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THE SOUND ENGINEERING MAGAZINE

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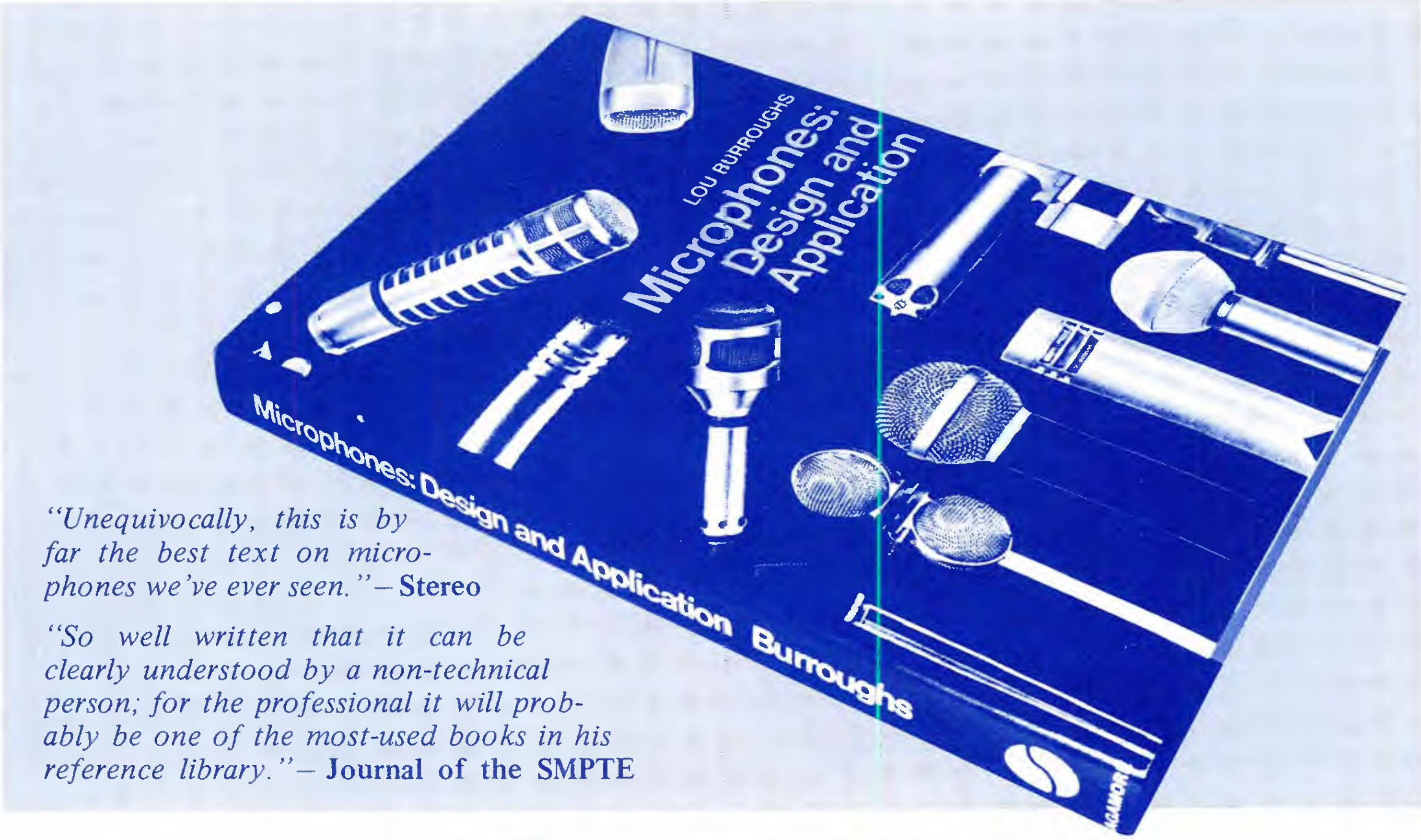

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Coming Next Month

- Commercial Sound will occupy some of our pages in March. In Speech Privacy in the Open Office, R. Max Mayer describes the intricacies of creating discrete sonic zones in an office complex.
- What happens when you connect a sixteen ohm speaker to an eight-ohm tap on an amplifier. Dan Keen's short article tells you what to expect and how to calculate it easily.
- Robert C. Ehle returns to our pages with An Experiment in Aesthetics. Many studios are working more and more with avant-garde music. The author describes an experiment designed to show that such music is preponderantly of a random nature.
- The db Tests feature returns to our pages with a report on the Leader LAS-5500 Audio System Analyzer. This desk top unit combines an audio oscillator, a.c. millivoltmeter, oscilloscope, and wow/flutter meter in a compact single package of modest price.
- Coming in March in **db, The Sound Engineering Magazine.**

About The Cover

- Robert Frost said, "Education is... hanging around until you've caught on." Sometimes we think that education is hanging around until you forget what it is you were hanging around for!

db

THE SOUND ENGINEERING MAGAZINE

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db Calendar

FEBRUARY

28-Mar 3 **A.E.S. Convention,** Hamburg, Germany, Congress Center. Contact: A.E.S., 60 E. 42nd St., New York, N.Y. 10017, (212) 661-2355 or Dr. Joerg Sennheiser, Sennheiser Electronic KG, Postfach 3002, Wedemark 2, Germany.

MARCH

1-5 **Hobby Electronics Fair,** Anaheim Convention Center, Anaheim, Ca. Contact: A. Kozlov, 222 W. Adams St., Chicago, Ill. 60606. (312) 263-4866.

1-3 **NYU Management Seminar, "Managerial Skills for the Developing Manager,"** New York City. Contact: Heidi E. Kaplan, Dept. 14NR, New York Management Center, 360 Lexington Ave., New York, N.Y. 10017. (212) 953-7262.

5-10 **Audio-Visual Institute,** Contact: Dr. E. L. Richardson, Indiana University, Audio Visual Center, Bloomington, Ind. 47401. (812) 337-2853.

15-17 **Smith-Mattingly Seminar, "Multi-Camera."** Smith-Mattingly Productions, 515 Kerby Hill Rd., Oxon Hill, Md. 20022. (301) 567-9265.

17-19 **Intercollegiate Broadcasting System Convention.** Biltmore Hotel, New York City. Contact: Convention Committee, c/o IBS, P.O. Box 592, Vails Gate, N.Y. 12584. (914) 565-6710.

20-22 **NYU Management Seminar, "Understanding Finance for Manufacturing & Production Mgmt," Chicago.** Contact: See above.

20-23 **Noisexpo '78,** National Noise and Vibration Control Conference and Exhibition. Holiday Inn, O'Hare/Kennedy, Chicago. Contact: NOISEXPO, 27101 E. Oviatt Rd., Bay Village, Ohio 44140. (216) 835-0101.

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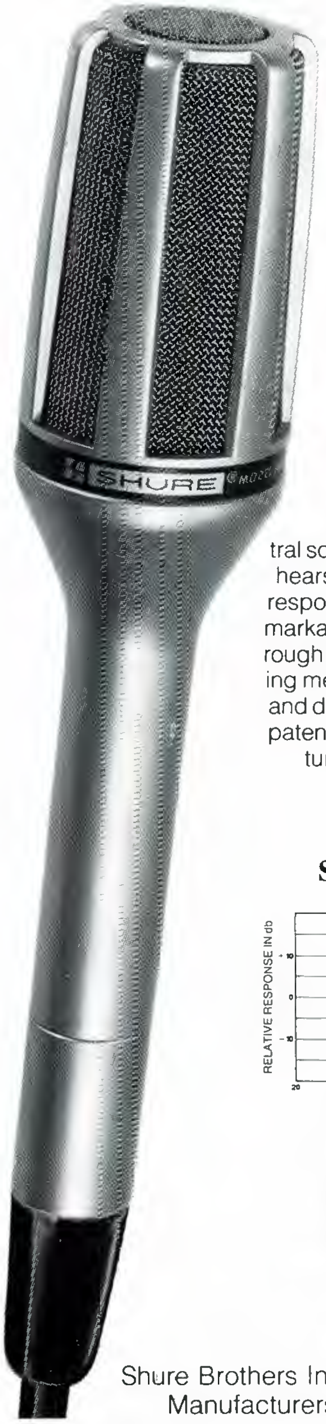

SM59

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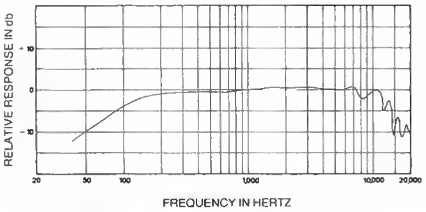

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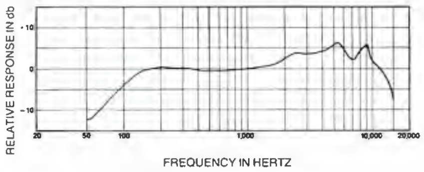

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7 **National Radio Broadcasters Assoc. sales management seminar,** for sales managers of member stations, at the Welsh Co., Tulsa, Okla. Contact: NRBA, Suite 500, 1705 De Sales St., N.W., Washington, D.C. 20036. (202) 466-2030.

8 **Midwest Acoustics Conference, "Audio Transducers."** Norris Center, Northwestern U., Evanston, Ill. Contact: David S. Goldsmith, 8359 S. Crandon Ave., Chicago, Ill. 60617. (312) 731-1388.

10-11 **Wharton School Seminar, "Effective Production Planning & Inventory Mgmt."** Toronto, Ontario. Contact: Heidi E. Kaplan, Dept. 14NR, N.Y. Management Center, 360 Lexington Ave., N.Y.C. 10017. (212) 953-7262.

12-14 **NYU Seminar, "Effective Communications for Engineers,"** Los Angeles, Ca. Contact: See above.

13-14 **Electronic Music Festival & Workshop.** Jersey City State College. Contact: Abigail K. Hoffman, Music Dept., Rossey 206, Jersey City State College, 2039 Kennedy Blvd., Jersey City, N.J. 07305.

19-21 **NYU Seminar, "Management of New Technology Projects,"** Houston, Texas. Contact: See above.

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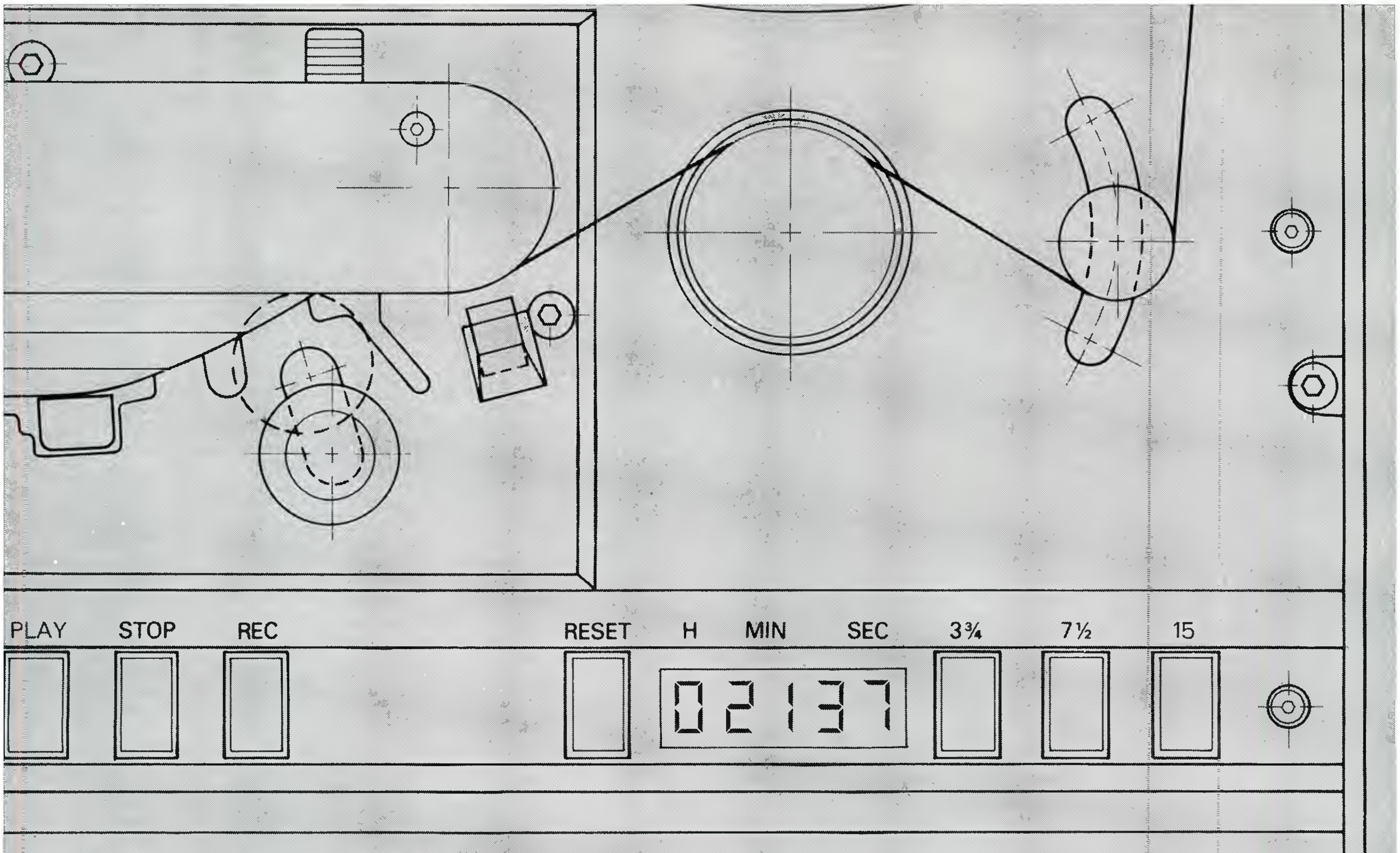

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Intermodulation Distortion

● One of the gremlins that can downgrade the fidelity of the audio signal is called *intermodulation distortion* (imd). This particular form of distortion can happen in rf systems as well as in the audio system, but our main concern this month is for the station's audio system and some of the ways in which it can occur.

WHAT IT IS

As the name implies, intermodulation is actually modulation of one component of the program audio signal by another component of that program signal. Conditions must be right before this can happen and there must always be at least two different program signal components present. When the modulation does occur, it is an amplitude modulation, the same as that which occurs in the modulation process that takes place in the transmitter of the a.m. broadcast station. The only real difference between transmitter modulation and intermodulation is that with intermodulation there is no rf carrier signal present. One of the higher frequency audio components will become the carrier and this will be modulated by lower frequency audio components. This modulated audio carrier becomes a modulated wave with two sidebands.

Whenever an audio stage begins to act as a modulator or a detector, imd will occur when the program passes through that stage. This is a very undesirable form of distortion.

FAMILIAR PROCESSES

The processes which can produce intermodulation in the audio system are very similar to certain processes we have been doing for many years in rf circuits. The rf processes, however, are initiated deliberately and in a controlled manner so as to produce a desired result. Seldom are these processes applied deliberately to audio, although there are cases where some communications systems use audio for carriers.

We are familiar with the normal modulation processes in the a.m. transmitter, but there are some other processes which use the same or similar principles to produce other results, for example, heterodyning. This process is common in microwave repeater work where one signal is translated to another signal, but perhaps the most common use is the creation of an i.f. signal in the regular superheterodyne receiver. A somewhat different approach is that used in a communications receiver to create a bfo note so we can copy a carrier wave station transmitting Morse code.

In all these processes, the results may be desirable or undesirable. When we deliberately create the process in a controlled manner, they serve useful purposes, but if conditions are initiated because of circuit problems and the process occurs in an uncontrolled manner, it produces a very undesirable form of distortion.

MIXING

We mix and blend a variety of audio signals together in the mixer or console to produce our finished program audio signal. Although all these signals are blended together and occupy the same signal path at the same time, each of them will retain its individual identity; the instantaneous voltage or current in the circuit at any moment will be the sum of all these individual voltages combined. A typical example that is easy to observe on an oscilloscope is the high frequency bias signal and an audio sine wave tone fed to a tape recorder head. Each of these signals will retain its identity and individual signal amplitudes. The a.c. axis of the high frequency bias will follow the amplitude of the lower frequency audio tone, and the peak-to-peak voltage across the circuit will be the sum of these two signals.

TWO WAYS

There are esentially two different routes creating the same undesirable intermodulation ends: actual modulation, or mixed signals and rectification.

The modulation process will produce an amplitude modulated wave with two sidebands: one at Fc + M and one at $F_C - M$. F_C is the higher audio tone or signal that becomes the

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carrier, M is the lower frequency tone or signal components that modulate the carrier. These two sidebands are entirely new signals now appearing in the audio signal that were not present before the modulation occurred.

The mixing and rectification process will produce a difference or beat frequency between the two intermodulating components. This beat frequency is an entirely new signal component present in the audio that was not present before the process took place.

MODULATION

When intermodulation occurs by the modulation route, this is the same process that happens at the modulated stage in the transmitter. If the lower frequency audio component takes control and varies the voltage parameters of a stage that is also amplifiying a higher frequency component, then modulation of that high frequency component will result. This voltage variation can be the collector, emitter or bias voltages (similar elements in a tube stage), and since these voltages now vary at the lower frequency rate, the amplitude of the high frequency signal will also vary at this rate.

Perhaps a more common cause for intermodulation is non-linearity of a class A audio stage. The transistor or tube may be faulty so that it is non-linear, or the bias may be incorrectly adjusted to operate the stage low on its input/output curve; this stage can become a modulator. Modulation will occur in this manner: when the low frequency audio component is several times the amplitude of the high frequency component, then its amplitude will take control and operate the stage, forcing the amplification of the high frequency component to follow the amplitude of the low frequency component. Since the stage is operating on the lower, non-linear, part of its curve, the amplified output signal will be non-linear also. When the modulating signal swings positive, the stage gain increases in non-linear fashion so that the output is very high, but as the modulating signal swings negative, the output signal is severely compressed. The output current pulses that flow through the load will exhibit the typical amplitude modulated waveform, and besides this, all the signal characteristics are now present because *it is* an amplitude modulated wave!

DETECTION

Intermodulation can take the second route of the mixing-rectification process. The audio certainly has well mixed signals, so if rectification takes place in any stage, then intermodulation will occur. We do not need rectification in the form of discrete diodes; peak clipping in a stage will produce similar results. This particular process is that which is used by some superheterodyne receivers to produce i.f. signal. The stage is labeled as "mixer-1st detector." In high frequency work, a crystal diode is used for both the mixing and the detection. In the rf process, a strong local oscillator signal is mixed with the incoming rf signal and then the combination is rectified (detected). This will produce a strong difference or beat frequency that is then filtered and amplified as the i.f. frequency.

When clipping of signal peaks is taking place in an audio stage (this may be due to lack of head room or simply overloading), the stage begins to act as a detector. So now we have conditions ripe for intermodulation by the second route.

RESULTS

Whenever an audio stage operates in a non-linear manner or actual peak clipping is taking place (some limiters deliberately clip signal peaks), we open the door to signal degradation. Peak clipping will also produce harmonics, but harmonic distortion is more tolerable than imd because the harmonics are harmonically related to the signal peak that is clipped, whereas intermodulation components are new and spurious signals present that do not have the same direct harmonic relationship. The imd components will detract from the signal far more than will harmonic components. Besides that, many of the harmonics will be out of the audio bandpass and thus are filtered out, but the intermodulation components are in the audio bandpass and can't be filtered out.

Even though stage conditions are ripe for intermodulation, this does not mean that the process is taking place on a continuous basis, with loud squeals and similar disturbing signals present all the time. It will only happen on particular signal components, for example loud passages in music, or low frequency notes of an instrument, or high signal peaks, etc. Nor will the amplitude of these components be anywhere near that of the desired audio signals. All this will be a very low, but disturbing, background noise or interference in the program. Ordinarily, intermodulation distortion will produce about twice the amount of irritation to the listener as will harmonic distortion.

MEASUREMENT

Special test instruments are required to measure imd. The regular distortion

A JBL MONITOR KNOWS ITS PLACE.

A studio monitor is only a tool. It is not supposed to enhance, add to, subtract from, or in any way modify sound.

That's your job.

What a studio monitor is supposed to do is tell you precisely what's on tape. Because you have to know everything that's there. And everything that isn't. Before it's too late.

That's why JBL monitors are in thousands of recording and broadcast studios around the world. In fact, according to the Recording Institute of America, JBL's were used to make 30 of last year's top 50 albums.

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And put a JBL monitor in your place.

analyzer and audio generator are not suitable for measurement of imd because these instruments work only with a single sine wave tone. There must be two signals present to measure intermodulation distortion.

The intermodulation test instrument will provide a dual output signal composed of a pair of audio tones, for example 60 Hz and 7,000 Hz. Other pairs may also be available. The amplitude of these two signals will be in a ratio of 4 to 1 and sometimes 1 to 1, or other ratios may be suitable. These are coupled to the input of the amplifier or system under test. The measurement section will then accept these signals after passage through the system. The signals go through a high pass filter to remove the low frequency audio signal, and the high frequency audio tone is coupled to a regular a.m. detector, where any sideband information present is removed, filtered and the resulting audio modulation measured on a meter in percentage.

PREVENTION

Since we can do little to filter out imd after it occurs, the best practice is prevention. Keep the system in good adjustment and well within its normal design parameters. Maintain correct signal levels throughout, and especially, select standard levels that conform to the units' designs, and allow adequate headroom.

If the special test instruments are not available, then use the oscilloscope and the regular analyzer as an indirect indicator. Observe program signal peaks for peak clipping and readjust to prevent this. When measuring the harmonic distortion of the system, beware of measurements that indicate a high harmonic distortion content. The system conditions that may be causing the harmonic distortion with the sine wave may be the same which will produce intermodulation distortion when program is applied. Try to maintain the harmonic distortion figures of the system at a very, very low value.

SUMMARY

Intermodulation distortion is a very undesirable element that can creep in and downgrade an otherwise good audio system. It can happen when there is inadequate headroom that causes signal peaks to be clipped, and it can happen when stages are operating non-linear. Without special test equipment, keep the harmonic distortion figures of the system very, very low. ■

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NORMAN S. CROWHURST

db Theory & Practice

Damping Factor

• A few months back, I promised to talk some more about damping factor. So here it is. To understand how the damping factor works, you need to think of a loudspeaker as an electromagnetic motor. Like most other electromagnetic motors, it can also behave as a generator; this fact is what makes the damping factor work.

A while back, we were talking about analogs, which are useful to help us visualize what happens. However, the electromagnetic transfer of energy is more than an analog; it is something that happens in the real world. When voltage and current are put into a loudspeaker voice coil, forces and movement are produced. And, conversely, when forces and movement are present, voltage and current are produced. It works both ways.

So which corresponds with which? When we were talking about analogs, we considered force as being *like* voltage, and movement as being *like* current, for example. Now we are talking about what actually corresponds, in the electromagnetic transfer of energy.

When the coil moves in the magnetic field provided for it, a voltage is produced at its terminals. Movement produces voltage. If you connect a voltmeter to the terminals of a loudspeaker and physically move its cone without any amplifier or other source of audio being connected, the voltmeter will read whenever you move the cone.

Moving it forward produces, say, a positive voltage. Moving it backward produces a negative voltage. And either voltage only appears while the cone is moving. As soon as you stop the movement, the voltmeter reading drops to zero. That is the first relationship.

Now, when an amplifier or other audio source delivers a voltage to a loudspeaker voice coil because it possesses impedance (or more accurately, because it possesses admittance), the coil will take some current to go with the voltage. This current is what provides the force that moves the cone. Normally, the cone will move just fast enough to produce a voltage that balances the voltage fed to it.

If you lock the voice coil mechanically, say, by putting a small wedge between it and the magnet pole, and feed the loudspeaker with a given voltage at an audio frequency, it will take a certain current at that frequency. If you now release the coil so it can move the cone, the current will drop.

This happens because when the cone moves, it produces a voltage to offset that provided by the amplifier called a "back e.m.f." (e.m.f. stands for electromotive force). When it does not move, the only opposition to current flow is the static impedance of the coil, so more current flows in an effort to force the coil to move.

So current produces force. Make sure you remember that: movement produces voltage, and current produces force. Now, it's a fact of life, with the possible exception of horns, that loudspeakers, with their associated enclosures, have resonances. These are frequencies at which the acoustic properties of the assembly work together to provide bigger output for a given input than at other frequencies.

If you can see the cone, you will see the resonance as you vary the frequency of an audio generator used to explore this situation, by noticing that the cone moves much further than it does at neighboring frequencies. You will recognize it because of a greater sound output at the same frequency. Now, does the loudspeaker take more current, or less current, at such a resonant frequency?

Figure it out. The voltage is the same, because the amplifier you use to feed the generator output to the loudspeaker provides a substantially constant voltage. But the *movement* is greater. This means the offsetting voltage is greater, reducing the current. Because of the resonance, *less* force is needed to provide an equivalent output. And that less force requires less current.

Now, in modern loudspeakers, we use resonances to hold up the low frequency response. It would be nice if we didn't have to, but it's a fact that we do unless we use a very big horn-type loudspeaker, which is not very popular these days for most purposes. So what is bad about a resonance if it helps us get the music out?

Well, of course, every musical instrument uses its own kind of resonance to produce the sound we recognize as being characteristic of that musical instrument. But every loudspeaker is expected to *re*produce these sounds, characteristic of other instruments, not to produce its own kind of sound. It is not, in itself, a musical instrument, but should be a reproducer.

CONTROLLING RESONANCE

If its resonance is allowed to run free, it will make its own characteristic sound whenever that frequency is stimulated by being present in the reproduced audio so that all instruments that include that frequency in their sound will sound alike. Their individual characters will be lost and they will sound instead like the loudspeaker.

This is what damping factor seeks to obviate. While still helping to get these low frequencies reproduced, it stops the loudspeaker as soon as it tries to do its own thing. All the while that low frequency voltage is being delivered by the amplifier, the speaker cone reproduces it, using resonance to help get the necessary movement.

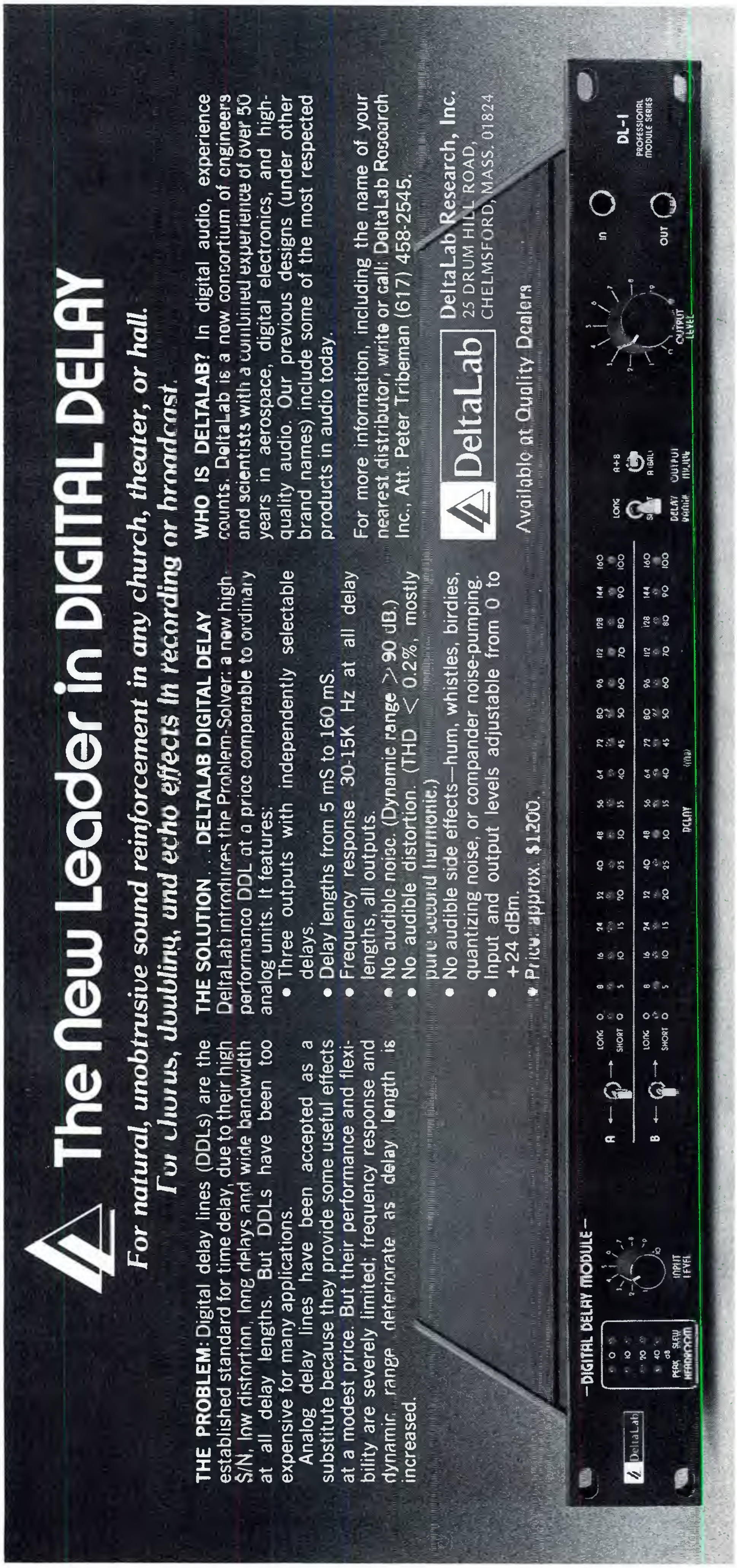
But when the low frequency stops, instead of resonance keeping it going in a way characteristic of the loudspeaker's design, the damping factor stops it. How does it do this?

While the frequency is present in the amplifier output, the cone keeps moving to produce a voltage to offset that output voltage. But as soon as the frequency stops and the loudspeaker wants to keep moving a bit longer in its characteristic manner, that movement generates a voltage and the damping factor allows a current to flow, stopping the movement in its tracks.

Damping factor puts the brakes on such spurious movement, not authorized by the amplifier output voltage. That is what it does, but how does it do it?

DAMPING ACTION

If you take the loudspeaker and tap the cone without it's being connected to anything, you will hear a sound characteristic of the loudspeaker's resonance, a little bit like



Circle 16 on Reader Service Card

tapping a bass drum. But if you now short-circuit the voice coil terminals, and tap it again, that "drum" sound will be killed.

If you feel the way the cone moves, you may even notice that it seems stiffer with the short-circuit on the voice coil than without it. Damping factor does the same thing, by arranging that when it is not providing a driving voltage, the amplifier provides such a "short-circuit" for the voice coil.

If you try this with different loudspeakers, you will find the effect more marked in some than others. Why the difference? Go back to the first experiment—moving the cone with the voice coil connected to a voltmeter. The damping force depends on how much current this voltage produces in the coil.

When the coil is open, no current flows; there is no damping force. When you short-circuit the voice coil, the current is limited only by the voice coil resistance or, more accurately, its impedance. So the effectiveness of damping depends on the loudspeaker's efficiency: how much of the energy provided by the amplifier is used to overcome voice coil impedance, and how much is used to provide a driving force for the cone?

The amplifier provides, basically, an output voltage, as a result of which the loudspeaker accepts an output current to go with it. Now, the output voltage that, from the viewpoint of the amplifier, causes the current, is also, from the viewpoint of the loudspeaker, the result of the current acting on the various loudspeaker parts.

Due to the voice coil's impedance, which is largely resistance at low frequencies, the output current produces a voltage drop. Because of the movement, there is a back e.m.f. The combination of these voltages is what exactly balances the output voltage from the amplifier, that provides the electrical driving force for the current.

Now if at resonance the bigger part of the output voltage goes to moving the cone, then the damping factor can have a greater effect. But if the greater part of the output voltage is needed to overcome voice coil resistance, the damping factor will have relatively little effect. Even with the voice coil shorted, voice coil resistance will restrict current flow so that the damping force is too small to have much effect.

A NUMBER OF UNITS

So far, I have talked about one loudspeaker unit being fed by one amplifier output. Now what about one amplifier feeding a number of units? Does that make any difference? In other respects, as I have commented, putting units in series or in parallel just provides different ways of dividing the power and, so long as the power is properly divided and the combined loudspeaker impedance matches the amplifier's needs, it makes no difference. But for damping factor, it does make a difference.

When you have a bunch of loudspeaker units connected in parallel, and all that connected to the amplifier output, each loudspeaker has the amplifier output terminals connected directly across it. The amplifier's low-internal-impedance damping factor operates on each loudspeaker's tendency for spurious movement, to put the brakes on. There will be no electrical feed from one loudspeaker's spurious movement to the other units.

But when units are connected in series, if you look at the thing from the viewpoint of one unit's resonance overshoot, the amplifier's short circuit connects through other voice coils. So the current generated to provide a braking force for this unit at the same time provides a driving force for the other units. Damping is completely messed up.

A couple of decades or so ago some audiophiles had a sort of mania for transformerless amplifiers. They believed that the main source of distortion was the output transformer, so they wanted to eliminate it. This belief was based on the fact that the magnetizing current for the core material is quite non-linear, and thus would result in non-linear distortion.

Actually, this touches on quite a big question that produced many arguments in the old days. The fact is, the amount of distortion they were trying to get rid of was much smaller than the amount they introduced in the effort. But that prejudice has repercussions today, many still think it is better to do without transformers if you can.

THE USEFUL TRANSFORMER

So when you have a multiple-unit loudspeaker, such as a column array, it may be easier to avoid using a matching transformer if you use either a series, or a series/parallel arrangement. Now, if you cannot get an appropriate matching transformer to enable you to use all-parallel connection, you may have to settle for something like that. But do not make the old transformerless-amplifier enthusiast's mistake of thinking it is best.

By using such an arrangement you will deteriorate the damping factor of the system, which, using an appropiate matching transformer with parallel connection, would improve. As with so many things, the choice is often a trade-off. ■

MARTIN DICKSTEIN

Rapid Transmission & Storage System

• As almost everyone knows, the field of education is probably the largest user of audio visual devices. In recent years, a great amount of research has been done on the development of methods, hardware, and software to improve learning efficiency. The latest of these learning systems is called Rapid Transmission and Storage a t.v.-based system of instruction (RTS), developed by Goldmark Communications. A patent was granted last year.

Up until recently, learning facilities have been offered only to those who attended an educational institution. The primary means for distributing knowledge or information was through the printed word and the instructor. This meant formal classes, with someone teaching and using an audio-visual device when needed. It was found, however, that about 25 per cent of the population did not finish high school, and that about 20 per cent of adults wanted to learn things of their own choosing without going a distance to school; they wanted the information provided near where they worked or lived.

To meet this need, an agreement was reached between the Association of Community Colleges for Excellence in Systems and Service (ACCESS); Electronic Publishing Inc. (E.P.I.), a subsidiary of Goldmark Communications; and Cambridge Book Co., a division of *The New York Times,* to market and distribute RTS in the United States and Canada. Primarily, six courses will be developed. The first two were Consumer Education and Child Development. As of this month, Introduction To Business, and Health Science will be completed. The last two will be World Cultures, and Applied Mathematics. The participating Community Colleges, with an enrollment of more than 200,000 students, include Central Piedmont Junior College District of Charlotte, North Carolina; Chicago City Colleges; The Coast Community College District of Costa Mesa; Lane Community College District of Eugene, Oregon; and Metropolitan Community Colleges of Kansas City. Eventually, the program will spread to other community colleges (there are some 1,200 of them in the country), and towards those businesses and industries who also recognize the need for and value of employee instruction.

The late Dr. Peter Goldmark with some of the equipment used in the RTS system.

MARK I

The original system, Mark I, was developed to provide storage for 60 separate half-hour programs (incorporating both sound and video) on a one-hour long 1 inch video tape. Of these, 30 are played simultaneously and can feed 30 individual t.v. sets, scattered in rooms or distribution systems, each of the programs feeding independently to the desired locations. Storage is also possible for 30 one-hour programs, or 120 fifteen-minute shows, or 360 five-minute programs.

The sound is actually the primary medium. There are 30 individual tracks of audio, each picked up by its own section of a 30-track head. Within the audio tracks, there are signals which trigger the images. The system primarily accommodates still frames, although there it also has capability for motion pictures at normal, fast, or slow speed. The images for all 30 programs are multi-plexed on the tape. Thus, a one-second interval on the tape which moves at 7 in./sec. is divided into 30 segments. If, for example, the first segment is used for the first program's image, there will be a picture in each of the first divisions. This program is recorded also through a multi-plex system so that, by computer control, only that segmented portion is erased and recorded over. The other segments are not impaired in any way.

Similarly, the second, then the third, and so on, are recorded (individually), each under the control of the computer time code control. It is, therefore, possible to go back to the original video tape from which each of these programs was dubbed, change anything desired, even a single frame, and re-record the program in its proper position on the 30-program tape. By using different languages, or different complexities of program material, the programs can be altered to suit various audiences. It is also possible to use as many of the programs as desired in one area for a multi-screen presentation with multi-audio and independent cues for each screen.

BLACK BOX

The key device in the system is the "black box" between the video player and the t.v. set. It contains the electronics for feeding the individual signals to the proper t.v. unit, as well as a rapidly rotating magnetic disc which holds the image frame called up by the cue signal on the video tape. There are 30 heads for playback of the images (15 on top, 15 on bottom). If the tape is stopped at any point, the last image recorded on the disc will remain as a still frame on the t.v. screen.

The recording process on the disc is f.m. The images can be recorded and held on the disc, and called up by the cues on the tape.

There are also other versions of the Mark system. A Mark I.5, Mark II, and Mark III are in the works, Mark II for application in the home. This is the place where the system will probably be most appealing to those who wish to learn without going to school. The system is geared to transmit, at 30 times normal speed, all of the material on the tape.

Thus, during off hours, late at night for example, an educational channel could feed a full hour tape over the air. At home, at a designated time, the recorder would operate, and record only the program for which it has been set. Then at some convenient time, the person at home could play the tape at normal speed and have the instructional material he wants. Between midnight and 8 a.m., about 240 different 30-minute lessons can be sent out. These can also be recorded in other locations, such as schools, libraries, industrial offices, etc. The material on the master tape can also be transmitted by standard t.v. stations, cable, or microwave systems, in real time if desired.

COST

A relative cost picture shows that the Mark I runs about $20,000. A popular ¾ in. video machine would run somewhat less, but not when consideration is given to the quantity of units required to do even partially what RTS can do. Just considering print cost for the video cassette, for 30 courses with 30 lessons each (total of 900), there would have to be 900 individual cassettes, compared to only 15 RTS tapes. Although the 1 inch tape costs as much as six times the cassette, the quantity of cassettes needed makes their total cost much higher than using the reel-to-reel recorder. In the final step, equivalent programs would require 4500 cassettes for 150 courses over five years, but only 75 RTS tapes.

The late Dr. Goldmark, developer of RTS, who received his first patent in his teens, held a total of 160. He was instrumental in the development of the l.p. record, and the first practical color (color disc) t.v. system. The Mark system was his last enterprise. He received the Presidental Medal of Science for Development of Educational Technology. Dr. Watson, President of ACCESS, said: "RTS provides a total system which we believe meets effectively the need of people to be able to learn at their own convenience and in the community learning centers away from the main campus". Just what the Dr. (Goldmark) ordered. ■

New Products & Services

POWER AMPLIFIER

● Modularized amplified output stages and front panel clipping indicators are two features of the Model 250C power amp, which delivers 100 watts/channel into 8 ohms with a claimed less than 0.03 per cent i.m. distortion, and 150 watts/channel into 4 ohms at 1 kHz. The unit also contains relay operated delay and speaker protection, front panel gain controls, front panel mounted magnetic circuit breaker, separate chassis and signal grounding rear panel connections for elimination of ground loops, rear panel convertible bridged mono operation slide switch, fail-safe transistors, and plug-in matching input transformer provision with mechanical guard.
Mfr: BGW Systems
Price: $559.00
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COMPACT MICS

● Swedish line of small-size microphones encompasses t.v. and entertainment needs where size is a consideration. The line includes a wireless mic system, an interference tube (shotgun) system, and a complete range of accessories and power supplies for SYMSI 12 and 48 volt system. The condenser mics have a rectangular diaphragm and f.e.t. preamplifiers. Two models have variable pickup patterns. Dynamic, electret, and condenser models are represented in the line.
Mfr: A. B. Pearl (Cara Intl. Ltd.)
Price: $40.00-$1,125.
Circle 51 on Reader Service Card

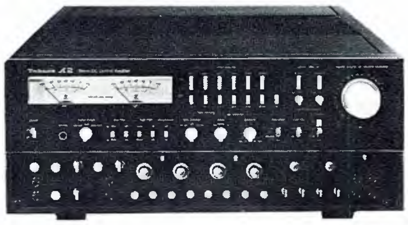
ANALOG PANEL METER

● Solid state 1 μ sec. f.s. analog panel meter APM-4 features a 3 in. scale accurate to 1 per cent, all electronics including zero and f.s. adjust, and over- and under-range indicators. The unit, available in vertical or horizontal design, draws 0.75 watts, available with 14 standard d.c. voltage and ampere ranges. Input impedance is 100k ohms. Lighting one l.e.d. in a row of 100, the device offers excellent visibility except in direct sunlight. Convenient to handle, it measures 4.125 x 0.57 x 3.75 inches. Options include a.c. input signal, center zero, front panel mounting and custom front ends.
Mfr: Bowmar/ALI
Price: $65.00.
Circle 52 on Reader Service Card

HEAD CLEANER KIT

● Lint-free foam swabs used for removing oxide and dirt accumulations from recorder heads, capstans, and guides are included in the QM-85 foam and cleaner kit. The accompanying liquid cleaner is used in conjunction with the swabs to loosen the accumulations. The swabs, non-abrasive and therefore suitable for heavy scrubbing, are reusable. The cleaner is safe for rubber parts.
Mfr: Nortronics Co. Inc.
Circle 53 on Reader Service Card

PREAMP/EQUALIZER



● The functions of a preamplifier and parametric equalizer are combined in Model SU-A2 stereo amplifier. Class A amplifier operation is employed in all stages of the SU-A2, eliminating switching and crossover distortion. Claimed signal/noise ratio is 95 dB at 2.5 mV (107 dB for 10 mV) for MM phono input signals, 80 dB at 100 uV for MC input signals. A d.c. equalizer circuit replaces coupling capacitors. Active thermal servo circuits substantially reduce d.c. drift. The amplifier also features fade-in/fade-out touch switches, a built-in test generator, universal frequency equalizer, rapid response peak meters, variable loudness control designed in accordance with the Flecher-Munson curves, a built-in oscillator, and a toroidal transformer with constant voltage in all power supply stages. There is 10-ganged volume control. The microphone terminal is equipped with switchable input impedance. A separate amplifier for headphones has level control.
Mfr: Technics by Panasonic
Circle 54 on Reader Service Card

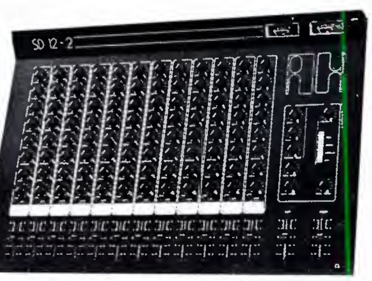
Circle 22 on Reader Service Card

Circle 29 on Reader Service Card

CONDENSER MIC SYSTEM

● A number of elements of the System C microphone setup can be interchanged to fit the application. The system includes two electronic preamplifiers, one for handheld use and one for boom application—the boom preamplifier operates from either phantom or AB remote power. Four interchangeable capsules include omnidirectional, cardioid, hyper-cardioid and Cardiline® shotgun formations. Accessories such as windscreens and shock mounts are available. The mics are made with a proprietary charging process which is claimed to render them as rugged as dynamic mics.
Mfr: Electro-Voice Inc.
Circle 55 on Reader Service Card

COMPACT CONSOLE



● In a unit measuring 20 x 17 x 3½ ins., console SD 12-2 packs 12 low impedance microphone and line inputs, direct channel outputs, mic trim; four band equalizer; cue and echo sends; pan pot and solo on each input. Also, it offers a headphone monitor circuit and illuminated v.u. meters in the output section. The output and monitoring facilities have been designed to adapt to four-track recording.
Mfr: Allen & Heath (Audio Marketing Ltd.)
Price: Under $1,000.00.
Circle 56 on Reader Service Card

Circle 26 on Reader Service Card

INCREMENTAL POWER AMPS

● Five configurations are possible with Model 2200 incremental power system. A 7 in. rack-mount card cage contains up to eight 75-watt power amplifiers, an electronic crossover, a balanced or unbalanced input card, and driver amplifiers with matrix switching for console-like signal processing. The amplifiers can be combined in increments of 75 watts in parallel mode to drive high-power, low-impedance loads; in bridged mode to drive balanced 70-volt lines; parallel/bridged mode to drive high-power balanced 70-volt lines, or other high-power loads. Incremental power enables the system to control high-, mid- and low-frequency loudspeakers with separate power amplifiers; connect far-, middle- and near-throw horns to separate power amplifiers with separate level controls; provide power up to four separate balanced 70-volt systems from a single card-cage main frame; power extremely complex sound systems by combining the abilities of two or more incremental power systems.
Mfr: Altec Sound Products
Circle 57 on Reader Service Card

SPECTRUM MONITOR

● Peak reading real time analyzer Model 142A spectrum monitor, with dual memory, has varied applications in testing, before and after comparisons, analysis, equalization, and calibration. The unit contains a 28 by 11 l.e.d. matrix for the display of 27 one-third octave channels from 40 Hz to 16 kHz plus one broadband channel for overall indication of level. A front panel switch selects display ranges of 10 dB or 30 dB. The input is calibrated in 10 dB steps from −40 dBm to +10 dBm or 50 dBspl to 100 dBspl. Each one-third octave channel is peak reading with a decay time of ½ second.
Mfr: White Instruments, Inc.
Price: $2,500.
Circle 58 on Reader Service Card

DIGITAL PROGRAM TIMER

• Compact digital clock DS-200 utilizes mos i.c. technology, with all-electronic control and a dimmable l.e.d. display. It will automatically turn off a stereo system after allowing it to play for a set time between one and 59 minutes. Unattended recording can be performed with the Nakamichi 1000, 700, and 600 cassette decks through the remote control socket of the deck, or with any cassette deck equipped with automatic self-start. At a pre-set time, DS-200 will turn the system on and will automatically place the deck into the record mode.
Mfr: Nakamichi Research
Price: $145.00.
Circle 59 on Reader Service Card

DUAL TRACE OSCILLOSCOPE

• A continuously variable delay from one μsec. to 5 sec. is featured on LBO-515 dual trace, dual channel 25 MHz bandwidth oscilloscope. The device offers 5mV/Div. vertical sensitivity, permitting a view of the leading edge of a pulse train to determine a subject's characteristics. Features included are a rectangular crt with internal graticule; high accelerating voltage for bright display; selectable synchronization, automatic, normal, single trace and reset modes with high frequency rejection—20 Hz to 10 kHz. Claimed overall accuracy level for automatic trace and reset modes in both channels is ± 3 per cent. The oscillator also includes a beam rotator for stray magnetic field correction; trigger for channels 1 & 2 with a polarity inversion switch for channel 2; a front panel astigmatic control; ten times magnification and a rise time of 14 nanoseconds.
Mfr: Leader Instrument Corp.
Price: Under $1,400.00.
Circle 60 on Reader Service Card

PHONO CARTRIDGE

• Top-of-the-line 530-mp phono cartridge contains a diamond stylus and beryllium cantilever. Individually-calibrated, the device has a direct-coupled transducing system, a patented twin-pivot design. Frequency response is 5 Hz to 20 kHz, ± 1.25 dB. Tracking force range is 0.7 to 1.4 grams and channel separation is nominally 30 dB at 1 kHz, 15 dB at 10 kHz.
Mfr: Micro-Acoustics Corp.
Price: $200.00.
Circle 61 on Reader Service Card

OPEN REEL DECK

● Constant tape tension, regardless of the mode of operation and undisturbed by spool diameter or changes in mode is featured on the SG-630 10½ in. open reel stereo deck. The unit has three-speed operation—1⅞, 3¾, and 7½ in./sec.—and stabilizes tape speed through an Omega loop drive system, which eliminates the pinch roller, drive couplings, springs, and function wheels. The computer-controlled system has a four-motor drive system, including two d.c. fast hub motors, a collectorless electronically regulated motor for the capstan drive, and a servo motor to form the loop. Actual tape speed may be verified with a built-in stroboscope disc, working in conjunction with an accessible speed control. The deck has a built in "Dia-Pilot" for recording signal impulses and an automatic slide projector control for either a single projector or a multi-media show. Other features include a switchable peak level limiter, separate stereo headphone power storage with volume control, separate bass and treble tone controls, a/b monitoring, and remote control facilities. Optional half and quarter-track four head assemblies are available.

Mfr: Uher of America, Inc.
Price: $1,279.
Circle 62 on Reader Service Card

TRIPLE OPTIMIZER

● Three functions are incorporated in audio signal processor Model 221: automatic gain control, compressor, and limiter. The gated gain-riding AGC amplifier compensates for long-term variations in program input levels over a ±10 dB range at a correction rate of 0.5 dB per second. Control over program dynamics is provided by a gated open loop compressor. The peak limiter produces controlled phase inversion and adjustable limiting symmetry for a.m., with a separate 25-/75-μsec high-frequency limiter for f.m.. Claimed response is within 1 dB of flat from 20 Hz to 20 kHz; noise claimed is less than 70 dB below the 100 per cent modulation output level with claimed distortion below 1 per cent t.h.d.

Mfr: Inovonics, Inc.
Price: $760.00.
Circle 63 on Reader Service Card

PULSE CODE MODULATION

● Using a Betamax or similar video cassette as its base, the PCM (pulse code modulation) audio stereo recording-playback system operates through computer technology, to reduce distortion. The device digitally encodes a sound, converting it into on-or-off pulses, processing only the digital pulses. Because the reproduction is not dependent upon the intensity of a magnetized signal, tape saturation at sudden loud peaks is avoided; tape hiss is not picked up by the encoding device. The PCM can record 12 bits of information on each channel with a special circuit capable of squeezing the equivalent of 16 bits per channel onto the tape, producing more than 1.7 million bits per second.

Mfr: Sony Corp.
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Editorial

This issue of **db** takes a long look at the subject of education and audio. As John Woram's lead story points out, our mail box is usually full of letters asking about getting started in audio. Too many beginners think that their eventual success will be directly related to knowing the right people, or getting a certificate that says "official audio expert" on it.

Unfortunately, the "romance of audio" often obscures that fact that the business is not always "party time." As in flying planes, building bridges, practicing medicine or whatever, competency pays off. Without it, you may have some momentary excitement, but your long-term prospects of success are about "100 dB down." So, Mr. Woram takes a general survey of the subject and then we get down to some specifics.

Lest we forget that audio is not always recording, Professor Richard F. Schwartz describes Michigan Technological University's courses in noise control, electroacoustics, and theoretical geophysics. As Mr. Schwartz points out, the study of acoustics is ". . . very much alive and vigorous." And it's yet another aspect of the world of audio, as any sound reinforcement team will readily agree.

Meanwhile, for those who are thinking about a career in recording, Irv Diehl outlines a four-point program of study. Diehl, a co-founder of the highly-respected Institute of Audio Research, bases his observations on the time-tested program offered at the Institute. However, his notes should apply as well to any school that offers a meaningful educational program in this area.

We note with interest that New York University now offers a degree program in Music, Business and Technology, in cooperation with the Institute of Audio Research. Recording-oriented students may receive up to 26 points toward their NYU degree by registering for the IAR's courses.

Our education section concludes with a brief look at Music Engineering Technology, as offered at the University of Miami. As we see it, the curriculum represents an ideal "mixdown" of music and technology. Space does not allow us to describe each course in detail, so write directly to Miami for more information.

And don't forget to do your homework! *L.Z.*

JOHN WORAM

In Search of an Education

As in everything else, results are proportional to input.

Dear db;
Where do I go to learn about audio?
Yours truly,
Faithful Reader

Although the above may not quite be a word-for-word reproduction of a recent letter, it does sum up—in ten words or less—an impressive amount of our weekly mail.

Usually—in fact, always—the letters are much longer, and the writer supplies some background information—previous education, interests, goals and such. And then there are the inevitable questions, related to the writer's particular interests.

Unfortunately, the questions are usually simple enough, but the answers never are. In fact, without some sort of one-to-one confrontation, it's just about impossible to offer "*the* answer" to any of these inquiries. For one things, we don't really know the writer. If we did, *we* would ask:

How much time (and money) do you have available?
What sort of background (musical, technical, both, neither) do you already have?
Are you *really* looking for an education, or a short cut into "show biz"?
And, so on.

But even if we had the answers to all these questions, we still have the disadvantage of not knowing more about the various places that now offer education in audio. For it seems that hardly a day goes by without the arrival of another brochure, announcing the creation of a brand new "Audio University."

"YOU CAN'T TELL A BOOK BY IT'S COVER"

Just under that tired old cliché is another one that says. "You can't tell a school by its catalog," and that's our problem. Some of these announcements appear to be almost fraudulent—others look quite legitimate. But that's just the catalog. Does the same thing apply to the school itself?

One claims it has a "special arrangement" with the Audio Engineering Society (it doesn't), and that its founder is a charter member of that Society (he isn't). Another outfit awards its graduates a certificate which is "an authorization . . . to work as a recording engineer." In New York City, that certificate, plus fifty cents, will get you a free ride on any subway. Enough said?

Perhaps these preposterous statements are merely the work of over-zealous copy writers, and the schools are quite legitimate. But, who knows? Perhaps they are counting on the gullability of the beginner, who may be taken in by the air of respectability of these statements. So, although we know of the existence of these places, can we in good conscience recommend them? Obviously not—we just don't know enough about what really goes on there.

So, where does that leave the would-be student, in search of an education? Or us, for that matter? Perhaps we should stop right here, tell the writer to find his own answers, and leave us out of it. That's safe, but not satisfactory. (Besides, we'd get a lot of subscription cancellations, and we certainly don't want that!)

As an alternative, we'll offer an overview of the education scene as it look from here and hope that this will assist each writer to make his own decision, based on what he knows about himself and his own particular requirements.

WHAT DO I NEED TO KNOW?

First, that when it comes to audio, sound recording is not the "only game in town." Although most of our readers express a particular interest in this aspect of audio, there are many other fields that might be considered—all the way from sound reinforcement to psycho-acoustics. Obviously, the more "theoretical" the field, the more an academic background becomes important. In some areas, common sense is worth more than college credits; in others, a degree is an absolute must.

WHAT ABOUT THE RECORDING STUDIO?

It's a pretty safe bet that most of today's successful recording engineers do not have academic degrees. But that's today. By tomorrow, who knows? Even within the relatively-small recording studio industry, the technology grows more complex almost daily. It is no longer enough to have a little manual dexterity and a musical ear. Some years ago, a bit of technical background may have been of little consequence. Now, it's a distinct advantage. A few years more and it may have become an absolute necessity.

Anyone who has seen an automated console or a digital tape recorder will know that the more education he can get the better off he will be to cope with the demands of tomorrow's recording studio. As for the precise amount of education that's necessary, that depends on you. If you're looking for "instant entry into the glamorous world of recording," a minimal education will be more than enough. Get involved with the right group of musicians and if you (and they) are lucky, they will make a hit record while you are sitting behind the console. People will ask you how you got such a great drum sound, and you will tell them you always add +8 at 3 kHz (or was it +3 at 8 kHz?), and use a modified super-omni located 3 cm. under the drummer's seat. Sooner or later, the group will fade from view, and so will you. You will have had your moment of fame, but now it's someone else's turn, and you're left reading the want ads.

If that's not enough for you, you'll need to put a little more effort into your education, but you'll eventually get a lot more reward. You might even find a life-long career in audio, rather than just a few moments to remember as you pump gas.

But that brings us back 'round again to the dilemma of selecting the right place to seek out an education.

CHOOSING A SCHOOL

As a general rule, be especially cautious in evaluating recording studios that transform themselves into recording schools during idle time. Such places may give you a good education, but the odds are against it. If you want a real education, you'll have to find a real school somewhere, just like everyone else in the real world does. Audio—even in the recording studio—is a science, not a game. That means hitting the books, not "learn while you play." Watching an engineer demonstrate how he twiddled the knobs on his last session may be fascinating, but it's no education. In other words, make sure your tuition goes for something more substantial than a guided tour through studio land, unless that's all you really want. If it is all you really want, be prepared for the consequences later on.

Of course, it may be next-to-impossible to determine the validity of a recording studio/school until it's too late. Some are capitalizing on the "glamour" of the recording studio mystique; others may actually imagine they are performing a worthwhile service. Still others are legitimate in every sense of the word. But unfortunately you can't distinguish one from the other by reading the brochures. So, unless you already know the reputation of the outfit, ask to "sit in" on a class or two. Talk to the students. If they can tell a volume unit from a decibel and offer a passable explanation of bias, you're reasonably safe. On the other hand, if they're too busy adding 3 kHz to the snare drum, you've stumbled into the wrong place. Get out and keep looking.

WHAT ABOUT COLLEGE?

At the other end of the academic ladder, many four-year colleges now offer courses in audio. As may be expected, these come in a variety of formats. Some offer a sequence of courses to introduce audio to students majoring in television, film, music or business administration. Others go into greater detail, preparing the student for a career directly related to audio. If you are thinking about college, make sure the college you are thinking about really offers the audio program that makes sense for you. Here, a little "comparison shopping" is in order. Study the catalogs of at least a few schools before making a decision.

POST-GRADUATION EDUCATION

Remember that a major part of your education will come *after* you get a job. This is the time to apply your "book learning" to the realities of making a living in audio. But regardless of the amount of schooling you have acquired, don't expect to start at the top (unless you open your own business). You'll start at the bottom, just like everyone else. However, you'll have the advantage of being better prepared to grow with the job and eventually work your way to the top.

And whether "the top" means engineering hit records, designing studios, or installing sound reinforcement systems, a good education will help you get there faster. And stay longer. ■

Circle 30 on Reader Service Card

IRWIN DIEHL

Sound Recording Training

A well-balanced classroom/laboratory/workshop technical school program prepares a student for apprenticeship in a professional studio.

As THE 60's drew to a close, it became apparent that some sort of thorough, but concise, training program for professional sound recording was fast becoming a necessity. This was the period of the dawn of multi-track recording. Innovations in technology and technique were becoming more and more frequent. In the control room, sophistication and complexity increased at such a rate that, if you weren't there at the beginning, your attempts to keep abreast of the technology might leave you breathless, and a little bit confounded by the experience.

Individuals wishing to enter the field as beginners found the going much rougher than expected. Many who were hired found it impossible to acquire the necessary technical background in the studio between sessions. The atmosphere was neither conducive to the growth of studio business nor very gratifying to the individual who had dreamed of working in a professional studio, and then discovered frustration and disappointment, once given "the big break."

People began asking, "What do I have to know to begin a career in sound recording? How does one go about preparing for that 'big break'?"

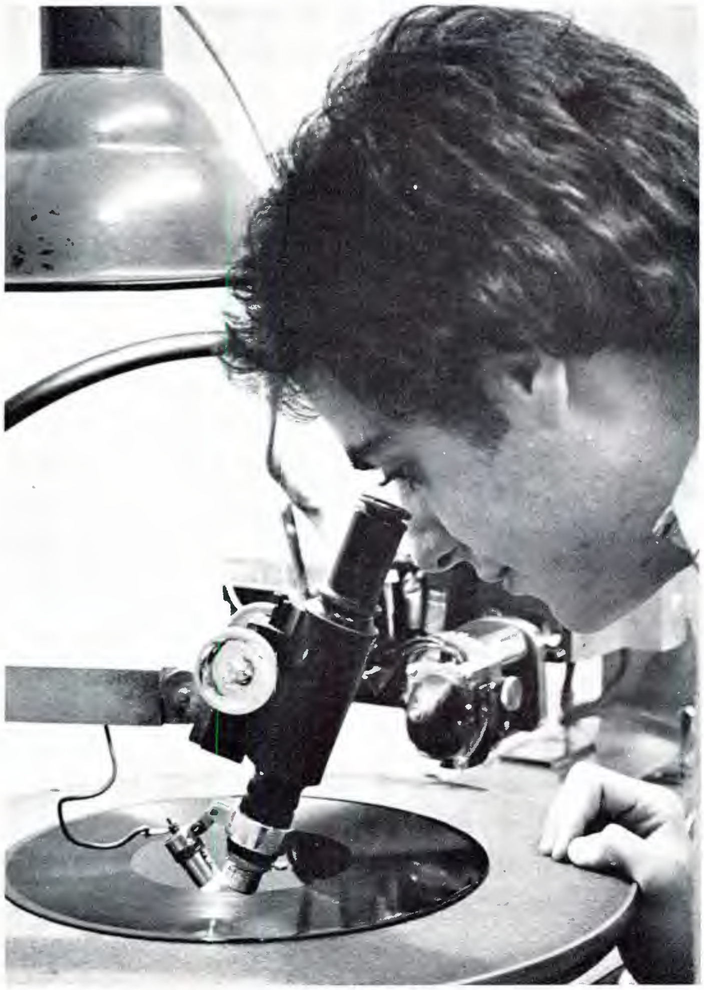
Many disciplines come together in the studio environment, including electronics, physics, mechanics, music—even psychology—to name but a few of the more obvious. The beginner must be ready to cope with all of these if he is to eventually progress into the responsibilities of full-time recording. The following outlines a typical solid training program.

CLASSROOM STUDIES

A thorough study program will consist of three, and ideally four, types of training. First is the conventional classroom lecture, which is the foundation of the complete program. For, given an opportunity later on to observe or participate in studio operations, the student cannot hope to benefit unless he has acquired some rudiments of electrical technology, the physics of sound, and equipment performance characteristics. The ideal atmosphere for study of these topics is of course the classroom.

IAR students work in lab teams to assist one another with predetermined laboratory procedures.

Irwin Diehl is co-founder and Dean of Administration at the Institute of Audio Research, 64 University Pl. New York, N.Y.



A student inspects freshly recorded grooves in the school's disc recording lab.

Another student critically positions an AKG 414 above a guitar amplifier.

THE LABORATORY

But this type of training in itself is not sufficient; it must be integrated with laboratory training. The laboratory is defined as a training environment comprised of the various professional systems and devices that one may expect to find in today's modern recording studio. Unlike those occurring in the studio, the experiences confronting the student in the laboratory will be carefully prepared and directed to reinforce key aspects of the classroom lecture.

These two types of training are the essence of a program that will provide a thorough development in technical principles as well as individual application of these principles to professional systems and equipment. A training program consisting of only these two types of training may be reasonably effective in preparing an individual for entry level assignments in professional sound recording. But a third type of training is the "icing" in a sense. This type is referred to as the Workshop.

THE STUDIO WORKSHOP

Workshops may begin near the end of the training program, after substantial development of the fundamentals of recording technology has been accomplished. The workshop will allow the student to perform "under fire," even if it is only a simulated attack. Such a workshop may be conducted in a commercial multi-track recording studio where small groups of students have an opportunity to work with skilled musicians, conducting the multi-track sessions and acquiring at first hand some insight into directing and managing a recording session. This type of workshop combines earlier classroom theory with laboratory experiments, thereby becoming a kind of final exam, while at the same time introducing the student to the real world of recording.

ON-THE-JOB TRAINING

Once the student has developed the essential technical understanding and has had the opportunity to acquire proofs of laboratory and workshop theories, he may begin his internship or apprenticeship in a studio. And now, the fourth type of training—as essential as the previous three —begins. It is important to realize that the knowledge gained from this type of training cannot be supplanted by any of the former types. Though the student may have gained some technical proficiency during his formal training period, he is generally lacking in artistic judgment, if only through lack of real on-the-job experiences. For as difficult as it would be for even the most knowledgeable recording engineer to offer a between-sessions explanation of hysteresis loops as they relate to magnetic recording, so it is difficult within the school environment to "teach" the rapport that must prevail between engineer and artist or the important aspects of good production, to say nothing of something as illusive, yet vital, as "good vibes." So, this fourth part of the complete education program is really on-the-job training in the *art* of recording. It is obviously separate from formal school training, and dependent on the student eventually securing a job in a studio.

LEARNING ENVIRONMENT

In what type of environment should these various stages of training take place? Of course, classroom training prop-

The intricacies of a patch bay are learned as a student works in signal processing equipment while the studio is readied in the background.

Drummer Paul Morgan of The Invisible Man *tunes up his set, while a student engineer "tunes up" the mics.*

erly belongs in the classroom, free from the distractions of laboratory or studio. Laboratory sessions require a studio-like facility, and *could* be conducted in an actual studio, though this is not recommended. A recording studio's business is recording, and systems are designed and laid out for this purpose alone. Many important principles may be obscured, or totally concealed from the student by systems which are intended to meet the needs of commercial recording. To cite an obvious example, presumably the commercial studio has already worked out all the equipment interface problems, so that the equipment is pretty much ready to use, as is. On the other hand, in the laboratory the student must work out these problems as he proceeds with his work, and in so doing, gains much valuable knowledge.

Furthermore, at this critical stage in the student's training, it is important that the academic integrity of the training program be maintained at all times. Activities having ends other than the actual training of the student should not intrude upon this training. Later on, as the student's formal education proceeds, workshops may out of necessity be conducted at a commercial studio. But even here, it should be kept in mind that the student and his school are the clients and the session is to be conducted solely for the purposes of learning. At this point in time, the studio becomes an extension of the classroom/laboratory. Real life working experiences will come later on after employment—the learning period continues long after school is over.

A program such as described here, consisting of classroom laboratory and workshop studies is presently available at the Institute of Audio Research, and has been in operation for some years. The IAR program consists of 405 course hours, and requires about twelve months to complete. ■

RICHARD F. SCHWARTZ

Acoustical Education at MTU

FOR MANY YEARS, most traditional engineering curricula included acoustics as a separate and distinct field. Mechanical engineers viewed it as a special branch of dynamics. The electrical engineer tended to relegate it to the position of a topic within Communications Engineering. Physicists regarded acoustics as a part of classical physics, certainly less exciting than either solid-state or high energy physics.

There were, of course, always those few who specialized in acoustical problems, often people from mechanical engineering, electrical engineering, physics, and elsewhere. But it was not until well after World War II that acoustics became recognized as a field that represented big successes and big failures in technical society.

The war itself gave rise to sonar and many other acoustic-related applications. Then the jet age came along, to dramatize the importance of noise in community planning. Suddenly we became aware of the noise environment in which we work and live. The OSHA office was born.

Meanwhile, the hi-fi industry became big business, with manufacturers scrambling over one another to develop products with greater frequency response, less distortion, more power, and various other attractive characteristics. As recordings were made of live artists in concert, we became aware of the acoustical defects of some modern auditoria when compared with some of the traditional performance halls. The musical instrument industry was revitalized by the application of science to the study of wind, string, and percussion instruments. The electronic organ reached fruition and the synthesizer emerged.

As the role of acoustics emerged from its pre-war dormancy, it was not universally accompanied by bold new curricular innovations. But a gradual increase in professional society interest encouraged a renaissance of acoustics. Professional interest groups in the IEEE and ASEE developed and grew, and new societies, such as the Audio Engineering Society and the Catgut Acoustical Society joined those already in existence.

In 1978, we find acoustics very much alive and vigorous. Musical acoustics courses are given at a number of universities. Vibration and noise control engineering are offered as part of many mechanical engineering programs and electroacoustic courses have appeared or reappeared in several electrical engineering curricula. Sound technology also can be studied at a number of special institutes.

At Michigan Technological University, there are presently five courses dealing with acoustics. These are:

NOISE CONTROL ENGINEERING

Both theory and practice are emphasized in this course, which introduces the student to the analysis and measurement of sound and vibration as applied to noise control. The basic concepts of vibration and acoustic theory are developed and a variety of sound and vibration measuring equipment is used in laboratory experiments. The student works on team projects analyzing some actual noise problems. Special topics from the current literature in acoustics and noise control are presented.

NOISE CONTROL ENGINEERING II

In-depth treatment of the practical aspects of noise control as applied to products, machinery, buildings, vehicles, and other systems. Topics covered include: sound propagation, sound in small and large enclosures, design of enclosures and ducts, muffler design, vibration, isolation, and damping, field and laboratory measurement and analysis of sound, vibration, and shock. Laboratory sessions emphasize measurement and analysis of noise and vibration data. Special topics from the current literature in acoustics and noise control are presented.

ELECTROACOUSTICS I

A survey course in the application of electricity to the field of acoustics with particular emphasis on music and speech. Topics covered are: review of the nature of sound, modes of vibration, wave forms and harmonics, transducers, amplification and processing, noise and distortion, sound recording and reproduction, electronic music production.

ELECTROACOUSTICS II

A detailed look at several areas of electroacoustics. Topics include transducer theory and design, theory of sound recording, signal processing techniques, introduction to ultrasonics.

INTRODUCTION TO THEORETICAL GEOPHYSICS

A comprehensive treatment of the propagation of disturbances through compressible and incompressible fluids and through deformable solid bodies.

NOISE/VIBRATION CONTROL

The Noise Control courses were introduced at about the same time that several research projects began, concerning noise and vibration control in industry. In connection with this work, facilities were acquired, including an anechoic chamber, a reverberant room, and equipment for sound-level measurements and analysis.

The first Electroacoustics course is a survey, open to any student. A course of this sort normally begins with establishing notions about vibrations and waves. From the physical picture developed, the course proceeds to the subjective aspects of sound, such as loudness, pitch, and tone quality. This leads to a discussion of the physiology of the ear and the extent to which psychology enters the hearing process. Noise and its effects are mentioned, even though detailed courses may be available on this subject elsewhere on the campus. The relationship of all of

Richard F. Schwartz is a professor and head of the Department of Electrical Engineering, College of Engineering, Michigan Technological University, in Houghton, Michigan.

these ideas to music can be brought out easily by demonstration and discussion. Consonance and dissonance, intervals, and harmonics lead to a discussion of temperament and scales.

At this point, the emphasis shifts to a discussion of amplifiers, loudspeakers, microphones, sound recording, and musical synthesis. Electronics is kept to a "black box" descriptive level, but details about how loudspeakers, microphones, recorders, phonograph pickups, and other devices work are presented. Understanding of decibels, distortion, gain, power output, stereo separation, etc. is promoted by demanding accurate word definitions of these terms. A suitable examination question might ask for an explanation of the specifications on a consumer product such as a tape recorder. The final topic of musical synthesis always interests students because it illustrates how much we know about making music and yet, how imperfect we are in imitating or improving upon conventional instruments.

Unfortunately, no textbook at the proper level exists. Books on "hi-fi" are usually aimed at hobbyists and are sufficiently imprecise in their language so as to be inappropriate for a college-level course. Specialized books on microphones, loudspeakers, and tape recorders exist but are too narrow to use for this course. On the other hand, available textbooks on electroacoustics are highly technical and not in consonance with the aim of surveying the field. Consequently, this course is taught from notes which probably will eventually become a textbook.

In the second electroacoustics course, coverage is greater in depth and less in scope. Detailed solutions and discussion of the wave equations are covered, and analysis in some depth of loudspeakers and microphones is attempted. The book used is Kinsler and Frey, *Fundamentals of Acoustics*. Typically, laboratory work is equally divided between learning how to make acoustic or electroacoustic measurements, and projects, such as the design of a loudspeaker enclosure. This laboratory is supported by a wide range of equipment.

TEACHING AND RESEARCH

What we see emerging is a strong program of teaching and research. Students entering the engineering courses often have strong interests in sound reproduction. Some are amateur musicians or hi-fi buffs. Interest has also been expressed by the Humanities Department, whose theater group has recognized the emergence of a new specialty called "technical theater." People in this field require a wide range of skills in sound, lighting, structures, and mechanisms. Following this interest, the Humanities, Mechanical Engineering, and Electrical Engineering departments have worked out a dual-degree program leading to a B. A. and a B.S.E. with a flavor of either M.E. or E.E.

Michigan Technological University has recognized the universal importance of sound to human activities and has developed offerings in several department. The offerings are diverse enough so that minimal overlap occurs. The laboratory facilities are complementary and are also available for research projects. Students with the proper background can take these courses regardless of their degree intent. However, recognizing that perhaps a new breed of technically-minded arts people are emerging, a dual-degree program aimed at technical theater has been developed.

We conclude that the subject of acoustics is now very much alive, and that its application to various fields is such that a reasonable number of students can be attracted to appropriate courses. ■

Circle 17 on Reader Service Card

HAZEL KRANTZ

Music and Engineering: One Educational Package

Intense training in both music and audio engineering is offered to the ambitious student.

THOSE WHO DREAM of the perfect recording situation sometimes go beyond the magic of technical aids, to the human element. Their ideal engineer would not only be a paragon of technical expertise, but versed in professional engineering and—not as an afterthought, but very important—a knowledgeable musician who would be able to comprehend and interpret the subtleties of the performing artist. In fact, these super people are not impossible to find. At **db**, where we often get queries from young people who are interested in getting into recording, from time to time we come across a person, usually from a musical background, who is interested in developing these combined talents. In Europe, such double training has been going on for some time, creating individuals known as "Tonmeisters," literally, masters of audio.

Recently a school offering this intensive training has been established in conjunction with the School of Music at the University of Miami at Coral Gables, offering a degree of Bachelor of Music in Music Engineering Technology. The curriculum was designed in cooperation with sixteen nationally known experts in the audio industry.

The Music Engineering Technology program is interdisciplinary, including courses in music, electrical engineering, physics, math, communications, psychology, and business. Freshman students are required to enroll in calculus, which carries a prerequisite of trigonometry and analytic geometry. Prospective students are expected to have a strong background in both math and music. This is not a watered-down program, but something offered to the superior student—sometimes we forget that we're still producing individuals attuned to excellence.

The four year program includes two years of basic music theory, one year of advanced music theory, including orchestration and arranging, three years of principal instrument study, two semesters of music literature and history, two years of secondary piano, four semesters of electrical engineering, two semesters of calculus, two semesters of psychology, two semesters of business courses, two semesters of communications, a year of music merchandising including the study of copyright practices, and courses in physics, sound synthesis, and acoustics. The final semester includes either an internship with a professional recording studio or an additional semester of full-time study in approved electives to be chosen from electrical engineering, business, and music. Throughout the course, the student's time is divided between academic work and practical experience.

Advanced courses in sound reinforcement and audio recording are taught in a 16-track professional recording studio operated by the University, under the supervision of Bill Porter, Director of Recording Services for the School of Music, assisted by Kenneth Pohlmann. Equipment in the control room includes a MCI mixing control board with an input and output complement of 24 channels, equipped with complete monitor mixing facilities for quad, stereo, and mono recording and playback. Other machines include MCI 16-, 4-, and 2-track machines, as well as quarter-track quad, stereo, and cassette machines by TEAC, Revox, and Nakamichi. Control room monitoring functions through Crown amplifiers and JBL loudspeakers.

In specific detail, the following lists the courses offered:

FRESHMAN YEAR

1st Semester	2nd Semester
Music Theory I	Music Theory II
Music Theory Lab I	Music Theory Lab II
Prin. Instr. or Voice	Prin. Instr. or Voice
Piano or Secondary Inst.	Piano or Secondary Instr.
Recording Workshop	Recording Workshop
Ensemble	Ensemble
English Composition	English Composition
Calculus I	Calculus II
Physics of Music	Electrical Circuits I

SOPHOMORE YEAR

1st Semester	2nd Semester
Music Theory III	Music Theory IV
Music Lab III	Prin. Instr. or Voice
Prin. Instr. or Voice	Jazz Piano
Jazz Piano	Recording Workshop
Recording Workshop	Ensemble
Gen. Prin. of Psychology	Acoustics
Electrical Circuits II	Audio Recording
Elec. Circuit Lab II	Electronic Circuits
Survey of Broadcasting	Electronic Media Wkshop

JUNIOR YEAR

1st Semester	2nd Semester
Orchestration	Sound Synthesis
Music Publishing	Music Lit. II
Prin. Instr. or Voice	Music Merchandising
Recording Workshop	Prin. Instr. or Voice
Basic Conducting	Recording Workshop
Ensemble	Ensemble
Electronic Circuits II	Marketing
Elec. Circuits Lab I	Rec. Studio Equipment
Audio Eng: Mic & Mixing	

SENIOR YEAR

1st Semester	2nd Semester
Modern Arranging	Internship or courses in electrical engineering, business and music.
Evolution of Jazz	
Adv. Audio Recording	
Recording Wkshp.	
Ensemble	
Bus. or Elec. Eng. Elective	
Psychology	

For further information regarding the program at the University of Miami, contact: Mr. Bill Porter, Director of Recording Services, School of Music, P.O. Box 248165, University of Miami, Coral Gables, Fla. 33124. ■

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SPECTRASONICS custom console, 16 x 16, rotary pots, good quiet board, $8,000. 16-track Scully 100, perfect condition, remote and custom meter panel, $11,500. $17,500 takes both. Eventide phasor, make offer. **Fifth Floor Recording, (513) 651-1871.**

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EVENTIDE OMNIPRESSORS, 2 @ $350 ea. formerly $700, w/bal. in-out; Eventide instant phaser, $350, was $600 w/ bal. in-out; Binsen echo rec, $350, was $700, inc. frt.—or complete package, $1,300, three years old, hardly used. **Sweetbay Studio, 1317 Jackson Bluff Rd., Tallahassee, Fla. 32304.**

TWO 16-TRACK MM1000 with 8-track heads; one 3M Model 59 16-track with 8-track heads; two Ampex d.c. servo motors for 440, no electronics; one pre-wired Westlake monitor rack; assorted empty P.A. cabinets. **Michael Guthrie, day (914) 679-7303, night (914) 679-8900.**

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New Products & Services

• **Larry LeKashman** has rejoined **Electro-Voice** of Buchanan, Mich. after six years, returning to his post of vice president of marketing. During the interim, Mr. LeKashman had been occupied in executive responsibilities in two large distributor organizations.

• **Roger Ponto,** formerly national sales manager for **Shure Bros., Inc.** has joined **Freehart & Sullivan, Inc.** of Seattle, Wash. as a vice president. Mr. Ponto's responsibilities will center mainly on marketing and sales promotional activities.

• The introduction, application, and sales of all t.v. test equipment coming from **Philips Test & Measuring Instruments, Inc.** of Mahway, N.J. to outlets in the U.S. and Canada is now the responsibility of newly appointed Bob Grassi. **Mr. Grassi** comes to Philips from **Panasonic.**

• Aiming to increase concentration in the industrial intercom market, **Edward M. Fitzgerald** has assumed the post of national sales manager for **Clear-Com Intercom Systems,** of San Francisco. Before coming to Clear-Com last spring, Mr. Fitzgerald was with **Telex Communications.**

• **RCS Audio International, Inc..** has moved to a new address: 1314 34th St. N.W., Washington, D.C. 20007. All correspondence should be sent to the above; shipping and receiving remains at 1055 Thomas Jefferson St. N.W., Washington, D.C.

• Responsibility for hi-fi marketing at **Sony Corporation** of New York City, has been assigned to newly appointed **Frank J. Leonardi.** Mr. Leonardi's experience with stereo stems from his previous position, national sales manager for **Panasonic** equipment.

• Coordinating the activities of regional sales managers in the U.S., **Ewald Consen** has commenced his new position as field sales manager for **James B. Lansing Sound, Inc.** of Northridge, Ca. Mr. Consen has come up through the ranks at JBL, his association dating back to 1970.

• A Digital Audio Standards Committee was formed at the November A.E.S. convention to establish communication among the manufacturers and users of digital audio systems for all applications, and to discuss the standardization problems and possibilities. The committee is a joint effort of the **Audio Engineering Society,** the Joint Committee on Inter-Society Coordination of the **Electronic Industries Association,** the **Institute of Electrical and Electronics Engineers,** the **National Cable Television Association,** the **National Association of Broadcasters,** and the **Society of Motion Picture and Television Engineers.** At a meeting on December 1, 1977, the committee discussed analog-to-digital conversion with a general consensus that a 16-bit system is desirable. The next meeting will be Feb. 1, 2 at the Sheraton Hotel, Atlanta, Ga. Contact: **John G. McKnight, Magnetic Reference Laboratory,** 229 Polaris Ave., Suite A, Mountain View, Ca. 94043. (415) 965-8187.

• Responsibility for admissions procedures for the **Audio Engineering Society** is in the hands of newly elected **Howard Durbin.** Mr. Durbin is vice president for engineering at **James B. Lansing Sound, Inc.** of Northridge, California.

• The appointment of **Howard Krivoy** as sales promotion supervisor at **Pioneer Electronics of America** of Long Beach, Ca. has been announced. Mr. Krivoy had been a technical editor at **J.B.L.** and had also been associated with **Raynolds-Bauker & Associates** advertising agency.

• A group headed by **Joseph Schlig** has purchased **Bozak, Inc.** of Darien, Conn. Mr. Schlig will serve as president of the new firm. **Rudolph T. Bozak** will continue his association, as assistant to the president. **Robert Blumberg** has been appointed to the post of sales director.

• The **Morris F. Taylor Co.** has moved to the ORI Professional Building in Silver Spring, Maryland. Their telephone number is (301) 589-4002.

• Dallas f.m. broadcasting station, **KOAX** is planning to move their studios to the Reunion Tower, a new building in downtown Dallas. The studios will be on the observation-deck level in an all-glass setting, and open to visitors. The entire installation will permit total control by one operator fom the central console location. The station is owned by **Metroplex Communications** of Cleveland, Ohio.

• **Peter P. Ruese** has been appointed general manager of **IGM,** of Bellingham, Washington. Mr. Ruese has been with the company since 1968. He formerly served as production mgr.

• **J. Frank Leach,** president of **Arcata National Corporation** of Menlo Park, Ca. has been elected to the board of directors of the **Ampex Corporation.** Mr. Leach replaces **A. E. Ponting,** who recently resigned. Mr. Leach served as chief executive officer of the **Electronic Industries Association** from 1971 to 1972, and has had most of his experience with the automobile industry, at the **Ford Motor Company** and **Studebaker Packard.**

• The position of national sales manager at **University Sound** of Anaheim, Ca. has been filled by **Ron Means.** Mr. Means has been promoted from the position of field representative and district manufacturer. He will coordinate manufacturer's reps in the U.S. and Canada.

• **Hazeltine Corporation** of Greenlawn, N.Y. has acquired an exclusive license under all patents and patent applications of **Leonard R. Kahn** covering the a.m. stereo broadcast transmission system and receivers which Mr. Kahn has developed. Mr. Kahn's firm, **Kahn Communications Inc.** has petitioned the FCC to adopt standards for compatible a.m. stereo broadcasting which would permit implementation of the Kahn system, and has been granted a license by Hazeltine for the manufacture and sale of broadcast transmission equipment for the Kahn system.

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