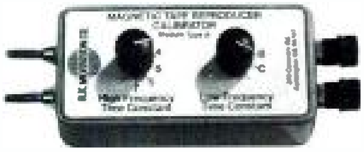
©1980 TEAC Corporation of America. 7733 Telegraph Road, Montebello, CA 90640

*Circle 21 on Reader Service Card*

## STANDARD TAPE MANUAL

This valuable data book is for the AUDIO recordist, engineer or designer. Offered at $45.00 you may order direct from publisher.

## MAGNETIC REPRODUCER CALIBRATOR



This is induction loop equipment of laboratory quality for primary standardization of tape recorders and tapes. Send for detailed information, prices and formats.

**R. K. MORRISON ILLUSTRATIVE MATERIALS**
819 Coventry Road
Kensington, CA 94707

*Circle 17 on Reader Service Card*


makers—the engineers. They tried to apply the law in the study of acoustics, and found that the law did not hold up. The decibel, a measurement of sound energy, worked in logarithmic units, so it should have been completely satisfactory as a direct application of the law. But they found that 100 decibels was not twice the loudness of 50 decibels (the former being about the level of a jet plane 1,000 feet overhead, and the latter being the level of a quiet library). The level of the plane is actually about 30 times the level of the library.

Further tests, with subjects rating sound levels by magnitude estimation, led to the development of a new scale, called the "sone" (Latin for sound) scale. The psychophysicists found that each time the intensity was increased by 10 db's (or dB's as they are now written) the sensation of loudness was doubled. This showed that the sensation multiplied, not added as Fechner believed. Mathematically, this meant that loudness increases as the intensity raised to a power. The exponent, or multiplying factor, for sound was calculated to be 0.3. Thus, a 10 decibel increase raises the sone or loudness perception by 10 raised to the 0.3 power. Another increase of 10 decibels would raise the sone level to two times 10 raised to the 0.3 power, and so on. This is a fortunate situation, since a power of less than one means that the loudness grows more slowly than the physical intensity, and the ear is subjected to levels many billions of times the loudness of the faintest audible sound.

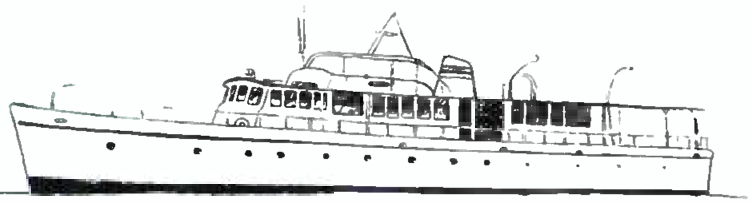
It is this new experimentation that also gave birth to other sensation magnitudes. In each physiological system of the body—vision, smell, taste, heat sensation, electrical shock, etc.—it was found that this "power law" held up under test. Each sense was found to have its own exponent, from 0.3 for hearing, 0.33 for the visual sense of brightness, up to 3.5 for the sensation of feeling an electric current through the fingers. (Don't stick your fingers into a lamp socket.)

The sone was defined as the loudness of a 1,000-cycle (now called Hertz) tone at an intensity of 40 decibels above the average subject's threshold of hearing. To bring you right up to date, this subjective intensity/sensation research is still going on to try to help those who have total loss of hearing. Attempts are being made to provide a mechanical bypass for the defective part of the ear so that the person will be able to hear, but there are still some problems with the achievement of sufficient level and satisfactory quality.

Before we finish up with this subject of sound and hearing, it might be interesting to realize that no animal produces any sound above or below its range of hearing. Of interest, also, might be the ranges that exist in common animals. For example, for a man, the normal frequency range of hearing is 20-20,000 Hertz, but his voice is only in the 85-1100 Hertz range. Dogs hear from 15-50,000 Hertz but emit sounds in the 300-3000 Hz. range. Bats emit sounds in the 10 kHz-120 kHz range, but they can hear from 1 kHz. to 120 kHz. Porpoises can hear in the range of 150-150 kHz., and emit frequencies from 7 kHz. to 120 kHz. For cat lovers, their favorite animal hears from 60-65 kHz., but makes sounds in the 760-1500 range. One exception is the grasshopper which can make sounds (by rubbing its legs against its abdomen) from 7 kHz. to 100 kHz. but can only hear in the range of 100-15 kHz.

Fairly recently, this column had a short study on how the eye perceives light and color. The research project with which I am now involved includes the study of the effectiveness of multi-image and its applications; the content and design of slides for a single projector as well as multi-image operation including color and background; location within the slides of most-important information and other details, and other factors which go into making up a presentation using audio-visual aids. Perhaps, in the not-too-distant future, some of the results will be available for you to see. Maybe we'll also include some of the psychophysical information associated with those findings.

In the meantime, best wishes for a Happy Holiday Season, and a Happy and Healthy New Year. ■

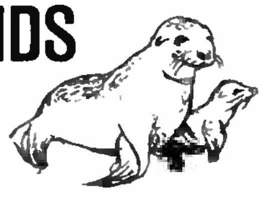



Join db, on a two-week

**South American Adventure**

to

# THE GALAPAGOS ISLANDS AND MACHU PICCHU

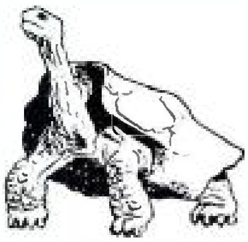


***February 22 to March 8, 1981***

**Sold Out! Inquire for Future Trips**

Editor John Woram and publisher [illegible] invite you to join them, aboard a luxury [illegible] yacht for a week [illegible] Darwin's incredible "enchanted isles"—the Galapagos Islands—[illegible]00 miles off the coast of Ecuador.

Then, we fly to Peru, [illegible] Lima, Cuzco, and the [illegible] Inca citadel of Machu Picchu.



*For more information, write to*
**SAGAMORE PUBLISHING CO., INC.**
**1120 Old Country Road**
**Plainview, New York 11803**
Or phone: (516) 764-8900

# db New Literature

### USERS GUIDE

• This new, four-color 10 page brochure details Hewlett-Packard's complete line of instruments and systems for dynamic signal analysis. Applications for products in this line include vibration analysis, control system performance, structural analysis, analysis of rotating machinery and analysis of biological signals. A two-page foldout selection guide enables the reader to compare and choose the products most suited to his or her application. **Mfr: Hewlett-Packard Company, 1507 Page Mill Rd., Palo Alto, CA 94304.**

### EDUCATIONAL SYSTEMS AND INSTRUMENTS CATALOG

• This full-color, 40-page catalog details course information on 17 complete self-instruction and group instruction college-level programs in electronics, microprocessors, automotive, and computer programming. Information on experimental trainers for laboratory sessions is also supplied. The catalog also features product descriptions and specifications on more than 40 available test instruments, including: oscilloscopes, power supplies, chart recorders, signal generators, and TV service instruments. **Mfr: Heath Company, Dept. 350-370, Benton Harbor, MI 49022.**

### FALL CATALOG

• This new publication features Global Specialties' full line of benchtop instrumentation, frequency counters, logic probes and solderless breadboards. Along with full product descriptions and specifications, Global Specialties also introduces several new products in the catalog, including, the Model 4401 Benchtop Frequency Standard and the Model CTB-2 Benchtop Case. **Mfr: Global Specialties Corporation, 70 Fulton Terrace, P.O. Box 1942, New Haven, Conn. 06509.**

### ELECTRONIC COMPONENTS AND HARDWARE CATALOG

• The newly published catalog 810 for design engineers and purchasing agents is a multi-colored, 100 page, full line catalog that features a number of new products including the recently developed Safety Engineered Test Lead Package. This permits the user to assemble complete test lead systems from standard shelf items to retrofit with existing and new equipment. Other new items offered in the catalog include: an extended group of Printed Circuit Board Supports, Flat Wire Cable Clamps, and many new Spacer types in aluminum, brass, and nylon. **Mfr: Herman H. Smith, Inc., 812 Snediker Ave., Brooklyn, NY 11207.**

### SOUND DESIGN GUIDE

• The new engineers' and architects' Design Guide offers charts, formulas and graphics useful to consultants and contractors planning fixed sound installations. The guide describes techniques to predict acoustical performance and gives electrical, dimensional and acoustic specifications for the Bose 802 professional loudspeaker. The Direct Sound Field Contour Maps included in the guide can aid installers in calculating sound pressure and uniformity of coverage with a variety of speaker placements and configurations. **Mfr: Bose Corporation, Department ADG, Framingham, MA 07101.**

***MOVING?***

Send in your
new address *promptly*.
Enclose your old
**db** mailing label, too.

Write to:
Eloise Beach, *Circ. Mgr.*
db Magazine
1120 Old Country Rd.
Plainview, N.Y. 11803


**audiotechniques**
**RENTALS**
**Warning!**

Our new Rental Rate Schedule dated November 1, 1980, is now in effect. Tear up your old one and call us toll free for our current rate card.
(We've added lots of new gear, dropped some prices . . . and raised **none**!)

**1-800-223-2486**

**Audiotechniques Rentals, 1619 Broadway, New York, NY 10019 (212) 586-5989**

*Circle 36 on Reader Service Card*

# db New Products & Services

## EXTENDED RANGE PLAYBACK SYSTEMS

• JBL has announced the addition of two new loudspeaker products to its Professional Series: the 4690 and 4695 Extended Range Playback Systems. Capable of high acoustic output with minimum distortion, the 4690 Full Range and 4695 Subwoofer are ideal for a variety of permanent and portable applications. The 4690 is a compact, two-way system engineered for full range music playback. Componentry consists of JBL's E140 15-inch low frequency loudspeaker, 2306 high frequency exponential horn, 2410 high frequency compression driver and a specially designed 3101A dividing network. Combining efficiency, controlled dispersion and wide range response, the 4690 will provide complete coverage of typical listening areas. When maximum sound levels of low distortion bass are required, the 4690 can be used in conjunction with the 4695 Subwoofer. Featuring JBL's new E155 18-inch loudspeaker housed in an optimally tuned reflex enclosure, the 4695 can handle 600 watts continuous program down to 30 Hz. The 4690 and 4695 are packaged in ¾-inch multi-laminate hardwood enclosures.

*Mfr: James B. Lansing Sound, Inc.*
*Circle 43 on Reader Service Card*

## SOUND EFFECTS LIBRARY


• The Sound Effects Library for professionals contains more than 2,000 sound effects, with descriptions and time for every effect. 100 boxed reels of master quality recording tape are alphabetically catalogued and cross-referenced. In all, there are over 20 hours of sounds, recorded in-studio or on location by Sound Ideas' staff, available at either 7½ ips or 15 ips. The format invites the integration of all other sound effects, giving the professional one central control.

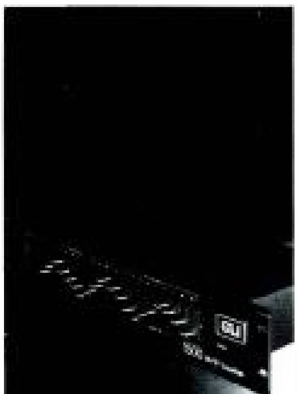
*Mfr: Sound Ideas Recording Studio*
*Price: 7½ ips: $1,500.00, 15 ips: $1,750.00*
*Circle 45 on Reader Service Card*

## DISTORTION ANALYZER

• According to the manufacturer, the Model 6880 is the first totally automatic Distortion, Voltage, and Frequency Measurement system with IEEE-488 Bus compatibility. The 6880 measures total harmonic distortion in percent or dB, down to .003% (−90dB), with .001% (0.1dB) resolution, and automatically tunes itself to the frequency of the external signal over the entire range of 1 Hz to 110 kHz. The unique Auto Set Level circuit presets the amplitude reference level for any input between 0.1-130V RMS. As a frequency counter, the 6880 will measure and display the fundamental input frequency from 1.000 Hz to 999 kHz. Additional features of the 6880 include: selectable high pass and low pass filters; a distortion output; an analog output providing a DC voltage proportional to the distortion, and an ultra-low distortion (< .003%) 1 kHz sinewave output.

*Mfr: Krohn-Hite Corporation*
*Price: $3,500.00*
*Circle 44 on Reader Service Card*

## GRAPHIC EQUALIZER



• GLi has recently introduced a 10-Band EQ-1500 Graphic Equalizer. In addition to providing state-of-the-art gyrator and low-noise Bi-Fet circuitries, the unit offers a high slew rate and includes three sets of selectable inputs complete with tape monitor function. The EQ-1500 has a range of ±12 dB and provides a high output capacity of 10v, before clipping. A relay circuit mutes the audio output, preventing turn on/off transients from reaching amplifiers and speakers. The EQ-1500 mounts in a standard 19-in. rack.

*Mfr: GLi*
*Price: $250.00*
*Circle 46 on Reader Service Card*


# IF YOU THINK DIGITAL IS JUST AROUND THE CORNER, YOU'RE ALREADY A STEP BEHIND.

These days, most people agree that digital is the recording technology of the future. Unfortunately they're also under the impression that it won't be available until then.

There are, however, some notable exceptions to that philosophy. Like Warner Bros. Records, Record Plant, Westlake Audio, A/V Rents and Sound Ideas. Along with some of the most successful studios in England, Germany, Japan and France. You see, they've all installed the multi-track digital system that's available right now.

3M's 30-channel Digital Mastering System.

Already, it's been instrumental in the production of more than 60 records. Because digital captures all the pure, full-range highs and lows and surrounds them with clean, no-hiss silence. The result is transparent, distortion-free sound itself. Whether it's the first generation or the twentieth. All of which adds up to the real reason why these and other outstanding studios are using 3M Digital equipment. Whether it's our 4, 15, or 30-channel recorders, or our sophisticated electronic-editing and digital preview units.

They like to stay a step ahead.

Write: Digital Mastering/3M, Building 223-5E/3M Center, St. Paul, MN 55144.

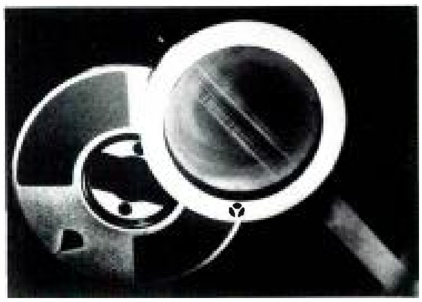
**3M DIGITAL MASTERING. WE DIDN'T INVENT SOUND. JUST THE PUREST WAY TO RECREATE IT.**

*Circle 61 on Reader Service Card*

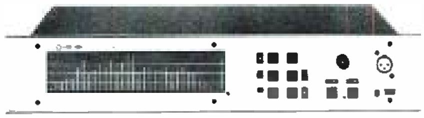
3M

## MAGNETIC TAPE VIEWER

• The DVM 01 is a patented, lightweight (2.5 oz.), circular device designed for the viewing of magnetic digital data. Composed of a large transparent screen of organic glass on the upper side and backed by a non-magnetic membrane, the viewer is filled with a special solution of stable, high permeability ferromagnetic ferrite powder, allowing viewing of high definition and good contrast. Areas of application include: reading of bank cards; inspection and arrangement of synchronized tracks on video recording tapes; alignment of magnetic heads; verification of drop-outs on computer tapes; detection of spurious magnetic fields, and more.
*Mfr: Thomson-CSF*
*Components Corporation*
*Price: $200.00*
*Circle 51 on Reader Service Card*



## REAL TIME ANALYZER



• The DN60 features three memories, peak-hold display, selectable resolution and time constants, and facility for 'A' weighting. The noise source is internal, as is provision for calibration to a specific microphone. The display is an easy to read 30 x 16 high intensity LED configuration with separate display for overall SPL level.
*Mfr: Klark-Teknik*
*Price: $3200.00*
*Circle 55 on Reader Service Card*

## AUDIO OSCILLATOR

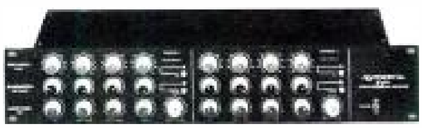
• The Model 700 externally adjustable audio oscillator can be used as a level set reference in audio consoles, laboratories and tone generator sets. The unit is amplitude stabilized to 1± dB over the audio band.
*Mfr: OPAMP Labs Inc.*
*Price: $35.00*
*Circle 52 on Reader Service Card*

## MICROPHONE

• The PL77AA condenser cardioid microphone is the broadcast version of the PL77A entertainer's vocal microphone. The PL77AA can be powered by either a phantom power supply from the mixing board, or from its internal battery.
*Mfr: Electro-Voice, Inc.*
*Circle 56 on Reader Service Card*

## PARAMETRIC EQUALIZER

• A four band per channel parametric, the SF-400 also features 18 dB per octave, independently switchable sub-sonic filters with roll-off at 35 Hz. The equalizer is constructed in a 3½-in. high rack-mount chassis measuring 7-in. in depth. Visual status indicators for each channel include EQ-In, Subsonic Filter In, and a +18 dBm PEAK light which flashes 3dB before the equalizer's clip point.
*Mfr: Symetrix*
*Circle 53 on Reader Service Card*



## DIGITAL REVERB PROCESSOR

• System 5 incorporates a full 15 bit digital design with a full 14 kHz bandwidth to give a truer acoustical room simulation. Dynamic range is 103 dB and signal-to-noise is 83 dBv. There are four individual reverb programs included: number one is similar to a plate, number two is a medium density reverb, number three is low density, and number four is straight echo. Four presets, 16 equalization settings and microprocessor control allows a total of 48,000 possible reverb effects. The System 5 controller is a calculator-styled unit that sits on the mixing console and can be patched to the companion rack-mounted electronics mainframe through normal audio lines. The mainframe processor features a pull-out circuit card drawer for easy access and occupies only 5½-in. of rack space.
*Mfr: Quad-Eight Electronics*
*Circle 57 on Reader Service Card*

## DIGITAL REVERBERATOR

• The DRE-2000 features a ten-program memory; convenient hand-held controls; four reverberation modes, two for echo, two for delay, as well as a non-volatile memory and the flexibility of direct interface with both analog and digital systems. The main unit is rack-mounted and controlled by a hand-held 10-key board. Up to ten programmed combinations of variable parameters can be stored in the non-volatile user memory for repeated use. Reverberation time for the DRE-2000 is 0 to 9.9 seconds, while delay time varies from 0 to 999 milliseconds. The flat 10 to 15,000 Hz frequency response can be varied by the use of variable low-cut and high-cut filters. The unit provides processing for 16-bit quantized digital signals.
*Mfr: Sony*
*Price: $15,000.00*
*Circle 54 on Reader Service Card*

## MIXING CONSOLES

• The Series 4 is designed to offer the professional the optimum features and performance for both sound reinforcement and four or eight-track recording sessions. Available in either 12 input or 20 input fully modularized mainframes, the Series 4 offers: transformerless input circuitry; three band, continuously variable equalization in each channel; peak LED and 20 dB pad on each input; three independent foldback sends; full provision for multi-track monitoring and assign; eight independent returns, PFL, and six out buss assign through submasters (4) and R L stereo busses.
*Mfr: Tangent Systems*
*Circle 58 on Reader Service Card*

## DIGITAL FREQUENCY COUNTER


• The IM-2420 512 MHz portable frequency counter features four gate times and 8-digit resolution for precise readings. A period function can give cycle time in seconds, while the frequency ratio function provides the ratio between two input frequencies. For more accurate measurements, a standby power switch can keep the crystal oven warm for maximum frequency accuracy. The oven is proportionally-controlled to keep the internal time base within 0.1 part per million over a wide temperature range. The crystal-controlled time base provides long-term stability, with drift controlled to less than 1 ppm per year. Four gate times and a large, 0.43-inch-high, 8-digit LED display provide the resolution necessary to measure UHF signals. The IM-2420's 4-15 mV typical sensitivity allows counting of low level signals. Frequency measurements can be made by direct connection, or by using the optional SMA-2400-1 Swiveling Telescopic Antenna. The IM-2420 Frequency Counter can be wired for either 120 or 240 VAC operation.
*Mfr: Heath Company*
*Price: $239.95*
*Circle 59 on Reader Service Card*

## COMPRESSOR/EXPANDER

• The VSC Model AV3 compressor/expander utilizes the Wollensak Bi-peripheral Drive to insure long-term reliability. A simple movement of the VSC speed control lever plays any standard audio cassette from 60 percent to 2½ times normal speed, or about 90 to 375 words per minute, without pitch distortion. VSC operates by sampling the high-frequency speeded audio signal at sub-audible rates and discarding every other sample. The remaining samples are then stretched out, returning them to their original frequencies and filling the gaps left by the discarded samples. These remaining samples are joined in a way that minimizes "splicing noise." With VSC, the actual "stretching" of the signal samples is accomplished with a variable delay line for which a low-noise bucket brigade device (BBD) can be used. The Model AV3 can provide high-speed inspection of printed circuit boards, wire wrapping matrices, cable harnesses and pin connections. It also offers separate tone control to adjust sound for maximum clarity and comfort, cue and review, digital tape counter and remote pause control.
*Mfr: VSC Corporation*
*Price: $495.00*
*Circle 60 on Reader Service Card*


# Electronics Engineer

### Southern Connecticut

This expanding division of CBS Inc. has an immediate opportunity for an electronics engineer with a BSEE and 3-5 years experience in audio engineering, disc manufacturing and tape duplicating technology.

Position requires a background in the design of solid state audio and control circuitry. Ideal candidate will be familiar with NEC and OSHA. Approximately 65-70% travel required.

In addition to fully commensurate salary and excellent benefits, you'll enjoy working in Milford, CT, a beautiful suburban setting not far from New York City's cultural and entertainment attractions. Find out more about the professional career growth we can offer by sending your resume, including salary history and requirements, to: Professional Placement Manager, P.O. Box 87, Parcel Post Station, Milford, CT 06460.

CBS RECORDS
A Division of CBS Inc.

Men and Women of All Races Desired

# db Editorial

As we go to press, the digital decade is about to celebrate its first birthday. Of course, we are still a long way from a standard digital format, although we are perhaps a bit closer than we were at the beginning of the decade (not *much* closer, just a little). There is still little agreement on sampling rate, although most manufacturers have settled on a 16-bit quantization format.

The multi-track recorders from Mitsubishi, Sony and 3M are all open-reel, as are several two-channel machines. However, some manufacturers prefer digital audio processors, used in conjunction with VHS or Beta format video tape recorders for two-channel recording or mixdown.

Elsewhere in this issue, a comparison chart lists the specifications of most of the current generation of digital tape recorders and processors. A casual review of the chart reveals that a standard format is still not quite around the corner. Of the multi-track tape recorders listed, note that there is still little or no agreement on tape speed, sampling rate or encoding format. (Missing specs were not available to us as we went to press.)

Also note that "channel" and "track" do not necessarily mean the same thing. This is because some recorders require more than one digital data *track* for each *channel* of audio information. In such cases, the word "track" refers to the digital recording format, while "channel" tells us how many audio tracks—oops, audio *channels*—are available.

Despite the enthusiasm expressed in some quarters for digital audio, the lack of a standard will surely continue to act as a restraint on a wholesale industry-wide analog-to-digital conversion. With the exception of a handful of brave pioneers, few studio owners are prepared to make a large capital investment in any system which may obsolete itself before its time, if a rival system eventually becomes the standard.

Some time ago, there was a movement towards a digital standard, but this was quickly abandoned when inquiries of a possible anti-trust violation were brought to the attention of the US Justice Department. Here in the USA, companies are not permitted to collaborate on before-the-fact standards fixing.

While it would certainly make our immediate life much simpler if an industry-wide standard could be established, there is also a strong argument favoring the gradual evolution of such a standard. An industry standard, formulated today, would "freeze" digital technology at the 1980 level. Manufacturers would be compelled to temper tomorrow's R & D to fit within the constraints of yesterday's standard. No doubt, ten years from now—or maybe, quite a bit sooner—we would all regret being locked into an archaic system.

On the other hand, in the absence of a standard, manufacturers are encouraged to put forth their best, most creative efforts, in the hopes of capturing a bigger share of the marketplace. Ideas will be tried, modified, rejected or accepted, and the manufacturer who builds the best system will eventually prevail. When the studio owners begin converging on "Brand A," the competition will either have to build a still-better system, or work towards compatibility with the leader.

As with Charles Darwin, it's a case of "survival of the fittest." If you need to be convinced, just recall the days when both wire and tape recorders were available. Where would our industry be today if some standard organization had settled for wire? It seemed pretty good at the time, but just imagine the fun of editing a 24-wire master!

Our features this month present us with a digital technology update. Last February, Kunimaro Tanaka discussed the Mitsubishi Digital Audio System. This month, Mr. Tanaka gives us a close-up view of the specific PCM format found in Mitsubishi's open-reel recorders. Readers may want to review Sidney L. Silver's article, "Correcting Tape Errors in Digital Magnetic Recording" in the November, 1980 issue of db. Mr. Silver gave us a detailed description of error detection and correction schemes. In fact, the Silver/Tanaka stories are an excellent example of "theory and practice," as you'll find after reading them both.

Returning again to February of last year, we featured a brief look at 3M's digital editing system. And now, 3M's Del Eilers offers us A Look At Digital Tape. Although the fine points of magnetic tape manufacturing are probably not as exciting as the latest generation of digital hardware, Eilers makes the point that the new technology still depends on the often-ignored reel of tape for its success. Just as digital hardware differs from analog, so too do the two tape formulations.

Last month, we commented that our October "Mike Quiz" drew a meager response. Wrong again! Just after that comment went out for typesetting, the letters really started pouring in! Many of our readers must have spent quite a few hours with graph paper, calculator and computer, figuring out the answer. We're still sifting through the reponses, and will have those complimentary subscriptions on their way soon. And in a future microphone issue, we'll present an update on the whole subject.

Speaking of future issues, we're always interested in hearing about what you're interested in seeing in print. More often than not, we find out about it the hard way. When an occasional article is too simple (or too complex), readers waste no time in writing in to object. Of course, the objectors never contribute original material of their own—they merely complain about the work of others. A good part of that is understandable though: many of us don't feel qualified to contribute an authoritative article. Also, you don't have to be a chicken to recognize a rotten egg (or a writer, to spot a rotten story).

Obviously, it is the rare article that will satisfy *all* readers at *every* level. It is more-or-less up to us to "guestimate" the type, and level, of feature that will prove most valuable to most readers. Along with these, we occasionally add a feature that may have limited appeal, in the hopes of holding the interest of a smaller group—say, those who are just getting started, or perhaps the computer mavens.

Stand by for another "comp sub" offer. Do you have an idea that you'd like to see developed into a db feature article? Let us know about it, and your complimentary subscription will be on its way. There is a catch to this one: your idea must be original, or at least, imaginative. In other words, "Do a story about microphones" doesn't make you a winner. However, if you've always wondered about how to record whale sounds off the Baja, you could score. And, if you can write the story yourself, so much the better. You don't have to be the newest Hemingway to qualify. (If you were, we couldn't afford you anyway.)

If you look through our 1980 index in this issue, you'll find the names of professional writers, non-professional writers (after all, what's an editor for?), and just-getting-started amateurs. If your own name only appears on the mailing label, we both may be missing out on something. Think it over; fame (not much) and fortune (even less) could be yours. ■

# The UREI Electronic Crossover

The audio professional demands precision control, frequency division and flexibility for multi-amplification sound systems. He also requires performance he can count on. To optimize the quality of sound reproduction he must have confidence that the electronic crossover will properly handle the entire audio signal and then route it where it belongs; without coloration, without degradation and without fail.

The experienced professional relies on UREI. He also expects the quality that is engineered into the Model 525 Electronic Crossover.

Fixed installation or portable application, the 525 provides precision crossover performance in recording studio monitoring, live concert sound, discotheques, theaters, churches, schools — even sophisticated audiophile systems. Features that set the 525 apart from an ordinary crossover include:

- Exclusive frequency counter which accurately measures and displays each crossover frequency with 1 Hz resolution.
- Front panel mode switch for stereo 2-way, 3-way or mono 4-way or 5-way operation.
- 18 dB/octave slopes for unity summing and maximally flat response.
- Mute switches on each output to facilitate testing and set-up.
- Balanced inputs and transformer coupled outputs.
- LED's which indicate active controls in each mode of operation.
- Recessed mode switch and frequency controls to prevent unintended changes of critical settings.

To maximize the performance of sound reinforcement systems, the 525 is designed to augment UREI one-third octave equalizers and the unique Model 562 Feedback Suppressor.

From One Pro To Another — trust all your toughest signal processing needs to UREI.


**UREI From One Pro To Another**


United Recording Electronics Industries
8460 San Fernando Road, Sun Valley, California 91352 (213) 767-1000 Telex: 65-1389 UREI SNVY
Worldwide: Gotham Export Corporation, New York; Canada: E.S. Gould Marketing, Montreal


*Circle 20 on Reader Service Card*

See your professional audio products dealer for full technical information.

© UREI 1980

DEL EILERS

# A Look At Digital Recording Tape

*The emerging digital hardware places new demands on the software system, and the familiar analog formats of magnetic tape are not suitable for the saturation recording requirements of digital.*

FEW WOULD DISAGREE that the development of the digital recording process is one of the most exciting and significant advances within contemporary audio technology. Certainly, the digital signal processing hardware deserves all the attention it receives. However, while duly admiring the latest in digital technology, let's not forget that without advances in magnetic tape technology, the growth of digital recording would be severely impeded.

In either the analog or digital domain, the capability of the master tape effectively defines recording quality and dynamic range. The excitement that surrounds the new digital hardware does not set aside this fact. It is because the tape itself sets the limits that exhaustive development efforts were undertaken at 3M to create a new digital tape with the ability to fully realize the benefits of digital signal processing. Indeed, the capability of digital tapes, such as our 265, is one of the reasons we believe that the digital mastering process will soon become the "standard" for all high-quality professional recording.

## ANALOG AND DIGITAL: REVIEWING SOME DIFFERENCES

Analog and digital tapes have about as much in common as early wire recorders and today's studio-quality machines. But, while unlike in both degree and kind, analog and digital tapes are obviously meant to accomplish the same task, and therefore it would make good sense to explain the one with frequent reference to the other.

## SIGNAL ENCODING

Within the analog system, the input signal is generated as a series of positive and negative flux changes. The number of these changes-per-second defines the frequency, and the varying signal strengths correspond to the different signal levels. For the most part, the thickness of the oxide coating on the analog tape determines the dynamic range (signal-to-noise ratio) of the tape.

In analog recording, we are accustomed to taking great care to avoid tape saturation. By contrast, the digital process is always saturation recording. The digital input sampling rate-signal is constant in frequency (50 kHz on 3M machines), and at each sample, a series of pulses saturate the tape's magnetic surface. The digital system only needs to know whether a pulse is present (1) or not (0).

On a 3M digital tape recorder, these pulses—the digitized input signal—are formatted into frames consisting of 400 bits each. Each of these bits is 0.0357 mils in length, and each frame is 14.28 mils long. This configuration equals a packing density of about 28,000 bits-per-inch; a density without parallel in analog audio recording.

The high packing density, of course, places a large amount of sound information in a very small—literally microscopic—area. For example, the highest frequency in digital is 625 kHz, which—when encoded on tape at 45 ips—is equivalent to 0.072 mils. Comparing this to analog's highest frequency of 20 kHz, which would require only 0.75 mils at 15 ips, we can easily see that, in terms of packing density, digital applications are ten times more demanding than in analog.

*Del Eilers is Technical Services Supervisor of Magnetic Audio/Video Products Division/3M—St. Paul, Minn.*

## COERCIVITY

The 265 digital mastering tape has a new magnetic oxide, developed by 3M expressly for optimizing the results a digital system can deliver. This new oxide, the technology of which finds its roots in video tape development, has a coercivity of 720 oersteds. This exceptional ability to retain magnetism is required in the digital process to insure good results at very short wavelengths, and because of the extremely-high packing density. By comparision, our 250 analog tape has a coercivity of 365 oersteds. This difference in coercivity is one reason why digital tape will not function on an analog machine. None of the existing analog tape recorders will produce an adequate bias or erase current to handle such a high coercivity.

## BASE AND BINDER

The base material of the new digital tape is much thinner than that used in standard analog tapes. Because of the higher tape speed in the digital recording process (45 ips on 3M transports), a thin base is essential in order to provide adequate playing time on a single reel of tape. Equally important, the thin base insures optimal tape-to-head contact and excellent results when recording the very short wavelengths of digital signals. Comparing the base material of 265 digital tape to 250 analog, we find a reduction in thickness of about 40 percent.

The binder is also a new development, and is much more durable than the oxide binders used in analog tapes. One reason for this is that dropouts and thin size are much more critical factors in digital recording than they are in analog work. A stronger binder is a significant aid in preventing dropouts, by limiting ruboff and debris generation. In analog recording, debris capable of causing a 3 dB loss at analog's highest frequency (20 kHz at 15 ips) would be on the order of 0.000041 inches. However, in digital recording, the same loss would be caused by debris on the order of 0.0000039 inches. Although this is somewhat of an "apples-and-oranges" comparison due to the nature of digital recording, it does show that once again, digital requirements may easily be an order of magnitude more stringent than in analog.

## USING DIGITAL TAPE IN THE STUDIO

The care and handling of digital tape demands many of the precautions common to the handling of analog tape. But, just as the technology and precision required for the manufacture of digital tape exceeds that necessary for analog tape, so too do the steps required for handling and storing the tape in the working environment. Extraordinary measures aren't required—just a little more attention to detail should suffice.

Essentially, the problems encountered with digital tapes are physical in nature, and we classify error-causing defects as either transient or non-transient. Transient errors are caused by loose particles, dust and dirt, etc. Non-transient errors have as their source oxide clumps or foreign particles which have been covered when the magnetic oxide was applied to the base material. (To greatly reduce the possibility of these physical problems causing errors, digital tape undergoes many more inspection steps and cleaning/wiping operations than conventional analog tape.)

## STORAGE

All closed containers of digital tape should be stored on their edges, in order to avoid the possibility of crushing or distorting the tape edges. Also, the storage area should have temperature and humidity control that is the same as the control room's working area.

Additional care should be provided to insure that the dust and lint produced by cardboard and paper stock does not reach the surface of the tape. The best way to avoid these sources of contamination is to have the tape stored in plastic bags.

Reels being put into storage should also have been wound smoothly and under the correct tension. Naturally, a smooth wind offers built-in edge protection, thereby eliminating those protruding edges which are especially vulnerable to damage. The wind tension also plays an important part in tape care, and should be regularly checked. Higher tensions have the tendency to permanently distort the polyester backing, especially if the tape is subjected to temperature increases. Lower-than-recommended pressures allow slippage between tape layers, and folds or creases may develop. The resulting wrinkled surface will interrupt tape-to-head contact, and result in a series of errors.

## IN THE OPERATING AREA

The rules for working successfully with digital tape are not complex, but it is more important that they be followed more carefully than with analog tape.

First, the operating area should approach a "clean room" environment, with the absence of most airborne dust and lint. Smoke, food and drink should be kept well away from the working area, and the temperature and humidity controls should be kept within the ranges of ±10 percent.

Second, in handling the tape, the operator should exercise more-than-routine care, so as to insure that no fingerprints are deposited on either surface of the tape. While the oils and salts in fingerprints will not attack the oxide binder, they do create an area pre-disposed to attract and hold dust and dirt. Prints on the reverse side of the tape are just as serious as those on the oxide coating, as they will transfer to the coating of the adjacent layer on the reel.

Any cleaning agents used on the tape heads must be completely dry before the tape is used. And throughout the use of the tape, pressure must never be applied to the flanges of the reel, but only to the hubs. Finally, care must be taken to provide for a 24-hour equilibrium in ambient conditions. That is, the tape should be stored under the same environment before and after it is used.

## SUMMARY

The new digital recording tapes are literally at the forefront of professional audio recording. They are more complex than the latest generation of analog tapes, and consequently require more care and attention, if the digital recording system is to live up to its expectations. The additional attention to detail that comes along with digital recording is a natural adjunct to this far-more sophisticated approach to music reproduction. ■

KUNIMARO TANAKA

# The Mitsubishi PCM Recording Format

*The PCM recording format described here permits physical butt-splicing, as well as more-sophisticated electronic editing techniques.*

THERE EXISTS TODAY a large and expanding consumer demand for higher quality audio playback capability. In the past decade, the ability of the professional recording studio to keep pace with this demand has been very successful. Refinements in the areas of noise-reduction techniques, auxiliary analog hardware, maintenance procedures, and new formulations of magnetic tape have all nurtured this ability, but only up to a certain level. A law of diminishing returns exists that states that, the more an analog signal is processed, the less it resembles the original. The reasons for this are many and varied, but are primarily due to the modulation noise caused by inhomogeneities in the distribution of the magnetic domains and distortion arising from non-linearity of magnetic characteristics. Another problem associated with analog recording is the vague sound image caused by wow and flutter.

Perhaps a decade ago, engineers began to apply pulse-code modulation (PCM) techniques to audio design. PCM promised to free the audio signal from the types of analog problems just described, and to provide the listener with sound quality of an unparalleled dimension. In the early days of digital audio, hardware was expensive to build and maintain, complicated to operate, and generally unreliable. Supported by contemporary advances in semi-conductor technology, this is no longer the case. Digital recording techniques now offer a real and obvious alternative to analog in the recording studio. But for PCM playback to become popular in the home, a large catalog of digitally-encoded master tape software must first become available. To this end, Mitsubishi Electric has designed and is now marketing, a complete line of professional-type PCM audio components. Included in this chain are; a multi-channel recorder, a two-channel recorder, a digital mixer, an electronic editor, and a digital delay for disc mastering. (See the author's "The Mitsubishi Digital Audio System" in our February, 1980 issue for more information on the complete system—Ed.)

Mitsubishi X-80A 2-Channel Digital Recorder

*Mr. Tanaka is the senior design engineer in Mitsubishi Electric Corporation's Product Development Laboratory —PCM Products, in Amagosaki, Japan.*

## THE X-800 32-CHANNEL PCM RECORDER

Mitsubishi's multi-channel PCM tape recorder can record 32 channels of audio on one-inch tape, at a tape speed of 30 ips. To eliminate as much tape use as possible, we have designed our recorders using a fixed ferrite head. This allows reduced tape speeds, while still retaining the ability of high-density data storage and retrieval, typically greater than 30,000 bits-per-inch. In this type of high-density recording, we cannot expect every track to be in optimum condition all the time, especially when the recorder has to play back tape that was poorly stored, or was originally recorded on a slightly-misaligned deck. In this case, data errors tend to occur on a few particular tracks, while the remaining tracks are still in good condition.

In order to rectify this type of situation, we have devised what we call the "semi-separate" format (FIGURE 1). With this format, one audio channel is recorder on one track, and for error correction, two parity tracks are provided for every sub-group of eight-channels. In addition, each channel has its own CRC (cyclic redundancy check) code. Thus, we have a two-dimensional error-correction system, rather than the one-dimensional method found in some early PCM recorders. As a result, the signal can be recovered from a poor or weak tracks. In an extreme case where one track dies, recording, playback, and punch-in and punch-out on the track is still possible. Note that 40 digital tracks are required in order to record 32 audio channels.

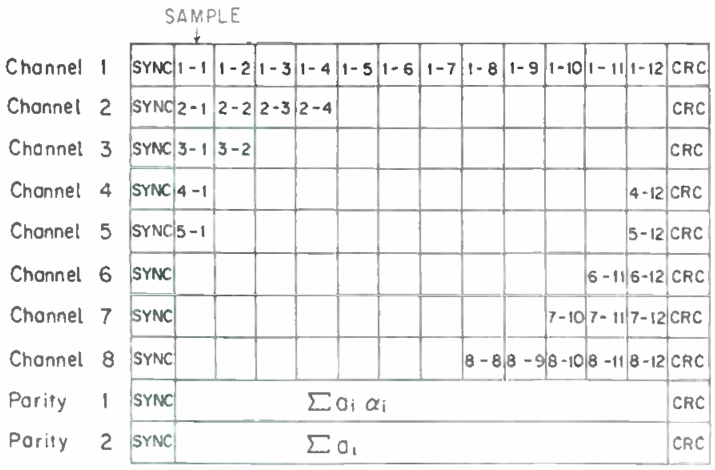
## ERROR CORRECTION AND CONCEALMENT

Other large data losses are from such things as nodules in the tape coating and scratches or creases in the tape. In order to cope with these defects, signals are inter-leaved when recorded. (For more details on these error-correction techniques, see "Correcting tape Errors in Digital Magnetic Recording" in our November, 1980 issue of db—Ed.)

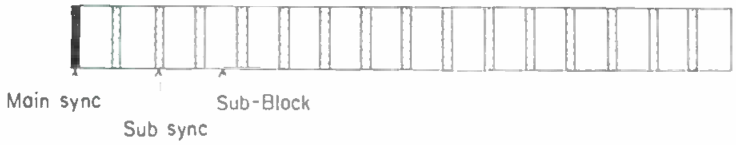
FIGURE 2 shows the largest error from dust that can be corrected, and the largest defect that can undergo error-concealment by one-sample interpolation (replacement of the bad sample with the average value of preceding and successive error-free samples). FIGURE 3 shows the correctability of this format for ordinary random error. Typically, these errors are caused by amounts of small dust or defects on the tape surface. The mean time between the occurrence of a miscorrection and error concealment is shown against the average bit error rate, $P_e$, and the average burst error length, B. In a bad case, with an average bit error rate of $10^{-4}$, and an average burst length of 200 bits, the mean time between the occurrence of error concealment is about 8.3 hours. The mean time between mis-correction (giving rise to an audible "pop" noise) is 21.6 years. These are reasonable, and quite practical, values.

In FIGURE 4, we can follow the signal path from input to output. Here, eight channels of audio pass through anti-aliasing low-pass filters, having a sharp cutoff frequency of 20 kHz. Then, the signals are sampled at a rate of 50.4 kHz and held in a sample/hold. This output is then converted into 16-bit linear PCM signals by A/D converters. A few channels out of each eight-channel group may be cross-faded with playback PCM signals at the fader, when the deck is in the "punch-in/punch-out" mode. The eight signals at the fader output are then combined at the RSC (Reed-Solomon Code) coder to make

*Mitsubishi X-800 32-Channel Digital Recorder*




(a) Construction of a Sub-Block.




(b) Construction of a Main-Block

*Figure 1. Construction of a Block; 1a. Construction of a Sub-Block: 1b. Construction of a Main-Block.*

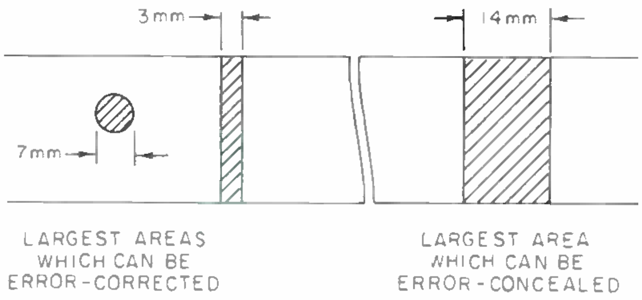


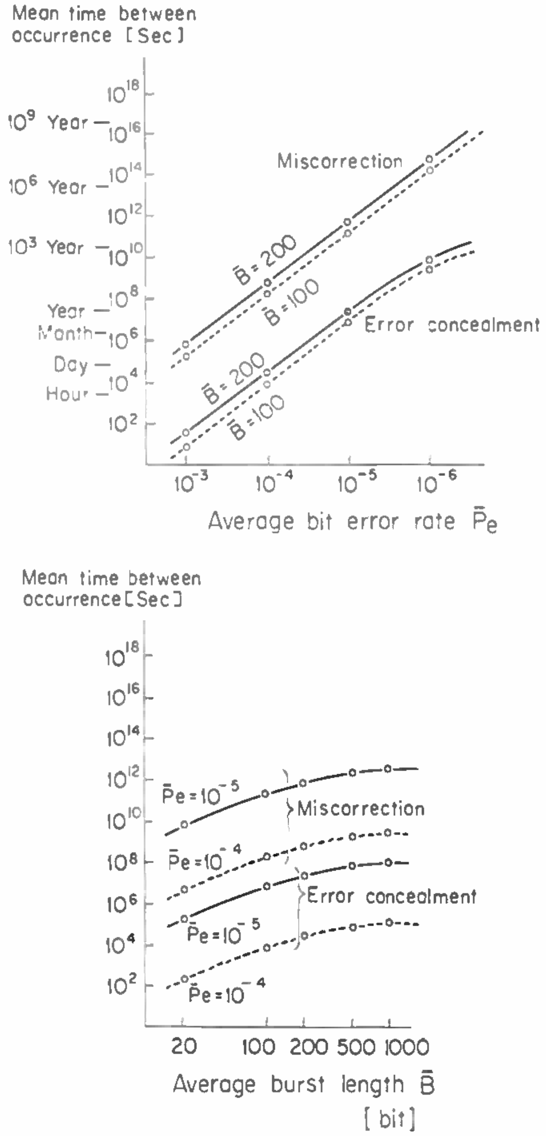

*Figure 2. Error correction and concealment.*

the signal format of the "semi-separate" format, and then interleaved. After passing through the modulator and write-compensation process, the data is stored on tape. During playback, the signals first pass through playback compensation and demodulation. Time-base error is corrected by the TBC, and error signals are corrected by the RSC decoder. Finally, the signals pass through a delay circuit whose delay is equal to the time in which the tape runs between the sync playback head and the record head.

### THE X-80 TWO-CHANNEL PCM RECORDER

In the case of our two-channel PCM recorders, this error-correction scheme is again used, to even more useful advantage. The tape employed is identical to the type used on the 32-channel deck, but in a quarter-inch variety, at a speed of 15 ips. There are ten tracks in this configuration; one track for monaural analog cueing, one track for SMPTE coding, six PCM tracks for encoded audio signal data, and two tracks for

*Figure 3. Error correcting capability of RSC code.*




STL Offers The Most

**Complete Selection**

Of Test Tapes

Available Anywhere

STL can serve all your needs with precision test tapes for frequency alignment, level set, azimuth set, flutter & speed tests, sweep frequency tests and pink noise analysis. Also available is the Standard Tape Manual & the Magnetic Tape Reproducer Calibrator.

*Phone for fast delivery or free catalog*

STANDARD TAPE LABORATORY, INC.

26120 EDEN LANDING ROAD #5 HAYWARD CALIFORNIA 94545 • (415) 786-3546

*Circle 32 on Reader Service Card*

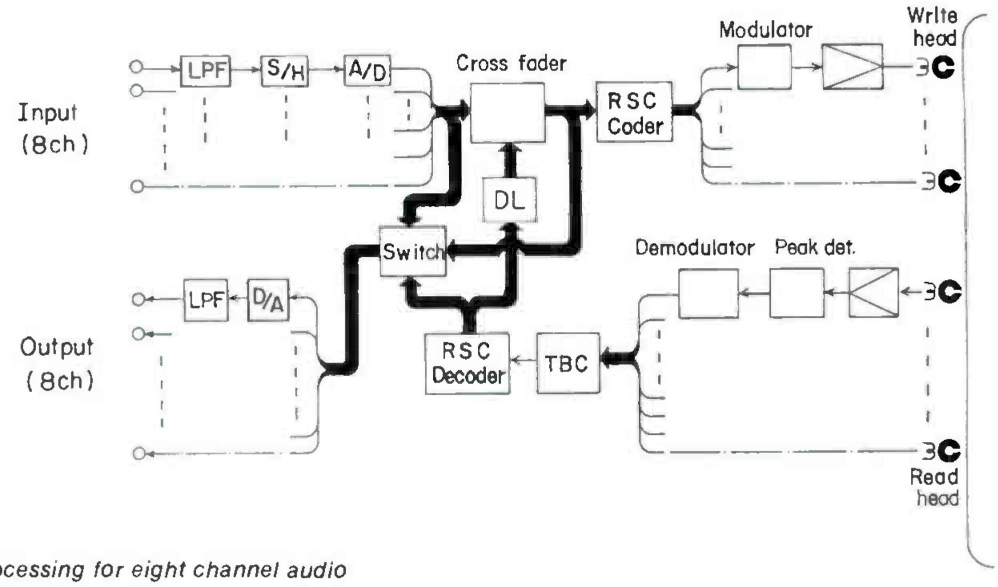



*Figure 4. Signal processing for eight channel audio signals.*

parity checking (FIGURE 5). By again interleaving the data, the tape can be edited by the cut-and-splice method. This is of immense value to the user, but would not be possible without a very powerful error-correction capability. The methods used are very similar to the ones used in typical analog splicing, except that care must be taken in the handling of this precision tape. One cues the proper material by monitoring the analog signal, marks the exact point with a fluorescent video-type marker (to reduce the chance of contaminating the tape) and cuts vertically using the supplied splicing block. The two sections are then joined, using a specially-formulated video splicing tape, used in this case to insure good tape-to-head contact.

FIGURE 6 shows the effects of two types of splicing tape. Note that when thick splicing tape is used, the signal deteriorates in the vicinity of the splice due to poor head-to-tape contact. The signal loss caused by the splicing tape is seen in the middle of each photograph in the figure. When played back, the error/loss is detected and is automatically cross-faded over the splice, insuring that no audible signal discontinuity, or "click" noise is heard.

One of the problems to be solved in making cut-and-splice editing possible is to keep the capstan-servo system locked in sync when encountering a splice. The capstan of the fixed-head type PCM tape recorder is driven by a phase-locked loop (PLL) type servo. The purpose of this is to lock the synchronization of


# De-Esssss

The Orban 526A single-channel Dynamic Sibilance Controller is a *simple*, economical dedicated de-esser—without the complexity and compromises of multi-function processors. It sets up *fast* to produce sibilance levels that sound natural and right. Features include mic/line input, fully balanced input and output, LED level meter, GAIN control, compact size and more. Special level-tracking circuitry assures consistent results with varying input levels. And our control technique doesn't emphasize residual IM when de-essing occurs.

De-essing doesn't have to be complex, expensive, and time consuming. The 526A does it fast and *right* in recording studios, cinema, broadcast and cassette duplication.

The 526A De-Esser is available at your Orban pro-audio dealer.

**orban**

**Orban Associates Inc.**
645 Bryant Street
San Francisco, CA 94107
(415) 957-1067

*Circle 34 on Reader Service Card*

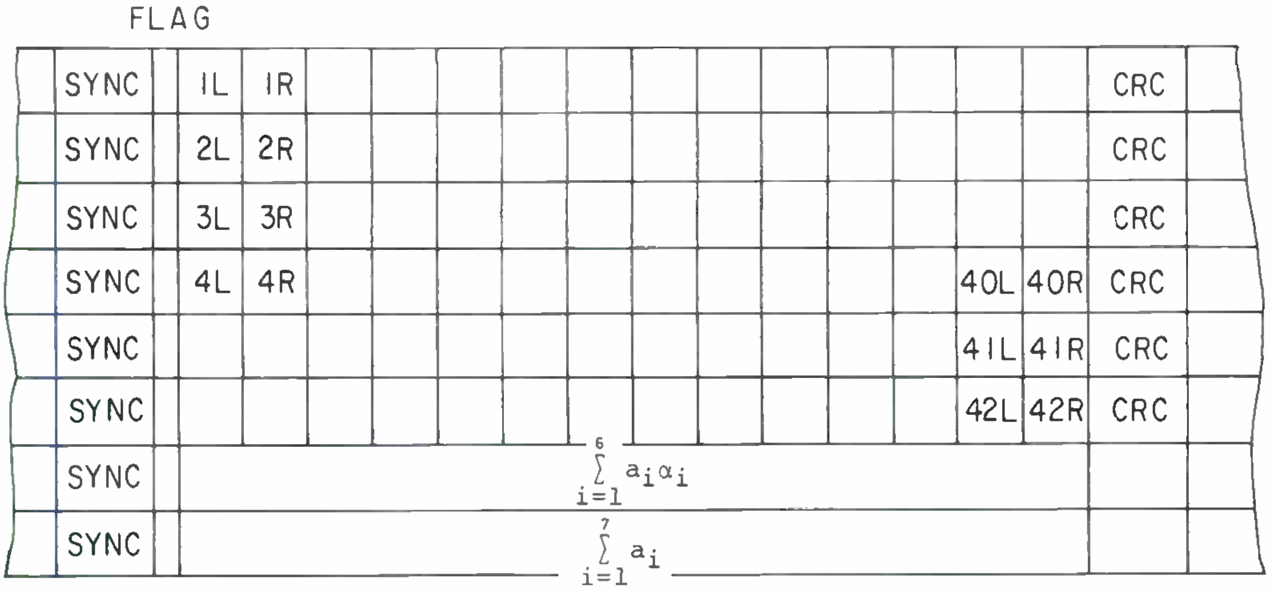


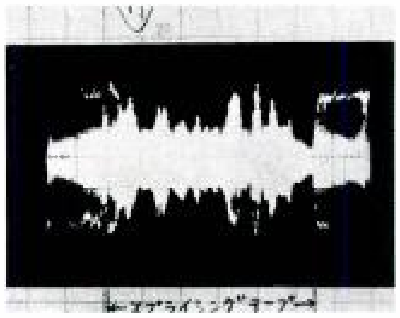

*Figure 5. Signal block configuration.*

the reproduced signal to an internally-generated reference signal, in this case by a quartz-crystal oscillator. In the case of the X-80, the phase of the reproduced sync signal is locked to the phase of the reference signal. The phase jump at the splice point varies from zero degrees. That is to say, there is no phase jump to ± 360 degrees. We devised a phase selection system to cope with this problem. As illustrated in FIGURE 7, two sub-sync signals, separated by 120 degrees, are generated by the reproduced sync signal. Usually, one of them is selected to be used for the servo-lock of the capstan. When there is a phase jump at the gap, another sync signal is selected to minimize phase jump. Using this method, jump is suppressed to less than ±60 degrees, and phase lock is assured. With the ability to splice edit and the high-precision of the semi-separate PCM format, we feel that reliability and stability are beyond question, thus making digital recording very accessible to the user.

**FUTURE PROSPECTS FOR PCM**

When PCM recorders are used in conjunction with digital delay to master lacquers, incredible fidelity is possible. Our efforts in the very near future (a few months) will include the unveiling of a digital mixing console, and a PCM electronic editor. The mixing console will offer full fading and panning ability, and the editor will have the ability to tie up to three 2-channel decks together in perfect synchronization and edit multi-channel material. With these units in the field, we have effectively completed a chain of high-quality professional PCM audio components that will allow the recording studio and the musician the opportunity to use completely-digital recording techniques. Our efforts will then be aimed at the perfection of the digital audio disc system for home use. Only then will the consumer finally be able to take advantage of true playback—a very promising and exciting ability. ■

*Figure 6a. Effect of thick splicing tape*



*6b. Effect of thin splicing tape.*

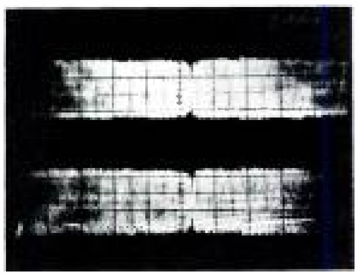
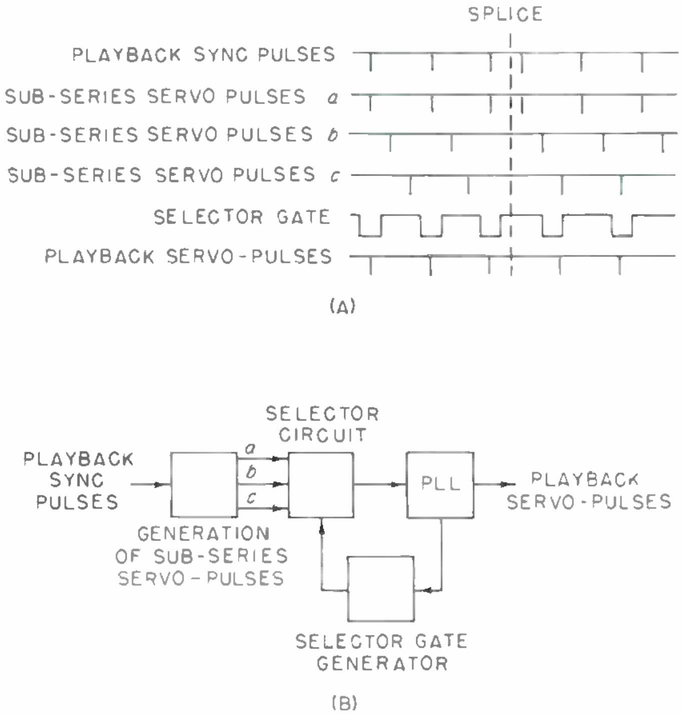


*Figure 7. Phase selection of servo system.*



JOHN DIAMOND, M.D.

# Human Stress Provoked by Digitalized Recordings

*Dr. Diamond again renews his claim that the digital recording session may be a stress-producing experience.*

Music is one of the great therapies. Throughout recorded history, in all parts of the world, music has been used as therapy. In fact, of all factors that have been investigated, probably none enhances the life energy and reduces stress more effectively than music.[1] Perhaps the most obvious example of this is the fact that at the age of seventy, when some 50 per cent of American males are already dead, some 80 per cent of musical conductors are still alive, healthy, and productive. The tremendous therapeutic power of music has always been recognized, and it has been the subject of many discourses, from the time of Pythagoras to Moses Maimonides and beyond. To me—as it was to Pythagoras—music is not entertainment or *a*musement (the absence of the muse), but therapy. It is one of the most potent modalities that exists for activating what the Greeks called the *thymos*, what Hippocrates called the *vis medicatrix naturae*, the healing power of nature that exists within us all. There are still many cultures in which there has been no divorce between music and healing. For example, in many so-called primitive societies, the healing shaman is nearly always a musician, and music and incantation is as important as all the other aspects of his profession. The only remnant we see of this is the use of music in religious ceremonies, a custom which dates back to a time in our society before the divorce between medicine and religion. And thus, throughout the centuries and today, over and above the intellectual satisfaction or the more physical enjoyment we may derive from music, there is another quality; and it is this other quality, this life-energy-enhancing quality, to which I have devoted a major part of my research over the years.

At the Institute of Behavioral Kinesiology, we have now tested some 25,000 phonograph recordings recorded over a period of over eighty years, and it has been found that almost without exception this music has been highly therapeutic.[2] In fact, we have used it for years for anesthesia, analgesia, stress reduction, relaxation, general tonification, as part of modified acupuncture techniques, and as adjunctive therapy in drug withdrawal programs. Music has also been used in programs to overcome fears and phobias, alleviating insomnia, and even for the "tranquilization" of acutely disturbed psychotic patients.

About two years ago, this changed. I suddenly found that I was not achieving the same therapeutic results as before, that playing the same compositions to the same patients was producing a completely contrary effect! Instead of their stress being reduced and their life energy being activated, the opposite was occurring. Music examples that we had long used to promote sleep now seemed to be actually aggravating the insomnia.

*Dr. Diamond currently conducts research through the Institute of Behavioral Kinesiology. He is a graduate of Sydney University Medical School.*

And we found in one case that instead of the music helping a patient withdraw from tranquilizers, it seemed to increase his need for them. Special tapes for businessmen to use during their rest periods seemed suddenly to increase rather than reduce their stress. These findings were very alarming.

When I investigated these paradoxical phenomena, I found that in all cases they were related to the use of digital recordings. These were commercial recordings made from digital masters.[3] When I substituted analog versions of the same work, sometimes even with the same performers, the positive therapeutic effects were again obtained. There seemed to me little doubt that something was "wrong" with the digital process. Apparently the digital recording technique not only did not enhance life energy and reduce stress, but it was actually *un*therapeutic—that is, it imposed a stress and reduced life energy. Through some mechanism of which I am not aware, as I am not an electronics expert, the digital process was somehow reversing the therapeutic effects of the music.

In a number of instances I had analog and digital performances that we could easily compare. One was of Zubin Mehta conducting the Beethoven Emperor Concerto. We found that the digital performance (on London) had a stress-inducing effect whereas the old analog performance (on Vox) did not. We also found that the early LP transfers of Caruso and McCormack were life-energy enhancing, whereas the restored (digitally) versions had the opposite effect. Yet these were recordings of the same performance. The only difference was the digital process. And this was apparent even though the original recordings had been made nearly seventy years ago. Other examples were the PCM recordings of various Czech performers whose earlier versions were on the Supraphon label. They were the same performers and the same works. The only difference appeared to be the digital process.

As part of my work in clinical practice and as one of my research tools, I employ the technique of Behavioral Kinesiology. This involves the precise, accurate testing of any muscle in the body as an indication of the degree of stress to which an individual is subject at the moment. For many practical reasons, the deltoid muscle is tested. This testing, which I was taught first in medical school many years ago, is best described in the text, *Muscles: Testing and Function* by Henry O. Kendall et al. (Baltimore: Williams & Wilkins, 2nd Edition, 1971).

To perform a simplified version of the Behavioral Kinesiology test,[4] have the subject stand facing the tester with his left arm extended out from his side perpendicular to the body, with no rotation at the elbow. Now, the tester presses down with his right hand fairly swiftly and sharply on this outstretched arm using approximately eight to ten pounds of pressure. There should be a spring in the shoulder joint and the arm should bounce back to its original position. The deltoid muscle's function is to raise the arm up from the side of the body to ninety degrees. Thus to test it, one pushes down on the outstretched arm. It will be found that in nearly every case, the arm will test strong. This is a measure of the individual's life energy. As one audio engineer described it, he felt a springiness like having a fish on the end of a rod. If the subject is under a great deal of stress at that time, there will not be a "spring" in the shoulder joint, and he will not be able to resist the tester's eight to ten pounds of pressure. If this situation exists, you will find that playing any classical music recording and most popular music during the testing procedure will reduce his stress and so energize him that he will test strong.

But should you instead play a digital recording, it will be found that the arm that was previously testing strong and could easily resist the pressure, will be unable to do so—the digital effect has so stressed the subject that he cannot resist the pressure. Something has happened. Some stress has been introduced which is now manifested in this negative response. Perhaps even more striking is the differences in stress effects found upon testing a recording session in which digital and analog recordings were made simultaneously.[5] Similar effects are also apparent with the human speaking voice using this newer digital recording process.

Obviously, this effect is not due to the performer nor to the composer, since other recordings (analog) of the same performer and the same composer do not have this effect. In fact, they are therapeutic—that is, they reduce stress and enhance life energy on testing. There is a yet-to-be-identified factor involved in the digital technique which is causing this stress. At some level the ear is perceiving a signal which it recognizes as being unnatural and alarming. This instantaneously causes a stress reaction which is manifested in the loss of muscle strength on test.

Many audiophiles state that they have noticed that they can discern something vaguely "wrong" with the digital recording process but cannot quite pinpoint the problem. Using the BK test, in both its more popular and its more subtle research forms, it can easily be shown that a difference between analog and digital does exist. While we certainly enjoy the benefits of this major technological breakthrough, there are subtle physiological effects still to be considered.

It is important to emphasize that this is *not* a test of muscle strength. It is more of, although not entirely, a test of reaction time. It is a test of the integrity of the acupuncture system of the body. This is the system through which flows the electromagnetic energy of the body. A heavy, powerful testing is a test of muscle strength, not of reaction time, and it is, in essence, a different test.[6] When I demonstrated my findings at the AES conference in Los Angeles in May '80, I was accused of pushing too hard when the subjects were failing during the times the digital recordings were being played. In point of fact, pushing "too hard" will, if anything, fail to demonstrate the effect. It is not—repeat NOT—a test of muscle strength but more of, although not entirely, a test of reaction time.

It can also be shown with more subtle testing[7] that an imbalance between the two cerebral hemispheres has been introduced such that there is now either left or right hemisphere dominance, usually left hemisphere. This indicates that there is mental stress and concomitant with this, reduced creativity.


# SURVIVAL KIT

The Crown Real Time Analyzer (RTA-2) can help you stay ahead of the competition. It will show you what's wrong with frequency response in studios, control rooms, circuits or equipment. You'll know exactly where to start to improve signal quality.

**The RTA-2 is yours free, for thirty days.**

It's easy to use, rugged and self-contained. 60dB dynamic range. Five-inch CRT. Complete with high-quality microphone. If it doesn't help, send it back. No obligation.

*Call Dennis Badke at 219/294-5571 for the details.*

crown

1718 W. Mishawaka Rd., Elkhart, IN 46517.

*Innovation. High technology. American. That's Crown.*

*Circle 15 on Reader Service Card*

This test has been performed both by myself and others under double blind test situations on many occasions, and the results always tend to be about the same, with these provisos: there will always be some people whose life energy is so high, or if you prefer, whose stress thresholds are so high, that they will be impervious to the digital effect. And paradoxically, there are those whose life energy is so low (these are usually severely physically debilitated patients) that they are not affected by it. I also wish to emphasize that for accurate testing there are many variables that must be controlled, many more than I can elaborate upon in this short presentation. Furthermore, as we have previously stated, for accurate interpretation at the Institute, we test not just at the one superficial level of testing that I have described above, but in twelve deeper levels as well. It is only when all the variables are accurately controlled and testing is carried out at all twelve levels that the findings are meaningful.

I and many of my colleagues have performed this test for many years. It has been used in many aspects of clinical practice and has been firmly established in a number of disciplines. I am more aware than any pro-digital advocate of the shortcomings of the test. And I would like nothing more than to be able to read a meter instead. However, although many electronics experts have tried over the years to help me to design such an instrument, they have never been successful. They finally realize that perhaps the body itself may be a better test device than any instrument that we can make. I personally believe that the proper research tool can be designed, but it will not be related to the muscle test. It will involve measuring the change in electromagnetic activity in that part of the body where is situated what we may call the acupuncture central headquarters, because it is the electromagnetic disturbance there which is manifested as a weakening of the test muscle. And it is here, centrally, that the stressful effect of the digital recordings occurs.

What if my findings, and those of my colleagues, are correct? Before long, I would presume, nearly all recordings of classical music, of otherwise therapeutic music, will be made using the digital process. The implications of this for our future are very disturbing. If the major therapeutic recording artists of today are recorded for posterity using the present digital technique their efforts will be valueless for us and valueless for future generations. No more will we be able to call upon the therapeutic powers, the true healing powers, of the musicians of our day as we have called upon the musicians of previous days. This will mark the end of the therapeutic era of recorded music. The great technological advance of being able to bring the greatest performers into our homes for entertainment, and much more importantly, to raise our life energy, will have been destroyed.

When a man comes home stressed after a day's work and puts on a recording of a Schubert piano sonata to help him over the stresses, the opposite will occur. He will become more stressed. And he will learn over a period of time that music does not help him to relax as he had expected. Or, a person who as part of his religious pursuit plays a record of the Bach B Minor Mass, will perhaps recognize that he is further removed from his goal—that instead of serenity, instead of a feeling of life enhancement, the opposite has occurred.

We will then cease to regard music as being what it is, one of the great therapies. Our recorded musical heritage will still satisfy the brain, but will do nothing for the rest of the listener. Our true recorded musical heritage will cease.

I have frequently been in the position where discoveries first made through Behavioral Kinesiology have later been validated by what would be called the more usual scientific methods, and I have no doubt that in the future it will be recognized that the BK findings concerning digital recordings will be validated. But by that time, it may be that many works of our great artists will have been preserved in an unacceptable form.

Science today has become identified with the use of meters, gauges, and masses of statistics. Some say that the testing techniques we have employed are not science. I would be happy to cooperate in any *true* scientific research to help solve this problem. What I am suggesting is an active research program with cooperation from the digital manufacturing companies. (Such cooperation has certainly not materialized in any way to date.) In this program, as they modified their recorders, we would be able to offer feedback to assist them in correcting the problem. By correcting the digital technique, we may actually be able to make recordings more therapeutic than they have ever been before. By discovering the central problem in existing digital recording techniques, we may then be in a position to so improve them that we ultimately have advanced the therapeutic benefit to mankind.

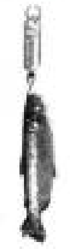
Digital recording techniques obviously offer many advantages, and it is the hope of the Institute that a joint research project can be undertaken in order to overcome the negative effects involved and ensure that recorded music remains one of our greatest therapeutic heritages. ■

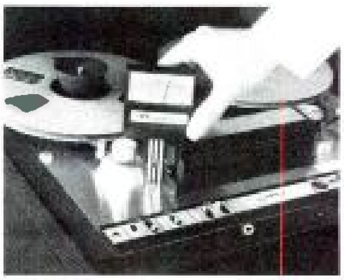
**FOOTNOTES:**

1. *Your Body Doesn't Lie*, John Diamond, M.D., Warner Books: New York, 1980.
2. We define "therapeutic" as that which enhances life energy and reduces vulnerability to stress on BK testing. The three possible values for a stimulus are: (1) therapeutic, (2) non-therapeutic, or neutral, and (3) untherapeutic.
3. And then I realized that the digital recordings that I had in my private collection went unused. I seemed to play them once and then put them aside. It occurred to me that I had been reluctant to play them again in response to some stress-provoking factor.
4. Of course in an actual clinical/experimental setting we test at much deeper levels using more sophisticated testing techniques.
5. Haydn Symphony Number 100, Vanguard recording VA25000. One side is digital and the other is analog.
6. *Behavioral Kinesiology Report #10*, December, 1977.
7. *Behavioral Kinesiology Report #15*, May, 1978.


HOW DO YOU MEASURE TAPE TENSION?

*If something SOUNDS FISHY it may be your fish scale approach to measuring tension*





The Tentel Tape Tension Gage is designed to diagnose problems in your magnetic tape equipment. Virtually all recorder manufacturers use and recommend the TENTELOMETER® for use with their equipment.

The TENTELOMETER® measures tape tension while your transport is in operation, so you can "see" how your transport is handling your tape; high tension causing premature head and tape wear, low tension causing loss of high frequencies, or oscillations causing wow and flutter. Send for the Tentel "Tape Tips Guide". The T2-H20-ML sells for $245 - complete.

TENTEL

50 CURTNER AVENUE
CAMPBELL, CALIF. 95008
(408) 377-6588

*Circle 18 on Reader Service Card*

# db Special Report

# A Post-Script on Digital Stress

DR. DIAMOND'S THOUGHTS on digital distress first came to our attention at the May, 1980 convention of the Audio Engineering Society. Reporting on Dr. Diamond's talk (in our July issue), we expressed the hope that more-conclusive tests would soon be conducted.

Since then, we suspect that more heat than light has been shed on the subject. In this month's issue, Dr. Diamond suggests an active research program (more about that, later on) to help solve the "problem." But, in a letter to the editor in the prestigious Journal of the Audio Engineering Society (September, 1980), Dr. Nelson Morgan (of the Electronics Research Laboratory, University of California—now with National Semiconductor) suggests there is no problem: he finds no correlation between digitalization and stress in his own tests.

In a recent edition of the Syn-Aud-Con Newsletter (Fall, 1980), there is a printed charge that the AES refused to print Dr. Diamond's reply to Dr. Morgan's remarks. (The complete letter is printed in the Syn-Aud-Con Newsletter.) It is not our place to comment here on the propriety of any of this. On the one hand, it might seem that Dr. Diamond is entitled to "equal time." On the other, he already had the opportunity to present his findings in a scientific manner (at the May convention) and, his letter *is* extraordinarily lengthy, contains several unsubstantiated accusations, and presumably would need to be edited for publication. And that would probably be enough to start another round of letters, and so on.

And so the matter rested, until we encountered Dr. Diamond at the most recent AES convention in New York. Understandably, he was distressed at the unfortunate direction in which this whole matter had turned. But also understandable is the distress that other, more scientific, observers feel over the manner in which Dr. Diamond has been presenting his position. Unfortunately, much of the bad feeling that now exists could have been avoided by a minimal attention to detail: the procedures for objective testing are no secret to anyone really interested in an un-biased experiment. In fact, a recent AES preprint carefully describes many of the procedures, as well as some of the hardware to be used. ("The Great Debate: Subjective Evaluation," by Lipshitz and Vanderkooy—AES Preprint #1563.)

The paper states that, "...the burden of proof must lie with those who make new hypotheses regarding subjective tests. This alone would wipe out most criticisms of the controlled tests reported in the literature. Speculation is changed to fact only be careful experimentation." The preprint was published in February, 1980.

With all of this as background information, we invited Dr. Diamond to share his research with our readers. Obviously, most of us are quite interested in digital audio, and would like to be kept up-to-date on both its benefits and its drawbacks, if any. And, since this is fast-becoming an emotionally-charged issue, we place the burden of presentation entirely on the author. That is, no corrective blue-pencil surgery would be done by us (except for some minor punctuation and the omission of two specific references to producers of digital recordings).

To the best of our recollection, this is the first time that a **db** article has been followed by such an editorial post-script. Usually, there is an implied post-script to any article—the one that goes, "...the opinions expressed here do not necessarily represent those of the editors" etc. However, in this case we feel that something more is required, since we've long since learned—to our acute dismay—that almost anything that appears in print may often be taken as gospel by many readers (one of the reasons we usually stay away from "How to Mike the Kazoo"-type stories). And, therefore, we offer these remarks, but not as a rebuttal, since we're going to ask our readers to slug this one out. Rather, we are acting in anticipation of the many letters we expect to receive on this matter.

We assure all our readers that we too can spot the unsubstantiated claims, unidentified colleagues, and incomplete references that appear throughout the article. We can only state that our author is no doubt aware of these omissions, and prefers to present his position in this manner. Obviously, he could have supplied more complete details if he had chosen to do so.

Then why publish the piece in the first place, only to follow it up with this elaborate p.s.? Surely, we could have used the space for something more constructive, and no doubt, less controversial. Well, despite the fact that Dr. Diamond chooses to present an inconclusive case, he is not alone in drawing our attention to this digital-stress issue. We have already received quite a few letters on the subject, largely in response to Mark Levinson's letter in our October issue. (More on this in a future issue.)

So it would seem that even in the absence of definitive test results, there may be something here that needs some investigating. We are not ready to accept Dr. Diamond's conclusions, but neither are we comfortable with the idea of simply ignoring the questions and comments on the quality of digital audio. And so, this post-script.

Dr. Diamond proposes a research program, in which manufacturers would modify their recorders in response to feedback that would be offered to assist them in correcting the problem. What problem? Why, the one that Dr. Diamond tells them they have! One doesn't have to be terribly bright to reject this sort of logic, and it should come as no surprise to anyone to learn that manufacturers are not exactly beating a path to his doorstep.

We recall the early days of Dolby noise reduction, when the system was accused of "changing" the sounds that were recorded through it (especially the drums). As we learned more about what we were doing, it turned out that we were *not* changing the sounds (especially those drums), and that some of us were so used to the distortion produced by, say, cymbals-plus-hiss, that we actually preferred it to the cleaner sound offered by noise reduction. Since the differences were subtle, we accused the system, rather than ourselves, of distortion. Eventually, we learned better, and maybe the same thing will happen to our perception of digital audio. In the meantime, we can profit by remembering past history, and at least proceed with caution.

Furthermore, the emerging digital technology certainly deserves something more positive than an exchange of accusations between one side and the other. Towards that end, we have a proposal to make.

We've just returned from a visit to the school of music at the University of Miami. The university offers a Bachelor of Music degree in Music Engineering Technology. To graduate, students must demonstrate a proficiency in both music and electronics (including digital audio). The school's multi-track recording studio is in almost-continuous use, both as a teaching instrument for the music-engineering students, and as a support activity for the large student body of performance majors. Consequently, the university has a large resource of highly-qualified music listeners, some with (and some without) an engineering background. A wide variety of music is readily available (jazz, rock, classical, electronic, etc.).

It would seem to be an ideal venue at which to conduct a series of tests on almost any aspect of music-and-engineering. Using the double-blind test procedures described by Lipshitz, Vanderkooy and others, it should be relatively easy to conduct a series of A/B tests to the satisfaction of any scientifically-trained observer.

However, the spectre of inviting digital audio to come and plead itself innocent to unsubstantiated charges should have no part in the proceedings. Listeners must be asked, "Can you hear a difference between recording A and recording B?" They must not be asked, "Which recording is more distorted?" The latter question implies a universal agreement on distortion. As we have learned from the early days of noise reduction, no such agreement exists. The same goes for perceived stress, and many other aspects of recorded sound.

Later tests might examine the sublimal effects of various recording techniques and hardware systems. Here again, we must be careful in our questioning, and in the conclusions which are reached. Are changes in muscle strength necessarily bad? Does analog punk-rock actually cause less stress than digital Mozart? Would you prefer music that created no effect whatever? And so on.

Even the most rigorous testing program will not supply us with all the answers, especially since we're still having some problem formulating the questions. But, a well-thought out program, supported (but not unduly influenced) by industry should go a long way towards advancing our knowledge of the art and science of recorded sound.

Several manufacturers have already expressed interest in participation, and the University of Miami is likewise prepared to offer its assistance. We'd be interested to hear any constructive thoughts that our readers may have on all of this. ■


# Perfect Timing

**If You've Wanted To Put Time Code On Your Tape, But Can't Afford The High Cost Of SMPTE:**

**The ES 280 TIME CODE GENERATOR/READER Is For You!**


The new, low-cost way to provide time information on all your tapes, **ES 280** generates a time code which includes DAYS, HOURS, MINUTES, SECONDS AND TENTHS OF SECONDS.

With the flip of a switch, **ES 280** becomes a reader, to locate that certain place on the tape.

An Amplitude Control knob is located on the rear, so that you can use the 280 with *any* recorder, Video or Audio.

The 280 uses tones that are compatible with the cue tones used in cartridge recording.

**ES 280 COSTS $500.00**

**ES 281 (READER ONLY) $375.00**

Contact us or one of our dealers, and we'll tell you how you can get your own 280.

**(213) 322-2136**
**142 SIERRA STREET • EL SEGUNDO, CA 90245**

*Circle 35 on Reader Service Card*

# A Guide to Digital Tape Recorder Specifications
## (and a PCM Picture Book as well)

| Manufacturer | Audio Channels | Digital Tracks | Frequency Response | THD | Dynamic Range | Cross-Talk | Sampling Rate | Quan. | Tape, Speed |
|---|---|---|---|---|---|---|---|---|---|
| Denon | 8 | VTR | DC -20 kHz +0.2,-1 | <0.1 % | >89 dB | >80 dB | 47.25 kHz | 14 | 2" |
| JVC | 2 | VTR | DC -20 kHz ±0.5 dB | <0.02 % | >90 dB | not given | 44.056kHz | 16 | U-Matic |
| Mitsubishi | 32 | 40 | 10 Hz-20 kHz ±0.3 dB | <0.02 % | >90 dB | >80 dB | 50.4 kHz | 16 | 1", 30 ips |
| Mitsubishi | 2 | 8 | 20 Hz-20 kHz +0.5,-1 | <0.05 % | >90 dB | >85 dB | 50.4 kHz | 16 | .25", 15 ips |
| Sony | 48 | 96 | 20 Hz-20 kHz +0.5,-1 | <0.05 % | >90 dB | not given | 44.056kHz | 16 | 2", 22.5 ips |
| Sony | 2 | VTR | 20 Hz-20 kHz +0.5,-1 | <0.05 % | >90 dB | >90 dB | 44.056kHz | 16 | U-Matic |
| Soundstream | 8 | not given | DC -21 kHz +0.5,-1 | <0.004% | >90 dB | >85 dB | 50.0 kHz | 16 | 1", 35 ips |
| Technics | 4 | 16 | 20 Hz-20 kHz ±0.5 dB | <0.05 % | >90 dB | >70 dB | 50.4 kHz | 16 | .25", 15 ips |
| 3M | 32 | 32 | 10 Hz-20 kHz +0.5,-3 | <0.03 % | >90 dB | >90 dB | 50.0 kHz | 16 | 1", 45 ips |

*Figure 1. An artist's conception of an early 3M editing system. When pre-production prototypes were judged overly complex for routine editing chores, the system seen in Figure 2 was developed.*

*Figure 2. The current 3M digital editing system was described in the February, 1980 issue of **db.***

Figure 3. Technics Editing Controller.

Figure 4. Sony DAE-1100 Digital Editor.

Figure 5. JVC Series 90 Digital Audio Mastering System, incorporating video tape recorders.

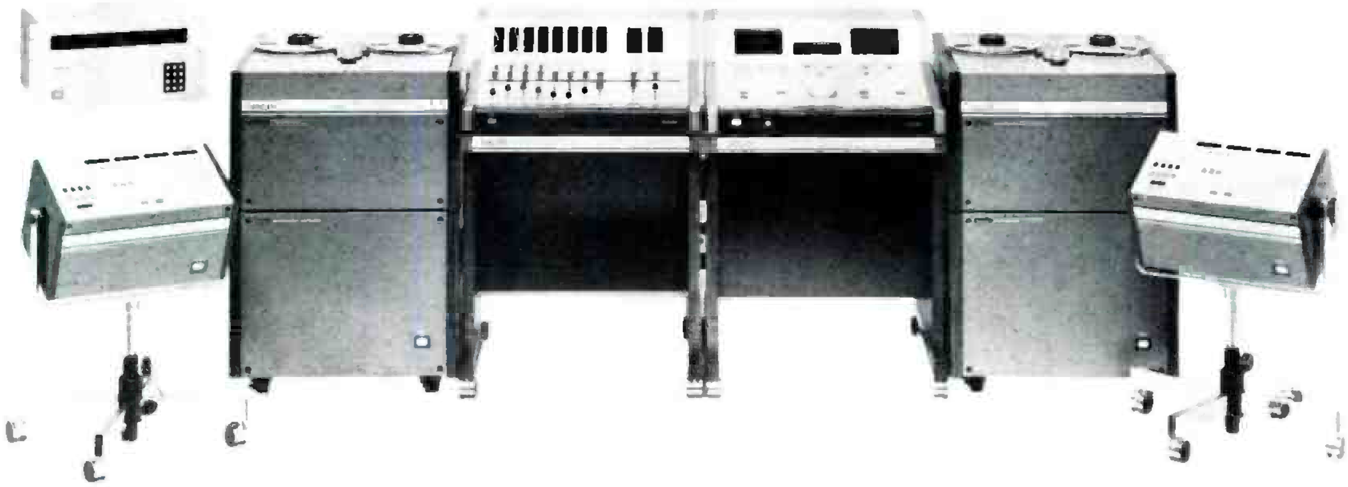


Figure 6. Technics Digital Audio Recording System, using open-reel recorders.

Figure 7. Peter Jensen of Digital Recording Systems at a Metropolitan Opera recording session. In front of him are: Sony's BVE-500A editing console, a Sony PCM-1600 Digital Processor, and a Mark Levinson preamplifier.

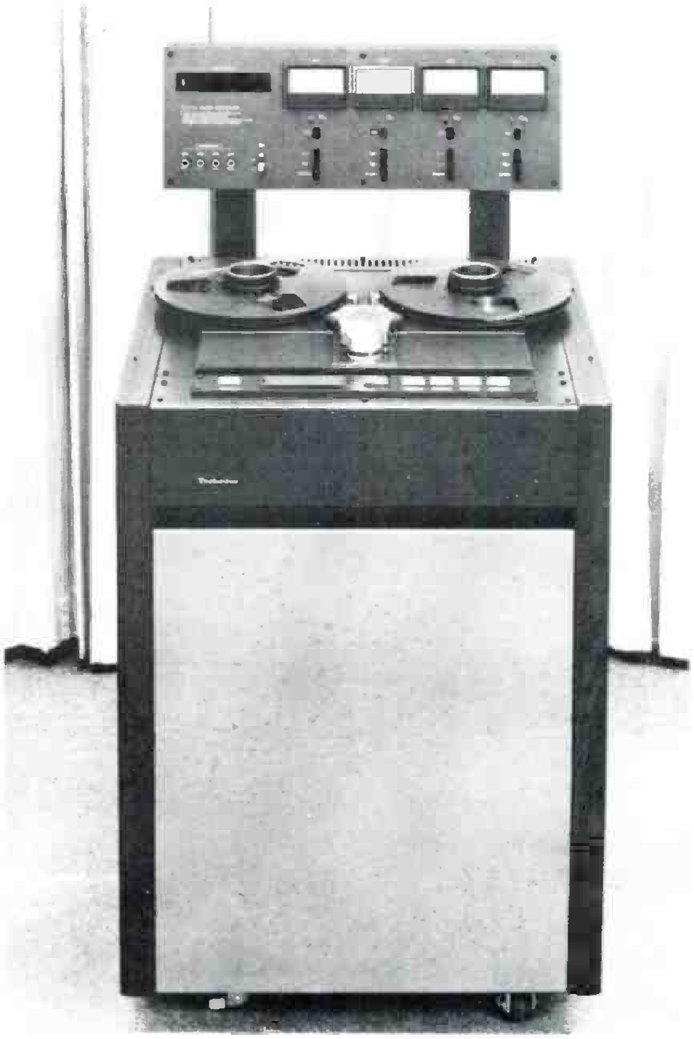


Figure 8. An experimental four-channel recorder from Technics.

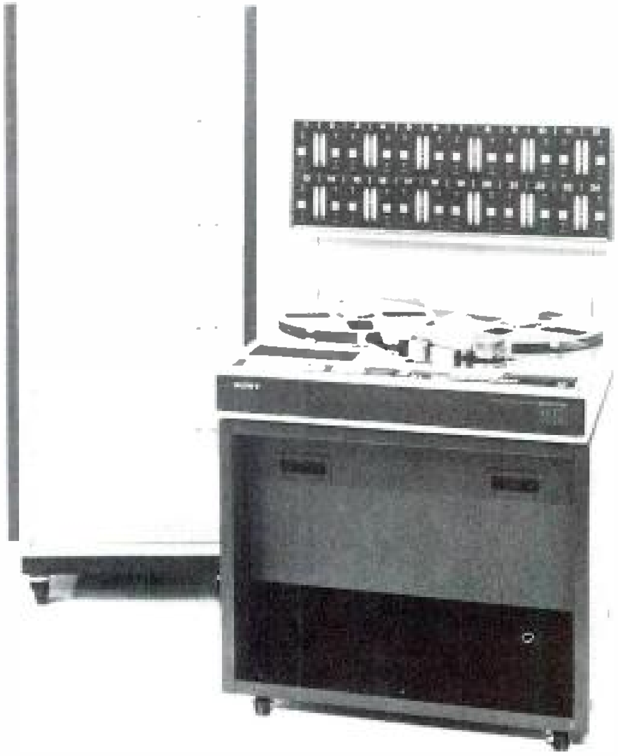


Figure 9. A prototype version of Sony's PCM-3324 Digital Recorder.

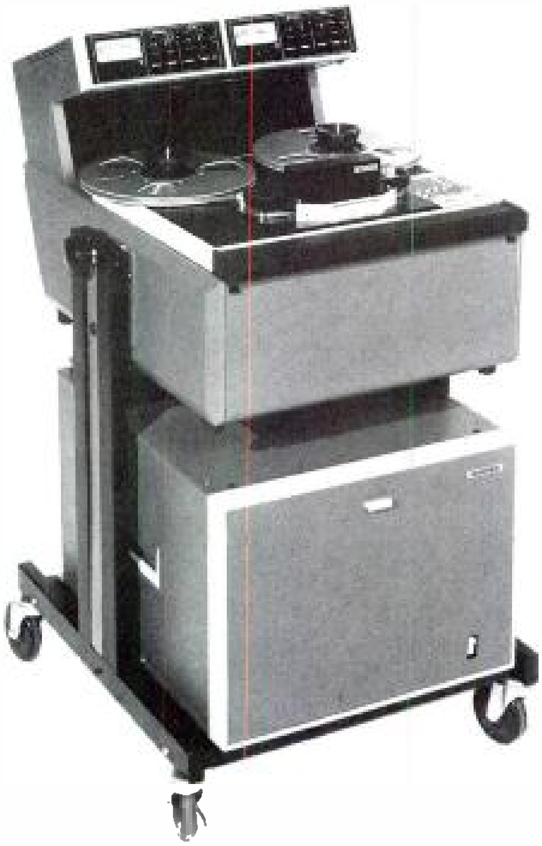


Figure 10. An Ampex digital prototype, offering four channels on quarter-inch tape (50 kHz sampling rate). A series of experimental sessions are planned for later this year.


Figure 11. The Sony PCM-3204 four-channel digital tape recorder.

# db Classified

Minimum order accepted: $25.00
Rates: $1.00 a word
Boxed Ads: $40.00 per column inch
db Box Number: $8.50 for wording "Dept. XX," etc.
Plus $1.50 to cover postage

Frequency Discounts: 6 times, 15%; 12 times, 30%

ALL CLASSIFIED ADS MUST BE PREPAID.

## FOR SALE

¼-INCH TAPE duplicating system. Six Crown 800 transports. New 4-channel heads. Solid state. Mint. $4,200.00. **(215) 338-1682.**

---

BGW: FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

PRO-SOUND equipment. Specializing in phone and mail orders. Free discount catalog. Write or call **Sonix Co., Dept. D, P.O. Box 58, Indian Head, MD 20640 (301) 753-6432.**

---

CARTRIDGE RELOADING. Factory authorized rebuild service on Aristocart, Capitol/Audiopak A-2, AA-3, Fidelipac Cartridges. Fast turn around. **Broadcast Cartridge Service, 15131 Triton Lane, #108, Huntington Beach, CA 92649. (800) 854-6419 or (714) 898-7224.**

---

**GUARANTEED LOWEST PRICES!**

**$50 CASH OFFER!**

***We will beat any legitimate advertised price or price quote on any 3M PRO audio product, or we will give you $50 CASH! Call now. Dealers excluded.***

AUDIO PRO SHOP

WHOLESALE DISTRIBUTORS
6628 HORNWOOD
HOUSTON, TX. 77074
(713)772-1153

SEND FOR OUR AUDIO PRO SHOP CATALOG.

---

FREE CATALOG & AUDIO APPLICATIONS

CONSOLES
KITS & WIRED
AMPLIFIERS
MIC, EQ, ACN, LINE, TAPE, DISC, POWER
OSCILLATORS
AUDIO, TAPE BIAS
POWER SUPPLIES

OPAMP LABS INC
1033 N SYCAMORE AVE.
LOS ANGELES, CA 90038
(213) 934-3566

---

REELS AND BOXES 5" and 7" large and small hubs, heavy duty white boxes. **W-M Sales, 1118 Dula Circle, Duncanville, Texas 75116 (214) 296-2773.**

---

DOLBY M16 cat. 22 & cat. 44 cards wanted. Reasonable! **Jay Sound, 4300 Watertown Rd., Maple Plain, MN. 55359—Ph. (612) 475-3151.**

---

SCULLY, NEW and used: FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

**PROFESSIONAL AUDIO EQUIPMENT**

Shop for pro audio from N.Y.'s leader, no matter where you live! Use the Harvey Pro Hot-Line. (800) 223-2642 (except NY, AK, & HI) Expert advice, broadest selection such as: Otari, EXR, Ampex, Tascam and more. Write or call for price or product info:

**Harvey Professional Products Division**
**2 W. 45th Street**
**New York, NY 10036**
**(212) 921-5920**

---

dbx 155: FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

101 RECORDING SECRETS MOST ENGINEERS WON'T TELL, $7.95 **Tunetronics, P.O. Box 55, Edgewater, N.J. 07020.**

---

AKG, E/V, Sennheiser Shure, Neuman; FOR IMMEDIATE DELIVERY most models. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

USED: AKG BX20, EMT 140, MicMix Studio B. Orban 111b, Tapco 4400, Sound Workshop 242A. New: Ecoplate original, Ecoplate II, MicMix XL210, MicMix XL305. Free comparison, demo tape available. **Audio House (303) 741-4746.**

---

**CANADIANS!**

Interested in semi-pro multitrack recording?

Headquarters for

OTARI · MXR · dbx · TEAC TASCAM · JBL

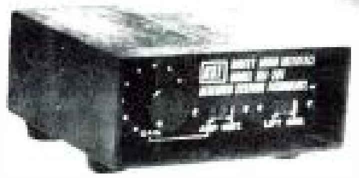
and many more

Write or call

**RICHARD AUDIO INC.**

**RST's DAI-201 DIRECT BOX**

# DON'T LET IT BLEED



RST RESEARCH SYSTEMS TECHNOLOGY INC
33447 Kelly Road • Fraser, MI 48026
(313) 296-1540
Dealer Inquiries Invited

---

AMPEX, OTARI, SCULLY—In stock, all major professional lines, top dollar trade-ins; 15 minutes George Washington Bridge. **Professional Audio Video Corporation, 384 Grand Street, Paterson, New Jersey 07505. (201) 523-3333.**

---

AMPEX AG-350-2: consoled, $1300.00; unmounted, $1100.00. Crown 800 transports-quad heads. Magnecord 1028-2 $225.00; no electronics $75.00. **(215) 338-1682.**

---

FOR SALE: MCI RECORDING desk model 636 with light meters, Parametric Equalizer option, 36 x 36 in and out—4 EXRA Wild VCA faders. Option for 2-24 track tape meter housing and 2 custom made producers tables—$75,000.00. **Criteria Recording Studios, 1755 N E 149 St., Miami, FL 33181. (305) 947-5611.**

---

BX20 AND BX10 AKG reverberation systems. FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

THE LIBRARY...Sound effects recorded in STEREO using Dolby throughout. Over 350 effects on ten discs. $100.00. Write **The Library, P.O. Box 18145, Denver, Colo. 80218.**

---

Lexicon Prime Time: FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

AMPEX, OTARI & SCULLY recorders in stock for immediate delivery; new and rebuilt. **RCI, 8550 2nd Ave., Silver Spring, MD 20910.** Write for complete product list.

---

ORBAN. All products in stock. FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

JFET TUBE REPLACEMENTS for first playback stages in most Ampex Professional audio tape recorders/reproducers available from **VIF International, Box 1555, Mountain View, CA 94042. (408) 739-9740.**

---

UREI: FOR IMMEDIATE DELIVERY most items. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

---

RADIO WAREHOUSE
+
Cash with order = Pro-Audio Equipment Savings
Example: AKG-C567E Lavalier Microphone, $165.00, plus shipping
All inquiries invited.

**RADIO WAREHOUSE**
**P.O. Box 2728**
**Dallas, Texas 75221**
**(817) 496-9000**

---

PROFESSIONAL AUDIO IN TUCSON—Crown, Otari, Altec, Sound Workshop, AKG, MXR-Pro, dbx & more. Sales, design, service and demonstration showroom. **Autograph Pro Audio, 601 E. Blacklidge Dr., Tucson, AZ, (602) 882-9016.**

---

SOUND WORKSHOP 1280 + Expander Super EQ—24 in/24 out, full patchbays, 4 8x2 line mixers. Console/producers desk, studio ready, $8,000. Firm. **(212) 253-0379.**

---

Neumann VG 66 Disc Cutting System—AM 32 B ½ Speed Lathe. SX68 head w/tube electronics Telefunken Master Machine with transfer panel. Priced to sell. Reply:

**Premore, Inc.**
**11058 Chandler Blvd.**
**No. Hollywood, Calif. 91603**

---

HAVE YOU EVER BEEN FRUSTRATED WITH FEEDBACK HOWL EVEN AFTER USING EQUALIZERS? FIND OUT ABOUT OUR FEEDBACK STABILIZERS MOD. NO. 741XR AND 742XR.

BODE SOUND CO.
1344 ABINGTON PL.
NO. TONAWANDA, N. Y. 14120
716-692-1670

---

LEXICON 224 Digital Reverberation. FOR IMMEDIATE DELIVERY. **UAR Professional Systems, 8535 Fairhaven, San Antonio, TX 78229. 512-690-8888.**

## EMPLOYMENT

MAJOR NEW YORK CITY recording studio needs additional maintenance men. **Dept. 111, db Magazine, 1120 Old Country Road, Plainview, New York 11803.**

---

WANTED: POSITION as a 1st or 2nd recording engineer, or position with a good professional sound company or professional audio equipment company—installations. Experience in studio recording, live sound reinforcement, video work and audio installations. Good, hard, efficient worker. **Eddie—(205) 263-6353.**

---

# ENGINEERS

## Research and Development

Join the development staff of SHURE. We are looking for engineers with electromechanical transducer design/development experience, plus a degree in Engineering or Physics for the following positions:

**High Fidelity** — You will work with the team that is developing phono cartridges to meet the highest standards in audio.

**Microphones** — Help us expand the state-of-the-art in professional and communications microphone development to meet the market demands of the 80's.

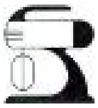
You will be working at our Company headquarters in Evanston, Illinois and will receive an excellent starting salary and company benefits. Learn more about these challenging and rewarding opportunities by calling Cheryl Young at (312) 866-2229 or submit your resume in confidence to:

Cheryl Young
**SHURE BROTHERS INCORPORATED**
**222 Hartrey Avenue, Evanston, Illinois 60204**
*An Equal Opportunity Employer for Decades*

® SHURE ®

## INSTRUCTION

**WANT TO RUN A MIXER?**



CONCORDIA COLLEGE AUDIO WORKSHOP
JUNE 21-JULY 3, 1981
Basic to advanced instruction in sound reinforcement, A/V, and recording.
Write or call
**Audio Workshop**
Concordia College
Moorhead, MN 56560
**218-299-4201**

## SERVICES

MAGNETIC HEAD relapping—24 hour service. Replacement heads for professional recorders. **IEM, 350 N. Eric Drive, Palatine, IL 60067. (312) 358-4622.**

ACOUSTIC CONSULTATION—Specializing in studios, control rooms, discos. Qualified personnel, reasonable rates. Acoustilog, Bruel & Kjaer, HP, Tektronix, Ivie, equipment calibrated on premises. Reverberation timer and RTA rentals. **Acoustilog, 19 Mercer Street, New York, NY 10013 (212) 925-1365.**

CUTTERHEAD REPAIR SERVICE for all models Westrex, HAECO, Grampian. Modifications done on Westrex. Quick turnaround. New and used cutterheads for sale. Send for free brochure: **International Cutterhead Repair, 194 Kings Ct., Teaneck, N.J. 07666. (201) 837-1289.**

HIGHEST QUALITY SAME SPEED (one to one) cassette duplication with half track, A/V format from your 7½ or 15 ips masters. **Toby's Tunes, Inc., 2325 Girard Ave. S., Minneapolis, Minn. (612) 377-0690.**

VIF INTERNATIONAL will remanufacture your Ampex or Scully (Ashland/Bodine) direct drive capstan motor for $175. Average turn around time—2-3 weeks. For details write **PO Box 1555, Mtn. View, CA 94042, or phone (408) 739-9740.**

**JBL AND GAUSS SPEAKER WARRANTY CENTER**
Fast emergency service. Speaker reconing and repair. Compression driver diaphragms for immediate shipment. **NEWCOME SOUND, 4684 Indianola Avenue, Columbus, OH 43214. (614) 268-5605.**

**Copies of db**

Copies of all issues of **db—The Sound Engineering Magazine** starting with the November 1967 issue are now available on 35 mm. microfilm. For further information or to place your order please write directly to:

**University Microfilm, Inc.**
**300 North Zeeb Road**
**Ann Arbor, Michigan 48106**


# Index 1980

### INDEX BY AUTHOR


**Bartlett, Bruce.** Hum, Pop, Thump and Other Microphone Noises. Dec. 1980, p. 32.

**Bensen, Tom.** Computer-Interface-able Eumig-1000. Sept. 1980, p. 38.

**Borwick, John.** If We Can Hear It, We Can Measure It. July 1980, p. 49.

**Borwick, John,** Made In Britain. June 1980, p. 48.

**Borwick, John.** Scene From Europe: A Classical Speaker Situation. Dec. 1980, p. 27.

**Brosious, Hamilton H.** Studio System Planning: Don't Forget the Bottom Line. Aug. 1980, p. 47.

**Buff, Paul C.** The New VCA Technology. Aug. 1980, p. 32.

**Clegg, Almon H.** On RMS: Kelly's Constant To The Rescue. Nov. 1980, p. 66.

**Clegg, Almon H.** Using Thevenin's Theorem In Audio. April 1980, p. 51.

**Cooper, Jeff.** The Construction of the Saul Zaentz Film Center. July 1980, p. 32.

**Costa, Guy.** The Motown System. Aug. 1980, p. 43.

**Dalton, Dirk.** Creating Synthesized Sounds For Star Trek. March 1980, p. 44.

**Davis, Carolyn and Don.** Time, Energy and Frequency Measurements For Sound Definition. June 1980, p. 37

**Diehl, Irwin,** Muscle Shoals Sound Studios. Jan. 1980, p. 43.

**Duncan, Kent.** Creating The Ultimate Environment. Aug. 1980, p. 42.

**Eargle, John.** Motion Picture Sound Systems. March 1980, p. 37.

**Eargle, John M.** Studio Microphone Techniques. Dec. 1980, p. 38.

**Feldman, Leonard.** Changes Loom For Both AM and FM Broadcasters. April 1980, p. 48.

**Fierstein, Alan.** Acoustical Troubleshooting. Oct. 1980, p. 36.

**Grundy, Albert.** Shielding and Grounding Revisited. Oct. 1980, p. 41.

**Halsall, Robert and Howe, Jr., Dr. Hubert, S.** A Computerized Recording Studio Console. Feb. 1980, p. 42.

**Hodges, Ralph.** Getting Down to Two Tracks Fast and Other Stories. Dec. 1980, p. 42.

**Hodges, Ralph.** Magnetic Reference Laboratory and The State Of Reproducer Calibration Tapes. Nov. 1980, p. 52.

**Hodges, Ralph.** Sound For The Cinema. March 1980, p. 35.

**Hufker, Barry.** Re-Inventing The Microphone. Jan. 1980, p. 50.

**Klingman, Mark.** Future Shock Today: Rocking Into Video. Aug. 1980, p. 50.

**Kofoed, Christine.** The New York Hilton Makes A Sound Investment. May 1980, p. 60.

**Long, Edward,** The Pressure Recording Process. Jan. 1980, p. 31.

**Metzler, Bob.** Packaging: A New Dimension in Audio Test Equipment. May 1980, p. 70.

**Meyer, Brad.** Reinforcing The Pope In Boston. May 1980, p. 50.

**Mosely, John.** COMTRAK. March 1980, p. 41.

Nady, John. Wireless Microphones—On Stage and in the Studio. Sept. 1980, p. 41.

Nikanorov, Vladimir. Cleaning Up The Sound of Radio. Oct. 1980, p. 44.

Pelking, Scott. The PRASP—And How to Build One. July 1980, p. 38.

Rettinger, Michael. A Live-End Environment For Control Room Loudspeakers. June 1980, p. 42.

Rettinger, Michael. Restricting Sound Radiation: Theory vs. Practice. Oct. 1980, p. 48.

Rettinger, Michael. Sound Reinforcement Systems In Amphitheatres. May 1980, p. 42.

Rollo, John. Indian Creek Recording Studio: State-Of-The-Art, Texas Style. June 1980, p. 44.

Silsby, Greg. Sound Reinforcement and Broadcast Audio at the Republican National Convention. Dec. 1980, p. 49.

Silver, Sidney L. Correcting Tape Errors In Digital Magnetic Recording. Nov. 1980, p. 62.

Silver, Sidney L. VU Meters Vs. Peak Program Meters. Jan. 1980, p. 46.

Small, Eric. Measuring The Sound of Radio. Sept. 1980, p. 32.

Sommerwerck, William. An Audio Micro-Computer For Tests and Measurements. Feb. 1980, p. 28.

Tanaka, Kunimaro. The Mitsubishi Digital Audio System. Feb. 1980, p. 33.

Tyler, Leslie. Broadcast Signal Processing: The dbx Approach. Sept. 1980, p. 48.

Weinstock, N.I. Sound Rehabilitation For Theatres. May 1980, p. 66.

White, Philip. Distortion-Measuring Microphones For Music Recording. Jan. 1980, p. 34.

Woram, John M. AES Convention Report—London. May 1980, p. 74.

Woram, John M. AES—Los Angeles. July 1980, p. 42.

Woram, John M. Books On Architectural Design For The Would-Be Studio Designer. June 1980, p. 54.

Woram, John M. Recording Studio Design and Acoustics. June 1980, p. 32.

Woram, John M. The Ampex ATR-124. Jan. 1980, p. 39.

Woram, John M. The Otari MTR-90. Nov. 1980, p. 59.

Youngquist, Robert J. Electronic Digital Editing For Multi-Track Comes Of Age. Feb. 1980, p. 38.

Zambuto, Sam. db Visits: The Grand Ole Opry. April 1980, p. 36.

Zambuto, Sam. Nashville Studios Shift to High Gear. April 1980, p. 41.

Zambuto, Sam. Spotlight on Pro Audio Manufacturers. April 1980, p. 44.

Zambuto, Sam. The Nashville Sound Is Alive and Well. April 1980, p. 33.

Zide, Larry. Fantasy Recording/Zaentz Film Center: Candy Store For The 80s. Aug. 1980, p. 38.

## INDEX BY TITLE

A Computerized Recording Studio Console. Robert Halsall and Dr. Hubert S. Howe, Jr. Feb. 1980, p. 42.

Acoustical Troubleshooting. Alan Fierstein. Oct. 1980, p. 36.

AES Convention Report—London. John M. Woram. May 1980, p. 74.

AES—Los Angeles. July 1980, p. 42.

A Live-End Environment For Control Room Loudspeakers. Michael Rettinger. June 1980, p. 42.

Ampex ATR-124, The. John M. Woram. Jan. 1980, p. 39.

An Audio Micro-Computer For Tests And Measurements. William Sommerwerck. Feb. 1980, p. 28.

Books On Architectural Design For The Would-Be Studio Designer. John M. Woram. June 1980, p. 54.

Broadcast Signal Processing: The dbx Approach. Leslie Tyler. Sept. 1980, p. 48.

Changes Loom For Both AM And FM Broadcasters. Leonard Feldman. April 1980, p. 48.

Cleaning Up The Sound Of Radio. Vladimir Nikanorov. Oct. 1980, p. 44.

Computer-Interfaceable Eumig-1000. Tom Bensen. Sept. 1980, p. 38.

COMTRAK. John Mosely. March 1980, p. 41.

Construction Of The Saul Zaentz Film Center, The. Jeff Cooper. July 1980, p. 32.

Correcting Tape Errors In Digital Magnetic Recording. Sidney L. Silver. Nov. 1980, p. 62.

Creating Synthesized Sounds For Star Trek. Dirk Dalton. March 1980, p. 44.

Creating The Ultimate Environment. Kent Duncan. Aug. 1980, p. 42.

db Visits: The Grand Ole Opry. Sam Zambuto. April 1980, p. 36.

Digital Tape Recorder Directory. Feb. 1980, p. 45.

Directory of Microphone Manufacturers. Dec. 1980, p. 48.

Directory Of Nashville Manufacturers. April 1980, p. 55.

Directory Of Studio Construction Services. July 1980, p. 41.

Distortion—Measuring Microphones For Music Recording. Philip White. Jan. 1980, p. 34.

Electronic Digital Editing For Multi-Track Comes Of Age. Robert J. Youngquist. Feb. 1980, p. 38.

Fantasy Recording/Zaentz Film Center: Candy Store For The 80s. Larry Zide. Aug. 1980, p. 38.

Future Shock Today: Rocking Into Video. Mark Klingman. Aug. 1980, p. 50.

Getting Down to Two Tracks Fast and Other Stories. Ralph Hodges. Dec. 1980, p. 42.

Hum, Pop, Thump and Other Microphone Noises. Bruce Bartlett. Dec. 1980, p. 32.

this publication is available in microform

Please send me additional information

University Microfilms International

300 North Zeeb Road
Dept. P.R.
Ann Arbor, MI 48106
U.S.A.

18 Bedford Row
Dept. P.R.
London, WC1R 4EJ
England

Name ______
Institution ______
Street ______
City ______
State ______ Zip ______

**If We Can Hear It, We Can Measure It.** John Borwick. July 1980, p. 49.
**Indian Creek Recording Studio: State-Of-The-Art, Texas Style.** John Rollo. June 1980, p. 44.
**Jay McKnight And MRL.** Nov. 1980, p. 56.
**Made In Britain.** John Borwick. June 1980, p. 48.
**Magnetic Reference Tapes And The State of Reproducer Calibration Tapes.** Ralph Hodges. Nov. 1980, p. 52.
**Measuring The Sound Of Radio.** Eric Small. Sept. 1980, p. 32.
**Mitsubishi Digital Audio System, The.** Kunimaro Tanaka. Feb. 1980, p. 33.
**Motion Picture Sound Systems.** John Eargle. March 1980, p. 37.
**Motown System, The.** Guy Costa. Aug. 1980, p. 43.
**Muscle Shoals Sound Studios.** Irwin Diehl. Jan. 1980, p. 43.
**Nashville Sound Is Alive And Well, The.** Sam Zambuto. April 1980, p. 33.
**Nashville Studios Switch To High Gear.** Sam Zambuto. April 1980, p. 41.
**New VCA Technology, The.** Paul Buff. Aug. 1980, p. 47.
**New York Hilton Makes A Sound Investment, The.** Christine Kofoed. May 1980, p. 60.
**On M-S and Other Microphone Combinations.** Dec. 1980, p. 47.
**On RMS: Kelly's Constant To The Rescue.** Almon H. Clegg. Nov. 1980, p. 66.
**Otari MTR-90, The.** John M. Woram. Nov. 1980, p. 59.
**Packaging: A New Dimension In Audio Test Equipment.** Bob Metzler. May 1980, p. 70.
**PRASP—And How To Build One, The.** Scott Pelking. July 1980, p. 38.
**Pressure Recording Process, The.** Edward Long. Jan. 1980, p. 31.
**Recording Studio Design And Acoustics.** John M. Woram. June 1980, p. 32.
**Reinforcing The Pope In Boston.** Brad Meyer. May 1980, p. 50.
**Re-Inventing The Microphone.** Barry Hufker. Jan. 1980, p. 50.
**Restricting Sound Radiation: Theory Vs. Practice.** Michael Rettinger. Oct. 1980, p. 48.
**Saul Zaentz Film Center, The Construction of.** Jeff Cooper. July 1980, p. 32.
**Scene From Europe: A Classical Speaker Situation.** John Borwick. Dec. 1980, p. 27.
**Shielding And Grounding Revisited.** Albert Grundy. Oct. 1980, p. 41.
**Sound For The Cinema.** Ralph Hodges. March 1980, p. 35.
**Sound Rehabilitation For Theatres.** N. I. Weinstock. May 1980, p. 66.
**Sound Reinforcement and Broadcast Audio at the Republican National Convention.** Greg Silsby. Dec. 1980, p. 49.
**Sound Reinforcement Systems In Amphitheatres.** Michael Rettinger. May 1980, p. 42.
**Spotlight on Nashville's Pro Audio Manufacturers.** April 1980, p. 44.
**Studio Microphone Techniques.** John M. Eargle. Dec. 1980, p. 38.
**Studio System Planning: Don't Forget The Bottom Line.** Hamilton H. Brosious. Aug. 1980, p. 47.
**Time, Energy and Frequency Measurements For Sound Definition.** Carolyn and Don Davis. June 1980, p. 37.
**Using Thevenin's Theorem In Audio.** Almon H. Clegg. April 1980, p. 51.
**VU Meters Vs. Peak Program Meters.** Sidney L. Silver. Jan. 1980, p. 46.
**What's New At The FCC?** John M. Woram. Sept. 1980, p. 51.
**Wireless Microphones: On Stage And In The Studio.** John Nady. Sept. 1980, p. 41.

## INDEX BY SUBJECT

### ACOUSTICS

**Acoustical Troubleshooting.** Alan Fierstein. Oct. 1980, p. 36.
**A Live-End Environment For Control Room Loudspeakers.** Michael Rettinger. June 1980, p.42.
**Books on Architectural Acoustics For The Would-Be Studio Designer.** John M. Woram. June 1980, p. 54.
**Creating The Ultimate Environment.** Kent Duncan. Aug. 1980, p. 42.
**Restricting Sound Radiation: Theory Vs. Practice.** Michael Rettinger. Oct. 1980, p. 48.
**The PRASP And How To Build One.** Scott Pelking. July 1980, p. 38.

### APPLICATION NOTES

**Audio Pad Design Update.** Oct. 1980, p. 51.
**Keeping It Clean And Quiet.** Oct. 1980, p. 42.
**More On Audio Pads.** March 1980, p. 47.
**On M-S and Other Microphone Combinations.** Dec. 1980, p. 47.
**On RMS: Kelly's Constant To The Rescue.** Almon H. Clegg. Nov. 1980, p. 66.
**Still More On Audio Pads.** May 1980, p. 80.
**Using Thevenin's Theorem In Audio.** Almon H. Clegg. April 1980, p. 51.

### BROADCAST AUDIO

**Cleaning Up The Sound Of Radio.** Vladimir Nikanorov. Oct. 1980, p. 44.
**Measuring The Sound Of Radio.** Eric Small. Sept. 1980, p. 48.
**What's New At The FCC?** John M. Woram. Sept. 1980, p. 51.

### COMPUTERS

**A Computerized Recording Studio Console.** Robert Halsall and Dr. Hubert S. Howe, Jr. Feb. 1980, p. 42.
**An Audio Micro-Computer For Tests and Measurements.** William Sommerwerck. Feb. 1980, p. 28.
**Computer-Interfaceable Eumig-1000.** Tom Bensen. Sept. 1980, p. 38.

### CONVENTION REPORTS

**AES Convention Report—London.** John Woram. May 1980, p. 74.
**AES—Los Angeles.** John M. Woram. July 1980, p. 42.
**Good Engineering Practices—SPARS Recording Conference III.** Nov. 1980, p. 47.

### DIGITAL TECHNOLOGY

**Correcting Tape Errors In Digital Magnetic Recording.** Sidney L. Silver. Nov. 1980, p. 62.
**Electronic Digital Editing For Multi-Track Comes of Age.** Robert J. Youngquist. Feb. 1980, p. 38.
**The Digital Format Dilemma.** Feb. 1980, p. 46.
**The Mitsubishi Digital Audio System.** Kunimaro Tanaka. Feb. 1980, p. 33.

### DIRECTORIES

**Digital Tape Recorder Directory.** Feb. 1980, p. 45.
**Directory of Microphone Manufacturers.** Dec. 1980, p. 48.
**Directory of Nashville Manufacturers.** April 1980, p. 55.
**Directory of Studio Construction Services.** July 1980, p. 41.

**Spotlight on Pro Audio Manufacturers.** April 1980, p. 44.

FILM SOUND

**COMTRAK.** John Mosely. March 1980, p. 41.

**Creating Synthesized Sounds for Star Trek.** Dirk Dalton. March 1980, p. 44.

**Motion Picture Sound Systems.** John Eargle. March 1980, p. 37.

**Sound For the Cinema.** Ralph Hodges. March 1980, p. 30.

MICROPHONES

**Distortion-Measuring Microphones For Music Recording.** Philip White. Jan. 1980, p. 34.

**Hum, Pop, Thump and Other Microphone Noises.** Bruce Bartlett. Dec. 1980, p. 32.

**Re-Inventing The Microphone.** Barry Hufker. Jan. 1980, p. 50.

**Studio Microphone Techniques.** John M. Eargle. Dec. 1980, p. 38.

**The Pressure Recording Process.** Edward Long. Jan. 1980, p. 31.

NASHVILLE

**db Visits: The Grand Ole Opry.** Sam Zambuto. April 1980, p. 36.

**Directory of Nashville Manufacturers.** April 1980, p. 55.

**Nashville Studios Shift to High Gear.** Sam Zambuto. April 1980, p. 41.

**Spotlight on Nashville's Pro Audio Manufacturers.** April 1980, p. 44.

**The Nashville Sound Is Alive and Well.** Sam Zambuto. April 1980, p. 33.

NOISE AND NOISE REDUCTION

**Keeping It Clean and Quiet.** Oct. 1980, p. 42.

**Shielding and Grounding Revisited.** Albert Grundy. Oct. 1980, p. 41.

SOUND REINFORCEMENT

**Reinforcing the Pope in Boston.** Brad Meyer. May 1980, p. 50.

**Scene From Europe: A Classical Speaker Situation.** John Borwick. Dec. 1980, p. 27.

**Sound Rehabilitation for Theatres.** N. I. Weinstock. May 1980, p. 66.

**Sound Reinforcement and Broadcast Audio at the Republican National Convention.** Greg Silsby. Dec. 1980, p. 49.

**Sound Reinforcement Systems in Amphitheatres.** Michael Rettinger. May 1980, p. 42.

**The New York Hilton Makes a Sound Investment.** Christine Kofoed. May 1980, p. 60.

SPECIAL REPORTS

**Good Engineering Practices—SPARS Recording Conference III.** Nov. 1980, p. 47.

**The Digital Format Dilemma.** Feb. 1980, p. 46.

**What's New at the FCC?** John M. Woram. Sept. 1980, p. 51.

STUDIO REPORTS

**db Visits: The Grand Ole Opry.** Sam Zambuto. April 1980, p. 36.

**Fantasy Recording/Zaentz Film Center: Candy Store for the 80s.** Larry Zide. Aug. 1980, p. 38.

**Getting Down to Two Tracks Fast and Other Stories.** Ralph Hodges. Dec. 1980, p. 42.

**Indian Creek Recording Studio: State-of-the-Art, Texas Style.** John Rollo. June 1980, p. 44.

**Motown System, The.** Guy Costa. Aug. 1980, p. 43.

**Muscle Shoals Sound Studios.** Irwin Diehl. Jan. 1980, p. 43.

**Nashville Studios Shift to High Gear.** Sam Zambuto. April 1980, p. 41.

**Saul Zaentz Film Center, The Construction of.** Jeff Cooper. July 1980, p. 32.

**The Motown System.** Guy Costa. Aug. 1980, p. 43.

TAPE RECORDERS

**Ampex ATR-124.** John M. Woram. Jan. 1980, p. 39.

**Computer-Interfaceable Eumig-1000.** Tom Bensen. Sept. 1980, p. 38.

**Digital Tape Recorder Directory.** Feb. 1980, p. 45.

**The Otari MTR-90.** John M. Woram. Nov. 1980, p. 59.

TESTS AND MEASUREMENTS

**Broadcast Signal Processing: The dbx Approach.** Leslie Tyler. Sept. 1980, p. 48.

**If We Can Hear It, We Can Measure It.** John Borwick. July 1980, p. 49.

**Magnetic Reference Laboratory and The State of Reproducer Calibration Tapes.** Ralph Hodges. Nov. 1980, p. 52.

**Packaging: A New Dimension in Audio Test Equipment.** Bob Meltzer. May 1980, p. 70.

**Time, Energy and Frequency Measurements for Sound Definition.** Carolyn and Don Davis. June 1980, p. 37.

## INDEX BY COLUMNISTS

BARRY BLESSER

**An Introduction to Digital Audio.** July 1980, p. 22.

**Digital Audio.** Sept. 1980, p. 12.

**Digital Audio.** Oct. 1980, p. 12.

**Implementation of the Analog-to-Digital Conversion.** Nov. 1980, p. 14.

**Quantizing: The Digital Counting System.** Aug. 1980, p. 16.

**Realities of Digital Technology, The.** Dec. 1980, p. 10.

NORMAN H. CROWHURST

**A.G.C. and Masking.** Aug. 1980, p. 24.

**A.G.C. and Other Things.** July 1980, p. 10.

**Grounds and Hum.** Feb. 1980, p. 10.

**Information Theory.** Nov. 1980, p. 24

**More About Nature and Techology.** April 1980, p. 14.

**Seeking a System.** Dec. 1980, p. 16.

**Sound and Hearing.** March 1980, p. 8.

**Sound Separation.** Oct. 1980, p. 18.

**System Phasing.** Jan. 1980, p. 14.

**Systems: People and Machines.** June 1980, p. 18.

**Toward Realism In Reproduction.** May 1980, p. 14.

**Voice Prints and Stress Analysis.** Sept. 1980, p. 18.

MARTIN DICKSTEIN

**AV or Not AV, That Is The Question.** Jan. 1980, p. 8.

**More Organizations and Conferences.** May 1980, p. 22.

**Multi-Media/Multi-Image Equipment.** June 1980, p. 22.

**N.A.V.A.—1980.** April 1980, p. 22.

**Slide Business Is A Funny Business.** March 1980, p. 14.

**Sound With Images.** Aug. 1980, p. 28.

**Sound With Images.** Oct. 1980, p. 24.

**Training '79.** Feb. 1980, p. 16.

N.I. WEINSTOCK

**Corrective Devices.** Nov. 1980, p. 20.

**Film Vs. Video.** Sept. 1980, p. 24.

**Scenes From a Video Notebook.** Dec. 1980, p. 19.

**Videotape: Advantages and Disadvantages.** July 1980, p. 16.

# db People/Places/Happenings

• **The Signal Companies, Inc.** and **Ampex Corporation** have jointly announced an agreement in principle to merge Ampex with Signal through an exchange of common stock. The agreement calls for the exchange of 0.85 of a Signal common share of stock (prior to an announced stock split) for each common share of Ampex Corporation. The merger is subject to the completion of a definitive agreement to be approved by the board of directors and shareholders of each company, a favorable tax ruling, and approval of various regulatory agencies. The merger should be consummated by January, 1981.

• **National Radio Broadcasters Association** (NRBA) Board Chairman **Robert Herpe** has announced the appointment of **Lisa Friede**, NRBA director of operations since December of 1979, to vice president of the association. The announcement was made in Los Angeles at the **American Radio Expo**, NRBA's annual convention.

• **Richard Sirinsky** has been appointed marketing manager of **Ampex Corporation**'s Audio-Video Systems Division. The move was announced by **Donald V. Kleffman**, vice president-general manager of the division. Sirinsky will develop and implement marketing activities for the division's professional audio and videotape recorders, broadcast cameras, switching systems and computerized editing and video storage systems. He will be located at the corporate headquarters in Redwood City, California. He returns to the Audio-Video Systems Division after a two-year assignment as vice president and general manager of the Europe, Africa and the Middle East area for Ampex International.

• Beginning January 1981, the **Editall Corporation**, widely known for its professional tape splicing products, will become a division of the **XEDIT Corporation**, with its own 10 year experience in manufacturing high quality splicing blocks and electronic products for the recording industry. Editall was founded in 1952 by **Mr. Joel Tall**, the foremost pioneer in tape editing. The combined operation will be located at 133 South Terrace, Mt. Vernon, N.Y.

• **Dave Kelsey**, acting as temporary national chairman, has announced the formation of a national trade association for professional audio dealers. **"PADA" (Professional Audio Dealers Assocation)**, is to be headquartered in Los Angeles, California. Initial membership is limited to dealers of professional audio equipment whose sales exceed one million dollars annually. The purpose of the organization is educational in nature, with emphasis on successful business operation.

• **Frederick (Rick) Kukulies**, President of **Tangent**, has announced the following changes: **Gary F. Bailey**, former assistant vice president at **United Bank** (Arizona) has assumed the newly created post of general manager; sales manager, **Thomas M. Scott** will concentrate his activities on broadcast sales and the development of international markets, and **Craig N. Olsen** has been appointed national sales manager and will concentrate his activities on domestic sales to recording studios and the sound reinforcement markets. **Neilson/Anklam, Inc.**, has been appointed Tangent's advertising agency.

• **Quad-Eight Electronics**, an industry leader in custom automated console systems, has announced the signing of a contract with **S.A.I.T.** of Brussels, Belgium for two custom Quad-Eight Coronado Console Systems. The consoles are destined for The Palace of The Arts in Sophia, Bulgaria. They will be used for live theater sound reinforcement, live recording and Radio/Television broadcasting. These two systems will be the first ones in the Eastern European community to incorporate a microprocessor based Compumix 111 disc-memory, SMPTE/EBU time-code based automated electronic editing systems.

• **Altec Lansing** has announced the appointment of **Pietro "Pete" Costantino** to the post of Plant Manager at the firm's Oklahoma City facility. Altec's Oklahoma City facility manufactures the **Voice of the Highway** autosound speakers, home high-fidelity speakers and **University Sound** products.

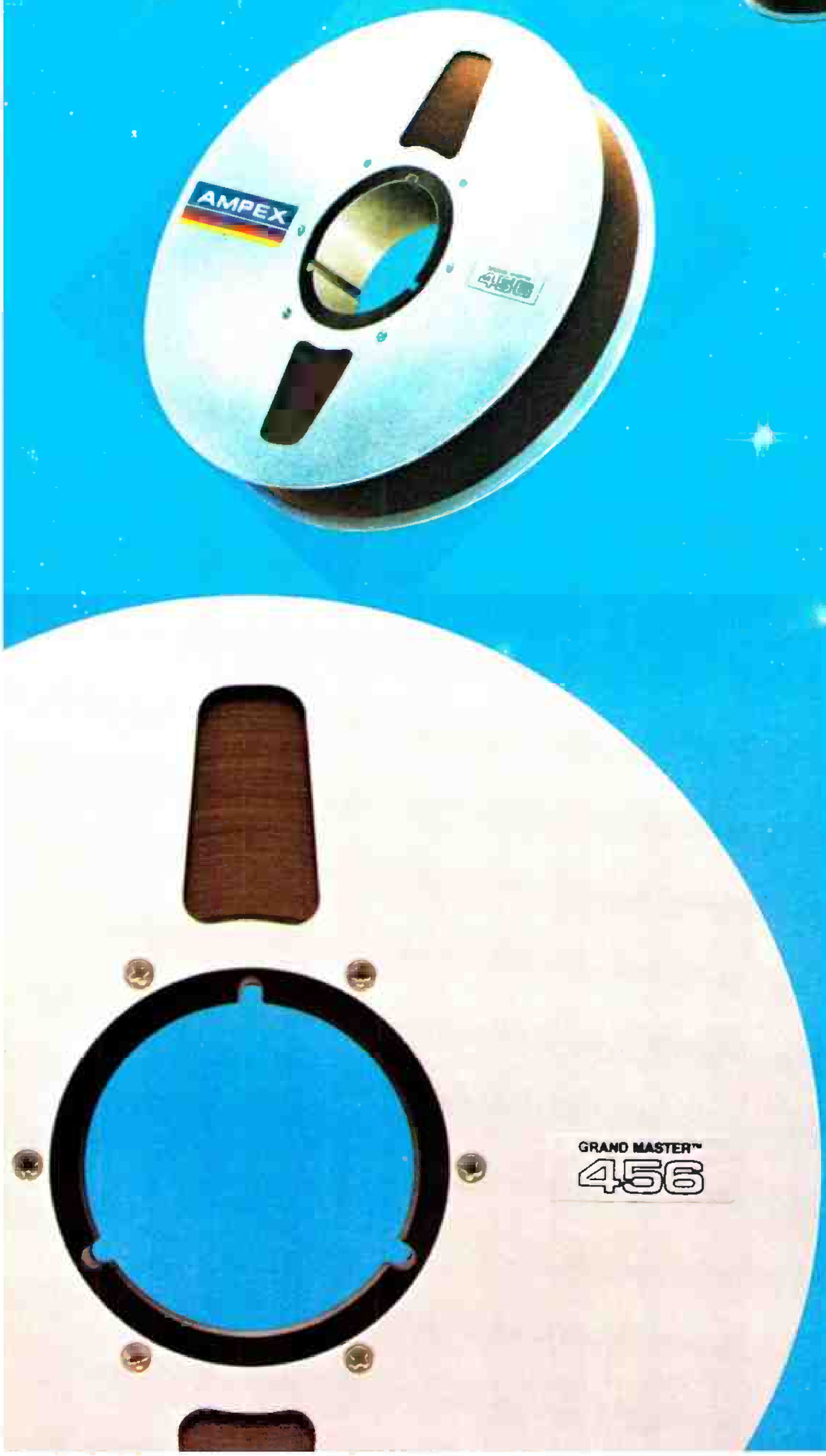
• Some residents of France's popular coastal resort of Saint-Malo no longer "let their fingers do the walking." Instead, their electronic telephone directory promptly displays the number they need on a screen in their home or office. Dozens of Saint-Malo residents and businessmen became pioneers this past summer in the first large-scale test of France's plan to completely eliminate conventional telephone directories and the telephone "information" service. The electronic directory, says the French telephone company, is easier to use, faster and cheaper. The electronic directory terminal, a nine-inch black and white screen connected to the telephone, is linked to the data base through the regular telephone line. Customers will obtain the requested telephone number by typing the requested name on the keyboard to enter the system—the number will appear within seconds on the display screen. The electronic directory is one of several new telecommunications projects being developed under a national program known as **Telematique**.

• **Rockwell International Corporation** and **Continental Electronics Mfg. Co.** have jointly announced the sale of Rockwell's **Collins** broadcast products business to Continental. The sale includes Collins line of AM and FM radio transmitters, audio consoles and other related radio broadcast equipment.

• **RTR Industries** of Canoga Park, California, announced the appointment of **Edward B. Duggan** as Chief Executive Officer. RTR is a major speaker company and markets finished products under the labels of RTR, **RTR Series III, Synergistics**, and **Acculab**.

• **Matt Biberfeld**, program director at **WNCN** (104.3 FM) for the past four years, has been named general manager of the classical music station owned by **GAF Corporation**. As program director, Mr. Biberfeld was instrumental in developing live and remote broadcasts from the **New York City Opera**, the **Chamber Music Society of Lincoln Center**, the **Caramoor Festival**, the **92nd Street Y**, **Juilliard** and other musical centers.

# AIM HIGH FOR MORE HITS. DEPEND ON AMPEX TAPE.




**3 OUT OF 4 RECORDING STUDIOS DO.**

In just 7 short years, Ampex Grand Master 456 Professional Recording Tape has become the unquestioned leader. And it is now used by 3 out of 4 recording studios in America. Ampex professional tape is used to master more hit albums than all other brands combined. Impressive facts. But, so are the reasons.

For one thing, Ampex 456 has a wider dynamic range than any other professional recording tape. It's bias compatible, so you won't have to waste valuable studio time adjusting bias. And it's a "hotter" tape—the kind that professionals demand.

Naturally, Ampex 456 has all the other characteristics you'd expect from a professional recording tape. Like the highest possible signal-to-noise ratio and a saturation capability that's the best in the business. It also has the industry's lowest distortion, unwavering physical stability, high durability, and the ability to perform perfectly after the most prolonged or adverse storage conditions.

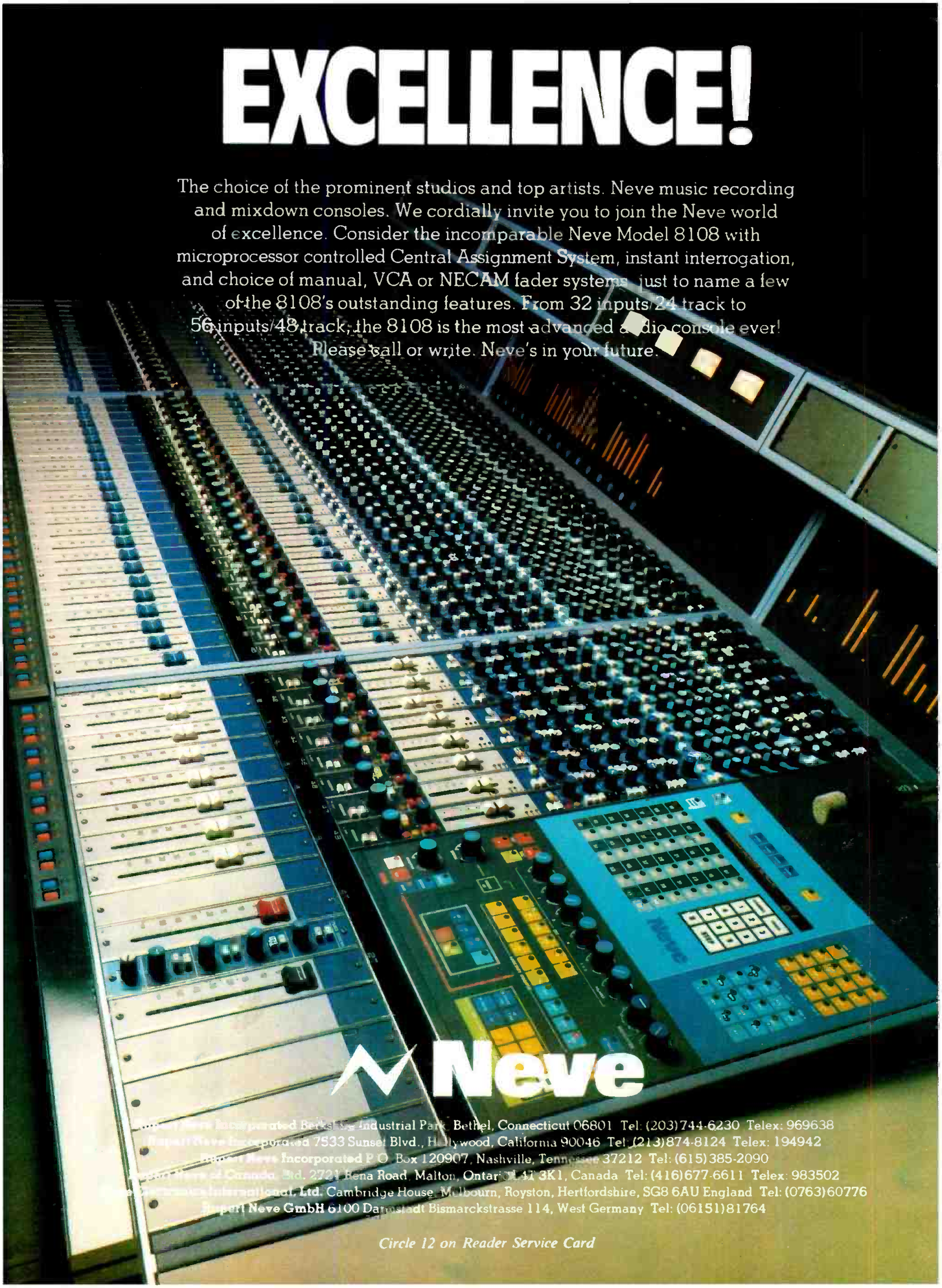
If you still can't decide which tape to use for your next session, here's a simple test. Ask 4 studios. Ask 40. Odds are they'll recommend Ampex 456.

**AMPEX**

**REFLECTIONS OF REALITY. AND BEYOND.**

Ampex Corporation, Magnetic Tape Division,
401 Broadway, Redwood City, CA 94063 415/367-4463

*Circle 11 on Reader Service Card*


EXCELLENCE!
The choice of the prominent studios and top artists. Neve music recording and mixdown consoles. We cordially invite you to join the Neve world of excellence. Consider the incomparable Neve Model 8108 with microprocessor controlled Central Assignment System, instant interrogation, and choice of manual, VCA or NECAM fader systems, just to name a few of the 8108's outstanding features. From 32 inputs/24 track to 56 inputs/48 track, the 8108 is the most advanced audio console ever! Please call or write. Neve's in your future.
Neve
Berkshire Industrial Park, Bethel, Connecticut 06801 Tel: (203)744-6230 Telex: 969638
7533 Sunset Blvd., Hollywood, California 90046 Tel: (213)874-8124 Telex: 194942
Incorporated P.O. Box 120907, Nashville, Tennessee 37212 Tel: (615)385-2090
Ltd. 2721 Rena Road, Malton, Ontario, Canada Tel: (416)677-6611 Telex: 983502
Ltd. Cambridge House, Melbourn, Royston, Hertfordshire, SG8 6AU England Tel: (0763)60776
Neve GmbH 6100 Darmstadt Bismarckstrasse 114, West Germany Tel: (06151)81764
Circle 12 on Reader Service Card