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## coming next month

● In January we go down the winding trail of disc-mastering. First, we shall see how Capitol-Audio Devices makes acetates and presses them into discs at their Winchester, Va. facility. It's quite a procedure.

● Next, we shall have a look at a disc-mastering facility in beautiful downtown Burbank — Kendun Recorders — where some of the best masters have been cut by impresario Kent Duncan.

● And if all you know about CD-4 cutting is what was published a few years ago (and those monstrous racks that were then needed), you will be interested to see, via John Eargle's illuminating article, just how the hardware has shrunk while the technology has expanded.



THE SOUND ENGINEERING MAGAZINE

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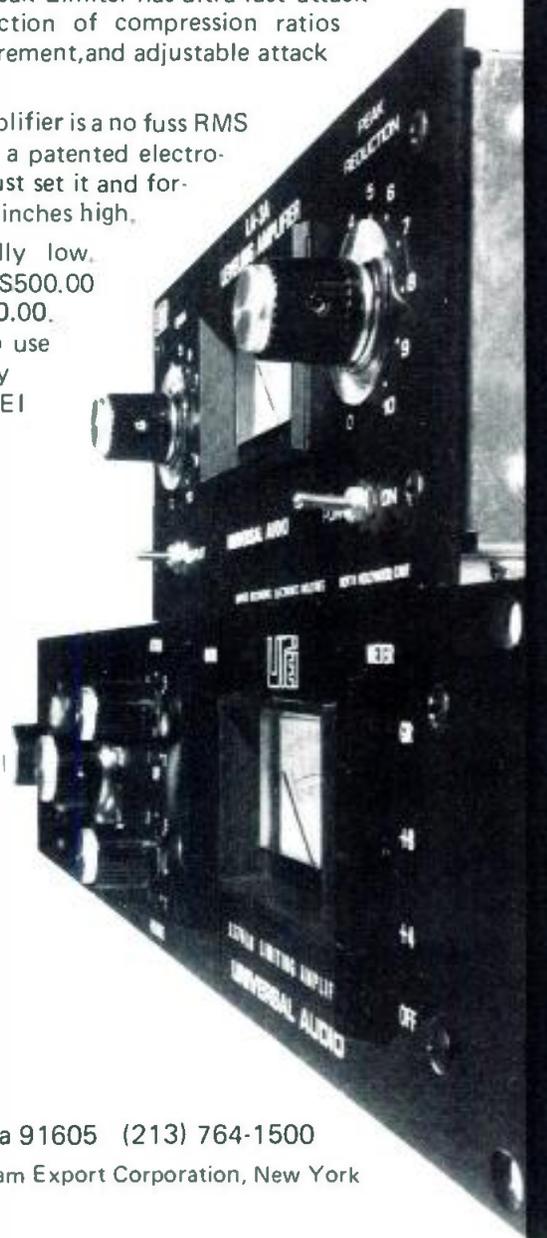
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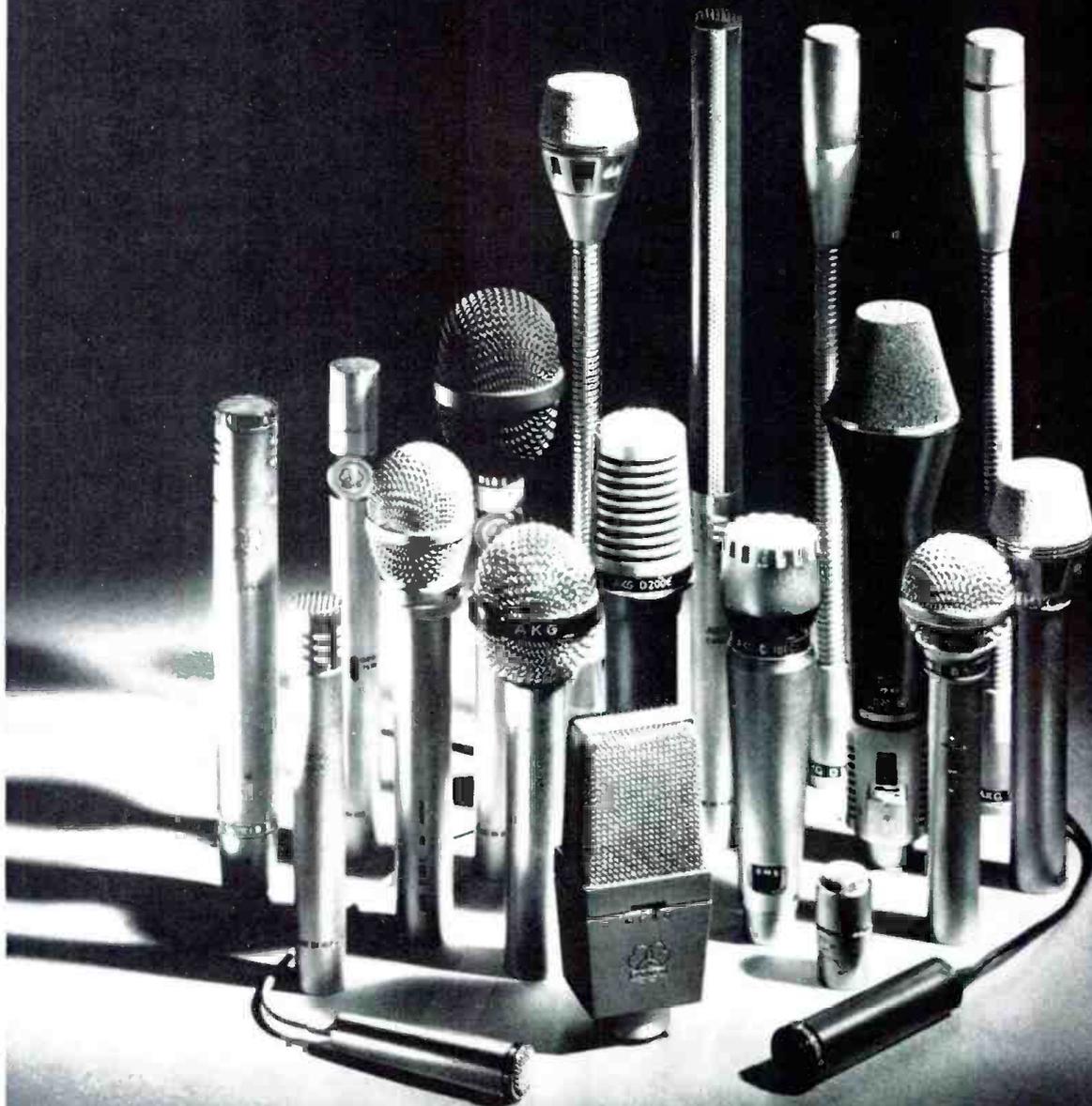
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## db letters

### THE EDITOR:

Thank you for a highly useful article on preamp design by R. S. Mintz. I would like to ask Mr. Mintz some questions pertaining to my application of his design. The first deals with the stated operating voltage (+40 V). I have checked the data on the LM-381A and noticed it can be operated anywhere from +9 to +40 V. If I were to operate it at 10 V, would I lose out on its noise and output advantages at +40 V? Secondly, used in a mixer for film sound, would it be possible to use both sections of the preamp as separate mic inputs or is the isolation of 60 dB too small to figure for safe separation?

DANNY MICHAEL  
New York, N.Y.

### R. S. Mintz replies:

You can modify my design so that it will operate from other supply voltages. The formulae are contained in the National publication, *Linear Applications*, available for \$1.00 from National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, Ca. I chose 40 volts because that would provide the maximum output voltage without clipping. Use of a lower supply voltage would limit the output voltage swing to about two volts less than the supply voltage. I believe 60 dB separation between channels would be sufficient for your application.

### THE EDITOR:

The following errors have been discovered in the article, "A Simple and Superior Microphone Preamplifier," by R. S. Mintz, which appeared in the September, 1975 issue of *db*.

On page 28 in FIGURE 1, the emitter of Q11 should be connected to a second collector lead of Q12. As drawn, it appears that the base and emitter leads of Q11 are connected together. In the same figure, the base of Q5 should connect to the emitter of Q4.

On page 29, in FIGURE 2,  $R_1$  should really be 3,900 ohms, as the vu meter is driven by a low impedance source in this circuit rather than by a 600-ohm source loaded with a 600-ohm load.

The significant error in the article is a repetition of the same error appearing in "Noise Considerations in Audio Amplifiers," which appeared in the October, 1974 issue of *db*. Both articles treat the amplifier's source

resistance  $R_s$  as the coil resistance of the secondary of the input transformer. This is incorrect. The total source resistance presented to the amplifier must also include the effects of primary coil resistance and the resistance of the source (such as the microphone) that is connected to the transformer primary. If transformer inductance and core loss is neglected,  $R_s = (R + R_{pri}) \times a^2 + R_{sec}$ , where  $R$  is the resistive source connected to the primary,  $R_{pri}$  and  $R_{sec}$  are coil resistances of the primary and secondary, respectively, and the turns ratio of the transformer is 1:a. Note that the resistances on the primary side are transformed to the secondary side by the square of the turns ratio. This total value of  $R_s$  is the noise source for the LM381A.

The total equivalent input noise of the preamplifier circuit is not -130 dBV as stated in the article. In order to calculate the correct value, the proper value of  $R_s$  must be calculated. For a 1:1 transformer as used in the article,  $a = 1$ . The article states that  $R_{sec} = 80$  ohms, and thus, it is likely that  $R_{pri} = 80$  ohms also. If the preamplifier is connected to a typical low impedance microphone, the microphone impedance will likely be about 200 ohms. Using these values,  $R_s = (200 + 80) \times 1^2 + 80 = 360$  ohms.

The equivalent input noise for the microphone-transformer-preamplifier system can now be calculated by

$$E_T = \sqrt{[e_n^2 + (i_n R_s)^2 + 4kTR_s]} \\ = 5.46 \times 10^{-7} V = -125 \text{ dBV}$$

This calculation assumes a temperature of 20 degrees C. and a noise bandwidth of 20 kHz, and follows the method presented by J. Byerly in the AN-70 Application Note for the LM381A by National Semiconductor Corporation.

Mr. Mintz' article states that ". . . improvement of 20 dBV over this value could be achieved by an ideal input transformer with a gain of ten." This is incorrect. The microphone's coil resistance of 200 ohms will yield an equivalent input noise of  $2.54 \times 10^{-7} V = -131.9$  dBV with no transformer or LM381A connected. No transformer can possibly make the equivalent input noise of the microphone-transformer LM381A system better than -131.9 dBV.

It is possible to use a step-up transformer to achieve better performance than the -125 dBV provided by the 600-ohm to 600-ohm transformer. A step-up transformer which yields a total value of  $R_s$  (not  $R_{sec}$ ) between 3 kilohms and 15 kilohms will be optimum for the LM381A. The lower

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end of this range is preferred for lowest 1/f noise and "popcorn" noise, and best input clipping level. The transformer should also have low coil resistance to minimize its noise figure.

A. DOUGLAS SMITH, *Manager*  
Electronic Development II  
Shure Bros. Inc.  
Evanston, Ill.

*Mr. Mintz replies:*

You are correct that db did not reproduce the schematic diagram for the LM381 properly from the published diagram I sent them with my manuscript.

Please note that a value of 3,600 ohms was chosen experimentally and corresponds to a calibration for a Dixon vu meter of zero vu for a one volt rms output at 1,000 Hz.

In a discussion of noise voltage, I must confess that I made no attempt to be rigorous. Although I cannot say that I agree completely with your analysis, I will concede that any thermally-generated noise voltage in the microphone itself would be amplified by a step-up input transformer. However, my discussion of the LM381 input noise values were based on using the LM381 alone, and I included an optional 1:1 input transformer only for convenience in using balanced input lines. The actual noise values in a complete system would, of course, depend, to some extent, on the microphone used, but my circuit did not include provision for a microphone, which is user-selected; therefore I considered the microphone-induced noise-voltage to be irrelevant.

The microphone-coil resistance should be as low as possible. As it approaches zero, the ideal case is realized. This point, I believe, is the crux of the matter—can a simple, inexpensive microphone preamplifier be superior to one with a more costly design which uses a transformer to provide voltage gain? I invite the reader to make his own comparisons.

R. S. MINTZ

THE EDITOR:

We appreciated the very nice detailed article by Bob Ehle in the August issue on the operation of our stuff. I read it through with considerable interest. Unfortunately, there is a significant amount of obsolete information and factual inaccuracy. I would like to list things which I noted.

First of all, our company is no longer called R. A. Moog Company, but Moog Music, Inc. We are no longer located in Trumansburg, N.Y., but in East Aurora, N.Y. Secondly, many of the modules discussed by Mr. Ehle are no longer manufactured. In

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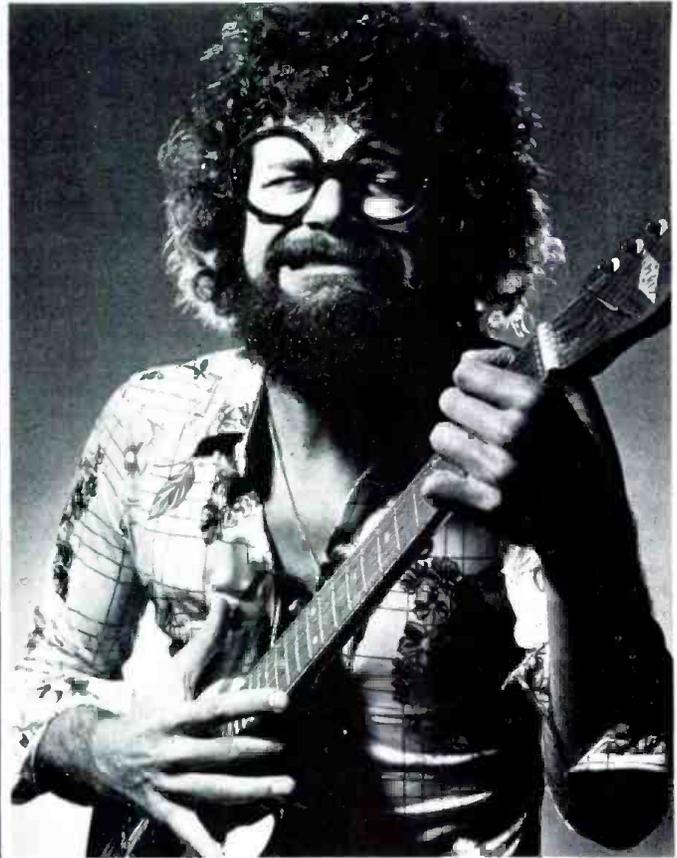
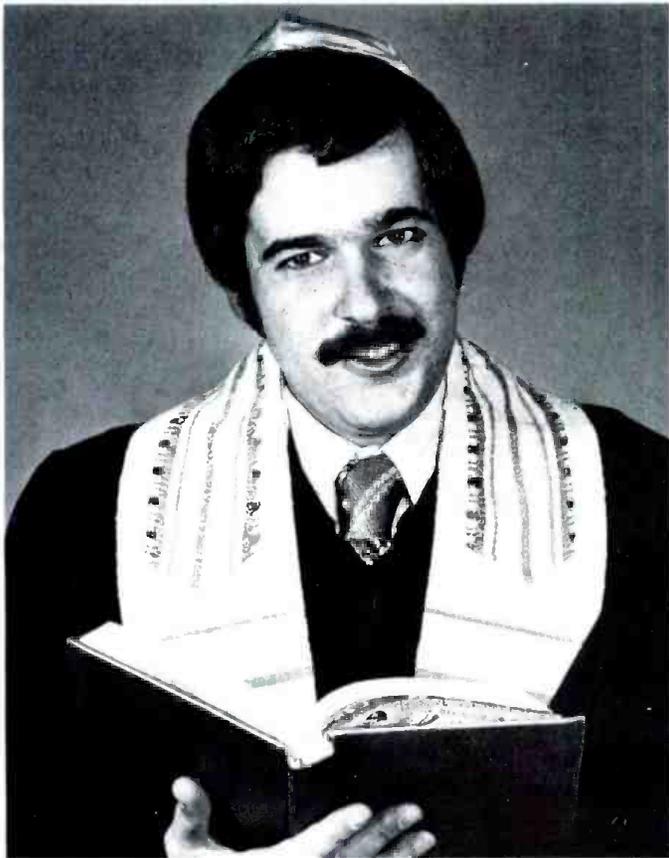
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exponential input sum.

On page 26 it says that simple mixers may be either "wet" or "dry," meaning powered or unpowered. I believe that the term "dry" denotes the absence of reverberation in professional audio terminology.

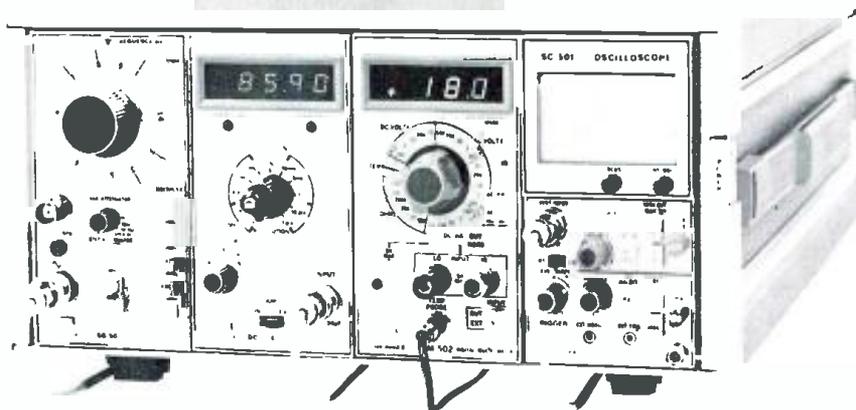
On page 27, the author states that the amount of intermodulation can be controlled by the setting of the panel control on our voltage-controlled amplifier. He states further that the voltage-controlled amplifier, when used as an amplitude modulator, produces more harmonic distortion than a well-adjusted ring modulator. Neither of these statements is correct. Intermodulation is a measure of sum and difference frequencies generated by the interaction between a mixture of two pure tones as they pass through a supposedly linear circuit. In the case of the voltage-controlled amplifier cited, intermodulation is independent of the setting of the panel control. Furthermore, it cannot be said that a voltage-controlled amplifier produces more harmonic distortion than a well-adjusted ring modulator, since a ring modulator by definition produces nothing but sum and difference frequencies.

On page 28, the author states that the Bode modulator produces much lower distortion modulation than equivalent circuits set up on the Moog synthesizer. While the use of a Bode ring modulator does have advantages over the use of our modular voltage-controlled amplifiers and mixers, the production of less distortion is not one of them. The Bode ring modulator is finely balanced to minimize direct leak-through of the input frequencies; residual leakthrough is eliminated in the Bode ring modulator by the use of a squelch circuit. Those are the advantages of the Bode ring modulator, not lower distortion.

At the bottom of page 28 it says that sounds picked up by a microphone may be ring-modulated with themselves if the overtones are filtered from one input. As far as I know, it is not necessary to do any filtering on either input. Finally, on page 29, the author states that the Moog sequencer is built from digital computer components and is based on a binary counter and for this reason, it has eight steps ( $2^3$ ). This is not correct. Our sequencer is not built on a binary counter, but is a shift register. The use of a shift register facilitates the skipping or the random access of individual sequencer columns. The reasons our sequencer has eight steps is simply that this is a reasonable and musically useful number.

ROBERT A. MOOG  
President, Moog Music, Inc.

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## FREE LITERATURE

### TOOL UP

A plethora of tools . . . hand, power, micro, electronic, etc. are contained in the 112-page catalog, "Tools for Electronic Assembly and Precision Mechanics." Mfr: Jensen Tools & Alloys. *Circle No. 94 on R.S. Card.*

### OSHA NOISE

This booklet discusses basic guidelines for firms beginning to undertake noise measurements and analysis in an OSHA-compliance effort. Covered are noise definitions, measurement, noise control, and personnel hearing conservation. Mfr: B & K Instruments, Inc. *Circle No. 95 on R.S. Card.*

### TAPE CARTRIDGE

This brochure describes the Master Cart cartridge, claimed to eliminate the twisting distortions inherent in conventional cartridges. Mfr: Fidelipac. *Circle No. 96 on R.S. Card.*

### CLOSED CIRCUIT TELEVISION

"The Executive's Guide to Closed Circuit Television" describes types of closed circuit t.v. systems, equipment needed, and actual installations. Mfr: GBC Closed Circuit T.V. Corp. *Circle No. 97 on R.S. Card.*



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## CALENDAR

### DECEMBER

**Sony Workshops:** Milwaukee Video, Milwaukee, Wisconsin. Vidcom, Phoenix, Arizona. Contact: Jeff Glasser, Sony Corp., 700 W. Artesia Blvd., Compton, Ca. 90220.

1-3 **National Telecommunications Conference.** New Orleans, La.

### FEBRUARY

17-20 **International Solid State Circuits Conference,** Philadelphia, Pa.

21-25 **PRO-IN '76.** Dusseldorf, Germany.

### MARCH

2-5 **Audio Engineering Society, 53rd Convention.** Hotel International, Zurich, Switzerland.

7-12 **Audio-Visual Institute for Effective Communications.** Indiana University, Bloomington, Indiana. Contact: Audio-Visual Institute, 3150 Spring St., Fairfax, Virginia 22030. (703) 273-7200.

21-24 **National Association of Broadcasters Convention.** Chicago, Illinois. Contact: NAB, 1771 N St., N.W., Washington, D.C. 20036. (202) 293-3500.

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● Putting together mediated materials is much like any other form of communication: the more natural it is the better. Unfortunately, this breaks completely with the tradition of textbook writers, both at the school level, and at the levels of various professional establishments. It might be interesting to conjecture on why this difference exists, but it will be more constructive to find ways to overcome it.

### FOLLOWERS OR LEADERS

Perhaps part of this condition springs from a habit of wanting to follow others. Most of us have been led to think a teacher is someone we should follow. Actually, a good teacher is one who develops in his students the capability to be leaders, or at least to move ahead on their own. There is an anonymous saying, very true, that the measure of a good teacher is the degree by which he enables his students to surpass him.

However, in the traditional educational environment, teaching roles have become confused. A person wanting to develop a new course, to write a textbook, or to develop mediated materials wants something to copy, in one way or another.

Those who have gone before him have usually clothed what they wanted to say in deceptively esoteric language. I still remember some of my earlier efforts intended for publication. Following what was apparently the accepted procedure, I put together something that sounded like all the other engineering style articles I had read.

Engineering publications to which I submitted it turned it down because it described—in the best engineering terms, it is true—some new technology I had developed myself, material which was not in the textbooks, so their editors could not verify what I said. Publications intended for technicians and others not up on engineering lingo turned it down because they couldn't understand it.

One editor was helpful. He sensed that maybe here was something that represented a contribution to the art,

so he asked me to explain to him what it was all about. I explained in everyday language how what I had written was new and different from anything that had been published before. "Good," he said, "That I can understand. Now write it that way, so the reader can understand it, and we're in business."

If you look at educational materials, you will find they employ two kinds of communication. The best, of which there is too little, helps the reader to learn something the writer already knows, or has learned. The other kind, of which there is too much, conveys, or is intended to, the impression that the writer is awfully smart to know such complicated stuff.

It was years before I finally realized that virtually nobody actually understands all this stuff. They just become proficient at regurgitating the right sets of words, to convince others that they belong to the appropriate jargon club.

Perhaps it's difficult to tell leaders from followers in this kind of situation, because it becomes a case of the blind leading the blind! The first thing to recognize is that you should try to say everything as plainly as possible. A trick I still use is to write what I think I want to say, and set it aside. Then I come back and read it, a day or two later, with that editor's question in mind: what am I really saying? Then if I find that my first draft was obtuse, difficult, ambiguous, the things that interfere with plain talk, I trim it down. I break up long sentences into shorter ones. When I've started on another tack, without letting my reader know that I've changed course, I insert transitional words or phrases that tip him off. And so forth.

That's just to write a column, like this one, or an article, such as my series on Feedback. But what about writing lesson material? For that, clarity is even more important. Most db readers have some idea what I'm writing about. A student is trying to learn something he does not already know. So it's doubly important for me to make my message plain to him.

Now we come to an important distinction in function.

### EXPERT OR NON-EXPERT

By far most of the educational materials I have written have been about subject matter in which I am consid-

ered an expert. But if you get into mediating materials, it is far more likely that you will be just the mediator, while some expert in the subject you are to mediate will be responsible for providing the content. That changes the situation quite a bit. What can you do in that circumstance?

Really, the basic premise is not all that different. In both situations, your real problem is to put yourself in the student's shoes. Preferably, you should be able to visualize a variety of different students, and their learning problems, so you can generate flexible material suitable to their needs. This is what few subject-matter experts seem capable of doing. So you'd better take responsibility for seeing that it gets done.

If you prefer, you could perhaps try the role that editor played with me. Ask the subject-matter expert to explain his material to you, reducing it to its utmost simplicity. Try to develop that kind of role playing between yourself and the subject-matter expert. That is part of working toward good material.

But there is another, very important matter, and this requires almost a complete breakaway from traditional material.

### TELLING OR HELPING FIND OUT

One common feature in the traditional way of preparing instruction is the teacher's—or the textwriter's—compulsion to establish authority. A book, text, mediated material—whatever—that merely asks questions would be rejected as not authoritative.

For instance, let's go back to that 9th grade class to whom I referred a while back. They had been told "Do it this way—exactly what I say." Then they're instructed to do it some other way, forget what they'd been told before. Try to put yourself in their shoes.

Which way is right? Or are there more ways than one to solve a particular problem? The teacher always acts as if the way just being told is the only right way. So when should I try this way, and when should I try that way? They never get to find that out.

That is the key expression: we all learn best, what we *find out*, rather than what we are told. We believe what we find out for ourselves. After being told many conflicting things, we become apt to take anything we are

told with a grain of salt. Students are no different in this.

This was proved, very cogently, by what happened when I threw the thing open to them—asking them how to do it, and why some ways went wrong. The whole class turned on, with the impression that “Now we’re going to get to understand this stuff.” On the other side, some straight A students couldn’t explain why; they could just do what I wanted if I would tell them what that was.

The reason, I’ve concluded, that so many math teachers present the subject the way they do, is that they never learned it themselves. They just *did* it, like they expect their students to do. Their teacher adopted that high and mighty attitude: “You must be slow, if you don’t get that.” So they adopt the same attitude, as part of their stock in trade.

Text writers do the same thing. They want to get the material together without letting their prospective students see the holes, the parts they themselves never understood.

So now you come along, as mediator for a course such a text writer or teacher wants to prepare. He adopts the attitude of an expert. You must not impugn that, of course. So what can you do? Raise questions. Help him to see the problem—including his own—without telling him. Try to see it from his end.

You tell him that you want to see what it is you need to convey to the student. What will he think? “This man imagines he’s a jack of all trades!” So you must not be pushy enough to make that impression too strong. But you must make your point well enough for him to begin to realize that anyone, including himself and you, only really learns what he can find out and understand for himself.

You’ll run up against the old superiority angle: “That’s fine for you and me. We can think for ourselves. But for most people, we’ve got to make the subject so simple that they can assimilate it without having to think.” That’s balderdash. Everyone can think, believe it or not. But your subject-matter expert does not see it as balderdash, so you have to take it carefully until daylight slowly dawns.

An unfortunate fact with which we have to live, is that it is much easier to correct bad thinking habits in students than it is in teachers. This is because this perversity has been ingrained longer in the teachers’ minds. Remember that. If you can find a way to demonstrate the point, it is always better than trying to tell it. And always make a conscious effort to avoid looking like a “smarty pants” to the expert.

You will find, as you progress in developing better materials, that the best approach is one of candor: this is difficult to understand, because the way it is often taught results from the fact that most teachers don’t understand it themselves—or something to that effect. We are just saying that, for the sake of brevity. In a practical situation, you should demonstrate it with an example.

That way, you gain the student’s confidence. He pays attention. Then you don’t tell him. Instead, you ask him questions, many of them throwing him back on his own experience, to get him to think, so he finds out for himself. That way he next gains confidence in himself.

But to do this, you first must do it with your subject-matter expert, which is usually much harder than doing it with the students. It’s a tricky road to tread. You’ll undoubtedly make mistakes, from which you’ll also learn, as I have. But acknowledging that too, can help. If you came in with an attitude that said you know all the answers, nothing would raise your subject matter expert’s hackles quicker!

“We want to make this the best course in whatever it is, that’s ever been written, or put together, don’t we? So let’s you and I really beat it out, until it becomes just that.” Most subject matter experts will buy that attitude.

There’s a whole lot more, that we’ve touched on before. One thing we need to get into is the matter of meaningful testing. But space has crept up on me this time. For a long while, I hated multiple choice. Here’s an example of a bad one I could take from our state’s driver’s license exam: “When approaching another car, you should dip your headlights at (a) 100 ft., (b) 500 ft., (c) 1000 ft., (d) 2000 ft.”

My problem with that is that I know the best answer is, the further the better. But they want the precise legal answer. Who’s going to get out and measure the precise distance at which I dip my headlights? It’s not a practical question. Of course, a policeman may make a judgment on which he gives someone a ticket. And if the driver doesn’t dip his lights at all, there is no problem!

Questions like that are asked, with the answer, not with the way the student thinks, in mind. If you work on the basis of how a student thinks, when confronted with the question you are drafting, you will do a much better job. But more of that another time. And it must tie in closely with how the subject matter is mediated, which is why we need to devote attention to it. ■

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● As I have tried to do as often as possible in the past, I hope once again to whet your interest in attending conventions by telling you a bit about two that took place in New York just a couple of months ago.

The earliest of these was sponsored by an organization with which many of you may not be familiar—the Electronics Representatives Association, New York Chapter. The ERA (not related in any way to a long gone government agency) actually started in the '20s but got its official status in 1935. In 1942 it adopted its current name and has grown from a group of 32 to well over a hundred members extending from New York to geographic areas covering the entire country. The representatives who belong to the association handle almost all manufacturers of electronic products and just about all of the products.

The exhibit, called the Commercial Sound and Communications Show, took place at the Statler Hilton Hotel. Only manufacturers who use representatives were permitted to show their products; this year twenty displays presented the offerings of more than a hundred manufacturers. The first of these showings was in 1967, continuing in alternate years since then. For this, the fifth show, visitors came from many parts of the United States and Puerto Rico.

Every branch of the sound field was represented, featuring items from various microphone types through mixers, amplifiers, speakers, reverb units, headphones, source equipment such as turntables, equalizers, tape devices and accessories, connectors, and including CB equipment, walkie-talkies and antennas. Some idea of the diversity of the displays can be learned from this completely random selection of manufacturers: ADS (speakers), Able Manufacturing (CB), Arista Enterprises (playback styli), AudioTechniques (mini-mixer), Blonder Tongue (master t.v. antenna), Clifford Industries (power supplies), Electro-Vox (intercoms), Otari (tape recorders), Production Devices (electronic test equipment), and University (commercial sound).

One device that came out of the show that would fit into the visual applications we would normally discuss in this corner is the Simda/Tempo handled by Tempo AudiVision, Inc., Buffalo, N.Y. and Toronto, Canada. This equipment, made in France,

functions in slide presentations as a dissolve system. The Simda ED 3000 is the simpler unit and operates in a single dissolve situation. However, since the remote control device is a slide unit, the speed of the dissolve can be controlled manually for each slide change. This allows for different speeds within the presentation.

The ED 3300, the more complex of the two units, will operate three pairs of slide projectors. Each pair is controlled on a console with sliding controls to be able to vary the speed of changeover. It is possible to hold a dissolve and keep it in mid-change for as long as desired and then revert to the previous image if so desired. Both units produce a variable frequency carrier which can be recorded on audio tape so that all slide changes can be put down as a memory for future completely automatic and unattended presentation. Since the devices are made in Europe, they are provided with switchable power either for 120 or 240 volts, 50 60 Hz.

### VIDEO EXPO '75

The second convention was devoted entirely to video and took place at Madison Square Garden in New York City. Video Expo '75 was run by Knowledge Industry Publications, Inc. of White Plains, New York. We've discussed this one in the past—it is always a good display of the latest video equipment available. This exhibit was run in conjunction with Video Workshop '75, which took place at the New York Statler-Hilton, and covered, in twelve sessions, such subjects as The Portapak, Electronic Editing, Video Art, Color Video, VTR Software, and Introduction to Video Tape Recording. At the same time, the N.Y. Chapter of the International Industrial Television Association (ITVA) met at the Statler Hilton, and the International Tape Association (ITA) conducted a semi-technical seminar at the Essex House.

At this, the sixth annual international exposition devoted entirely to private, closed circuit and cassette delivery systems and programming, about one hundred exhibitors showed wares including film and tape cassette systems, cameras, tape recorders, time base correctors, and video projectors, as well as lighting, test, and studio equipment. Video Expo is the largest exposition of non-broadcast video systems and programming in the world.

Among the software producers such

names as Deltak, Edutronics, Time-Life Multi-Media, Medcom, Xicom, and Advanced Systems were in evidence. This year, a preview area was provided where visiting educators, program producers, or anyone else interested could take a borrowed cassette to play privately on a system set up for just this purpose. Fields covered were industrial, educational, health, and general entertainment. With over 4500 attendees, you could expect that a library-like system was initiated, and it seemed to work well.

Among the hardware exhibitors were such names as Adwar Video (introducing a color portable 2-camera switcher with vertical interval switching, preview, intercom, and fade), American Laser Systems (introducing their model 747 video transmission system), CMX Systems (CMX 50 videocassette editing system), Consolidated Video Systems (Digital Video Time Base Corrector and PAL SECAM Digital TBC), Convergence Corporation (Helical scan editing control system for cassette and open-reel vtr's) and IVC (broadcast and videotape recorders, studio and portable cameras, digital signal processor, cartridge-loaded 1 in. recorder).

Panasonic Video Systems showed a full line for open-reel, cassette, and

cartridge recording with a full line of cameras and monitors. Philips displayed their mini-studio equipment, vcr, and PIP equipment; Sanyo, Sharp, Shintron, and Sony all introduced one or two items; Video Automation showed its automatic video cassette changer and 12-hour automated t.v. and advertising system. Sound Systems of N.Y. showed Harris color camera systems and a Buhl mobile multiplexer that can be set up, taken down, and put up where needed with little effort.

Among the publishers at the show, the *Journal of the Electronics Industry* (of Japan) was provided to visitors. From this publication it was learned that Sony was planning to set up a second video tape plant in the U.S. in Alabama, which would be completed early in '77. This plant would supplement the operation of the present San Diego production plant. Also, it was learned that Hitachi, Ltd., was going to start production of its "focusing mask tube" next spring. This new color t.v. tube was claimed to be 50 per cent brighter than conventional tubes because of the voltage applied to the shadow mask in addition to that applied to the electron beam oscillation section only, in conventional tubes. The result is a brighter picture with

lower loss and greater sharpness.

## PROJECTION SYSTEMS

The large-screen video projection systems displayed included those from G.E., Sony, Teletronics, and Harvey Sound, the latter two showing the Advent VideoBeam. From the JEI publication, it was learned that Sony is now in the process of introducing its latest projection system. This is currently being presented to the Japanese market at 7 million yen (at about \$23,000, with the dollar worth 300 yen). This unit has a 120-inch screen and combines three Trinitron picture tubes. The previous unit, with a 50-inch screen had one gun. With quadrupled area, the picture is brighter and sharper. The system has two lenses, is instant-on in operation, and can be used in a fairly light room.

The specifications call for a horizontal resolution of 320 lines (NTSC), and a screen brightness of 20 feet lamberts. The unit requires a distance between projector and screen of 3.5 meters. Power consumption of the projector is 430 watts and 15 watts by the controller unit.

In 1976, Video Expo '76 will take place on Sept. 28-30, again at the Madison Square Garden in New York. Don't tell us we don't alert you in enough time. ■

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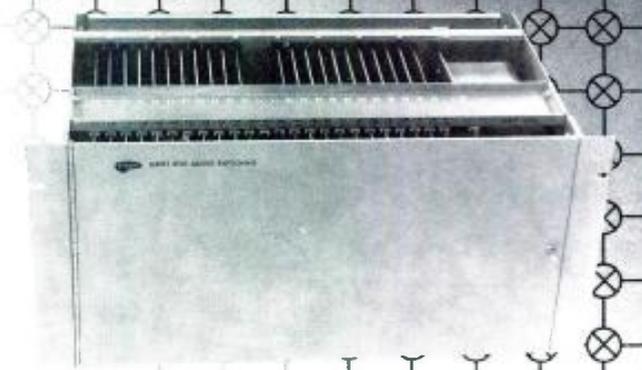
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*Mfr: Sinclair Radionics, Inc.*

*Price: \$79.95.*

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● All components and controls on this eight channel monitor/cue module are mounted on a standard Tascam 3-in. panel; no modification of the mother board is required. The monitor section features individual gain and pan controls for each channel. The cue section, which has individual gain control for each channel, can facilitate one 8-channel machine or one 4-channel machine through the use of a toggle switch. A headphone jack is supplied. It is possible to switch and punch up any one of the four multi-channel tape monitor speakers in stereo or quad.

*Mfr: Accurate Sound Co.*

*Price: \$895.00.*

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## TWO-CHANNEL EQUALIZER



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*Mfr: Technical Audio Products Corp.*

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## DIGITAL MULTIMETER



● Four-and-a-half digit, five-function digital multimeter model 3465A covers a d.c. measurement range  $1 \mu\text{V}$  to  $1 \text{ kV}$  with a mid-range accuracy of  $\pm (0.02$  percent of reading  $+ 0.01$  percent of range). A.c. measurement range is  $10 \mu\text{V}$  to  $500$  volts with a mid-range accuracy of  $\pm (0.15$  percent of reading  $+ 0.05$  percent of range) over a  $40\text{ Hz}$  to  $20 \text{ kHz}$  bandwidth. A.c. and d.c. current measurement range is from  $10$  nanoamps to two amps. D.c. current accuracy for the  $10 \text{ mA}$  range is  $\pm (0.1$  percent of reading  $+ 0.01$  percent of range). A.c. current measurements are made over a frequency band of  $40 \text{ Hz}$  to  $20 \text{ kHz}$  with a mid-band accuracy of  $\pm (0.25$  percent of reading  $+ 0.25$  percent range). Resistance range is  $10$  milliohms to  $20$  megohms with a mid-range accuracy of  $\pm (0.02$  percent of reading  $+ 0.01$  percent of range). Open circuit voltage on the ohms terminal when set to its lowest range does not exceed  $5$  volts.

*Mfr: Hewlett Packard*

*Price: \$425.00.*

*Circle 53 on Reader Service Card*

## SEX INTERCHANGEABILITY



● No, db is not going sensational—this is the claim of the manufacturer for Slim-Line II connector series. There are 55 types with interchangeable barrel inserts which allow any plug or receptacle to be male or female. The connectors offer shunt circuits in the female inserts, plus miniaturization. The connectors serve receptacles with two to five pins or contacts. Other features include D-shaped orientation for polarization, molded-in pins and contacts, extra-large cable strain relief and tapered drawn body with non-reflective finish. Housings shield internal connections and provide common ground connections without using pin/contacts. Cord plug models are available either with coupler ring or without ring. Receptacles come with flange mount, rear panel mount or front of panel mount.

*Mfr: Switchcraft, Inc.*

*Price: \$0.40 each (1,000 quantity)*

*Designers' Kit No. K-138, \$9.95.*

*Circle 54 on Reader Service Card*

## STEREO OCTAVE EQUALIZER



● Continuously variable controls characterize the model 10 stereo octave equalizer. The unit provides  $\pm 12$  dB control of 10 octave bands from  $30 \text{ Hz}$  to  $15.4 \text{ kHz}$ . Each octave may be independently adjusted to shape the frequency response of tape, disc, or live programs and to correct for poor characteristics of speakers, rooms, and recorded material. The equalizer features a direct-coupled output and time-delay relays to eliminate turn-on thumps. A defeat switch allows the signal to bypass the equalization circuitry.

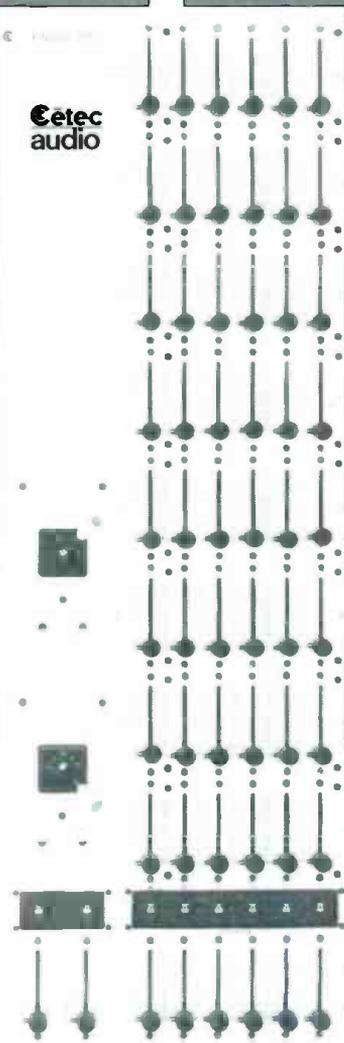
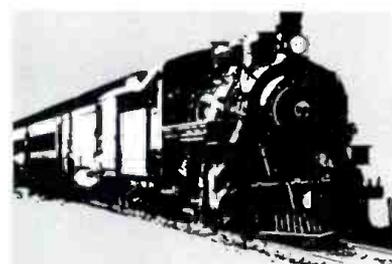
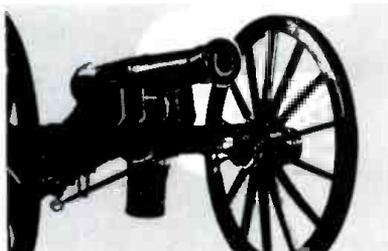
*Mfr: Thompson Electronics Co.*

*Price: Equalizer: \$525.00*

*Walnut Cabinet: \$37.50.*

*Circle 55 on Reader Service Card*

# PRE-SET DISTRIBUTION SYSTEM (PDS)



The roar of cannon, the clash of cymbals, the nuances of an actor's lines—all can be part of the audio effects of a live theatrical production. Till now, these effects were mostly live noise and a crude mixture of record and tape recording. For the first time, Cetec Audio's PDS makes it possible to pre-design, pre-test and pre-set a total audio effects program. With PDS, sound becomes as important an element of the design as the scenery or lighting.

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sound without  
Cetec  
audio**

A DIVISION OF CETEC CORPORATION

PDS, designed to work with Cetec's Series 20A Live Media Console offers total flexibility in 'creating effects', such as mixing, blending, over-dubbing or re-recording; 'reinforcing' a true P.A. function; and 'reproducing effects' to allow complete freedom in creating mood and movement, and even influencing the physical space relationship of a stage production. PDS offers a higher quality of performance through the ability to work out changes in rehearsal and the versatility of pre-designing and pre-testing audio effects. While designed to operate primarily with Series 20A Live Media Console. PDS can operate in a separate enclosure, thus making it simple to interface with existing audio control equipment. Write today for complete details—it could change your ideas about sound.

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# What would you expect an IMA to do?



- Perform SMPTE intermodulation analyses quickly and easily, even in the millivolt range?
  - Measure amplifier noise?
  - Measure transistor noise?
- Evaluate magnetic tape drop-out?
- Test oscillator amplitude stability?
- Measure tape recording distortion?
- Evaluate phono stylus wear and tracking?
  - Test electromechanical transducers for intermodulation?

*The Crown IMA does all of it. Internal intermodulation distortion is less than 0.005%. Write us for more complete information and application notes.*



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dbx eliminates tape noise when connected to any reel-to-reel recorder. You can make original recordings with no audible hiss or background noise, which even the most expensive studio recorders cannot achieve using conventional noise reduction systems.

dbx 157 is a two-channel simultaneous tape noise elimination system which permits monitoring off tape while recording. It is fully compatible with all dbx professional studio systems and costs \$600.00 from professional audio dealers. Switchable (record or play) 150 series noise elimination systems start as low as \$187.50 per channel.

For complete product information and a list of dealers serving your area, circle reader service number or contact: dbx, Incorporated, 296 Newton Street, Waltham, Massachusetts 02154, (617) 899-8090.

## dbx eliminates tape noise



**dbx** inc.

Circle 34 on Reader Service Card

products & services (cont.)

### INTERCOM STATION



• Permanently mounted intercom remote station, designated MR-102, has all electronics mounted on the back of a 4½ inch square brushed stainless steel plate. The assembly fits inside a standard 4 inch square conduit box, such as those used to house two light switches: the face plate is attached to the box with four screws. Compatible with any other intercom system from the same manufacturer, the remote station is wired to other main or remote stations by two-conductor shielded cable connected at the rear of the unit. An XI-type 4-pin connector is provided on the panel for a microphone-headset. Also on the panel are a volume control, a combination and call switch, and call light (or optional buzzer). The manufacturer claims a signal-to-noise ratio of better than 55 dBm.

Mfr: Clear-Com

Circle 56 on Reader Service Card

### CONSOLE INPUT MODULE



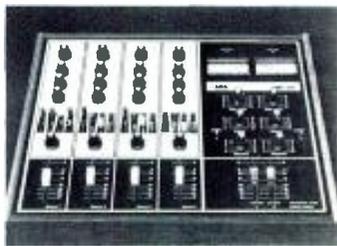
• All the functions necessary to perform multi-track recording, quad mix-down, and quad monitoring are present in model MAP 8422. The console input module features a low noise microphone preamplifier with an equivalent input noise of less than -129 dBm. Other features include a peak level indicator functioning in mic and line modes, a switchable 70 Hz high pass filter, quad panning, and direct track feed. The unit measures 14 x 1.5 x 6 inches.

Mfr: Modular Audio Products

Price: \$550.00.

Circle 57 on Reader Service Card

**PORTABLE QUADRIPHONIC MIXER**

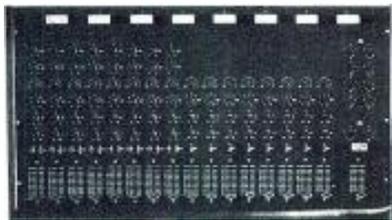


● Basic model 422, which has the normal two line outputs, also incorporates the necessary mixing networks and link jacks to form an 8/4 system in conjunction with the manufacturer's Mirror Image 424 mixer. (The two mixers are electronically identical, differing only in their panel layout and the arrangement of their four mixing networks.) Sub mixer 426 can also be used with model 422, providing mix input channels. Each input has an adjustable sensitivity over an unbroken range of 100 dB, with a maximum gain of 90 dB. Input impedance is suitable for 200 ohm mics at all sensitivities except the highest, where it becomes a line bridging input. Each source channel incorporates bass and treble cut and lift, plus mid-lift controls.

Mfr: Lamb Laboratories (Revox)  
Price: \$675.00.

Circle 58 on Reader Service Card

**16-IN/8-OUT CONSOLE**



● An independent stereo mix bus is featured on SP-800 16-input, 8-output console. The console also incorporates an 8-track monitor and pan section with automatic sync and program monitoring. Each input channel has XLR balanced inputs, 10 and 20 dB attenuation to the preamp section, low and high frequency equalization with 20 dB of boost or cut, 8-position rotary assignment switch, cue and echo send control, a conductive plastic slide fader, and a line/mic input switch on the first 8 channels. The output section has two echo returns, a stereo master fader and 8 rotary sub-master controls metered to +4 dBm at zero vu. Transformerless output lines are designed to drive 600-ohm loads with a claimed distortion of 0.1 per cent or better at +20 dBm.

Mfr: Speck Electronics  
Price: \$2,555.00.

Circle 59 on Reader Service Card

**NOISE REDUCTION SYSTEM**



● Model 1000 combines in one unit an Autocorrelator noise reduction and dynamic range recovery system. The noise reduction system is capable of differentiating between noise and music—it is possible to remove 10dB of noise without affecting the music. The circuit operates on any stereo source without pre-encoding. High frequency noise reduction commences at 2kHz and is 3dB, reaching 10dB from 4kHz to 20kHz. Low frequency noise reduction begins at 200Hz, ultimately reaching 20dB at 20Hz. Passive sub-sonic filter rejection of -35dB at 5Hz. Weighted overall noise reduction is -10dB from 20Hz to 20kHz. The dynamic range recovery system consists of three independent expander circuits tied together with logic.

Mfr: Phase Linear Corp.  
Price: \$349.00

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**Erase cleaner**



**Erase easier**



**Garner Model 70** cuts man-hours spent erasing audio and video tapes. Simple, safe continuous belt operation gives you "hands-off" professional erasures in only four seconds. Handles up to 7" reels, cartridges, and cassettes. Acclaimed by major users, yet priced low enough for the smallest studio or station to afford.



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All of these products are made to the same high acoustic and mechanical quality that has set standards throughout the world. For example, if your finances do not quite run to a new Revox tape recorder, try to find a secondhand one—in stock condition it will outperform other makes of new equipment at the same price!

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**MIXER PREAMP**



• Full stereo output from a range of inputs which include phono, tape, and mic are available on Clubman II mixer preamp. The unit has individual slider fader control on each input,

full equalization, overall master volume control, and pre cue and talk-over facilities. It can be adapted to either a mobile or permanent system.  
*Mfr: Meteor Lighting*  
*Price: \$449.00*  
*Circle 61 on Reader Service Card*

**MIXING CONSOLES**



• Long-throw, conductive plastic faders, solo input, program echo and return, independent cue mix, program return, independent 2 or 4 bus assign color-coded and illuminated pushbuttons), full monitoring control and an optional hi/lo equalizer are featured in Alpha I and Alpha II consoles. Alpha I has stereo outputs and Alpha II features 4 mixing busses. The consoles' size—22 x 23 x 9 in—opens the possibilities for remote as well as permanent use. The units are self-powered and have XLRs in and out.

*Mfr: Sphere Electronics*  
*Circle 62 on Reader Service Card*



# Our system is hard to beat

The all time favorite monitor system in U. S. recording studios is the Altec 604. Add our Mastering Lab frequency divider with its improved mid-range, distortion-free crossover and extended bass and you have a system that is truly hard to beat.

We have packaged 604s and M/L dividers in a bass reflex enclosure and named them Big Reds. For super bass response and increased sound pressure level, we add an extra 15" woofer, plus a low frequency crossover and call them Super Reds.

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 Sound Exchange  
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Springfield Sound  
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 Toronto Sound  
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Circle 36 on Reader Service Card



JBL's new 4315.  
There's never been a wider range  
studio monitor. Of any size.

And, four more things:

It's a four way system. It has the most sophisticated cross-over network ever designed. It's compact, shallow, portable. Perfect for wall mounting, horizontally or vertically. It's yours for \$714.

There's more. Much more. Go hear the rest.

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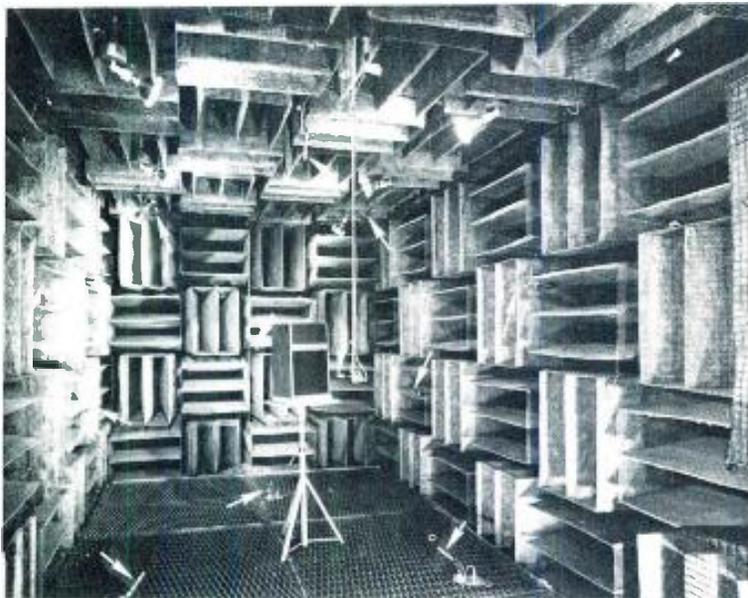
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The CBS Technology Center on High Ridge Road in Stamford, Connecticut.

# The CBS Technology Center



A loudspeaker is shown under test in the anechoic chamber. Note the microphones, arrayed in dodecahedral fashion. By selective switching, a rapid measurement of integrated sound can be made, or any individual direction can be selected for study.

IT'S A PLEASANT DRIVE from the db offices to Stamford, Connecticut where the offices and laboratories of the CBS Technology Center are located. When I arrived, I was met by the genial genius of the place, Benjamin (Ben) B. Bauer, who is vice president and general manager of the Center. Before being shown around, I was given a general history of the Center which, until recently, was known as CBS Laboratories.

## RECENT LABORATORIES HISTORY

CBS Laboratories, the research and development arm of CBS Inc. began its operation as a division of the Company in 1957 with the construction of a handsome, one story building on a knoll on High Ridge Road in Stamford, Connecticut. Its mission was to perform r&d in various t.v., radio, and audio areas. Some of its important contributions, headed by Benjamin B. Bauer, then vice president for acoustics and magnetics, resulted in improvements in stereophonic disc records, and in fine particle magnetic tapes that subsequently led to the development of the cartridge and cassette records.

The heady days of NASA's attempts to put a man on the moon, the acceleration of the cold war, and the involvement of the Indochina conflict placed many demands on American technology. The Laboratories accepted this added responsibility and became involved in a number of areas in audio and visual communications and underwater sound. There were commercial values and spin-offs stemming from these activities, and a department dealing with professional products was started, mainly involved in broadcast instrumentation, which grew to significant proportions.

By the mid-1970s, it had become evident, however, that the various peripheral activities of the Laboratories did not allow its resources to become strongly oriented toward

Frank Barr at the controls of the measurement and recording racks located just outside the anechoic chamber.

the future technological needs of CBS. A reorganization was clearly needed which took a year to complete. The manufacturing and professional product activities were sold to Thomson-CSF, S.A., a major French electronics company. The contract research and development activities were sold to EPSCO, Inc. of Westwood, Massachusetts. Other activities, such as ultrasonic medical display devices of no special interest to CBS were donated to the New York Institute of Technology. With the completion of these transactions by mid-1975, the Laboratories was renamed the CBS Technology Center, continuing its operation in Stamford, Connecticut, with Ben Bauer as its vice president and general manager.

### CBS TECHNOLOGY CENTER ORGANIZATION

The Technology Center has been divided along the areas of principal interest to CBS. One area of concentration is high density recording, headed by Robert A. Castrignano, which examines all the factors related to future audio and video recording processes. Of great importance is the emphasis on advanced t.v., under J. Kenneth Moore, with digital techniques of processing and transmitting t.v. image playing a major role. The audio systems technology department, headed by Emil L. Torick, works on developments which range from the means for improving the sound on 1 $\frac{7}{8}$ -inch cassette tape to the various possibilities of transmitting audio programs by means of bit-saving digital methods. The sound reproduction technology department, under Louis A. Abbagnano, concentrates on improved loudspeakers and on developing and improving methods of recording disc records.

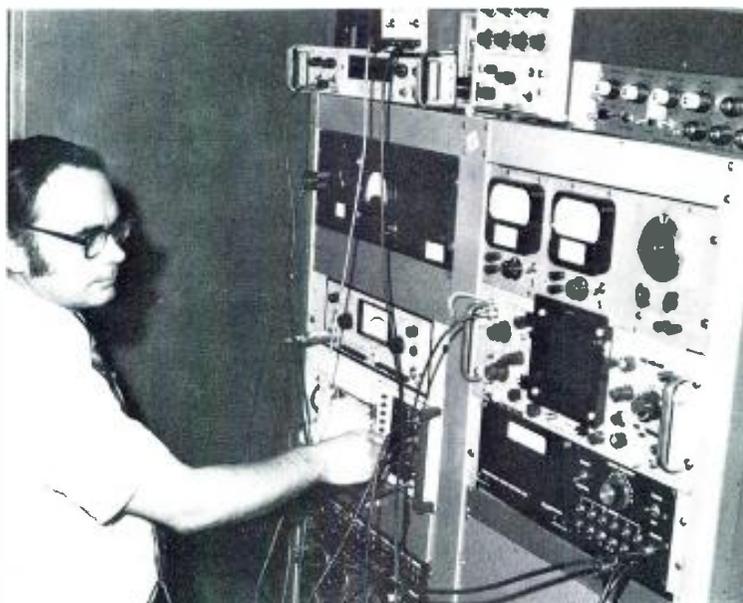
### AUDIO TESTING

The CBS Technology Center is actively engaged in the technical testing of audio equipment, mostly of a home use nature. I was shown the anechoic chamber and work area of Frank Barr. Under his direction audio products are put through their paces for *High Fidelity Magazine's* monthly test reports. The anechoic chamber is particularly impressive in both its size and versatility. It is used for speaker testing by having the measurements made by twelve calibrated microphones placed in a dodecahedral arrangement. Automatic plotting equipment permits a highly sophisticated and complex procedure to be made swiftly and consistently. Conventional electronic products are evaluated in standardized bench-tested ways.

### DIGITAL AUDIO TECHNOLOGY

Emil Torick demonstrated an advanced digital audio transmission system under development. The Center's excellent sound room was where I heard audio converted to digital signal, transmitted, and restructured to analogue audio. No, there is no imminent product line expected—this is development work only—but I was impressed by how much can be done now.

These digital processes offer considerable promise for future audio applications. Both signal processing and audio transmission will especially benefit from this new technology.



A significant problem in digital encoding is the wide bandwidth needed for accurate representation of the signal. A basic pulse code modulation system demands an information transfer rate on the order of one-half million bits per second for one channel of high fidelity audio quality—and the needs of multi channel programming increase this rate considerably. In the interests of transmission efficiency and economy, it is thus imperative that means be developed to reduce bandwidth requirements by new encoding schemes without significantly altering the perceived audio quality. From what I could see and hear, CBS Technology is well along that way.

### SQ FOUR CHANNEL TECHNOLOGY

The SQ matrix system comes, of course, from this center. Many of the basic patents are held by Ben Bauer under whose direction the system continues to improve.



Benjamin B. Bauer, the CBS Technology Center's vice president and general manager, at his desk.



The listening room at the Center. A remote switching box permits comparisons between SQ encoded and discrete tape sources playing from the turntable or half-inch Scully tape machine.

The listening room was used to demonstrate the most recent decoder systems. These are full logic systems of advanced design that can effectively create the impression of true discrete sound. Sony and Motorola have created integrated circuit designs that will lower the consumer cost while raising the performance level. The units I heard using these chips were excellent.

On another SQ front, CBS is pushing the use of encoders by radio stations. A relatively low cost product for this use is being made by Sony and is distributed by CBS. Stations can use this unit to either synthesize stereo sound to four channels, or to encode true discrete ma-

terial for transmission. The unit permits the station to select the method of SQ encoding that fits its musical format—such as concentration on front separation, or weighting the effect for four channel listeners to provide either increased ambient effect or surround sound.

#### DVX LOUDSPEAKER SYSTEMS

The listening tests I heard were conducted using recently designed Leslie DVX loudspeakers. The Center has been active in designing these units as consumer high fidelity speaker systems, building them into the facilities of Leslie Loudspeakers (the CBS Electro Music Division) for manufacture.

The DVX system uses a dipole dispersion pattern. Such loudspeaker concepts are not new; CBS themselves produced experimental monitors years ago. But the increasing popularity of four channel listening has made such designs desirable. In the enclosure, a dipole coupler in the form of a precisely shaped baffle is placed. Several drivers covering a range from 250 Hz upward are placed and allowed to perform optimally as dipole radiators. The baffle system can be moved within the cabinet for optimum results in listening rooms. (Frequencies below 250 Hz are handled in a conventional omnidirectional manner.) By manipulation of the dipole, it can be aimed for the center of the area to be covered, thus permitting the four speakers to be properly heard in the listening room.

The final section I was able to see is the one that deals with the CBS series of test records. This series, I'm happy to say, is in production with newly cut masters. The most recent addition to the series is a new disc specifically designed for testing SQ decoding systems.

The day ended all too soon. If I can sum up in one word my impression of the work being done by CBS Technology Center it is the word *sophistication*. It is evident that they have moved a long way toward reducing the black magic of subjective audio testing to science, and they are moving ahead in advanced work in a variety of areas of importance. It wouldn't surprise me to hear of important announcements coming soon from Ben Bauer. CBS Technology is certainly not resting on past laurels. ■



A studio/lab version, model 580 DVX of the consumer Leslie unit. The moveable dipole at the top can be aimed toward the listening area.

# Count Your AEPs

*Application of a simple formula makes it possible to control room reverberation.*

**P**ROBABLY THE MOST IMPORTANT factor influencing the quality of sound reception in a room is reverberation. Too little reverberation may cause some forms of music to suffer. This may be undesirable, but it is seldom disastrous. On the other hand, too much reverberation is not only bad for many forms of music but can be disastrous to speech patterns. Speech sounds blur together and become difficult or impossible to understand. If this is the case, then chances are that the reverberation time is too long. This condition exists particularly in large rooms.

The real irony is that the problem can be avoided. Reverberation is easy both to understand and to deal with. With a new short-cut, it is even easy to calculate.

But why calculate? Why not just measure the reverberation in the room? Well, that's a little hard to do when the room is nothing more than an assortment of lines on an architect's drawing. Even if the room exists, it may still be easier to calculate the reverberation, especially if you don't have the necessary testing equipment.

The reason such calculations haven't been done more in the past is plain: they weren't easy. The formula is not complicated, but it is often difficult to know the right numbers to plug into it. Even after you get the right numbers, a fair amount of calculation is needed. Besides, very few people have any idea how to go about doing it, so it all remains a mystery.

Not any more. There is a simple way to calculate reverberation, namely this formula:

$$\frac{\text{Room Volume (in cubic feet)}}{\text{Number of Persons in the Room}} \div 100 = \text{Reverberation Time (seconds)}$$

This simply tells us to find the volume of the room in cubic feet, divide by the number of people in the room, mark off two decimal places, and we have the answer. But is it really that easy?

Well, almost. If the room is not empty of people, or nearly so, and there is nothing else in the room to absorb sound, then it works very well indeed. In other words, if the people are the only significant absorber of sound in a room, then the formula works. This covers a large percentage of situations, but there are ways of extending this formula to include virtually all cases.

## THE SOUND ABSORBER FACTOR

What we have not yet considered is the effect of other sound absorbers in the room. Carpet, upholstered seats, draperies, acoustical tile, etc. all absorb sound the way people do, but to a greater or lesser degree. And that is the clue to the answer.

Five square feet of most acoustical tile, for example, absorbs about as much sound as one person. The sound in the room really can't tell much difference. We can think of this five square foot area of acoustical tile as having Absorption Equivalent to a Person. We can abbreviate this new unit of measure as the AEP. The pronunciation of this acronym is obvious.

Thus, 100 square feet of acoustical tile equals 20 AEPs, and 5,000 square feet equals 1,000 AEPs. That is, 5000 square feet of acoustical tile has the same effect on the reverberation in a room as 1,000 people.

It turns out that all the other materials in a room can be converted to AEPs in the same way. Here is a table of equivalents:

*G. R. Thurmond is an acoustic consultant from Austin, Texas.*

Class of Absorber	Examples of Materials	Number of Square Feet for Each AEP
Good	Acoustical tile, fiberglass, sprayed asbestos (1-inch thick)	5
Fair	Thick carpet, heavy draperies, unpainted concrete block, sprayed asbestos (½ inch)	10
Poor	Thin tight-pile carpet, thin panels, light drapery	25
Bad	Wooden floors, painted concrete block, plaster on lath, gypsum board, heavy wooden panels, indoor-outdoor carpet	50
Non-absorber	Concrete, masonry, terrazzo, glass, brick	100

Ahah! Now we see that all the surfaces in a room can be converted to AEPs. The AEPs are then totaled, added to the number of people in the room (if any), and plugged into the formula. Turn the crank, and out pops the reverberation time. That's all there is to it.

The only surface which this does not take into account is that of the seats. When they are occupied, no sound reaches them, so acoustically they are not there. When they are empty, however, they absorb some sound, so we need another conversion chart:

Type of Seat	Conversion to AEPs
Upholstered bottom and back	10 seats = 8 AEPs
Upholstered bottom or back only	10 seats = 5 AEPs
Not upholstered	10 seats = 1 AEP

This tells us that the reverberation time in a room with

hard seats will change with the number of people present much more than it will in a room with upholstered seats. This points out the acoustical importance of upholstered seats.

Let us look at some examples. Suppose we have a medium-sized church with a volume of 125,000 cubic feet, and 500 seats which are not upholstered. In addition, there are 625 square feet of thin carpet, 2,500 square feet of brick walls, a wooden ceiling of 5,000 square feet, 1,000 square feet of windows, and 1,000 square feet of thin paneling.

First, let us figure the empty reverberation. The seats represent 50 AEPs, the carpet, 25; the brick walls, 25; the ceiling, 100; the windows, 10; and the paneling, 40. This totals up 250 AEPs. Divide this into 125,000—mark off two decimal places—and we have a reverberation time of 5 seconds.

With 500 people present, the seats have 500 AEPs instead of 50, so that the total is 700 AEPs and the reverberation time is 1.8 seconds. Quite a change! If the seats were upholstered, the empty room would have 600 AEPs, and a reverberation time of 2.1 seconds. This is a relatively insignificant difference between empty and full.

But is this the correct value? Is it possibly too dead (too little reverberation) or too live (too much)? For that we have another chart:

Reverberation Time (seconds)	Type of Room
3	VERY LIVE
2	LIVE
1	MODERATE
0	DEAD

Speech can be understood easily in a dead room, but music sounds dull and lifeless. A moderate room can have good speech clarity and good enhancement of music, it has no other serious flaws. It is difficult to understand speech in a live room, but some kinds of music (especially church) benefit from such a room. A room with a reverberation time of over three seconds is suitable for only a few kinds of music; speech may be impossible to understand.

Most churches like a reverberation time in the two-second range; some want a little less, some more. Our theoretical church falls in this range when it is full, but is too live empty, with hard seats. Upholstered seats should be recommended.

### HIGHLY REVERBERANT ROOMS

In many cases such as this one, the solution to a problem becomes obvious as soon as we see the problem clearly. Things are not always so straightforward, though, as another example will show.

Let us assume a gymnasium which is 200 feet square and has a ceiling height of 25 feet, giving a volume of 1,000,000 cubic feet. The floor is wooden, the walls are brick and glass, and the ceiling is concrete. There are 2,500 hard seats which cover half the floor area and are placed against most of two side walls. For convenience, let us say that the two end walls are completely exposed to the sound in the room, while only 12½ feet of the height of the side walls is. This gives us a total of 15,000 square feet of wall area exposed to the sound (150 AEPs), 40,000 square feet of ceiling (400 AEPs), and 20,000 square feet of floor (400 AEPs), plus 250 AEPs for empty seats. This totals 1,200 AEPs, giving an empty re-

verberation time of over eight seconds!

Actually, in a highly reverberant room like this, where there is very little total absorption, every little thing becomes more important. That is, there are other things which we have previously ignored because they are insignificant in normal rooms, but which would be important enough in this room to bring its actual reverberation time down to six or seven seconds. We can ignore these errors because they are significant only in rooms where the reverberation time is over five seconds or so. Such rooms are much too live for anything except possibly church music anyway, which is all we really need to know.

If the seats in this gym were all occupied, then their absorption would be 2,500 AEPs instead of 250, bringing our total to 3,450. This brings our reverberation time down to a little under three seconds, which is still too live. What should be done?

Clearly, more absorption is needed, but how much and what kind? Since there might be several workable solutions here, we might start with a worst case and work back from there.

It is unlikely that the reverberation time in a gym will ever need to be under 1.5 seconds. In this case, that reverberation time would be achieved if there were 6.667 AEPs. The empty room contains 1,200 AEPs leaving us about 5,500 short. This could be provided by 27,500 square feet of good absorber.

This may be an overkill, however. Seldom will there be a case where sound quality is important in a room with no audience, especially a gym. With this much additional absorption and a full audience, there will be only about 1.1 seconds of reverberation time, providing an unnecessarily dead room. Furthermore, this much additional absorption will probably cost \$25,000 to \$50,000 to provide, depending on a number of factors.

Let us instead shoot for 1.5 seconds in a full room. For this, we only need 3,200 more AEPs, which could be provided by 16,000 square feet of good absorber. Now we are only talking about \$15,000 to \$30,000. Furthermore, the empty reverberation time will only be about 2.3 seconds, not too bad. An audience of 1,000 would bring this down to under two seconds.

#### MATERIALS AND METHODS

Now that we know how much absorption is needed, all that remains is to select the exact material and the method for installing it. We could use acoustical tile, mounted either flush or on furring strips or suspended. Instead of acoustical tile we could use rigid insulation board or cloth-faced ceiling board or other rigid absorbers. Sprayed asbestos can be applied either directly to existing surfaces or to a metal lath. We can select from a variety of possible thicknesses, no matter what the material. We could mount the absorber on the ceiling any number of ways, or on the walls, or even in the seating area. It is possible to concentrate it in one area or scatter it throughout the room. Or it could be left exposed or covered for cosmetic or protective purposes.

Are all these alternatives equivalent? Absolutely not! Some are equivalent to one another, but most vary widely in effectiveness, appearance, and cost.

If all this sounds as if we have just stepped in over our heads, that is exactly the case. The choices of exact treatments are so complex that the only wise decision would be to get expert help. Without such help, you can arrive at an approximate solution, but probably not an exact one. Of course, even an approximate solution is better than none at all. In other words, the AEP method may not get you completely out of the jungle, but it will certainly point you in the right direction. ■

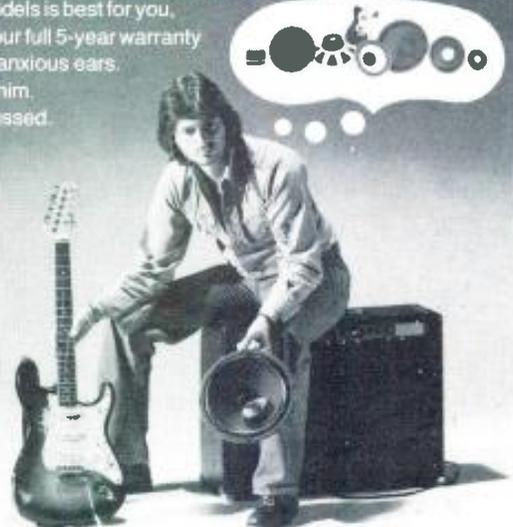
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# Sound Control by Barriers

*Outdoor performances bring obligations to the neighbors, and this requires careful acoustical management.*

**T**HE ATTENUATION of sound by barriers has become an important means in many fields of endeavor for controlling its propagation in directions not wanted. Examples are found in practically all recording studios in the form of flats placed between instrument sections to achieve clean multiple sound tracks. Some other attenuating devices include walls around amphitheaters and outdoor sports areas to prevent distribution of music and announcements to nearby residential environments, solid fences along freeways to reduce the transmission of ground vehicular traffic disturbances to noise-sensitive surroundings, and baffles above or alongside loudspeakers to restrict sound radiation vertically or horizontally.

The principle of physics underlying the propagation of wave trains over solid obstacles is known as *diffraction*, or the bending of light or sound rays as they pass over the impediment. The mathematical descriptive of the phenomenon is complicated. When I first wrote about the design specifics for sound-attenuative screens or shields, I used a chart for the graphic solution of problems in this field, and tables of Fresnell integrals for those interested in algebraic answers.<sup>1</sup> Diagrammatic evaluations are generally adequate because the mathematics does not include considerations of the factors unavoidably present in practice, such as reflections from nearby surfaces, the absorptive character of the noise guard, and the limited

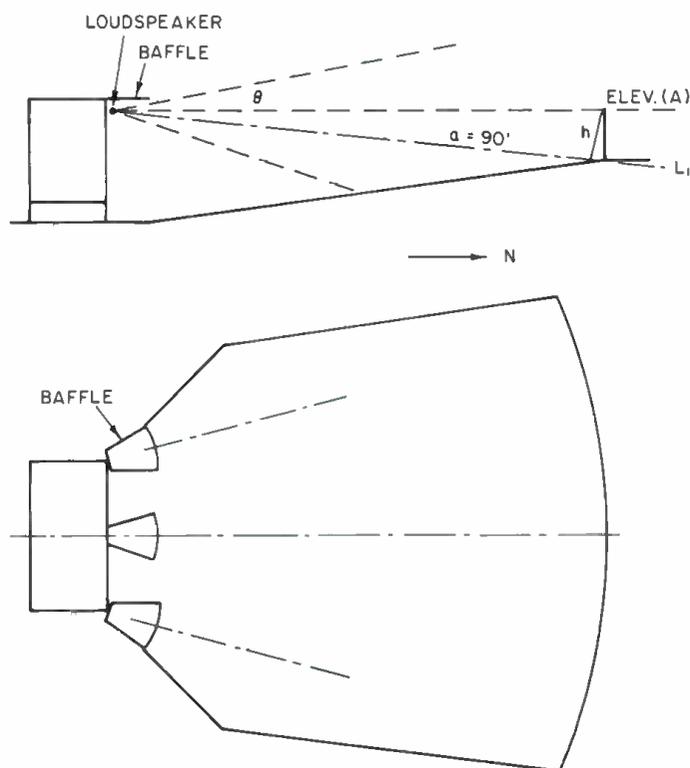
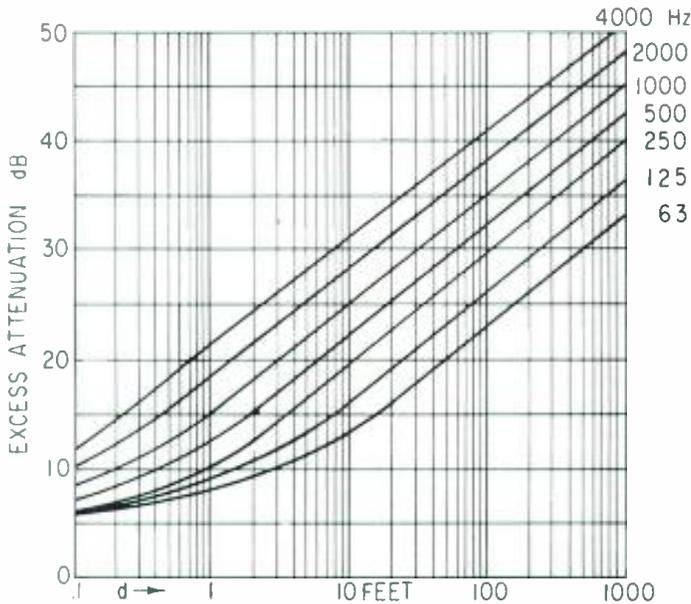


Figure 1. Plan and elevation of outdoor theater equipped with north wall barrier of height  $h$  to reduce sound radiation to the north.

*Michael Rettinger, a frequent contributor to db, is an acoustical consultant in Encino, California*



$$d \approx \frac{h^2}{2a} = \frac{h}{2 \tan \theta} \quad \text{IF } h \gg a$$

$$d = A + B - D$$

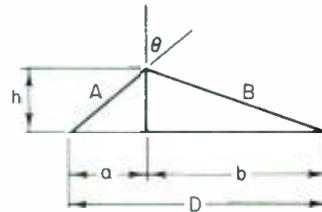


Figure 2. Chart for determining the excess sound attenuation of barriers.

dimensions of the sound interceptor in relation to the wavelength of the signal.

### OPEN-AIR ACOUSTICAL CONTROL

As a good starting point for the design of sound-attenuative barriers consider FIGURE 1, which shows the plan and cross-section of an outdoor concert hall. Such open-air recreational and entertainment centers in suburban areas are often found sound-intrusive and disturbing by the nearby residents. This is true also of football fields, baseball diamonds, racetracks for cars and horses, and amphitheaters.

The suburbanites say that acoustic privacy should no longer be considered an amenity of life, but a necessity to assure mental and physical well-being.

The noise situation of such stadia is complicated by the fact that sound levels for the larger arenas are often in the order of 100 dBA at 50 feet from the sound-reinforcement system radiators, and that the sound attenuation by divergence or wave spreading is generally no more than 4.5 dB for double the distance. Thus, for a thousand-fold increase in the reference distance—50,000 feet or nearly 9.5 miles—the signal reduction comes to only 45 dB, so that the level of 100 dBA appears as one of 55 dBA at that distant location.

Assume now that a solid barrier is planned for the north boundary of the outdoor theater shown on FIGURE 1 to protect the neighbors from the signals generated by the loudspeakers above the stage. Such a wall, obviously, is of benefit only if the elevation of the distant residents is below elevation A, that of the barrier top. The minimum height of the wall must be along the sight line from the loudspeaker to the observer, a height which will attenuate

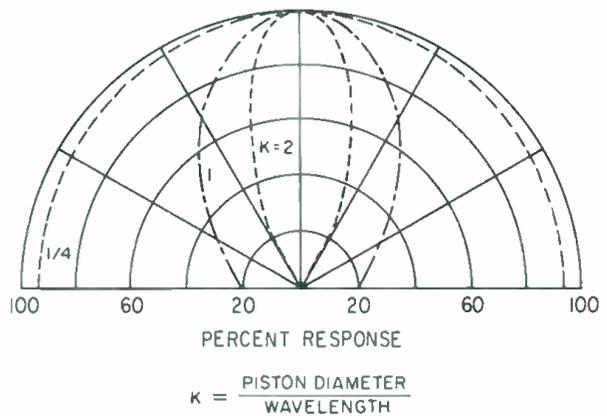


Figure 3. Radiation characteristics of a flat circular piston in a baffle for various ratios of piston diameter to wavelength generated.

the sound an extra 5 dB (above that produced by wave spreading only, in the absence of the wall). But 5 dB is barely enough even to compensate for the vagaries of the weather—the wind and temperature gradients which may cause more of the signal to be spilled over the wall than under normal atmospheric conditions. Hence a higher wall is necessary to still the complaints of the neighbors.

How high should such a barrier be? FIGURE 2 gives a ready graphic solution for the case where the observer is

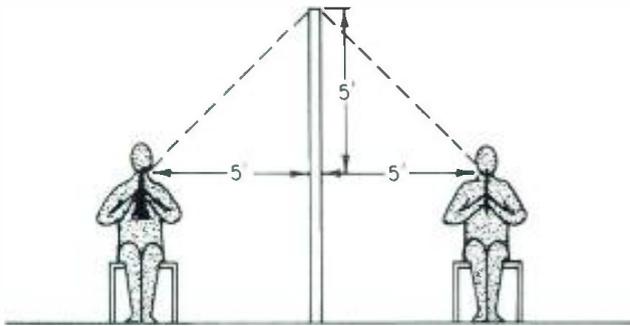


Figure 4. Sound attenuation gained by a baffle interposed between a flute and trumpet player for the simultaneous recording of the two instruments on separate sound tracks.

somewhere along the line  $L_1$ , and at a distance from the wall which is several times the distance ( $a$ ), that is, the distance between the loudspeaker and the wall, according to FIGURE 1, 90 feet.

According to FIGURE 2, when  $h = 20$  feet

$$\begin{aligned} d &\cong \frac{h^2}{2a} \\ &\cong \frac{20^2}{2 \times 90} \\ &\cong 2.22 \text{ feet} \end{aligned}$$

At 500 hertz the signal will be attenuated by 15 dB at the distant point of observation (indicated by a dot on the 500 hertz graph of FIGURE 2). Again, it should be noted that this is the excess attenuation—in excess of that provided by wave divergence in the absence of the wall.

#### VERTICAL EMISSION

But this may be only part of the sound-attenuation requirements. If there is considerable radiation of sound within the angle  $\theta$ , it is to the advantage of the observers beyond the barrier—which may be randomly placed, with some possibly above the line  $L_1$ —to restrict the vertical emission of the sound by the loudspeakers. While this may be done with very long, hand-crafted horns, it is more economical to place a large long flat baffle above the loudspeakers.

#### ATTENUATING THE LOUDSPEAKER

To gain an idea of the size exponential horn required to achieve a sufficiently sharp polar pattern for the purpose—say, where the response at a given frequency is down 10 dB at 15 degrees from the central axis so that the effective radiation cone has an included angle of 30 degrees—consider FIGURE 3. It shows the directional radiation characteristic of a circular flat piston set in a large baffle (to avoid interference effects from the sound radiated from the back side of the piston) for various ratios of piston diameter to wavelength generated. A similar pattern holds for the directional characteristic of a horn if we equate the horn mouth diameter with the piston diameter. The calculations for the directional characteristics are based on the assumption (well borne out

in practice) that the surface of the piston consists of a large number of individual small sources, so that at a point in the sound field the pressure becomes the resultant of all the piston elements radiating sound radially.

On the assumption that we are, as in the reproduction of music, interested in containing 250 hertz within narrow limits, the mouth diameter,  $D$ , of the horn should be four times the wavelength, or 18 feet. Let the cut-off frequency of the horn,  $f_c$ , be two octaves lower, or 63 hertz, to avoid distortion; let the loudspeaker cone diameter be 9 in. or 0.75 feet, and the sound velocity  $c$  be 1128 ft./sec. From the general equation of the exponential horn<sup>2</sup>

$$\frac{D}{d} = e^{2\pi f_c L / C}$$

we get

$$\frac{18}{0.75} = e^{6.28 \times 63 \times L / 1128}$$

so that the horn length  $L$  comes to 9 feet. ( $e = \log$ . constant 2.718)

Of course, if the theater management consents to reproductions from loudspeaker locations other than the proscenium arch, the undesirable radiation of signals from such a theater may also be curtailed by either placing a number of loudspeakers within the seating area, or on the north boundary of the theater, with the speaker axes pointing south. That is on the assumption that there is less of a noise-sensitive area to the south of the theater than to the north, and that the signals from the rear emitters are suitably delayed so that they cannot arrive before the direct signal from the stage has come to the spectator, to avoid the destruction of the illusion that most of the sound comes from the sources visible on the stage. Even so, however, the rear wall loudspeakers should be properly baffled to reduce signal radiation to the north.

FIGURE 4 shows a flat arranged between a flute and a trumpet player when it is intended to record the two instruments simultaneously on separate tracks. If the recording studio has a rather short reverberation, or if the two players are in a large studio where the reflected sound from the ceiling and the walls becomes negligible compared to the signal spilled over the top of the partition, we may calculate the amount of excess sound attenuation by calculating the path difference  $d$ , which is given by

$$\begin{aligned} d &= 2(\sqrt{a^2 + h^2} - a) \\ &= 2(\sqrt{5^2 + 5^2} - 5) \\ &= 4.14 \text{ ft.} \end{aligned}$$

According to FIGURE 2, the excess sound attenuation for this setup comes to 18 dB at 500 hertz; 21 dB at 1000 hertz; 24 dB at 2000 hertz; etc. ■

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2. Olson, H. F., *Acoustical Engineering*. Van Nostrand, Reinhold Co., New York. (Out of print.)

# The Signal Path

*The function generator has numerous variations, in the types of waveforms it creates and in their techniques.*

ONE AREA OF SIGNAL GENERATION which has always been a source of fascination to me is generation of the various fundamental audio waveforms such as sine, square and pulse, sawtooth and triangle. Such waveforms are basic to audio testing of course, but they are also just as fundamental in electronic music synthesis. There are almost an infinite variety of circuits you can use to generate these waveforms; a good understanding of their innards is useful in selecting a technique which is most useful for your particular needs of the moment. What we'll now do here is explore some of them and comment on their pros and cons and where or when each is right for the task at hand.

## THE FUNCTION GENERATOR

The function generator is a signal source which uses r-c section timing circuits as the basis for waveform generation. Its fundamental waveforms are the triangle and square wave, which are generated simultaneously. The sine wave, when required, is generated as a byproduct of the triangle. The features of this type of waveform generation are an extremely wide range of frequency control and/or frequency agility, and an inherently constant output waveform, independent of frequency. On the other hand, it does not feature the lowest sine wave distortion, since it is a synthesized waveform. Function generator signal sources can be phase-locked or synchronized easily and lend themselves readily to dynamic control of all waveform parameters.

A basic block diagram for a function generator which produces the fundamental waveforms is shown in FIGURE 1. This circuit is essentially comprised of a timing capacitor,  $C_1$ , across which is developed a triangle wave, a buffer stage to isolate the high impedance capacitor voltage

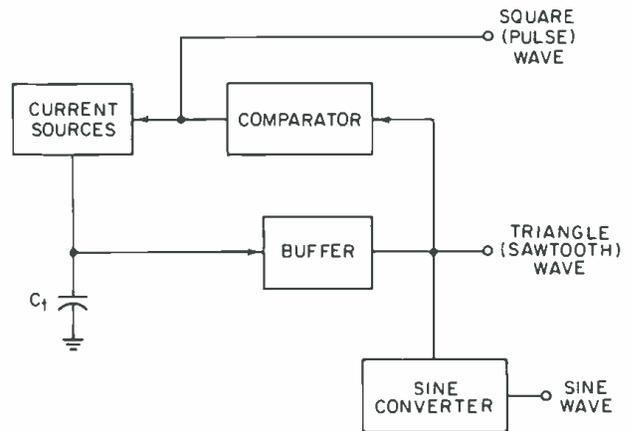


Figure 1. Block diagram of a function generator.

waveform from external loads, and a comparator which determines the (+) and (-) amplitude limits of the triangle. It also produces an output square wave and a current source (or sources) which creates constant currents to charge and discharge the timing capacitor. If sine waves are to be produced, a sine converter is also used, which converts the triangle wave into a low distortion sine wave.

If the charge and discharge currents into the capacitor are precisely equal, it will take equal time intervals to form the (+) and (-) slopes of the triangle wave. Under these conditions, the duty cycle is 50 per cent (or 50-50, if you wish) and both the triangle and square wave are perfectly symmetrical, as is the sine wave. This is shown in FIGURE 2(A). If the ratio of currents is altered, so as to be asymmetric, the waveforms will appear as in FIGURE 2(B). (No sine wave is shown here since it will not be a true sine wave under these conditions.)

Mr. Jung, who frequently writes on audio subjects, is a designer with the AAI Corporation, Baltimore, Maryland.

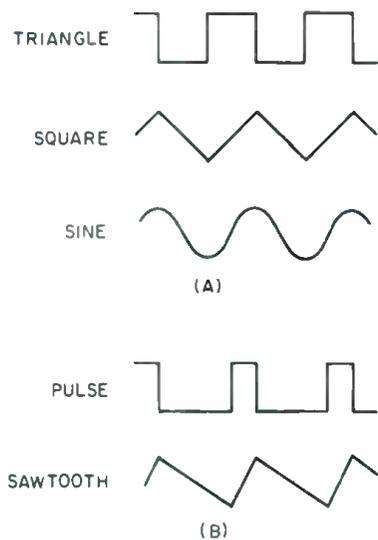


Figure 2. Function generator outputs.

Thus it may be seen that this system has the capability of producing all of the waveforms mentioned, given adequate flexibility in the circuitry used. Various types of technology can be used to implement the different blocks, dependent upon the performance required. Frequency (or pulse duration) can be either manually selected or made electronically variable by appropriate modification of the current sources or the timing capacitor itself. We now can take a look at some representative circuits to realize this system.

FIGURE 3 illustrates how very simply a function generator of this type can be implemented. This is an op amp based circuit,<sup>1</sup> which combines a couple of the basic system blocks, improving efficiency.

Here A1 performs the function of the comparator, with threshold levels established by the symmetric zener clamp. The function of current sources and buffer are actually combined within the stage A2.  $R_t$  determines the charge and discharge currents of  $C_t$ , along with the zener voltage. The triangle waveform is developed across  $C_t$  in buffered form, due to A2.

Frequency (or period) can be very easily controlled via either  $R_t$  or  $C_t$ , according to the simple relation shown. Since capacitors are not normally easily variable in continuous fashion, it's best to let  $C_t$  be switch-selected for coarse changes and to let  $R_t$  serve as a vernier. Note that if  $R_t$  is made a high value pot, 5 meg for instance, it can very easily vary frequency over a wide range when connected as a rheostat. Actually, one of the major keys to the usefulness of this configuration is in how well you can control frequency and duty cycle. FIGURE 4 illustrates some variations for  $R_t$ .

In FIGURE 4(A), a separate path for the two directions of current which charge  $C_t$  are provided by a pair of steering diodes. The pot serves to vary the proportion of resistance division between the two paths over a wide range. In so doing, it alters the effective value of  $R_t$  for charge and discharge of  $C_t$ , which serves to vary the duty cycle. So, an op amp function generator of this sort can produce all of the waveforms mentioned above (we'll get to sine waves in a moment).

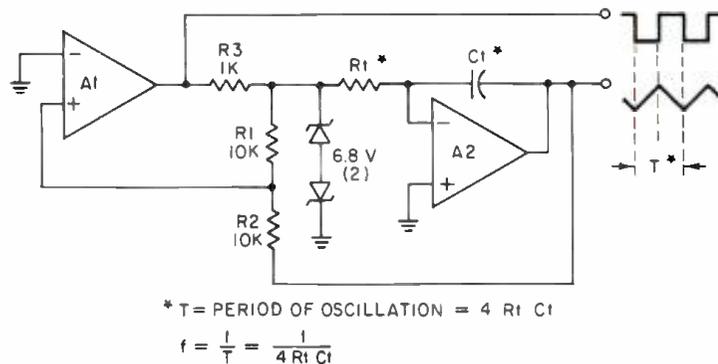


Figure 3. Op amp function generator.

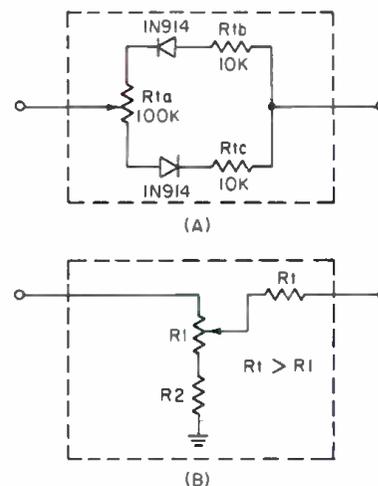


Figure 4. Methods of frequency variation.  
a: For variable duty cycle.  
b: For linearly variable frequency.

Another useful trick is to multiply the effective value of  $R_t$  by dividing down the voltage applied to its input end. This gives linear control of frequency *versus* pot rotation, with the range of frequency change capability equal to the division ratio of the divider used. A 100/1 divider gives 100/1 frequency range; 1000/1 gives 1000/1, and so on. The practical limit is reached at extremely high ratios when the output of the divider is at its lowest level of a few millivolts or so, which will approach the offset voltage of the op amp used. This creates large errors in frequency calibrations, or worse yet, oscillations cease.

## OP AMPS

Those are just a couple of simple techniques to manipulate frequency and/or pulse width. Before we get into more involved methods, some comment on op amps suitable for these sockets is in order.

Actually, a wide-range high performance function generator based on op amps is more than a little demanding in terms of device performance characteristics—it's downright tough. For A2, the device used should have both high slew rate and  $f_t$ ,<sup>3</sup> as well as a low bias current, and low offset voltage. A National 318 will satisfy the first two requirements quite well, but its bias current is high for very low timing currents. For this you'd like a f.e.t. input unit, such as RCA's 3130, or better yet, the newer National 356, which is fast as well. In terms of general purpose units, 741's are only good to a few kHz, but 310A's

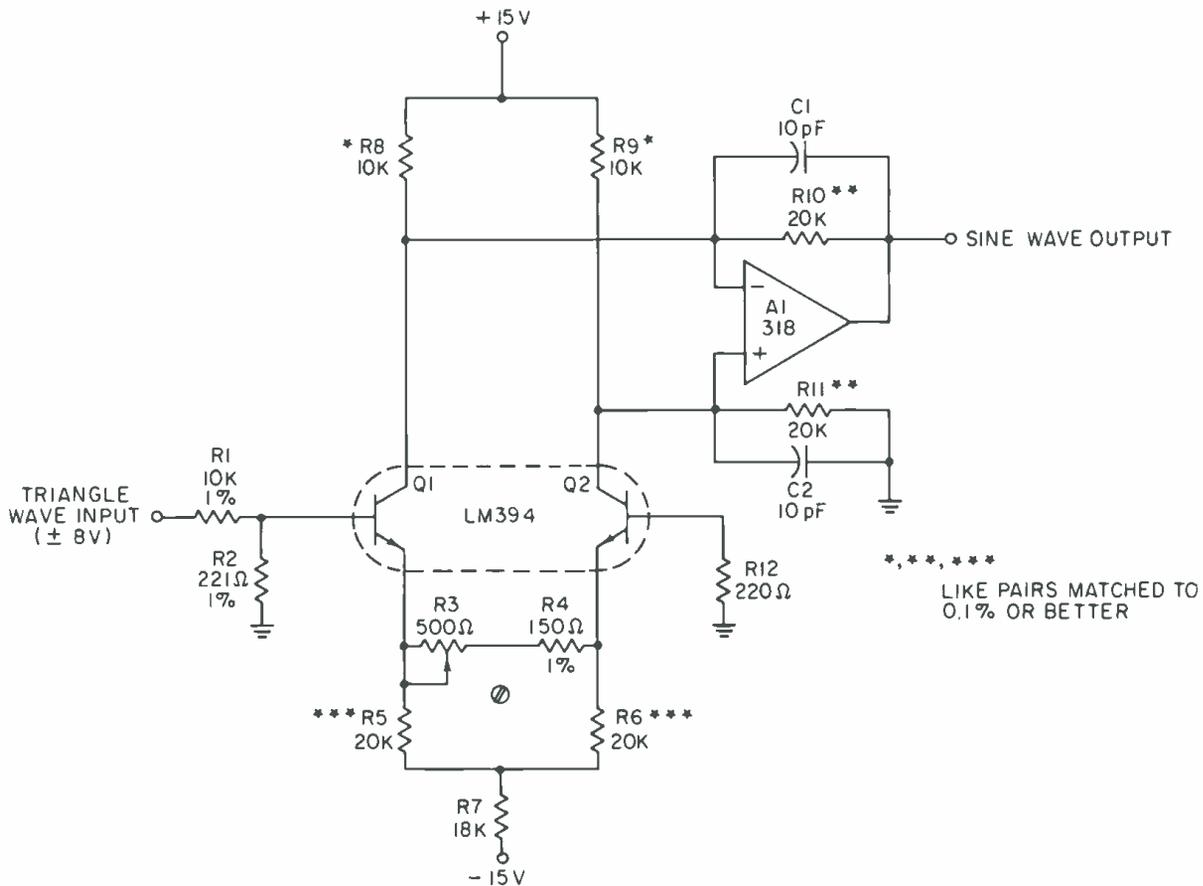


Figure 5. Sine converter.

are excellent speed-wise, if used in the feed forward mode.

As for A1, this device is actually a comparator, and as such needs not be frequency compensated. If an op amp is used here it should be an uncompensated unit, such as a 709, 715 or 301A, without their compensation caps. This makes for prettier square waves at the output and more accurate control of hf triangle wave levels. A device which is near optimum here is a 311 comparator, which is quite fast, yet moderate in cost.

The clamp diodes are also important for speeds above a few kHz. IN750 series zeners have high capacity and are not optimum in terms of speed. Monolithic transistor zeners work quite well here, such as 3018 or 3046 array transistors (zener connected) and provide matching as well. Ordinarily 2N3906 base-emitter junctions wired back-to-back also work well, but of course are not matched.

Good performance is also highly dependent on the type of units used for Rt and Ct. For best accuracy, predictably and stability, these would have to be of good quality. Rt can range in value from a few kilohms up to megohms, with the upper limit being determined by the bias current of A2. If A2 is an f.e.t. unit, there will be no restriction on Rt except the practical one of obtaining stable values above a few megohms. Rt should preferably be a close tolerance, low TC type such as a metal film unit. If pots are used, they should be low TC, high resolution units. Ct may range in value from a few hundred picofarads up to a  $\mu$ F or so. It can be optimized in terms of cost initially, with Rt then being selected next. Typically, Ct will be a polystyrene or Mylar dielectric type, with close initial tolerance (and low TC if at all possible).

## SINE WAVE CONVERTER

Once you've settled on a set of components for the function generator, a sine wave converter must be added to make it complete. FIGURE 5 illustrates a method of achieving this function.

The classic method of deriving a sine wave from a triangular wave is via two sets of biased diodes, one set for each slope of waveform polarity. This requires six or more diodes per set for low distortion, and is difficult to both set up and maintain. FIGURE 5, an alternate technique, operates on a different principle and has several advantages.

This scheme works on the principle of the non-linear cutoff characteristics of a bipolar transistor differential pair. If driven by a linear triangle wave input, a differential pair such as Q1-Q2 can be adjusted for a condition of emitter-to-emitter signal coupling which will result in a sine wave output current with quite low thd. When properly set up, distortion of 0.25 per cent or less is readily achieved.

Keys to the success of this technique are an optimum drive level to Q1-Q2, perfect symmetry of the input waveform, and the match of Q1-Q2. Lowest distortion is achieved with a drive to Q1 of about 350 mV p-p (directly at its base). Final optimization of drive for lowest thd is via R3, which is preferably a high resolution, multi-turn trimmer. Matching of Q1-Q2 in this example is well achieved by the 394 (National), an ultramatched pair with an offset of only 25  $\mu$ V. Other monolithic pairs will also work, but if their offset is greater than about 500  $\mu$ V, trimming will be required for lowest thd.

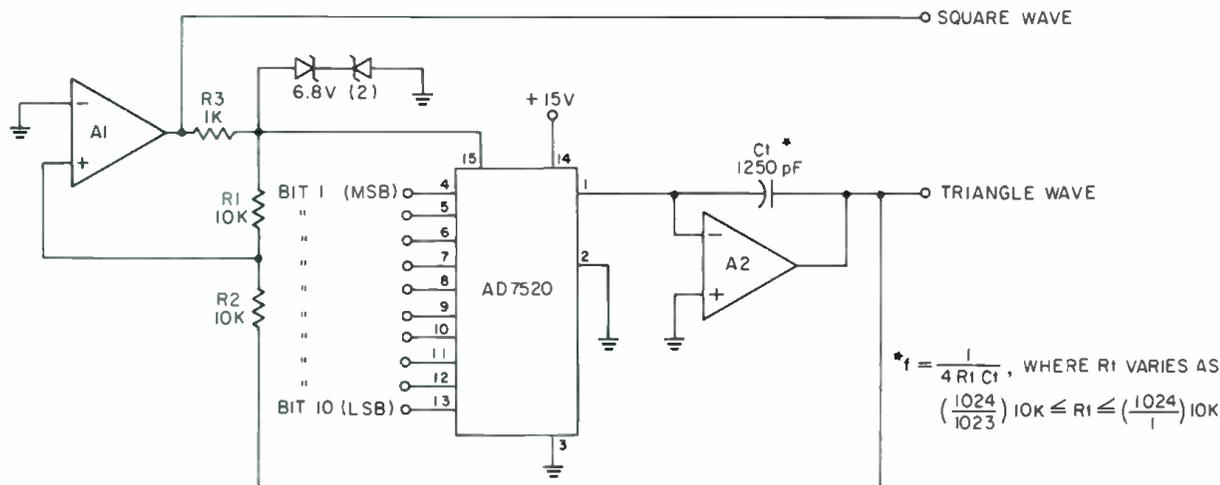


Figure 6. Digitally programmable function generator.

For good overall stability and low output errors, several resistor pairs should be matched, as noted. This may not be as formidable as it appears on the surface, as all of these pairs can be contained in a single network, and their absolute tolerance is much less critical—one or two percent being sufficient in this regard. I don't mean to scare anyone with the mention of 0.1 per cent resistor matches. The circuit will function with 5 per cent types; the errors will just be greater.

The values given for R1-R2 are designed for an ±8V triangle wave input, which is compatible with the circuit of FIGURE 3. For other input amplitudes, scale R1-R2 for a 350 mV p-p drive to Q1. Overall triangle-to-sine conversion gain is such that a 16V p-p sine wave is delivered at A1's output. This converter can be used with any triangle wave source which produces a symmetric, constant amplitude waveform, and is useful to well beyond 100kHz. Thus it is a ready companion to the previous circuit (and also circuits yet to be described).

**VARIATIONS ON THE BASIC FUNCTION GENERATOR**

At this point we are now ready to explore some of the possible variations on the basic function generator of FIGURE 3. This first of these is shown in FIGURE 6.

This circuit is similar in basic concept to the generator of FIGURE 3, except that  $R_t$  has in this case been replaced by a multiplying D/A converter, the AD7520 (Analog Devices). This change allows the effective value of  $R_t$  to be digitally programmed (in binary fashion) over a dynamic range defined by  $\frac{2^n - 1}{1}$  where n is the number of

bits of the convertor. For example, the 7520 is a 10 bit unit; therefore this allows a range of 1023/1. Resolution is set by the weight of the LSB, in this case  $\frac{1}{1024}$  of full scale.

With the  $C_t$  value shown, full scale is 20 kHz, this means the minimum frequency change increment is 19.5 Hz. If you care to try this circuit, I recommend a fast comparator for A1, and a low offset voltage type op amp for A2, such as the units previously mentioned. Also,  $C_t$  may need some padding for full scale frequency calibration, since the internal tolerance on absolute value of the 7520's ladder is relatively loose. For those interested in

this general idea, a similar 12-bit D/A unit is also available, the AD7521.

An obvious natural application for a generator of this type would be as part of a computer controlled test source. By adding a second 7520, output amplitude can also be programmed over similar dyna-ranges. We'll cover this aspect in a future installment, along with other gain control techniques.

Another interesting function generator variation is shown in FIGURE 7. This circuit is perhaps one of the least expensive, yet it possesses very high performance capability.

In this version, which is arranged for single power supply operation, three inexpensive i.c.s are used in a combination where the assets of each device complement one another. The 555 performs the function of level comparison, and produces two square wave outputs, a 15 V high level signal at pin 3, and a TTL compatible one at pin 7. The 555's internal voltage reference divider determines the end points of the triangle wave at voltage levels of 1/3 and 2/3 of V plus. This causes the triangle wave to be 1/3 of V plus in amplitude.

A1, a 3080A OTA (RCA) is used as a current source to charge and discharge  $C_t$  linearly. The resultant triangle wave across  $C_t$  is then buffered by A2, an f.e.t. input op amp. This particular device, RCA's 3130, is optimum for single supply use and its low input current allows timing currents to well below 1nA.

An interesting feature of this circuit is that the frequency is independent of supply voltage. Frequency can be programmed via  $R_{ABC}$  or  $C_t$  using the relationship shown. The dynamic range capability of the circuit is over 100,000/1 (100dB), ranging from the 3080A's upper  $I_{ABC}$  limit of 500µA downward. A practical upper frequency limit is about 50kHz, due to the 555 response time, but the lower limit is determined more by how well you can control  $I_{ABC}$  than the devices themselves.

The circuit is an excellent source of high quality waveforms, useful as a fixed frequency source, or controllable over a wide range. With modification, it can also be frequency-swept over a comparably wide range.

The example shown in FIGURE 7(A) is frequency programmed via  $R_{ABC}$ , which can be either switch-selected

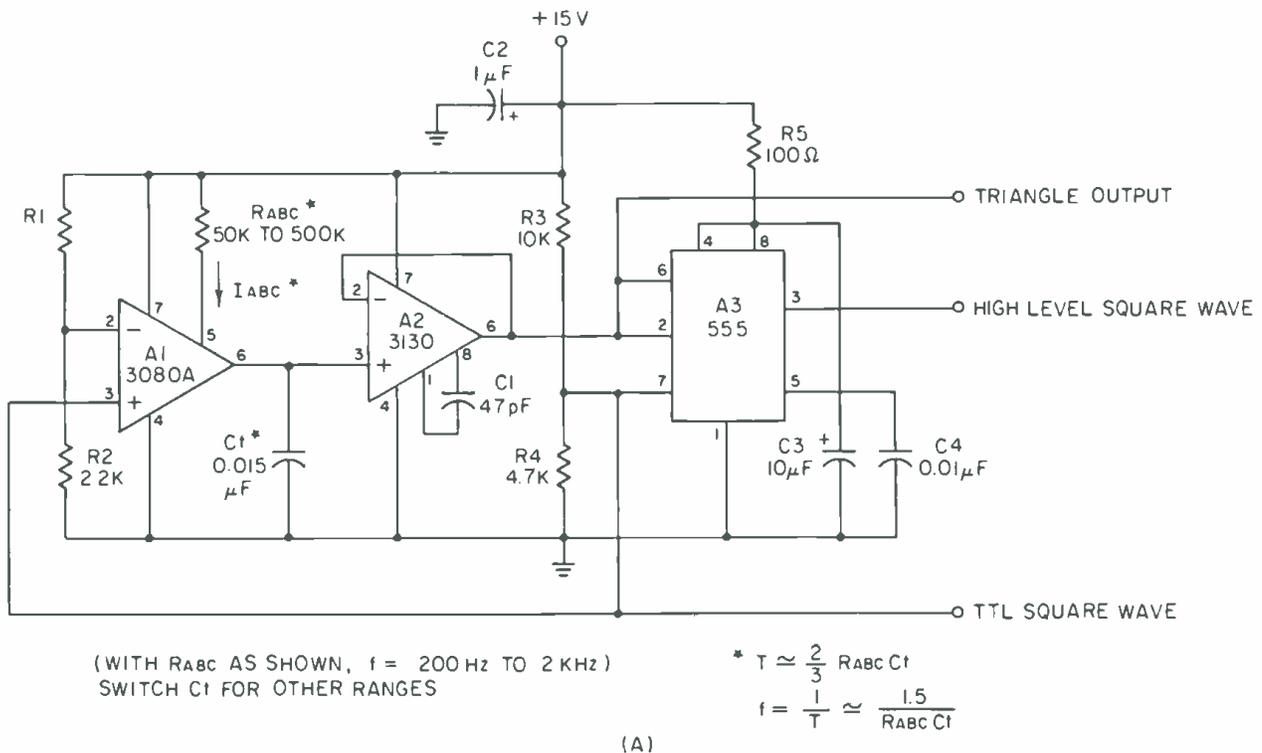


Figure 7(A). Wide range single supply function generator. a: Basic generator.

or operated via a rheostat. Unfortunately, (from a convenience standpoint), frequency doesn't vary linearly as pot rotation—period does. The circuit illustrated next overcomes this limitation, however.

FIGURE 7(B) shows an option, which when added to the basic circuit, converts it into a linear voltage-controlled version. By applying a control voltage  $E_c$  to  $R_{ABC}$ , the frequency can be varied linearly via a pot across the +15 V line. Thus the circuit is a voltage-controlled oscillator, or vco.

For widest dynamic range, the amplifier A4 should have a very low input bias current, and very low input offset voltage. In practical terms, this means for a three or more decade tuning range, an f.e.t. unit with its input offset voltage zeroed is desirable. The 356 mentioned previously would be a good choice; another would be the 8007 (Intersil), or the 3130 if  $\pm 7.5 \text{ V}$  supplies are used. If sufficient care is taken in the control circuitry, it is possible to achieve sweep ranges of 100,000 to 1. Note that this option requires a negative supply voltage in addition to the original +15 V.

### SINGLE CHIP FUNCTION GENERATOR

A version of function generator which is remarkable in its simplicity is shown in FIGURE 8. This circuit uses an Exar 2207, a single chip vco which provides both triangle and square wave outputs.

The 2207 is quite a versatile device. It can be frequency shift keyed via its two binary control inputs, it

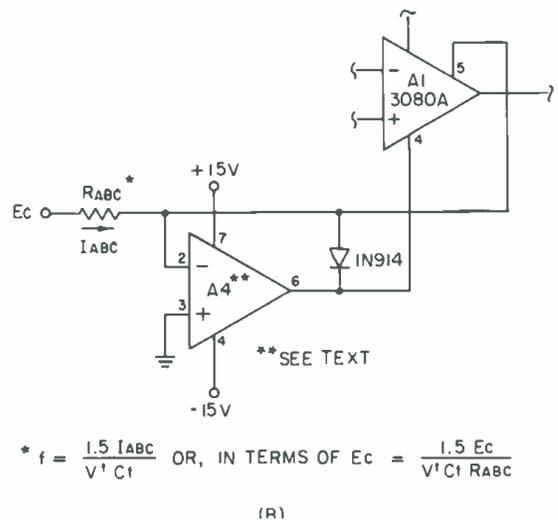


Figure 7(B). Linear voltage controlled option.

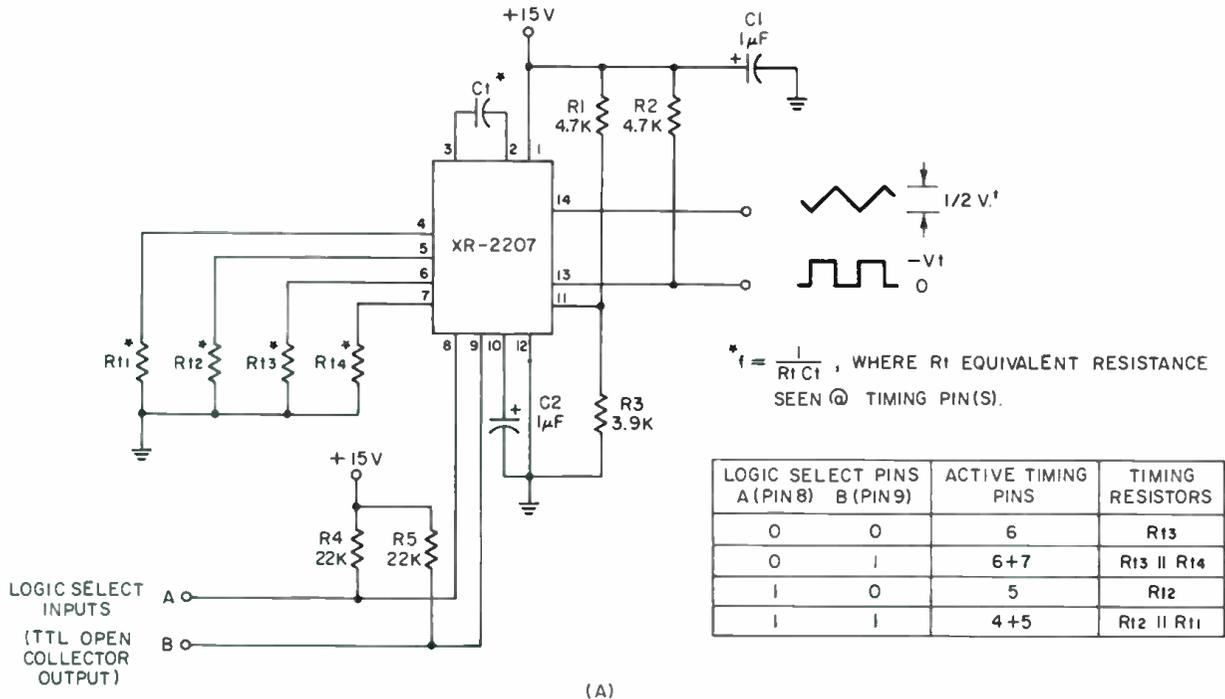


Figure 8(A). Single chip function generator.

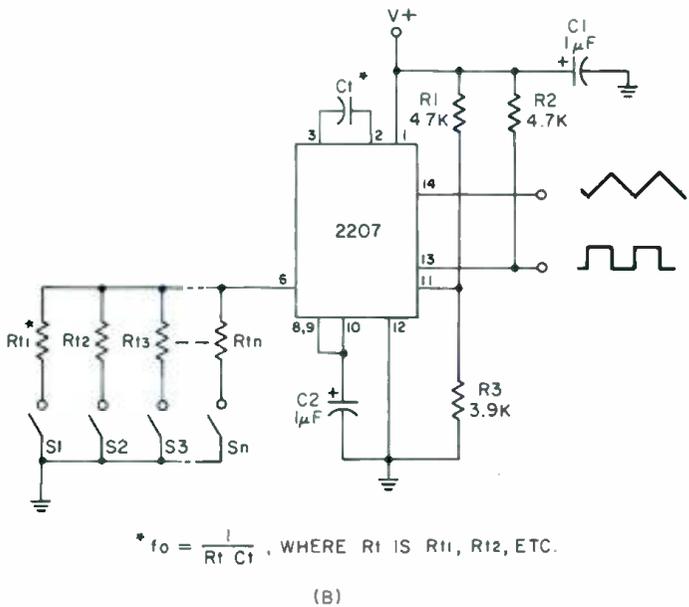


Figure 8(B). 2207 basic programmable oscillator.

can be either voltage- or current-controlled for frequency changes (over a 1000/1 range), and it is capable of asymmetric output waveform as well as 50 per cent duty cycle. Perhaps the best way to understand the device is to talk of it first in simple terms, such as the single supply circuit shown.

Four timing pins are available: pins 4, 5, 6 and 7. The current drawn from these pins through the timing resistors determines the output frequency, in conjunction with  $C_1$ .

The effective timing resistance may be either one or two of the four shown, as per the truth table shown. If FSK operation is not desired, the keying pins 8 & 9 may be simply wired to pin 10, which activates pin 6 only as the timing input. Outputs appear at pins 14 and 13, in the form of triangle and square waves, respectively. The triangle wave is at low source impedance, and its level is one-half of the supply voltage. The square wave is an open collector type output, so its most positive limit will be the positive supply return level used.

The 2207 is quite a stable device, possessing a typical frequency TC (drift) of 30 PPM/°C. This of course assumes you use low TC components for  $R_t$  and  $C_t$ . The comments stated previously apply here as well on timing component quality. Further,  $R_t$  is best kept between 4k & 200 k and  $C_t$  between 100 pF and 100 µF (non-polar) for best stability.

There are many ways you can build on a device such as this to enhance its usefulness. We've already seen how the binary inputs provide up to four digitally selected frequencies. In FIGURE 8(B), a method is shown where the number of discrete frequencies available can be expanded without limit.

Here  $R_{t1}$ - $R_{tn}$  are individual timing resistors which are activated by their respective switches  $S_1$ - $S_n$ .  $S_1$ - $S_n$  need not be toggle switches of course, but any solid state switch which can sink up to 3 mA and stand off 8 V in the off state. Examples would be one of 10 or one of 16 decoders in either ttl or cmos logic, for instance.

While there is no theoretical limit to the number of switches which could be used this way, a more practical technique for a great many different frequencies is a D/A converter. FIGURE 8(C) shows such an example, using an inexpensive ttl hex inverted package as 6 bit switches driving a binary ladder network. This arrangement will allow 63 discrete frequencies to be selected.

To go much beyond this really requires better hardware, such as in FIGURE 8(D). Here a 7520 is used to

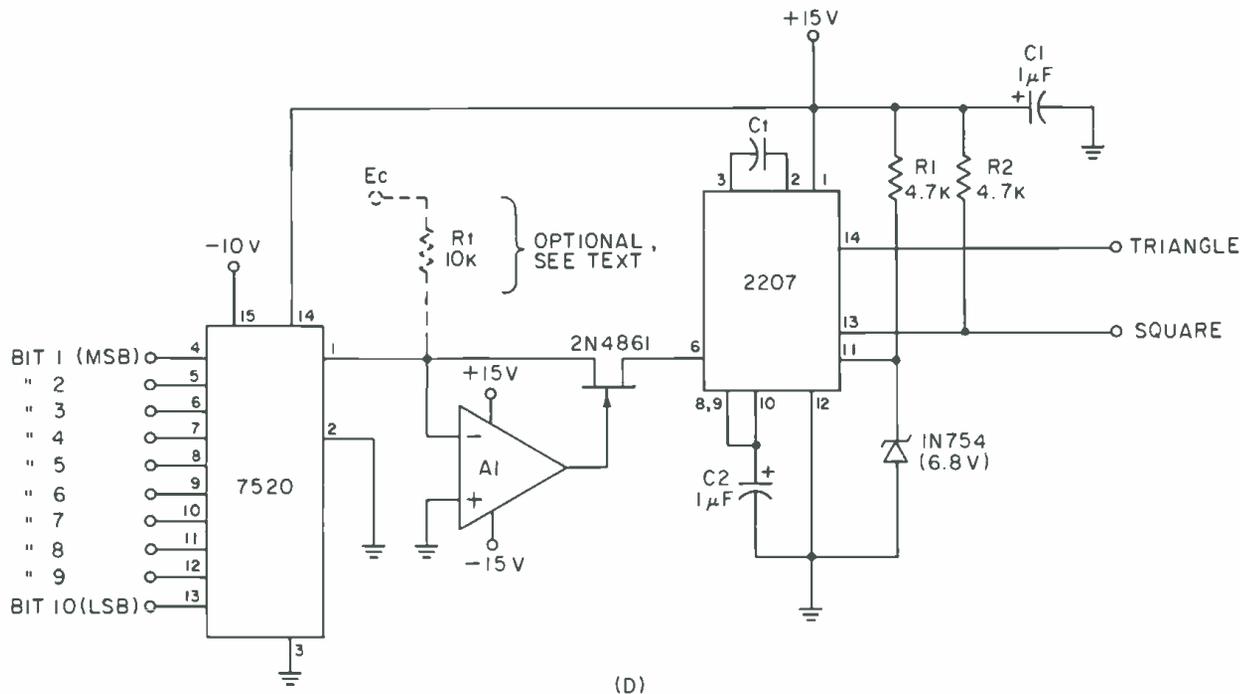


Figure 8(D). 10 bit D/A converter programming.

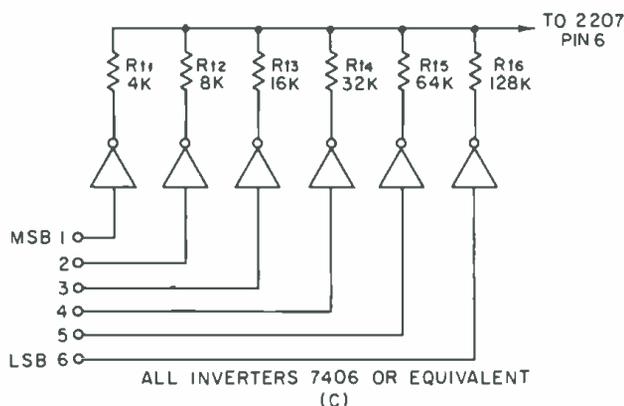


Figure 8(C). Simple D/A converter programming.

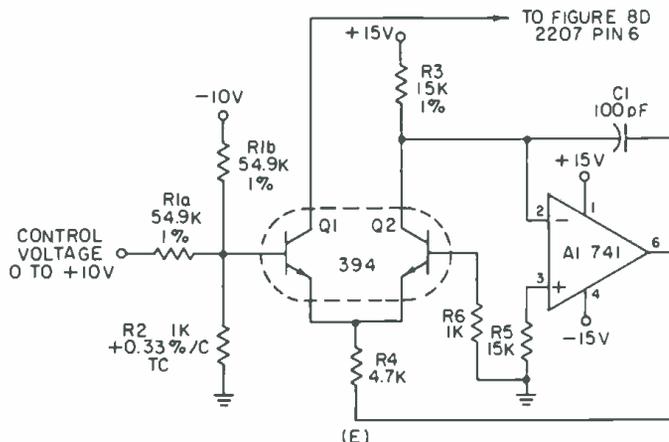


Figure 8(E). Exponential vco option.

program the current from the timing pin. An op amp and f.e.t. are used as a precision current converter to drive the 2207 timing pin. This type of circuit can also be used as a precision analog vco, by deleting the D/A and adding a resistor  $R_t$  to the summing point of A1. Voltages from zero to  $-10\text{ V}$  will then tune the 2207 over its range. If a very low offset voltage op amp is used, dynamic sweeps of over 1000/1 are possible.

One of the most useful type of vco or function generator is one with an exponential control relation. This feature may be added to a 2207 sweep generator by use of an anti-log converter to develop the timing current, as in Figure 8(E).

Here the 394 matched pair is the anti-log converter along with A1. The input divider to Q1 is scaled for a 1 V/octave control characteristic, thus 10 volts of control range changes output frequency by 10 octaves.

This installment has taken a look at some function generator techniques and hardware used. Next installment we'll explore the sine wave oscillator and some of its many variations. ■

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**USED, CONSOLE & 8-TRACK AMPEX;** Universal Audio tube type modules, 12-in/4-out modified to eight ch. 4 direct. 8 ch. monitor trim. & 8 ch. hp. trim. floor model cabinet, approx. 8 x 3 x 3 ft. \$5,000.00. Ampex AG-300-8 solid state electronics, in separate rack; 300 transport & sel/sync panels in matching console cabinet, \$5,500.00. Ampex AG-440B-8 console, \$6,000.00. **Leon Sides. W & W Dist. Co., 644 Madison Ave., Memphis, Tenn. (901) 527-4627.**

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**TASCAM REVERBS—\$500;** Tascam mixing consoles—\$2,350; Tascam ½-inch recorders; \$1,990; Tascam 8-track recorders—\$3,490. All shipped prepaid/insured, including free alignment/equalization/bias/calibration. **Music & Sound, Ltd., 11½ Old York Rd., Willow Grove, Pa. 19090. (215) 659-9251.**

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## WANTED

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WANTED: PRESTO 800 TAPE RECORDER, Conrac AV12E tuner. **Rose, 228 E. 10th St., New York, N.Y. 10003.**

WANTED: Educational public broadcast station needs surplus studio equipment, particularly magnetic tape and mixing equipment. Contact **Boulder Community Broadcast Association, 885 Arapahoe, Boulder, Colorado 80302.**

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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**

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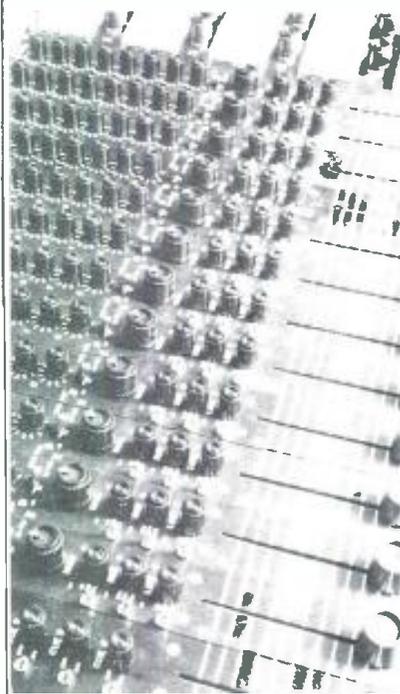
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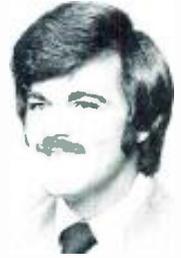
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DUNLAVY

● **Jim Quarles** has been appointed western district sales manager for **Systems Marketing Corporation**, of Bloomington, Illinois. Mr. Quarles will be responsible for nine western states. Prior to his appointment, he was a sales engineer for **Sparta Electronics**.

● **UREI**, of N. Hollywood, California, has named **Raymond B. Combs** to the newly created position of vice-president, operations. Mr. Combs, who will be working with plant management and customer relations, has been with the firm since 1968.

● **David H. Kaye**, formerly with **Bolt, Beranek, and Newman, Inc.** has opened his own consulting firm, specializing in sound reinforcement systems, noise masking, architectural acoustics, acoustical measurements, and transportation noise impact. His office is at 156 W. Newton St., Boston, Mass.

● Covering an expanse of five acres, including a 100,000 square foot plant, in El Centro Industrial Los Pinos in Tijuana, Mexico, **Audio Magnetics** has opened a new recording tape assembly plant. The plant employs approximately 1,400 workers and turns out more than eight million tape units a month.

● **Singer Products Company, Inc.** of New York City, will serve as the export managers for **Infonics** tape duplicator equipment in all areas except North America, according to an agreement made with **Infonics, Inc.** Another service firm connected with **Infonics** is **Tape & Production Equipment Co. Inc.** of Chamblee, Georgia, a division of **Tech Systems** of Atlanta. They will act as the southeast regional service center for **Infonics** tape duplicator equipment, providing sales and complete repair, overhaul, and rebuild service.

● Two new appointments have been made in marketing at **Quad/Eight Cinema**, the theater and studio sound products division of **Quad/Eight Electronics**, N. Hollywood, California. **Al Lewis**, whose expertise in sound motion pictures goes back to the field's inception in 1928, has been appointed vice-president, international marketing. Another industry veteran, **Igor Kozlov**, has been appointed vice-president, International Marketing. Mr. Kozlov, a native of Yugoslavia and fluent in Russian, has been involved in international sales in his own company, **Russian Translation & Consulting Services**. Previously, he had been with **Ampex**.

● **Arrest Records** recording company has been established at 1420 K St. N.W., Washington, D.C. The first of two recording studios will open shortly, with the second scheduled for completion next spring. Principals in the operation include **Oscar (Sonny) Smith, Jr.** as executive vice president and chief engineer, **Arthur Weiseger**, administrative head, and **Mitch Litman**, who will specialize in artists' development, as well as communications services and promotion.

● **William J. Overhauser**, founder and president of **Sparta Division of the Cetec Corporation**, of Sacramento, California, has announced his retirement. His responsibilities will be taken over by **Jack J. Lawson**, with the title of acting general manager. Mr. Overhauser will continue to serve as a consultant to the company.

● A renovation operation has been completed at **The Silvery Moon Studios**, of Los Angeles, including the installation of a 30-input, 24-track facility. Each input module features stepped reciprocal parametric equalization, programmable mute busses, and a special effects section. The studio is also planning new automation services.

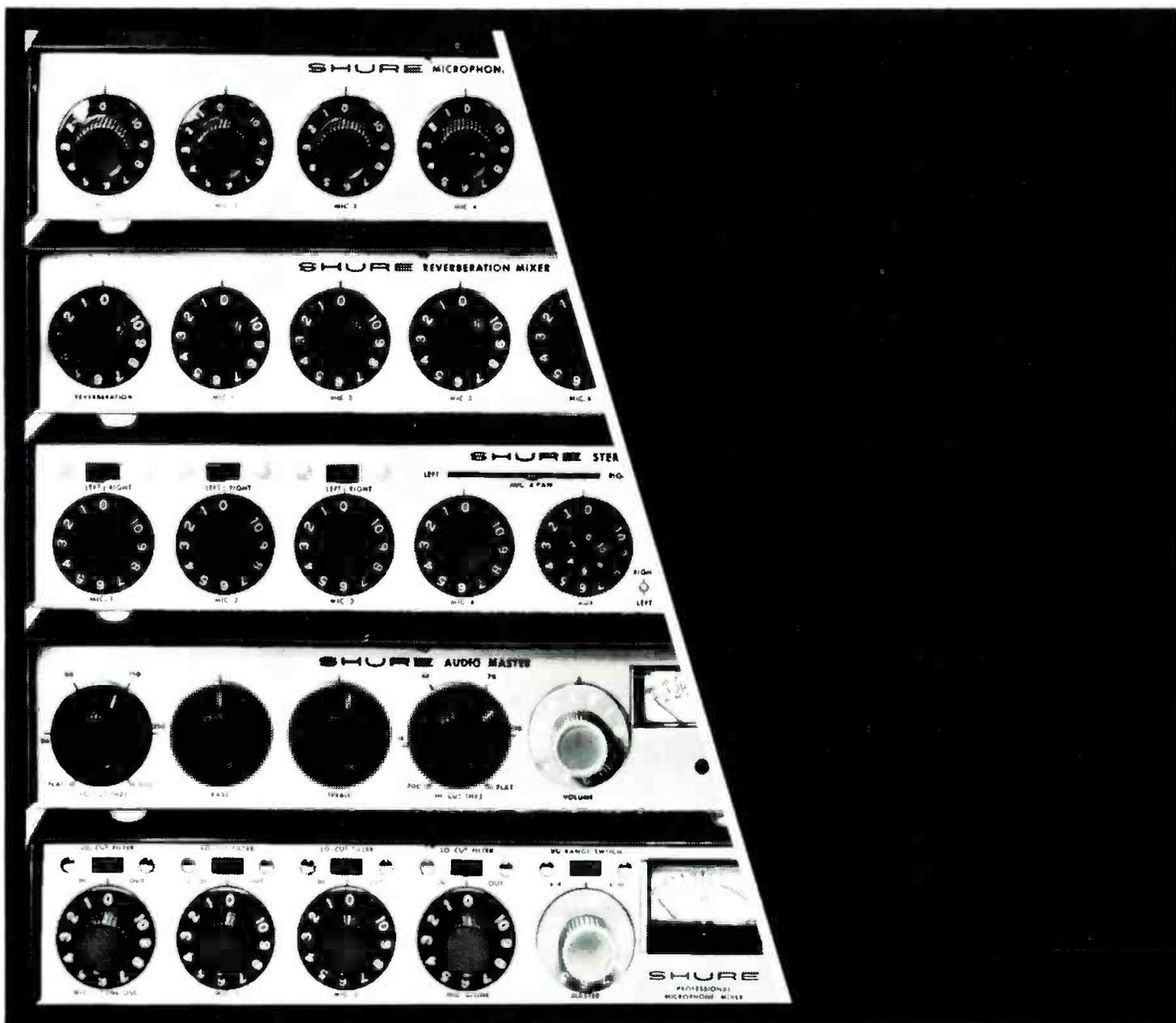
● **Rick Belmont**, formerly of **Fairchild Sound Equipment**, has joined **Modular Audio Products** of Bohemia, N.Y. in the post of sales manager. Mr. Belmont will be responsible for the overall sales and marketing activities for the Modular line of professional audio components and systems.

● Distribution of studio and duplicator products in the midwest for **Capitol Magnetic Products (Capitol Records)** will be focalized by **Richard L. Dunlavy**, recently appointed to the post of midwest regional sales manager for professional products. The region extends east-west from Pennsylvania to Colorado and north-south from Canada to New Mexico. Mr. Dunlavy will be based in Indianapolis, Indiana.

● **Cetec Corporation** of El Monte, California has announced an agreement in principle for the outright purchase of **Schafer Electronics Corporation** of Santa Barbara, California. The Schafer Corporation produces automated broadcast equipment for a.m. and f.m. radio stations. **James M. Cunningham**, president and general manager of Schafer, will retire but continue to serve Schafer in a consulting capacity.

● Licensing for Scheiber basic patents for quadriphonic matrixing and logic techniques can now be obtained directly from Peter Scheiber's **Audio-data Company**, of Bloomington, Indiana. **CBS** or **Electro-Voice**.

● Audio technology is recreating bi-centennial sounds throughout the country. One of the most notable of these is the **Battle of Bunker Hill**, being re-fought in a new multimedia theater at Charlestown, Mass. The **Bunker Hill Pavilion**, sponsored by the non-profit **Raytheon Historical Foundation Corporation**, allied with the **Raytheon Company** of Lexington, Mass, cost more than \$1,400,000. The 17-minute presentation employs seven sound channels and 14 projection screens to surround the audience with realism.



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