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THE SOUND ENGINEERING MAGAZINE

db

JANUARY 1979
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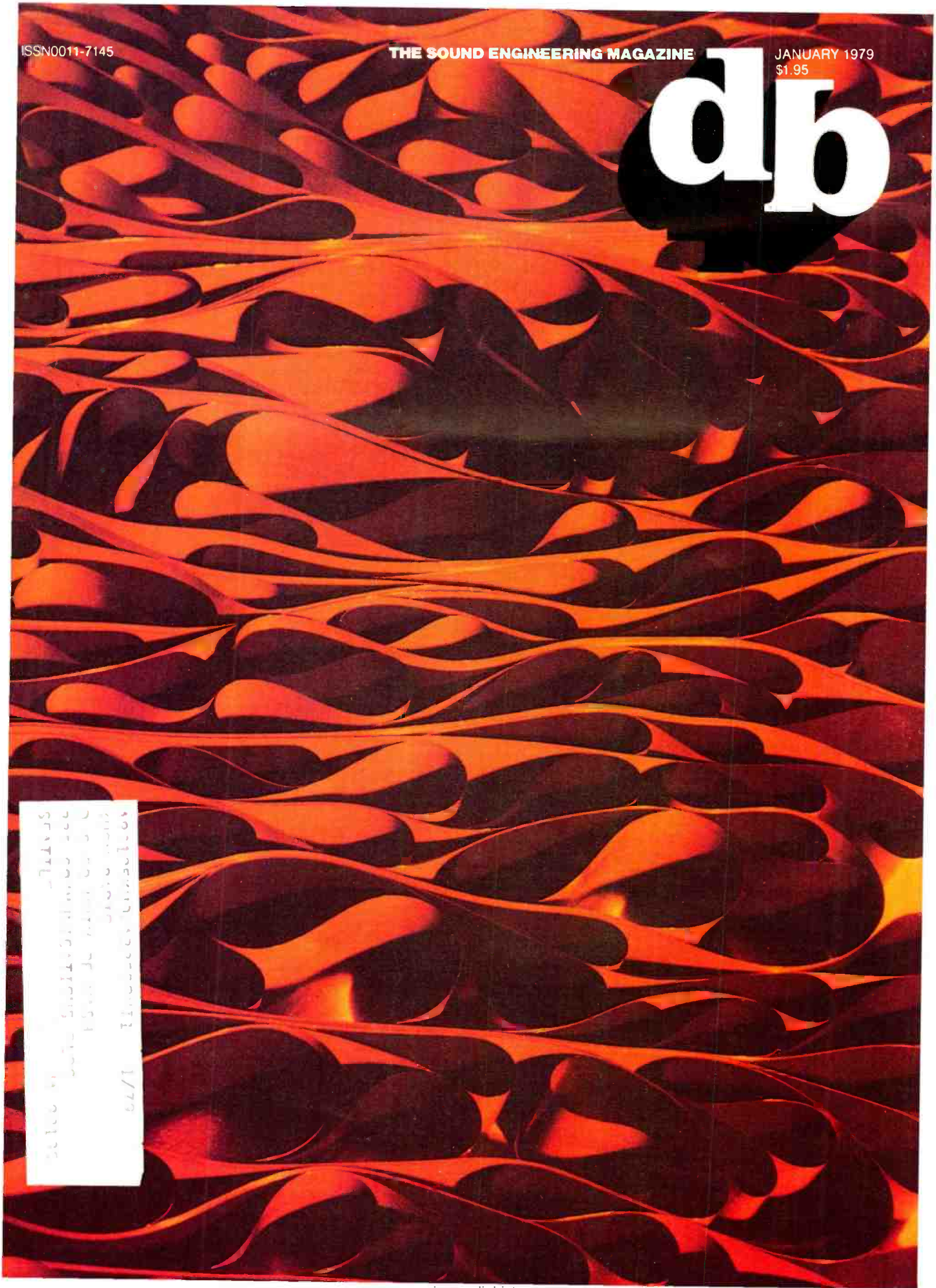

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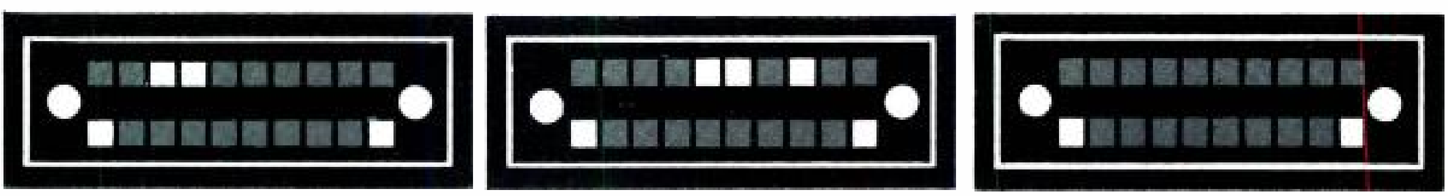

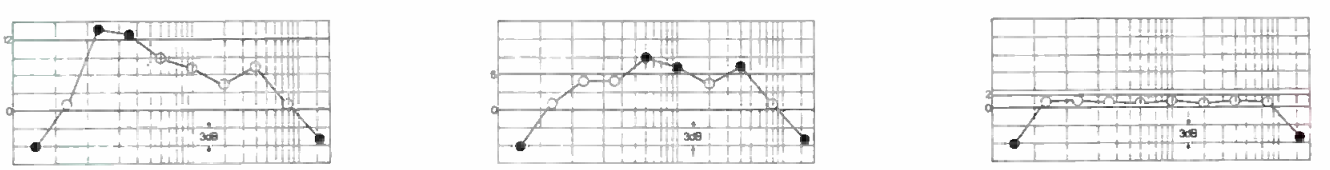

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Coming Next Month

• The topic will be Amplifiers and Loudspeakers.

• Dana Hathaway of Epicure details the use of feri-fluid materials in speaker designs. Both the theory and practical applications will be included.
Not to let this subject pass too quickly, Dave Rosen of Audio by Zimet, Inc., will show us how to use those ferri-fluid materials to retrofit existing loudspeakers. Yes, it can be done.

• *High Fidelity in the Control Room* is the title of an article by Dr. Floyd Toole of the National Research Council of Canada. There's more to it than you think.

• The fine points of the speaker/amplifier interfacing are discussed by noted consultant Dan Queen.

• John Eargle of JBL has contributed an article that examines the studio monitoring system.

• Almon Clegg of Technics explores the implications of phase alignment in loudspeakers.

• All this coming in **db, The Sound Engineering Magazine.**

About The Cover

• Here's one case where you *can* judge the book by its cover, both of which feature a close look at magnetic tape. For the cover, our thanks to Ampex for supplying this interesting close look at some mastering tape, collecting in the bin of a BLM-200 Bin Loop Mastering Recorder. As for the book, check our table of contents for more details.

db

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db Letters

THE EDITOR:

Regarding the article entitled **A Homemade Broadcast Console—Why Not?** by Louis Burke, Jr., some comments and improvements come to mind.

First, a substantial improvement in distortion performance can be achieved by including the output buffer stage in the feedback loop. This is done by replacing the 100 μf coupling capacitor on the LM301 output wtih a 100 ohm resistor and moving the 100k feedback resistor to bring feedback from the junction of the 33 ohm resistors. This modification has the potential to bring the distortion below 0.1 per cent.

Secondly, the 30 pf compensation capacitor is too large, unnecessarily restricting high frequency distortion and power output. The Texas Instruments "Linear Control Circuits Data Book," first edition, page 76, shows a graph of peak-to-peak output capability *vs.* frequency and compensation capacitance. Inspection of this reveals that at 20 kc/s only 7 volts p-p is guaranteed as available output if 30 pf is used to compensate the LM301. (Some are better and some worse, out of a batch of op amps.) The formula for the minimum C_c is also given—being approximately 30 pf/circuit gain (with feedback). With a gain of 10, 3 pf is obtained as the minimum C_c. Since a margin of safety is desirable, 5 pf is selected. Now the full output swing is available to above 40 kc/s. The effect is to increase the loop gain at high frequencies, lowering the distortion, as well as permitting full output swing without slew-rate limiting at 20 kc/s.

Thirdly, the output impedance is not 600 ohms as implied by the notation "Z = 600" on the circuit diagram. To raise the output impedance to 600 ohms, a resistor of approximately 560 to 580 ohms must be inserted in series with the output coupling capacitor before the transformer. (If the change in feedback mentioned above is made, 600 ohms is inserted.) This will be found necessary to prevent the sort of peculiar effects on frequency response (which are described in a previous article by Don Davis) caused by the interaction of the low source impedance and passive filters, as well as by transformers which may later be connected to the console externally, at which time strange words may be

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heard until someone finally decides to measure Z_0.

Note that the resistor will limit the output power level to +16 dBm into 600 ohms (assuming = +22 dBm without the resistor). The power may be restored by using another amplifier to drive the other end of the primary winding 180 degrees out of phase, creating a bridged-balanced amplifier. Since the electronics are much cheaper than transformers, the cost per module is not increased by too much.

Finally, the microphone preamp is shown with the input transformer operating into a matched load, which is not optimal. For the lowest noise (or higher output from the microphone), the microphone should see a bridging load. This will increase the input voltage available by 6 dB, which should translate to nearly 6 dB better signal-to-noise ratio.

These may not be large issues, but I am sure that those who are learning practical electronics the hard way, as I did, will appreciate any and all information adding to, or clarifying, construction and design articles.

JERROLD S. TIERS
Clayton, Missouri

THE EDITOR:

I found Bert Whyte's article regarding the details of direct-to-disc recording techniques very enlightening. However, I do have one question concerning the necessity for manual control of the groove pitch and depth during the mastering process.

Mr. Whyte refers to the use of an advance tape head feeding a computer to provide automated cutterhead control during the conventional tape-to-disc transfer. A later comment states that there is no possibility of automated control in the direct-to-disc recording chain due to the lack of an advance head. Why cannot an advance head be simulated through the use of a "state-of-the-art" time delay device situated between the recording console and the lathe? The "live" signal can feed the control computer, while the "delayed" signal would be fed to the cutterhead. While I may be unaware of inherent problems which could cause deterioration of the signal, it would seem that the finest of the current time delay units would perform well below the performance thresholds of the cutterhead and master lacquers. The benefit would be playback times comparable to those of conventionally recorded discs. I would be interested in any comments Mr. Whyte may have regarding the merits (or lack thereof) of using time

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delay in the direct-to-disc process.

I appreciate the greater understanding of direct-to-disc specifically, and audio in general, which Bert Whyte's contributions have fostered.

ROBERT B. COX
Commercial Consultant
Stuarts Audio, Inc.
Westfield, N.J.

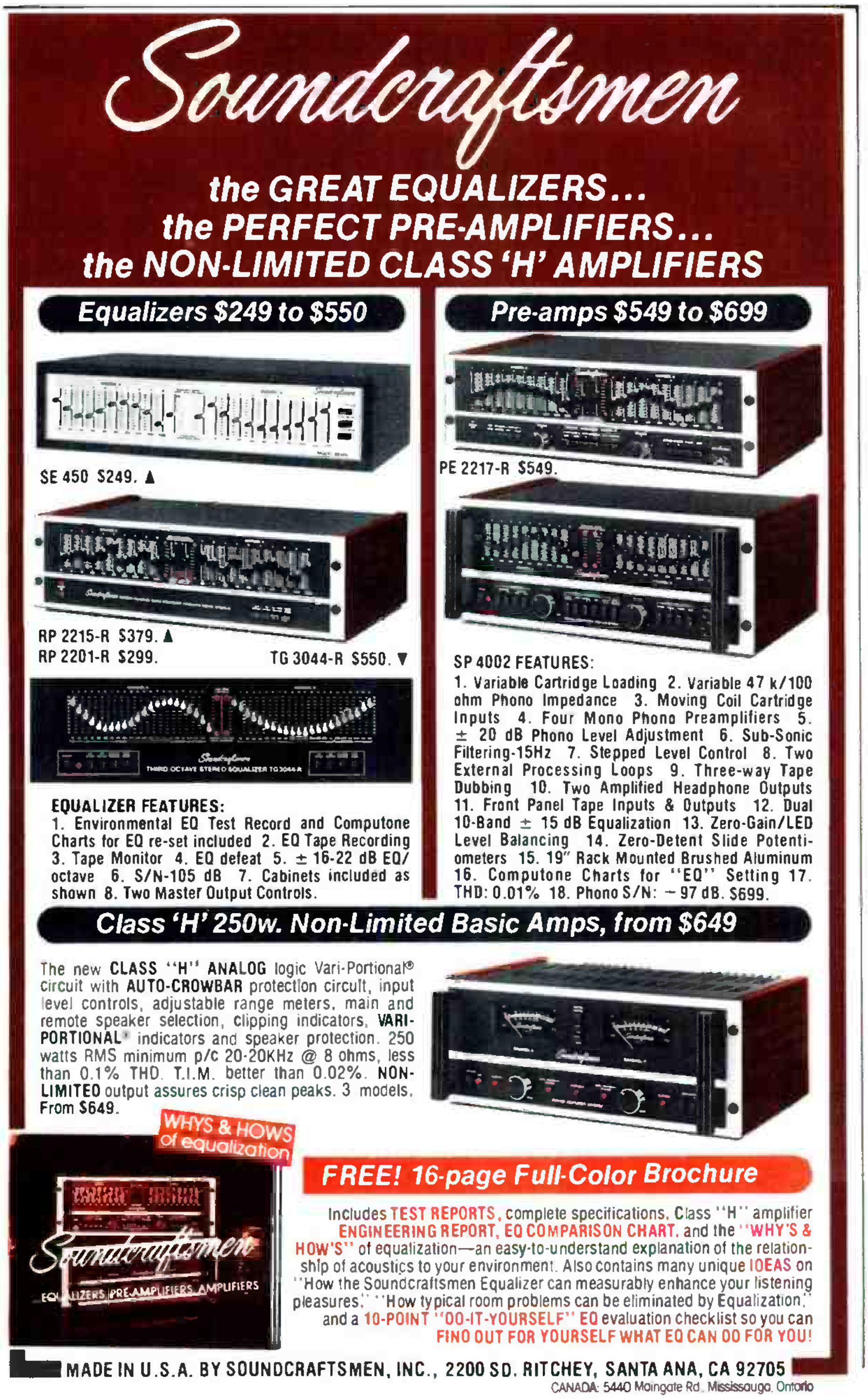
THE EDITOR:

More power to James Shelton ["a Look at the Record-Plating Process," October, 1978] and anyone else in this country who can help improve the abysmal quality of today's commercial discs. Perhaps the best hope is that record producers will become aware of quality operations such as Europadisk and use their influence to insist on high-quality plating, rather than relinquishing such a decision to some record-company flack who gets taken to lunch a lot by the high-volume/low-budget manufacturers.

Now that the record companies seem to be undertaking their third price increase in three years, we see the unfortunate truth starkly revealed: the marketplace has not demanded any improvement in the quality of the discs. Major pop artists should feel quite flattered that buyers are willing to pay high prices and endure poorly-manufactured records in order to listen to their performances. The sting of higher prices would be reduced for quality-conscious buyers if some of the increase was going into higher quality, but it looks more likely that the increases will just go into someone's pocket.

In the long run, we can all dream of the day when one of the new technologies which is indifferent to manufacturing defects, such as laser-scanned discs, becomes common. Today's disc is a good, practical, mass-distribution medium, however, with a potential for high quality which should not be ignored. What we need are more people likes James Shelton to remind the industry of that potential.

GEOFFREY L. BRYAN
Mountain View, CA



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THE EDITOR:

Your mini-guide to microcomputers made one very important omission—the PET computer manufactured by Commodore Business Systems. At $795 for a complete unit, with CRT, CPU/keyboard and 8K of memory, plus cassette storage, this is one of the cheapest home computers on the market.

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HEATHER WOOD
Marketing Manager
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Ed. Note:
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NORMAN S. CROWHURST

db Theory & Practice

What Does "DB Feedback" Mean?

● Recent columns have discussed load lines, damping factor and back e.m.f. And from that we have derived things like source resistance and perhaps inferred something like various forms of distortion. Some 4 or 5 decades ago, when audio was very primitive by today's standards, negative feedback was introduced as a sort of "beneficient genie" that could help with a whole stack of problems. Most important, or most immediately recognized, was its ability to reduce distortion. But then it was found it could also modify internal impedance, which later became tied up with damping factor, improve frequency response, another of the early recognized problems, and so forth. It was a while before some of us realized that, while it could do any of these things, it could not necessarily do all of them at once.

"db FEEDBACK"

The words in the title of this column, "db feedback" are usually taken to mean the amount, in db, by which gain is reduced when the feedback loop is "closed." That, in turn, assumes the form of feedback used is one that allows the loop to be "opened." To show what we mean by that, consider its application to an emitter-follower circuit, also called "grounded collector" operation of a transistor.

Assume we have a type of transistor that operates with an 8-ohm load, direct coupled to the emitter or collector, as the case may be. For the moment we will not discuss the d.c. component. For a peak-to-peak signal of 40 volts, this means we have a peak-to-peak signal of 5 amps, which could be a variation from zero to 5 amps, or could be plus or minus 2½ amps.

Now, if this transistor has a beta of 25, that change of current in the emittor or collector circuit, is achieved by means of a change of 5 divided by 25, which is 1/5th amp, or 200 milliamps. Working grounded emitter, such a change of current will be accompanied by very small voltage change, from base to emitter. But working grounded collector, the same change of current at the base will need a change of voltage of 40 volts peak-to-peak.

According to our concept of negative feedback, grounded collector, or emitter follower, uses what has also been called 100% negative feedback, while grounded emitter has none. Any feedback when you use grounded emitter, is obtained by feedback of some of the collector voltage swing, to some earlier stage in the amplifier. But when you use grounded collector, or emitter follower, all of the output voltage is feed back to the previous stage.

So how much feedback do you have in an emitter follower stage? We have called it 100%, but what is that in db? There is no simple answer. It depends on how much more gain you need, to get that 200 milliamps swing, when it goes with a 40-volt swing, than when there is virtually no voltage swing. You begin to see that this is getting complicated.

Now, in the above, we assumed an 8-ohm load. If it is somehow a.c. coupled—without going into how to do that for the moment—then we could remove the 8-ohm load so that the 40 volt swing could be achieved

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theory and practice (cont.)

with no current swing. That is. of course, an ideal. In practice there would be a small current swing, and it is easier to figure things through if you give that a value. Say it is 50 milliamps, instead of 5 amps.

Now, if the beta remains unchanged. the base current swing will be 2 milliamps, instead of 200 milliamps. For the grounded emitter. the base voltage swing will be even less than for 200 milliamps swing, while for grounded collector, or emitter follower. it will still be 40 volts peak-to-peak.

Using the emitter follower circuit, an input of 40 volts peak-to-peak will deliver 50 milliamps or 5 amps swing at the output, with equal ease. It is only contingent on the previous stage being able to deliver 200 milliamps peak-to-peak, along with the 40 volts. But with the grounded emitter, an input swing of 200 milliamps will want to produce an output swing of 5 amps.

If there is no 8-ohm resistor to receive the 5-amp swing, then the output stage will act like a switch, going from zero to whatever maximum current it does deliver—we suggested 50 milliamps. You will no longer have conventional amplification. But if you provide voltage feedback so that. when the current swing drops, a negative signal cuts back the input current swing. then removing the 8-ohm load may still result in the input swing dropping from 200 milliamps to 2 milliamps.

That is a change in level of 40 db. Does this mean it represents 40 db feedback? And because it does in the grounded emitter circuit, does it mean this is the amount of feedback also present in the emitter follower circuit? If you remember how we arrived at that 2-milliamp figure—more or less as a guesswork figure—you will realize how unreliable such an assumption would be.

BACK TO ALGEBRA

Feedback theory starts with some algebra. You assume the amplifier. without feedback. has a gain of A (sometimes the Greek μ is used, but we will give the typesetter a rest by using A), and the portion fed back is B (correspondingly the Greek ß may be used). If the original input is assumed to be 1, the output will be A. and the feedback component will be AB. So instead of the original input 1. with feedback we need 1 + AB, and the gain drops from A to A divided by 1 + AB.

In classic feedback theory. converting 1 + AB to a db figure, by taking 20 times log to the base 10 of it, gives "db feedback." To put some figures in. if A is 900, and B is 1/100, AB is 9. and 1 + AB is 10. 20 $\log_{10}$ 10 is 20, so that is 20 db feedback. All very neat. until you start trying to figure what units A and B are in. They could be voltage gain and attenuation, or current gain and attenuation. But in practice, it is never quite that simple.

How do you measure A? With the 8-ohm connected. or not connected? And what about B. when there is no separate feedback network. as in the case of the emitter follower? That is what we mean by calling that 100% feedback. Actually we are saying that B, or ß, is 1. But that still does not tell us what figure to put in for "db feedback," because finding out what A is *without* feedback, is difficult.

Now let us jump a bit. in the theory. Using the algebra. with appropriate block schematics. we can show that reduction in gain is by the factor 1 + AB. that the reduction in distortion within the amplifier contained in the feedback loop is also by the factor 1 + AB, that input and/or output internal impedance may also change—either up or down. according to circuit configuration—by the factor 1 + AB. and so forth.

We are, as we have already suggested, in a situation where we may use different figures for A and B. according to the purpose for which we are considering feedback: gain stabilization. impedance changing. distortion reduction. or what. But even then. we usually assume that A and B have definite values that we can assign to them for a particular case and purpose. Unfortunately that too can be wrong.

Take the case where change of output loading makes the output stage work like a switch. instead of as a Class A amplifier. It is either fully conducting, or it is not conducting at all. it is cut off. Of course, since the transistor is an amplifier. even though badly operated. there will be a short region where it amplifies. and over which region we could apply an appropriate figure for A.

Over this short region, the algebra will "work." The gain will be modified by feedback, from A to A divided by 1 + AB. But when the output transistor hits either saturation or cut-off, that figure of A suddenly changes to zero. If saturation is not quite complete, maybe it changes from a high figure to a very small one, instead of zero. But the effect is similar.

CUT-OFF

And when you go into cut-off something else usually happens. too. Within the conducting range, the transistor behaves as an amplifier. in which the input electrodes present a quite low

resistance or, more accurately, a fixed voltage drop, with the varying current. Even that is only an approximation, but it is more realistic than thinking of it as a resistance.

If varying current produces no voltage change, that is zero a.c. resistance. Now, when you hit cut-off, suddenly the non-conduction of the input junction makes the device change from zero a.c. resistance to open circuit. It now acts like a diode, rectifying the input signal, and changing the operating bias.

Now what happens depends on whether the stages are a.c. or d.c. coupled. If they are d.c. coupled, the clipping is instantaneous, with no after-effect. When the signal waveform comes back "in bounds" the device continues to act like an amplifier. But if they are a.c. coupled, the change in bias may last a little while, depending on circuit time constants. Getting back to normal amplification may take a little while, after such an excessive swing occurred.

And, whatever the cause of the cut-off condition, whether it just happened, or is a hangover from some time constant, the gain has disappeared for the duration. The feedback algebra no longer works. Right now, "db feedback" is zero, as is the output it is working on. You have momentarily lost your amplification.

So far, we have ignored phase shifts, because they certainly complicate matters. We have assumed, in using that particular algebra, that feedback is negative. That the AB adds to the 1, in phase. That makes it negative feedback. If the phase reverses, the feedback factor becomes 1 − AB, and AB must be less than 1, or you have an oscillator, instead of an amplifier.

But practically, phase shifts are another complicating factor. Various elements in the system, such as switching times, capacitor charging times, and so forth, mean that 1 does not always directly add to AB, or AB subtract from 1. Sometimes it is a vector summation. And that gets us into a whole lot more complications.

This has been a very quick run-through. We have not even touched on some of the factors, but have tried to show the more important ones, and what limits them. In general, using a simple circuit results in the algebra being more simply, or more directly applicable. But to use it all properly, you need to know what it is all about. It is perhaps one of the most interesting aspects of electronic circuit design. ■

db Calendar

MARCH

13-16 **62nd Annual Europe AES Convention,** Brussels/Sheraton Hotel, Belgium. Herman A. O. Wilms, Zevenburderslaan 142/9, B-1190 Vorst, Brussels, Belgium.

Synergetic Audio Concepts Sound Engineering Seminars:
13-15 The San Francisco Airport Hilton, San Francisco Airport, CA. 20-22 Hilton Inn, Salt Lake City, Utah. For registration forms or information on either seminar, contact: SYN-AUD-CON, P.O. Box 1134, Tustin, CA 92680. (714) 838-2288.

APRIL

2-5 **First Annual Architectural Acoustics Exposition and Seminar.** Hyatt Regency O'Hara, Chicago, Ill. Contact: Wayne V. Montone, Executive Director, 464 Armour Circle, N.E., Atlanta, Georgia 30324.

10-12 **Synergetic Audio Concepts Sound Engineering Seminar:** Sheraton Harbor Island, San Diego, CA. For registration forms or information, contact: SYN-AUD-CON, P.O. Box 1134, Tustin, CA 92680. (714) 838-2288.

MAY

12 **1979 Midwest Acoustics Conference. Topic:** Digital Technology: Impact on Recorded Sound. Norris Center, Northwestern University. Contact: William R. Bevan, Shure Bros., Inc., 222 Hartrey Ave., Evanston, Illinois 60204. (312) 866-2364.

15-18 **63rd Annual AES Convention,** Los Angeles Hilton, California; Chairman will be Martin Polon, Director, Audio Visual, U.C.L.A., C.A.S.O., Rice Hall 130, 405 Hilgard, Los Angeles, Calif. 90024, (213) 825-8981.

22-24 **Synergetic Audio Concepts Sound Engineering Seminar:** Sheraton-Universal Hotel, No. Hollywood, CA. SYN-AUD-CON, P.O. Box 1134, Tustin, CA 92680. (714) 838-2288.

JUNE

20-22 **APRS '79—Annual Exh. of Professional Recording Equipment.** Connaught Rooms, London.

Introducing the new TDK testing machines.

At TDK, we know that your test cassette is a vital element of your laboratory or service procedure. So when we created a series of test tapes, we approached them as integral components, with both tape and housing engineered as precisely as your test instruments.

You'd expect that from the makers of TDK SA, the high bias reference standard for many manufacturers' cassette decks.

TDK test cassettes don't jam and they're dropout-free. They're built to last under unceasing use. If you're a store service manager, assembly line quality control inspector, or highly discerning audiophile, you need that kind of precision and reliability. To make absolutely sure you get it, we custom quality-control each and every one.

No matter what data you need, TDK has a test cassette to help you find it out: bias/EQ alignment; playback level calibration; Dolby calibration; head azimuth alignment; wow and flutter and tape speed and 11, five and three-point frequency characteristics checks.

Check out the complete line of TDK test cassettes by writing, or calling (516) 746-0880. When you do, find out about our bulk duplication cassettes, bulk duplication pancake tape, audio visual, leaderless, data and endless cassettes, too. You'll find that the same TDK quality and reliability that goes into our test tapes applies all the way down the line.

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World leader in recording tape technology.

TDK Electronics Corp., 755 Eastgate Blvd., Garden City, NY 11530
2906 W. Peterson Ave., Chicago, IL 60645; 2041 Rosecrans Ave., Suite 365, El Segundo, CA 90245.

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MARTIN DICKSTEIN

db Sound With Images

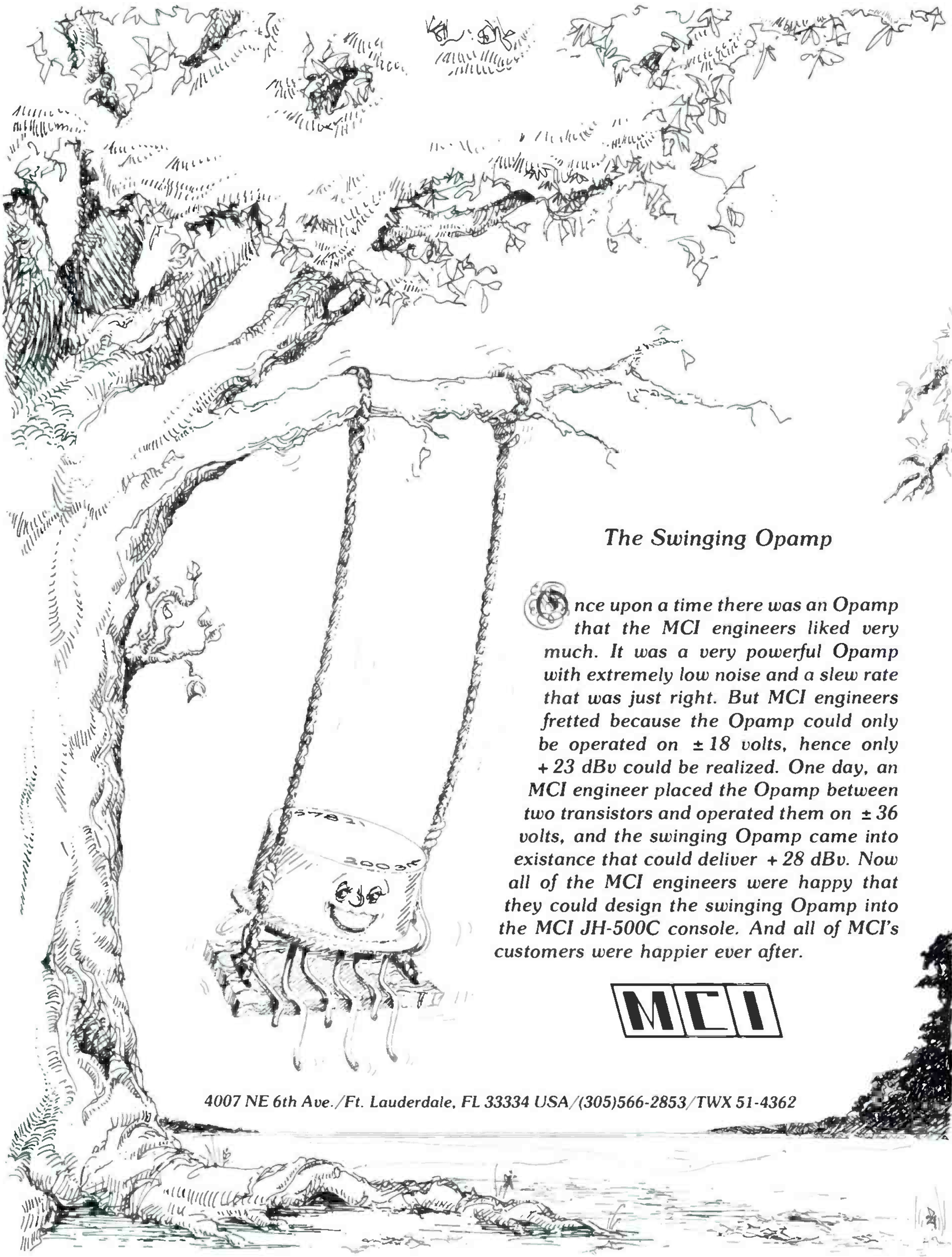
Resolutions for the New A/V Year

• On a recent trip for a client who was putting on several regional sales meetings with rear projection and live talent, several interesting occurrences came up which might be of interest to those of you who do meetings like this. In effect, these are additional tips to the people who work on setting up A/V equipment meetings and those who work behind the screen to keep the show running smoothly. Add these to the ones this column has been passing on for the past several months and it should make for a better a/v year for the speakers and audience as well.

In one location, the meeting director of the client company ordered equipment for rental through the hotel at which the meeting was taking place. The equipment arrived in plenty of time and was set up well ahead of rehearsal time. Low platforms were used as a base, then tables were placed on these, and more tables were placed on these to raise the projectors to the center line of the screen (a 27-foot wide rear screen). The operator then had to stand and walk on another table also raised onto a double set of platforms to get him to the proper height to change drums and load film conveniently. The lower set of tables under the equipment acted as a shelf on which drums, films, etc. were kept when not in use.

During rehearsal, it was found that tables to be walked on were not as stable as they should be. To avoid the possibility of the tables sagging in the center or moving apart or falling, heavy planks were placed across the full length of the tables. The weight then also acted to steady the tables, covered the gap between the tables, and gave the technicians a good walking surface. However, no such precaution was taken with the projection tables. No, they did not fall over, but they were not exactly the Rock of Gibraltar either. However, a space was left between the walking tables and the projection tables to avoid any shaking of the projection equipment while the techs were moving about.

Then a simple thing happened which no one noticed during the preparation but which showed up during the rehearsal. The slide trays had been flown in to the site, and to prevent any of the slides from falling out, the rings on top of the drums had been tightened to the extreme. When it came time to reverse the order of two slides, or to exchange a newer slide for an older one, the rings had to be loosened. The effort involved quite a bit of muscle, and in the awkward position of having to reach over to the projectors, the images on the screen shook rather badly. Not only the one on the projector at which the slide



Circle 18 on Reader Service Card

sound with images (cont.)

was being changed, but also on the other two by virtue of the shaky setup.

This arrangement leads to several suggestions, all of which should help one remember circumstances to be avoided in the future. Be sure the equipment is firmly set on a firm base. Be sure the set up gives the technicians freedom of movement and some space to work in—in safety. (Maybe you don't think much about the technician and his need for work space, but with insurance as high as it is—at least prevent his falling—because he can knock over the equipment on the way down, and you wouldn't want that to happen.)

Be sure all equipment is placed within convenient reach of the techs. Tape recorders, whether on the second level of the table setup, or on the first, should be within arm's reach and at a position near where the operator will be when it's time to play a tape. If there are dissolve units in the setup, place them so that the operators can see the status of the projectors and can reach the units themselves in case of a problem.

Leave space for a script or notes which the operators might need to cue them on when to change drums, or run the tapes, or start and stop the film projectors. Make sure there's place for a small lamp such as a Tensor and be sure the light can not be seen from in front of the screen. Put all drums, tapes, and films in easy reach and near the location where they will be used. Be sure all lock rings are sufficiently tight to hold the slides in place, but not so tight that they can not be loosened easily (the first locking position should be sufficient). Try to have all tapes made up with leader between cuts for easy finding and cueing, and even write the piece of tape coming up on the leader for quick identification.

Locate all sound mixing and amplification equipment where the operator can see the controls and meters and can reach the controls quickly if necessary. Label all positions on the mixers in some convenient way so the proper control can be adjusted with only a quick glance at the unit and avoid time-consuming searching during what is always the most hectic period of any presentation.

Speaking of labels, mark each slide drum with white tape on the side (or in any other easy way) and all the necessary information to help the operator know which segment of the show the drum is for, what projector it goes on, in what order, etc. This is especially essential when dissolves are

maxell UD XL 50-120B
Sound Recording Tape
maxell LN 35-180
Sound Recording Tape
maxell UD 35-180
Sound Recording Tape
maxell UD XL 50-60B
maxell UD 35-90
maxell LN 35-90
Sound Recording Tape
maxell UD 8T-90
maxell LN 8T-90
maxell UD C90
maxell UD C90
90
90

used, because putting the wrong drum on, or the right drum on the wrong projector can cause havoc. It would also be wise to indicate on the drum at which slide a segment ends or begins for easy identification. Just a line with a felt-tipped pen on the side tape might be all that is necessary.

Be sure there is a blank slide in the aperture of the projector before the first drum is put on. This will help speed up the drum change since the lamp does not have to be turned off and then turned on again. If the lamp is turned off for safety, be sure it's turned on again immediately after the change is made or it will be forgotten. Be sure you have a small coin in your pocket during rehearsal. It can come in handy if a slide jams and the drum has to be removed. Be sure the ring is on and locked before turning over the drum to fix a jam. (It would be a total disaster otherwise.)

If a slide jams, find out why. A cardboard slide can have frayed edges. A metal-and-glass slide can have a metal edge that's lifted slightly and causes it to hold up. A plastic mount slide might not be closed all the way and can quickly and easily be snapped shut. A slide jam can also be caused by a tight or bent metal bottom through which the slides drop. This might need a drum change if it can't be fixed easily. Maybe a tooth on the bottom of the drum has broken and the drum will not move around past the break. Maybe the wrong drum is being used and the slides are tight in the slots. This, too, would necessitate having the slides changed from one drum to another. (By wrong drum we mean the kind that is meant to be used with cardboard slides and is incorrectly used for thicker mounts.)

In setting up the cables, be sure that sticky tape is used to tie down the cables in the places where people have to walk over them. (It's bad enough if someone should fall, but think of the possibility they might take the equipment down with them.) Be sure all connections between cables are tight, and include a half-twist or a good tape job to keep the connectors together. With the mess that so many cables can cause, be sure that all cables are out of the way of the operators so they don't fall over them or don't have to reach around them to get to a piece of gear. Run all cables on the screen-side of the projection tables and keep them neat. It's murder to try to follow a cable in the event a change has to be made of the equipment, or some trouble has to be traced down, when the cables are all twisted together and others are then run through this maze. Following them down is difficult enough, but then getting them apart is even more difficult.

There are many, many more things to look out for in the setup of equipment, and one of them is the charges that will be incurred. In the opening example, it turned out the platforms were not supplied by the hotel. They did not have any. The rental supplier brought them in, and the charge added up quite a bit. Also, if a technician is needed to run a spot light, or on standby for any reason, be sure this cost is included in the original estimate to avoid embarrassment and arguments in the future. All side costs can add up to quite a bit over the original estimate and should be checked out before the contract is agreed upon.

Please do not use the equipment or the tables to hold coffee cups, food, ash trays, or any other extraneous material as all this could cause problems during the show. And, if a cigarette must be lit during the show, the match might be seen from out in front. Turn your back toward the screen, or in some way mask the light from the screen.

If all people involved with designing the a/v portion of the show, and all those setting up the equipment, and all those involved with the live talent, and all those working behind the scenes resolved to THINK as much as possible about these little details, there might still be some things they might overlook. But then look out for them the next time. In any event, may you all have a happy and healthy new year, and keep thinking audio/visual. ■

Editorial

SOME TIME AGO, during one of our planning sessions, we all agreed that it would be a great idea to start off the new year with something nice-and-easy; like magnetic tape.

We should have said, "nice-and-difficult," for by now we have discovered that there is nothing easy about magnetic tape. For example, consider **The Transfer Characteristics of Magnetic Tape,** by Peter Vogelgesang. We all know that, without bias, any tape's transfer characteristic is not only bad—it's unuseable. Bias seems to straighten things out nicely, but—as is so often the case—you can get too much of a good thing. Did you realize that a tape can be over-biased and under-biased at the same time? Of course, we knew it all the time, but we're glad that Mr. Vogelgesang clarified the point for the benefit of our readers. (I think I'm going to be ill—Publ.) And then there's also the matter of distortion, linearity, sensitivity, gap dimension, depth of coating and who knows what else. All things considered, its a wonder the stuff works at all. But work it does, and quite well at that.

Of course, its up to you to set the optimum bias level, by overbiasing at some high frequency. How much overbias? And at what frequency? Well, that depends. What's the dimension of your record head gap? At what speed are you recording? Are you more concerned with minimum distortion or long wavelength response? If you're sufficiently confused by now, try our **Application Note: Tape Sound Speed vs. Biasing.** Hopefully, it will be of assistance in sorting out all the variables. And, we've also thrown in a short conversion table that will take you from mils to microns, which may help out when trying to compare the coating thicknesses of various tapes.

If you have any older tape recorders lying about, you may have already discovered that some of them just aren't up to the demands of the newer tape formulations. And now, we are faced with the newest generation of tapes, which can't be recorded on any pro machines—old or new. Specifically, we are referring to metal particle tapes, which have been introduced in cassette format, and may eventually find their way into the professional open-reel market, thereby obsoleting just about every tape recorder around. What's it all about, and are they worth it? Kevin J. Byrne tells us something about the advantages of the new tapes, in his feature, **Metal Particle Tapes: Upgrading Analog Performance.**

And, to help you compare tape A with tape B, associate editor Sam Zambuto has prepared a **Cross-reference Guide to Magnetic Tape Specifications.** If you've been wondering about the difference between one tape and another, a careful comparison of the various magnetic, electro-magnetic and physical properties may give you some answers. For more information, please contact the manufacturers directly. To make that easy, we've compiled a **Directory of Tape Manufacturers,** which immediately follows the Cross-reference Guide. Tell 'em **db** sent you!

Recently, Robert K. Morrison—founder of STL (Standard Tape Laboratory)—published his "Standard Tape Manual." This is a valuable data source, in loose-leaf format, containing seven sections of useful reference material on head losses, flux levels, azimuth, reproduce amplifier response, and much else. We've reproduced a small part of section seven in the feature, **Using Induction Loops.** This handy little gadget—often called a Flux Loop—can be quite helpful in assessing the playback characteristics of a tape recorder, without having to wonder about the playback characteristics of the test tape too.

For a change of pace, we move on to a little audio problem solving, using a programmable calculator. In his article, **Audio Problem Solving with a Programmable Calculator,** Dr. Albert E. Hayes, Jr. tackles a pair of problems introduced to readers in an earlier issue of **db.** Hayes gives us the programs to solve both problems on an HP-97, plus sufficient explanatory details to "translate" his programs for solution on other calculators.

This feature may raise the question, "Are most **db** readers actually using programmable calculators?" The answer to that one may very well be, "No." Then why print the story? We're glad you asked. It's to show that calculators—just like computers—need not (indeed, must not) be confined to the "for experts only" category. Although the versatile HP-97 may cost a bit more than some of us are prepared to shell out ($750), less-ambitious models are available in the $100 bracket, which puts them within reach of the serious beginner.

But, if audio is your game, why bother getting into calculators and computers? This one's easy. You don't need to be told that our industry is getting more and more complex, almost with each passing day. Given the rapid pace of technology, its very easy to get left behind. Well, the calculator won't help you all the time, but every now and then, it can come in handy. It may not get you a better drum sound, but it will help you put together a notch filter, according to your needs—not someone else's. (Dr. Hayes will show us how, in a future issue—Ed.) So, why be dependent on "the experts" when, with a little homework (not too much), you can do it yourself? With a little luck, you can build that filter out of parts already available in your junk bin.

In other words, the calculator and the computer should be given serious consideration by any audio pro who would like to expand his technical horizons just a bit (or perhaps even a byte). With a few key strokes, all those complex formulae that you've been avoiding all these years can be stored in memory, and trotted out whenever you need a quick answer to a routine—or not-so-routine—audio problem.

For example, the Audiotools Company of Denver is using their Apple II Computer (see November, 1978 Sync Track) to solve some of their acoustic measurement problems. Future planning calls for utilizing it for automated studio and control room acoustic and electrical analyses, and to "model" acoustic environments in the design stages. Audiotools' Pat Cowdin has offered to share some of his programs with us, and we'll pass these along in a future issue of **db.**

We're also planning to publish a computer program which will solve the problems that Dr. Hayes tackles this month. Our program will work on the Apple II, as well as on Radio Shack's TRS-80.

J.M.W.

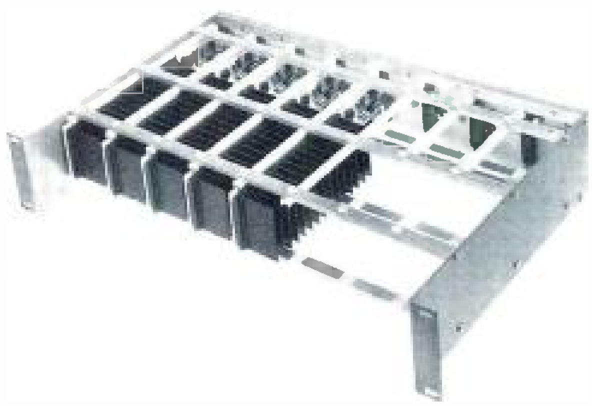
NEW!

A NEW "STATE OF THE ART" DC POWER AMPLIFIER . . .

from **SPECTRA SONICS,** the pioneer and leader in bi, tri, quad, and *five-way* professional amplification systems!

As the most experienced manufacturer of multi-way amplification systems, **SPECTRA SONICS** has consolidated over seven years of field experience into the design of a second generation DC modular power amplifier, the Model 701.

With such improvements as increased power output, lower noise, higher damping factor, LED fuse indicator, and less susceptibility to physical abuse, the new Model 701 warrants consideration as the most advanced power amplifier available today.



If you have not heard the new **SPECTRA SONICS** Model 701 Power Amplifier, it just might mean that you are missing the privilege of listening to the best. For complete specifications, see your Professional Audio Dealer, or contact:

SPECTRA SONICS

LEADER IN ADVANCED TECHNOLOGY

3750 Airport Road ■ Ogden, Utah 84403 ■ (801) 392-7531

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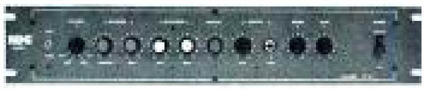
db New Products & Services

FLANGERS



● Available in two versions, FR-10 (mono) and FR-20 (stereo), this flanger employs a special regenerate feature allowing for added effects. Specs cite a nominal level: 0 dB to +12 dB; frequency response: 30Hz to 20 kHz ± 1 dB direct and 30Hz to 12 kHz ± 1 dB delay; distortion: at 1 kHz direct 0.05 per cent, delay 0.1 per cent; Noise: —75 dB (with manual control set to mid position); and Oscillator speed: 0.07Hz to 7Hz.
Mfr: RDG Audio
Circle 50 on Reader Service Card

PROGRAM AUTOMATION

● Micro-computer controlled System 90 uses a seven-day CRT display, incorporating dual intensity to highlight special inserted instructions. Repetitive day and hour entries (Monday through Friday) use only one entry in the time memory. Thirty pairs of program and commercial format locations may be labelled for recall, expandable to up to 10,000 events. Recall is instantaneous; it is not necessary to return to the main program. A "network-join" fade will automatically delete a programmed event that might otherwise cause the station to be late in joining the network.
Mfr: Harris Corporation
Circle 51 on Reader Service Card

SNAKE SYSTEMS

● Each unit in the MXC-Series features a removable steel stage-plugging box and a removable pigtail unit, terminated at one end with 3-pin box or contact professional audio connectors, and at the other end with a rugged milspec aerospace multi-pin connector for interface with a mating milspec connector on the extension cable. The snake cabling systems are available as complete units in 9, 11. 12, 15, 17, 19, 27, and 30 pairs; in lengths of 125 or 250 feet. All terminations are balanced and individually shielded.
Mfr: Concertaudio Manufacturing Research Corporation
Circle 52 on Reader Service Card

RECORD CLEANER

● A new cleaning method for phonograph records, Disco-Film removes dirt and grime from record grooves via a film-forming solution applied to the record, and peeled off when dry. One container of this solution will clean up to 70 vinyl LP record sides.
Mfr: Empire Scientific Corp.
Price: $29.95
Circle 53 on Reader Service Card

FUNCTION GENERATOR

● Electronically sweepable over a 10:1 to 100:1 range, the Model 2001 four-waveform function generator offers sine, square, triangle, and TTL square waves from 1Hz to 100 kHz in five pushbutton-seelctable overlapping ranges. Sine, square and triangle waveform outputs are variable over a greater than 40 dB range, and the TTL output will drive 10 TTL loads with rise and fall times of less than 25 nanoseconds. The voltage controlled sweeping oscillator may be zero referenced from any frequency setting.
Mfr: Continental Specialties Corporation
Price: $124.95
Circle 54 on Reader Service Card

MICROPHONE STANDS

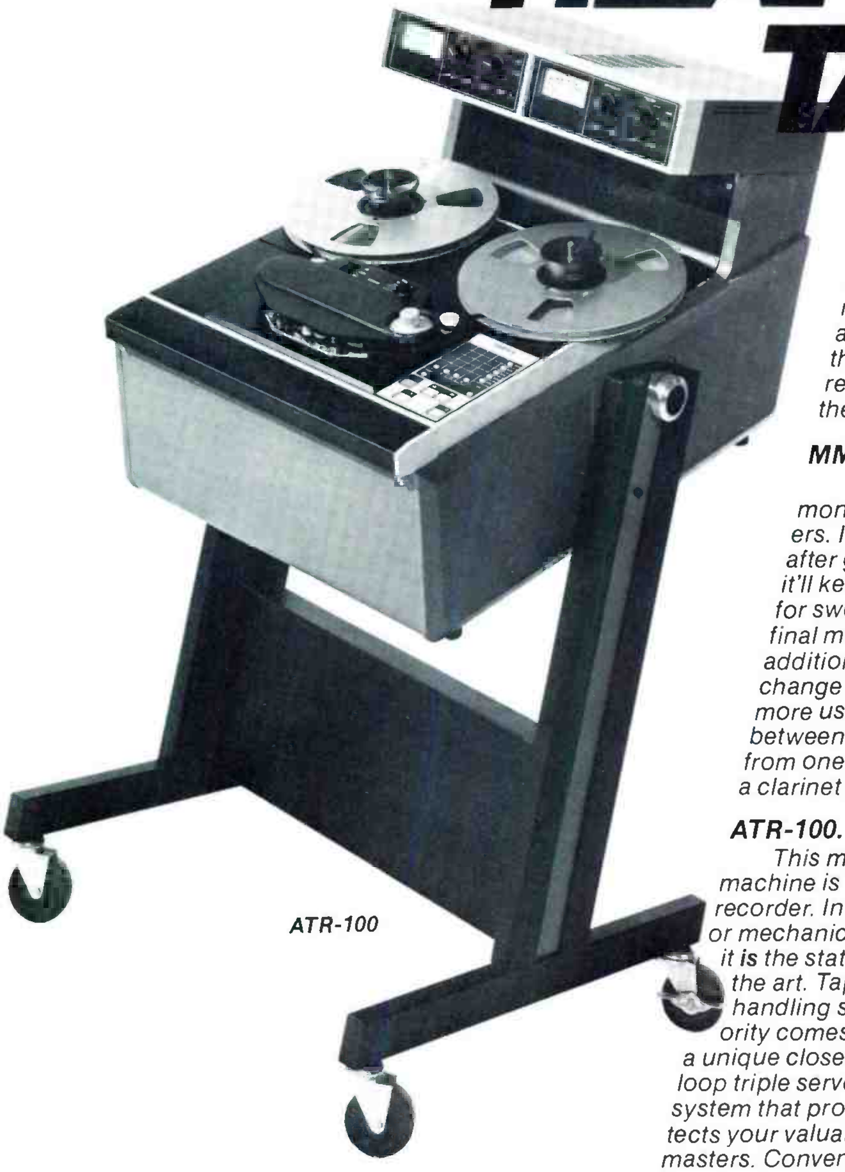
● Designed for portability and stability, the SHD/3 and HD/1 are two new entries to the microphone stand line. The SHD/3, made of steel and re-inforced aluminum, employs a large stemmed center support (fitted with a suction pad) that rests on the floor for extra stability. The stand has three collapsible feet and weighs 15 lbs. The HD/1, similar to the SHD/3 (minus the center support), is equipped with three castor wheels, each fitted with a brake, and weighs 12 lbs. A heavy duty boom arm with a tilt head is available as an accessory to the stands.
Mfr: Keith Monks (Audio) Ltd.
Price: SHD/3 $74.62; HD/1 $85.25; Boom Arm $65.68
Circle 55 on Reader Service Card

PHANTOM POWER

● Providing phantom power for up to ten microphones, the AC24 system consists of two separate units. The AC24M master module will provide 24-volt phantom power for two microphones. By connecting the AC24M with two AC24S slave modules, the master can be expanded to handle up to ten condenser microphones.
Mfr: Electro-Voice, Inc.
Price: AC24M-$96.00; AC24S-$81.00
Circle 56 on Reader Service Card

Circle 17 on Reader Service Card

WHAT IT TAKES TO REALLY HEAR THE TALENT



ATR-100

When you hear recording engineers talk about the "Ampex Sound," they're talking about the sound of transparency. To the limits of technology, Ampex recorders and mastering tape let the production qualities and the sound of the talent come through the recording process intact. Here's a brief review of Ampex professional products for the serious studio...

MM-1200. Lay Down the Ampex Sound

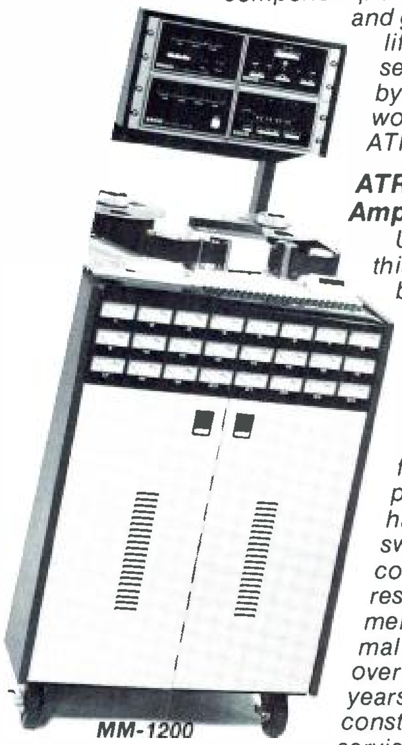
Ampex designed the MM-1200 as a money-making proposition for studio owners. It'll work around the clock as group after group lays down the audio, and then it'll keep right on working as you go back for sweetening, for a vocal, or even for a final mix to a video production (with the addition of a video layback head). Quick-change heads make the MM-1200 even more useful—you can go back and forth between 8, 16 and 24 channels, and switch from one-inch to two-inch tape as easily as a clarinet player changes reeds.

ATR-100. Mix Down the Ampex Sound

This modular one-two-or-four-track machine is the ultimate analog audio tape recorder. In every specification, electrical or mechanical, it **is** the state of the art. Tape handling superiority comes from a unique closed-loop triple servo system that protects your valuable masters. Convenience features begin with the wide-open

Grand M

component placement for easy maintenance, and go all the way to a compact lift-out remote control that sets up all functions, channel by channel. And for the last word on reliability, talk to an ATR-100 user.



MM-1200

ATR-700. Carry Around the Ampex Sound

Unsnap the cover of this reel-to-reel portable, plug in the power, and you're ready to work in monaural or stereo. The ATR-700 has a wider dynamic range than you'll find in most other portables, and it has heavy duty switches and connectors to resist the punishment of normal use over many years of constant service.

Switchable equalization makes for fast setup, and full meter monitoring takes the guesswork out of recording and playback. The ATR-700 is a solid money-maker in the studio, too, when you use it for producing and editing commercials.

Grand Master Audio Tape. The Medium for the Ampex Sound

You'll find a reel of Ampex Grand Master audio tape to fit every one of these professional machines. Every width and every length, packed on reels that fit most professional machines in current use. Best of all, you can use both Grand Master or 406/407 without changing the bias setting on your recorders. Use Grand Master or 406/407 tape for state-of-the-art performance by every measure, from dropouts to edge-to-edge consistency. This is the finest mastering tape you can buy.

Golden Reel Awards. The Reward for the Ampex Sound

A Golden Reel is more than just another award. It's a thousand dollars for the charity of your choice, if you earn it. To qualify for a Golden Reel, you must sell a million singles. Or half a million albums. And you must master your hit on Ampex tape. (Which over 70 top recording artists have done over the past two years.) We're proud of the people who win this Ampex award, and we're even prouder when they give it away to a good cause.

Go ahead and make a hit. The path will be smoother when the sound of the talent comes through, with the transparent performance of Ampex hardware and tape—for decades, the professional's choice.

ATR-700

AMPEX MAKES IT EXCITING.

Ampex Corporation, 401 Broadway, Redwood City, California 94063, 415/367-2011

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EQUALIZER MODULE

• Reciprocal peaking and shelving equalization of three independent overlapping frequency ranges is provided with the Model 3270, featuring 11 selectable frequencies per band. A total of 26 one-third octave center frequencies, provides an even coverage of the audio spectrum from 50 Hz to 16 kHz; with a ± 15 dB boost/cut.
Mfr: Modular Audio Products
Price: $415.00
Circle 57 on Reader Service Card

MIXER

• At home in recording applications or in PA systems, the MMX-2200A is a 12 channel stereo mixer featuring internal reverb, monitor, and extra effects capabilities. The mixer, with line select switches, slide pots, and VU meters, comes complete with a built in road case.
Mfr: Musimatic Inc.
Price: $1682.00
Circle 58 on Reader Service Card

db New Literature

A/V CASSETTE

"Heavy-Duty Audio-Visual Cassette Products for Educational and Industrial Use," features seven models currently in the professional audio-visual cassette line. Source: Robert Garbutt, Sharp Electronics Corporation, 10 Keystone Place, Paramus, NJ 07652.

MICROPHONE MIXERS

A newly introduced line of microphone mixers is described and illustrated in an engineering bulletin, complete with technical information and application data. Source: Industrial Research Products, Inc., 321 Bond St., Elk Grove Village, Illinois 60007.

CUSTOM AUDIO COMPONENTS

Outlining new custom audio components for the OEM market, a four page catalog covers services in product areas such as: communications microphones, audio microphones, cords & cables, plugs & sockets, and microphone components. Source: Mura Corporation, 177 Cantiague Rock Road, Westbury, NY 11590.

ANALOG/DIGITAL MULTIMETERS

The complete line of portable digital and analog multimeters is detailed in a four-page color brochure, containing full specifications for each model. Source. Soar Electronics (U.S.A.) Corp., 813 2nd Street, Ronkonkoma, New York 11779.

LOUDSPEAKER HANDBOOK

Now in its second printing, the 48-page "Loudspeaker Handbook and Lexicon" aims at providing a basic understanding of the science of speaker design. Source: The Little Speaker Company, Inc., 78 Stone Pl., Melrose, Massachusetts 02176.

VIDEO PRODUCTS

No larger than a roadmap, a compact 40-page foldout covers the complete range of video products for business, government, and other institutional users. Source: Sony Video Products Catalog, Sony Corporation of America, 9 West 57th Street, New York, NY 10019.

SPEECH CONTROLLER

"The Listening Plus: VSC," a four-page brochure, details the use of speech compressor/expanders in special education classes, libraries and media centers, reading and language labs, training programs, business and government offices, law enforcement agencies and hospitals. Source: The Variable Speech Control Co., 185 Berry St., San Francisco, CA 94107.

BACK PLANE WIRE

Terminating systems for back plane wires, is the subject of a new brochure, including four pages of tables and technical data on UL and military listings, conductors and various properties of back plane wire. Source: Brand-Rex Company (Back Plane Wire, EC5-78), P.O. Box 498, Willimantic, Conn. 06226.

COAXIAL CABLE

Covered in a new 20-page illustrated guide, are the selection and use of a broad line of CATV coaxial cables, including flooded, dual, and messengered constructions. In addition to technical data, a number of alternative shielding methods are also described. Source: Publication EL 10-78, Manager, Marketing Communications, Belden Corp., 2000S. Batavia Ave., Geneva, Ill. 60134.

INSTRUMENTS & BREADBOARDING EQUIPMENT

Solderless breadboard products, IC test clips, and a family of digital troubleshooting equipment and measurement products are contained in a new catalog. Source: Continental Specialties Corporation, 70 Fulton Terrace, New Haven, Conn. 06509.

■

PETER VOGELGESANG

On the Intricacies of Tape Performance

TRANSFER CHARACTERISTICS of active devices, such as transistors and vacuum tubes, can be analyzed to predict precisely the effects these devices will have on audio waveforms. Distortion, maximum signal level. amplifier gain and efficiency, as well as the optimum operating point can all be determined by studying published curves which express the relationship between inputs and outputs, the control functions and the dependent functions. Such techniques are well known and regularly used by system designers. In fact, few designers will undertake the development of an amplifier or other audio signal processing circuit without knowing the transfer characteristics of the active elements of the circuit.

Magnetic tape is also an active element, which magnetically transfers audio waveforms between an input (the electrically-driven recording transducer) and an output (the playback transducer), albeit with time delays as great as years. As with transistors and vacuum tubes. the transfer characteristics of tape influence distortion, maximum signal level, etc. But predictions of how a specific magnetic tape will affect such parameters are not easily made. nor are methods of prediction generally understood. The numerous performance curves often supplied in magnetic tape data sheets are derived from actual performance measuremnts. and consquently are applicable *only* when the tapes are used under closely-similar conditions. Universal transfer characteristics, from which all other performance curves can be derived, are not supplied. As an active element in the processing of audio waveforms, why is magnetic tape. such an exception to all other active devices?

MAGNETIC TAPE: AN ACTIVE COMPONENT

Two answers can be suggested. First, recording system design engineers frequently regard magnetic tape as a supply item rather than as the active system component it really is. Consequently, the tape is not looked upon as a controllable variable, and the designer simply works with whatever magnetic tapes are available, without regard to the intricacies of tape performance. Secondly, the numerous interactive and non-linear relationships that exist between tape and transducers. in both the recording and playback processes, are too complex to permit convenient and precise analysis, except by computer. Let us examine several of those factors which influence the transfer characteristics of magnetic tape, in order to better understand why utilization of these characteristics is difficult in designing a recording system.

D.C. MAGNETIZATION

The direct-current magnetization curve of a magnetic tape is illustrated in FIGURE 1. The curve is shown in the first and third quadrants, because the magnetic material of the tape can be magnetized in either of two directions (or opposite polarities). This curve is frequently used to show the necessity for bias in the recording process. since any attempt to employ the curve as is—as the tape transfer characteristic in a recording system—will result in severe distortion. The distortion is due to the hysteresis effect: the non-linear relationship between input and output. That is a phenomenon of ferro-magnetic materials.

THE EFFECT OF BIAS

The effect of bias on a direct-current magnetization curve is difficult to visualize: only those texts which go deeply into the subject provide a rigorous explanation. More often, the illustrations of FIGURES 2A and 2B are used to explain the effect of bias. A magnetic tape. subjected to a diminishing d.c. magnetic field as the tape moves past the record head, will be magnetized through the family of hysteresis loops shown in FIGURE 2A. A hypothetical transfer curve of the tape is plotted by drawing a line through identical points on the loops. This transfer curve, while it shows far less hysteresis at the center than the curve of FIGURE 1. will still generate considerable distortion in the reproduced audio signal. Through the use of a.c. bias, as shown in FIGURE 2B, it is supposed that the recorded waveform, which is riding on the peaks of the

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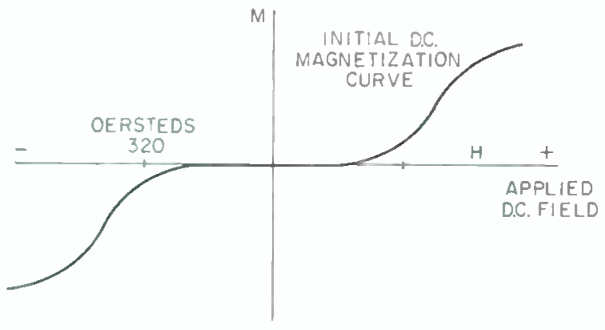


Figure 1. The initial d.c. magnetization curve of a magnetic tape having a coercivity of 320 oerstads. An increasing d.c. magnetic field applied to a magnetic tape will produce remanent magnetization which follows the curve. This curve resembles the transfer characteristic of a magnetic tape recorded without bias. Obviously severe distortion of the playback signal will result if bias is not used.

bias waveform, is moved into the linear region of the transfer curve, minimizing distortion of the recorded signal.[1,2]

This analysis of the effect of bias predicts that an increase of bias amplitude from zero to some optimum level causes distortion to change from a high to a low value. Although such an effect is observed, the same analysis also suggests that a continuing increase of bias magnitude beyond the optimum level will eventually increase distortion to a value equalling the zero-bias condition. But this effect is *not* observed; when bias amplitude is raised beyond the optimum value, distortion only modestly increases.

While this popular model of the effect of bias is easily visualized, and is obviously offered as a simplified expedient to understanding, it does not accurately explain bias recording and can lead to erroneous assumptions. It implies that the transfer curve derived from a family of hysteresis loops is the transfer characteristic of a tape. This conception is inaccurate. What, then, is the true transfer characteristic of a magnetic tape?

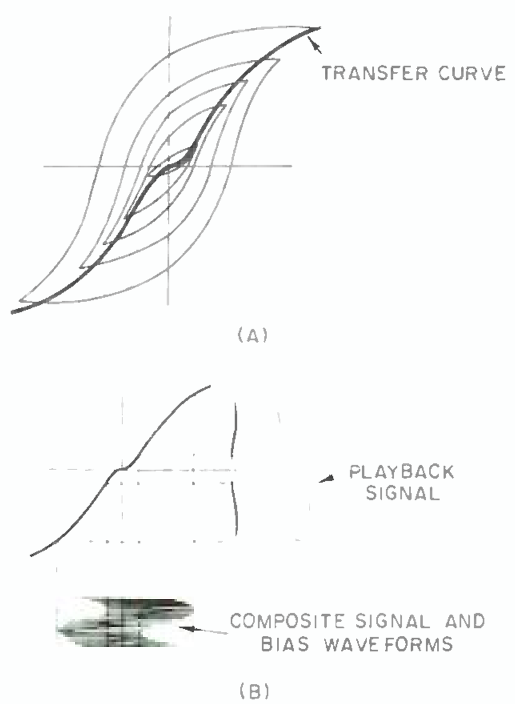
As stated earlier, magnetization of a magnetic tape caused by a steadily increasing d.c. applied field will follow the initial magnetization curve of FIGURE 1. An anhysteretic magnetization curve (one without hysteresis) is produced when a steady d.c. field is accompanied by at diminishing a.c. field. The anhysteretic curve more closely resembles the transfer characteristic of a tape. Hysteresis is eliminated in the recording process by the a.c. bias field produced in the recording transducer. But in an actual recording application, *both* the d.c. and a.c. fields are diminished simultaneously as the recorded areas of tape move away from the gap of the recording transducer. This condition produces a modified anhysteretic magnetization curve which is substantially (but not precisely) the transfer characteristic of the tape.

The modified anhysteretic magnetization curve (hereafter termed the MAM curve) can be measured using the apparatus shown in FIGURE 3. This apparatus is used to measure the bulk magnetic properties of a tape sample. It overcomes recording system measurement variables of the recording transducer, which produces a non-uniform magnetic field through the tape thickness. A short sample of magnetic tape is attached to an endless plastic belt, driven at high speed around roller guides. First, the sample passes through a magnetizing coil which simultaneously applies d.c. and a.c. magnetic fields. Since both fields are produced by the same coil, the fields within the coil increase and decrease with uniformity throughout the thickness of the tape. The tape sample then moves through a sense coil, which measures the magnitude of remanent magnetization of the sample. A family of curves showing how the initial magnetization curve is transformed into an optimum MAM curve may be generated by fixing the a.c. field at several different levels and then slowly increasing the d.c. field. A family of such curves is shown in FIGURE 4.

Note that the bottom portion of the "S" curve of the initial, or dc-only, magnetization curve quickly disappears as the a.c. component of the magnetizing field is added, and then increased. Also, the slope of the curve increases rapidly, reaching a maximum at an a.c. field intensity of 350 oersteds, which is close to the coercivity of the tape sample tested. Beyond this optimum level of a.c. field, the slope of the MAM curve again decreases, but the straight portion of the curve remains essentially straight.

Studies of the recording process using computer simulation and analysis have shown that the MAM curve of a magnetic tape is approximately the transfer characteristic of that tape. Although this curve is related in some way to the d.c. magnetization curve, the relationship is not obvious, and the d.c. magnetization curve cannot be used directly to predict transfer characteristics. A means of deriving transfer characteristics from d.c. magnetization

Figure 2. (A) A hypothetical transfer curve derived from a family of hysteresis loops. (B) Elimination of crossover distortion by the use of bias.
This mode is used widely to show how the bias field in a recording system overcomes the non-linearity of the hypothetical transfer curve of a magnetic tape. Linearization of the transfer characteristic reportedly takes place as the result of the audio waveform being moved by the bias frequency to the linear portions of the magnetization curve. This model cannot account for the lack of increased distortion which occurs when excessive bias is employed. Also, precise magnetization measurements have shown that the linear portion of the transfer curve thus derived is not the transfer curve of the tape.



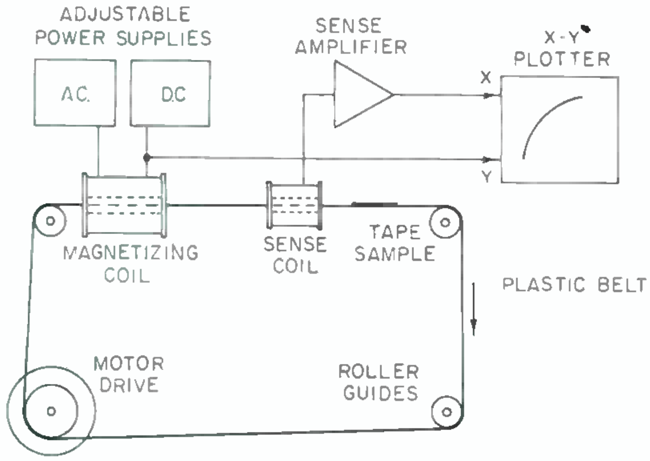


Figure 3. A diagram of appartus for measuring modified anhysteretic magnetization curves.
A tape sample is attached to a plastic belt which is driven at several hundred inches per second around roller guides. The sample passes first through a magnetizing coil which produces an a.c. field (representing bias) and a d.c. field (representing signal). The magnetized sample then passes through a sense coil which produces a pulse proportional to remanent magnetization. The value of remanence is then plotted against the d.c. field amplitude. By fixing the a.c. field at several different levels, and slowly increasing the d.c. field from zero to some maximum value, a family of modified anhysteretic magnetization curves is generated.

curves could be a highly useful tool for designing both tapes and machines. and is a subject worthy of future study.

The curves of FIGURE 4 can be used to show numerous characteristics of the tape. For example, sensitivity at various bias levels is a function of the slope of the curves. Signal distortion at various magnetization levels can also be predicted. Perhaps most importantly. the curves show why signal distortion with increasing bias level does *not* follow the simple model of FIGURE 2. Rather than increased bias causing the signal to ride higher on the hypothetical transfer curve (as the simple model predicts). it is seen that the transfer characteristic of the tape simply follows an over-biased MAM curve such as the 1000 oersted curve of FIGURE 4. This curve indicates reduced sensitivity with excessive bias, and a modest increase in distortion. Both effects are observed in a real recording situation.

RECORDING IN THREE DIMENSIONS

The analysis to this point seems straightworward and neat, but unfortunately magnetic recording is not that simple. To understand why the MAM curve is not precisely the transfer characteristic of a tape, we must recognize that magnetic recording is a three-dimensional process. In other words. the magnetic material of the tape is magnetized not only in the track length and width dimensions, but in the depth dimension, as well. A magnetic coating which is less than one thousandth-of-an-inch thick may seem thin enough so that the thickness dimension can be ignored. but such is not the case.

The magnetic field standing out from the gap of a recording transducer is very intense at the surface of the ploe pieces, but it decreases, approximately, as the square of the distance from the surface. This variation of field intensity with distance applies to the bias field as well as the signal field. and therefore the bias field intensity through the thickness of the magnetic coating is not uniform. In fact, in an optimized recorder, the surface of the magnetic coating is greatly overbiased, while at the full depth of the coating. the tape is somewhat underbiased. Only an imaginary layer somewhere within the magnetic coating is optimumly biased.

FIGURE 5 shows how bias intensity decreases with distance from the transducer surface, as derived from Karlqvist's equations.[3] Distance is expressed as a fraction or multiple of the length of the gap, which makes the curve applicable to transducers of most designs.

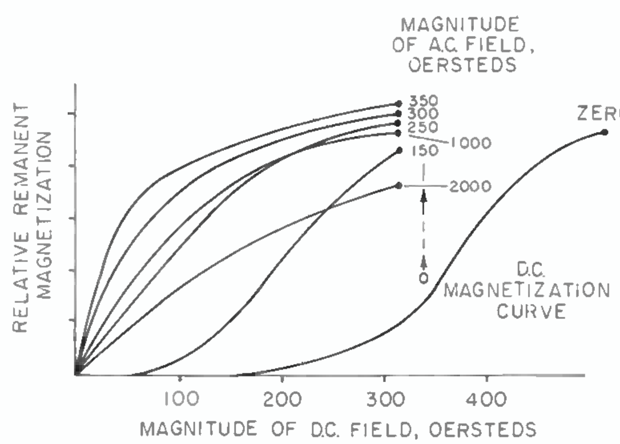
Using the example of a 260 microinch (6.6 micron) gap and a 500 microinch (12.7 micron) thick magnetic coating. FIGURE 6 shows how the field intensity varies within the magnetic material. An assumption has been made that relative permeability of the material is one, an assumption which has been shown to be valid in computer simulations of the recording process.

Zone (a) of the magnetic coating is biased with a field intensity ranging from 1,000 to 500 oersteds, and this zone will be operating with a transfer characteristic similar to the MAM curve for 1,000 oersteds in FIGURE 4. Zone (c) is optimumly biased, and is the only layer within the magnetic coating which operates on the ideal transfer characteristic curve. Zone (e) is greatly underbiased.

The true recording transfer characteristic of the transducer-tape combination, then, is not one of the curves of FIGURE 4, but rather, a composite of several different curves. Each zone through the thickness of the magnetic coating operates on a different MAM curve, and remanent magnetization of most zones after recording is either greater or less than that value which would produce an ideal transfer characteristic. Remanent magnetization of the total thickness, then, is the sum of remanences of all these zones, and the recording transfer characteristic is a composite of all the MAM curves employed during recording. Of course, one should not think in terms of individual zones and curves when visualizing the recording process. The real process produces variations of magnetization continuously through the thickness of the magnetic coating because the magnetic field standing out from the gap of the transducer varies continuously in intensity with distance.

A mathematical model of the recording process has shown that a tape is optimumly biased when the full depth of the magnetic coating experiences a bias intensity approximately equal to the coercivity of the tape. Of course, this means that the surface of the tape is greatly over-

Figure 4. MAM curves. A family of modified anhysteretic magnetization curves for a 320 oersted tape obtained by the technique shown in Figure 3.



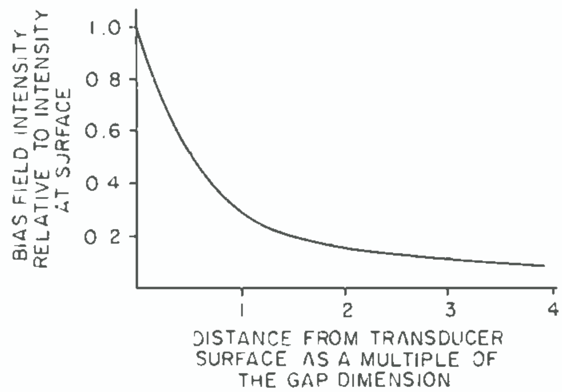


Figure 5. Bias field intensity as a function of distance from the recording transducer surface. When distance from the surface of a recording transducer is expessed as a fraction or multiple of the gap dimension, the bias field intensity diminishes, as shown by the curve. In terms of absolute dimensions, a large gap will produce a large field which diminishes comparatively slowly with distance from the surface, while a small gap produces a small field which diminishes rapidly with distance.

biased. An analysis of the MAM curves of FIGURE 4 shows why this bias condition must exist.

For a tape with a coercivity of 320 oersteds, linearization of the magnetization curve takes place rapidly as the bias level is increased from zero to about 250 oersteds. Any part of the magnetic layer which experiences less than 250 oersteds will contribute substantial distortion to the output signal because of magnetization non-linearity. The under-biased condition is conducive to signal distortion. On the other hand, the over-biased MAM curves remain essentially straight, and distortion increases only slightly with excessive bias. Insofar as distortion is concerned, a tape is much more tolerant of over-biasing than under-biasing. Thus an optimum bias level will be one which prevents under-biasing of any portion of the magnetic coating thickness. To summarize: adequate bias at the full depth of the coating requires over-biasing at the surface.

Bias uniformity is greatly dependent upon the recording transducer gap length. FIGURE 7 illustrates the field configuration of a recording transducer having a gap length of only 60 microinches (1.5 micron). Variations of field intensity within the tape are far greater in this case, and an even larger portion of the magnetic material in the coating is less-, or more-than, optimumly biased.

At first thought it would seem that a solution to this problem is to use recording transducers having very large gaps, since the field within the tape becomes more uniform as gap length increases. But this approach has other drawbacks relating to the frequency response of the transducer/tape combination.

THE TRAILING EDGE

It must be remembered that the magnetic field which magnetizes a tape during the recording process is the last field which the tape experiences. What happens to a discrete area of a tape as it passes over the first pole piece, or the center of the gap, is of little consequence. It is the field at the trailing edge of the gap which lastly, and permanently, influences the tape. Therefore, we need to be concerned only with the shape and intensity of the recording field at the trailing edge of the gap.

The gradient or "sharpness" of the field at the trailing edge is also dependent upon the gap dimension. A large gap will have a broadly distributed gradient, whereas a small gap will have a narrowly distributed, or sharp, gradient. This gradient is effectively the recording aperture of the transducer, and it establishes the spatial modulation transfer function of the recording system. A broad aperture cannot write close-spaced or short wavelength information; hence the large gap, while it is most effective in writing long wavelengths, will not be efficient at writing short wavelengths. Conversely the short gap can provide the sharp 10 degree gradient for writing short wavelengths, but cannot provide the uniformly penetrating field necessary to magnetize the tape uniformly for maximum long wavelength output.

The transfer characteristic of a magnetic tape/transducer combination is therefore frequency (i.e., wavelength)—dependent. Long wavelength recording of a tape is an anhysteretic magnetization process in which the MAM curves of the particular magnetic material used in the tape establish the transfer characteristic of the tape. However, as the recorded wavelength approach 1 mil (25.4 micron), the modulation transfer characteristic is no longer exclusively an anhysteretic magnetization process. The transfer characteristic at increasingly shorter wavelengths grows more dependent upon the dimensions and precision of the recording transducer gap and upon intimacy of contact between the tape and transducer surfaces. At 0.1 mil wavelength, a separation of just one microinch will produce approximately 1 dB of signal loss from combined recording and playback processes. A smooth tape surface, smooth transducer surfaces, and precision gaps in both the recording and playback transducers are critical to short wavelength performance.

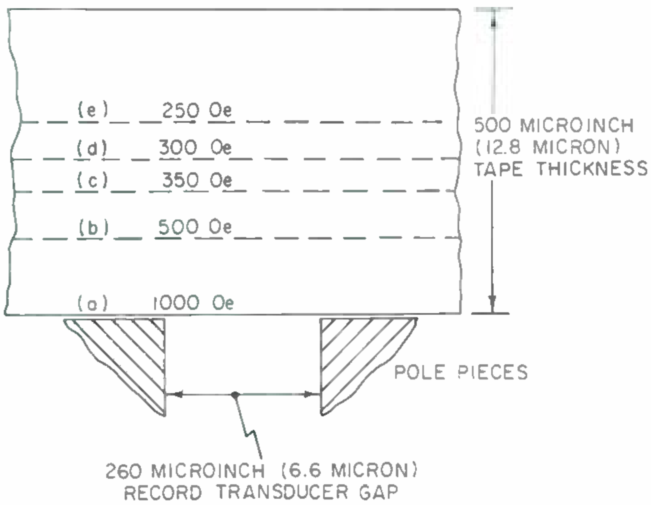


Figure 6. Variation of magnetic field intensity within a tape from a 260 microinch gap. With bias current through the recording transducer adjusted for a surface field intensity of 1000 oersteds at the center of the gap, the field is observed to decrease through the thickness of the tape in the manner illustrated. Each imaginary layer of tape is operating on a different MAM curve of Figure 4. Magnetic material adjacent to the 350 oersted depth is optimumly biased, whereas material closer to the transducer is overbiased and material deeper in the tape is underbiased.

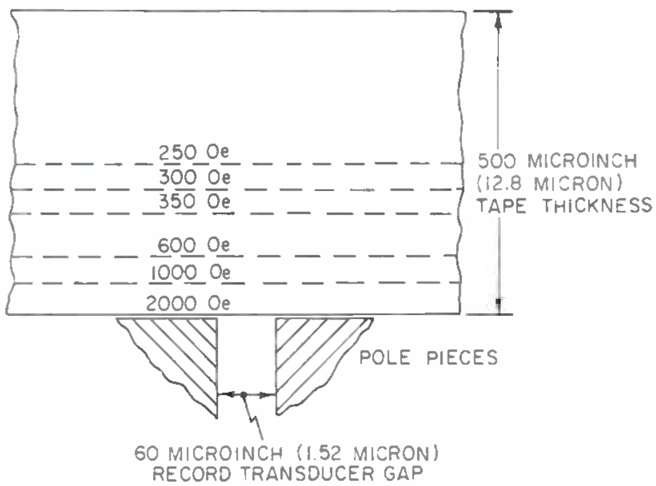


Figure 7. Variation of magnetic field intensity within a tape from a 60 microinch gap. The size of the magnetic field standing out from a small gap is also small. Although the surface field intensity can be increased to 2000 oersteds in an attempt to penetrate the tape more deeply, intensity diminishes more quickly with distance from the surface. Variation of bias field intensity within the tape is greater in this case than that of Figure 6, and less magnetic material will be optimumly biased with the small gap.

Assuming that all these interacting variables can be quantitatively defined, and assuming that the resultant magnetization of the tape can be precisely specified, we are still confronted with the difficulty of knowing how the various imaginary layers of tape will contribute to the reconstructed signal during playback. The magnetic material at the very surface of the tape is in direct contact with the pole piece of the playback transducer, and therefore is closely coupled to the magnetic circuit of the device. This surface material will contribute maximumly to the reproduced signal.

Again assuming that the magnetic material in the tape has a relative permeability of one (the permeability of air). the deeper imaginary layers of magnetic material will be less closely coupled to the playback transducer, and will, in fact, be operating as though they were physically separated from the transducer surface. These deeper layers will contribute less to the reproduced output signal. And, the deeper layers will contribute hardly at all to short wavelength signal output because separation loss increases as wavelength grows shorter. Thus the surface layers of magnetic material will contribute a greater portion of the output signal, and the contribution of each layer must be factored according to how deep it lies in the magnetic coating and according to the wavelength of the signal it contains.

To summarize, the following variables affect the transfer characteristics of a recording system:

1. The thickness of the magnetic coating.
2. The modified anhysteretic magnetization curves of the magnetic material used.
3. The dimension, shape, and precision of the recording transducer gap and the playback transducer gap.
4. The recording wavelengths.
5. The surface smoothness of the magnetic tape and transducers which in turn determines the intimacy of contact of tape and transducer.
6. Bias level.

These variables are all interactive, and one cannot be changed without precipitating a non-linear interaction with all the others. Although a mathematical model of the recording process is not impossible (such models have been constructed), the practical approach to system design is empirical. A general understanding of the effects and interactions of the variables will allow the experienced designer to make reasonably accurate estimates, which are then refined through experimentation to produce an optimized system.

Recording system designers may wish to have comprehensive transfer characteristics for specific magnetic tape designs, but the foregoing shows that such characteristics are determined as much by equipment design as by the magnetic materials and constructions used in tapes. Transducer design, particularly, is influential in establishing system transfer characteristics. Tapes and transducers. which together determine the operating parameters of a recording system. cannot be separated and treated independently. Over the years, a high degree of cooperation has developed between manufacturers of tapes, transducers. and recording systems. It is this cooperation that has developed the magnetic recording art to its current state of sophistication. ■

REFERENCES

1. Eargle, John, *Sound Recording*. Van Nostrand Reinhold. 1976, p. 208.
2. Olson, Harry F., *Modern Sound Reproduction*, Van Nostrand, 1972, p. 147.
3. Karlqvist, O., "Calculation of the Magnetic Field in the Ferromagnetic Layer of a Magnetic Drum," trans, Royal Inst. Tech., Stockholm, Sweden, No. 86, pp. 3-27, 1954.
4. von Behren, R. A., "Magnetic Tape for Video Recording," paper presented to the SMPTE, March 1958.
5. Wetzel, W. W., "Review of the Present Status of Magnetic Recording Theory," *Audio Engineering*, pp. 14-17 and 39. November 1947; pp. 12-16 and 36, December 1947: pp. 26-33 and 46-47, January 1948.

Tape speed vs. Biasing

The right frequency to overbias depends on tape speed and wavelength.

OVER THE PAST YEAR, several letters to the editor have addressed themselves to the subject of setting optimum bias level. As with many magnetic tape spec. sheets, the letters talked about overbiasing by some number of dB at a certain frequency—usually 10 kHz. But, as Peter Vogelgesang's article in this issue points out in detail, bias level is dependent on many variables, such as tape coating thickness, record head gap dimension, and recorded wavelength. In fact, the word "frequency" doesn't get much attention at all.

But, who listens to wavelengths? Well, we all do, though we think of them in terms of the resultant frequency. Yet any pipe organ tuner will cheerfully tell you that the relationship between wavelength and frequency depends upon

Record Gap Dimension (mils)	Frequency, at 7.5 15 30 i.p.s. (kHz)	Resultant Wavelength (mils)	Recommended Overbias (dB)	Typical Machine
1.0	5 10 20	1.5	1.0	Early MM-1000's
0.5	5 10 20	1.5	2.5	Later MM-1000's, AG-440
0.25	5 10 20	1.5	3.0	MM-1100's

a third variable: the speed of sound in air. (And *that* varies with temperature, that's another story, fortunately.)

On tape, the wavelength/frequency relationship depends on tape speed. Therefore, if you'd like to record a wavelength of say, 7.5 mils onto a piece of tape, you can do so by recording a 1 kHz tone at 7.5 in./sec., or a 2 kHz tone at 15 in./sec., or 4 kHz at 30 in./sec., and so on. Or, if you prefer to talk in terms of frequency first, you can hear a 10 kHz tone by playing back a recorded wavelength of 0.75 mils, at 7.5 in./sec., or 1.5 mils at 15 in./sec., or 3.00 mils at 30 in./sec.

So, when people talk about overbiasing at a certain frequency, f, they *really* mean a certain wavelength, λ, *and* a specific tape speed, v. But everyone records at 15 in./sec., and overbiases at 10 kHz. (Well, some people do.) And that's where the trouble begins, for we tend to ignore wavelengths, having trouble enough remembering all that other stuff.

But the tape recorder hasn't forgotten about wavelengths, even if it does record and playback frequencies for you. So, to keep your system happy, you must overbias at a certain wavelength, and let the frequency fall where it may.

NOTE OVERBIAS

So make a note of the frequency at which you overbias, since you will want to halve, or double, it when you change tape speed. That way, λ will stay the same, and your tape will be properly biased.

As a further variable, optimum bias level is also a function of the record gap dimension, which fortunately doesn't change until you replace the head stack. But, if you don't remember what the dimension is, you'll have to find out the hard way. (Read the tape recorder manual. It might not say anything, but there's probably an address which you can write for information.)

Finally, there's the tape itself. Different formulations require different bias levels, depending on the tape's chemistry and the depth of the coating.

To help sort out all these variables, various technical bulletins from tape manufacturers may help. An Ampex Application Note defines optimum bias (at 15 in./sec.) as ". . . that bias current resulting in minimum third harmonic distortion." This is achieved ". . . by peaking the output, using a 10 kHz signal, then continuing to add bias current until the 10 kHz signal has dropped a specified number of dB dependent on record gap width." For its 406, 407 and 456 series tapes, Ampex specifies varying amounts of overbias. This data is reproduced here in chart form.

From the chart, it will be seen that if your record head has a 0.5 mil gap, and you are recording at 15 in./sec., you should over-bias by 2.5 dB, using a 10 kHz tone. If you change tape speed, the easiest way to stay out of trouble is to change frequency, and never mind trying to guess the amount of over-bias required at 10 kHz. Remember, the record head is interested in λ, *not* f; so if you double the frequency whenever you double the tape speed, λ stays the same.

Also keep in mind that the recommended over-bias settings listed above are for Ampex 406, 407 and 456 tapes. If you are using a different tape, check the manufacturer's recommendations. You may (or may not) be able to find everything you need to know.

As a point of interest, Ampex also publishes biasing recommendations based on achieving maximum long wavelength response, rather than minimum third harmonic distortion. Again, using 10 kHz at 15 in./sec., the recommended overbias for 406/407 tape is 1.5 dB for record gaps of 0.25 and 0.5 mils. However, when using 456 tape, Ampex recommends overbiasing by 1.5 dB for 0.5 mil heads, and 2.5 dB for 0.25 mils.

For more information on long- *vs.* short-wavelength optimization, go back to Peter Vogelgesang's article. And before you decide you've already had more information than you can stand, think about recording pipe organs, electric bass, and such. Would you rather have minimum third harmonic distortion, or better long wavelength (low frequency, that is) response?

In talking about wavelengths, as well as tape dimensions, some manufacturers speak English, while others talk in Metric. Now, while everyone knows that there are about three feet in a meter, how many microns are there in a mil? (A mil is one-thousandth of an inch.) Here's a little conversion chart that may help out.

MIL-MICRON CONVERSION

mils	microns (or μm)
0.06	1.52
0.10	2.54
0.25	6.35
0.26	6.60
0.50	12.70
0.75	19.05
1.00	25.40
2.00	50.80
"X"	25.4(X)

KEVIN J. BYRNE

Metal Particle Tapes: Upgrading Analog Performance

New high coercivity metal particle tapes promise to help elude digital high costs by upgrading performance on more modest equipment.

THE IMPENDING INTRODUCTION by several cassette tape manufacturers of a new high coercivity metal particle tape has stirred quite a lot of interest in the compact cassette marketplace. Dramatic improvements that these formulations offer in performance, particularly in the area of expanded dynamic range, have many people contemplating the idea of applying this new tape technology to the open-reel format. It has been suggested that metal particale tape, if applied to the high speed, open-reel format, might indeed be able to rival the much more expensive digital (or pcm) tape recorders in many significant areas.

While open-reel metal tape products—even samples—are not readily available, in many circumstances we can calculate what the improvements *might* be in the significant electrical parameters.

We know, for example, that in the cassette formulation, the resultant improvements in the tape are:

1. Doubling of the remanance (Br)
2. Doubling of the coercivity (Hc)
3. A decrease of the coating thickness (d)

The improvements obtained by doubling the remanance are approximately a 3 dB increase in the low frequency signal capacity of the tape, and, therefore, a corresponding 3 dB increase in signal-to-noise ratio.

Doubling of the coercivity results in an increased output of 6 to 8 dB in the high frequency range. Clearly, this improvement is of utmost importance in improving the performance of the cassette, where tape velocity is 1⅞ in./sec., and high frequency output has been limited.

It is a fact that recent tape developments have primarily focused on improving the coercivity of the tape. However, it can be demonstrated that these improvements in coercivity have done little to improve the dynamic range capability of the high speed (15 in./sec.) open-reel tape recorder. The primary reason for this is that we have had to deal with a fixed 50 μsec playback equalization curve, according to 1963 NAB standards.

But as the coercivit of open-reel tape formulations improved, it became possible to reduce the amount of record pre-emphasis in the high frequencies that was necessary to obtain flat playback response with 50 μsec equalization. This reduction in pre-emphasis has, of course, resulted in improvements in the dynamic range of the tape recorder. However, it has been several years since coercivity became high enough to require no high frequency pre-emphasis at all, when using the 15 in./sec. tape speed (see FIGURE 1). In fact, with certain formulations it has been necessary to apply a small amount of de-emphasis to the high frequencies during record in order to obtain flat playback response with 50 μsec playback equalization at 15 in./sec. Clearly, this represents a poor application of the advantages of higher coercivity. As a result of this limitation, improvements in performance with higher coercivity tape formulations have been limited to slow tape speed operation, where a further reduction in record pre-emphasis is made possible.

To illustrate this point, let us examine the performance specifications of a specific tape recorder.

Frequency response: 50 Hz to 15 kHz, at 15 in./sec. ± 2 dB.

Dynamic range: Better than 60 dB, at 2 per cent distortion.

Of interest here is that these specifications apply to the Ampex Model 300, which was introduced in early 1949!

REDUCED TIME CONSTANT

Obviously then, the application of high coercivity metal particle tapes to the high speed open-reel format can deliver only minor improvements in dynamic range *unless* we re-evaluate the time constant used for playback equalization. It is important to understand that reducing the time constant results in a reduced amplification of high frequencies during playback, and therefore, a reduction in the hiss level produced by the tape itself. This, in combination with the increased output from the tape can be expected to significantly improve the dynamic range of the open-reel format.

COATING FACTOR

Keeping in mind the coating thickness of the tape can be helpful in determining the recommended time constant to be selected. In a recent AES paper, entitled "The Design of Audio Heads and Electronics for Application of High-

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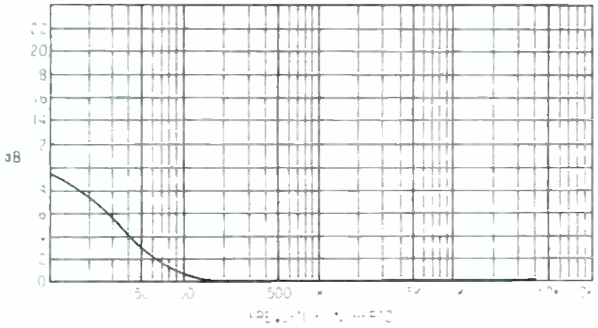


Figure 1. Record equalization curves of the Tandberg TD20A, at 15 in./sec. Note the absence of record preemphasis in high frequencies. Editor's note: This record equalization is meant to be used with a corresponding 35 μsec. (IEC Standard) playback curve.

Coercivity Tape," Dr. Herman Lia of Tandberg's Radiofabrikk in Oslo, Norway, illustrated that an appropriate time constant could be established using the formula:

$$RC=d/v$$

where RC is the recommended time constant, d is the coating thickness of the tape, and v is the tape velocity.

Application of this axiom, and the anticipation that the coating thickness of metal particle open-reel tape will be 5 microns. Tandberg has recommended a playback time constant of 10 μsec for 15 in./sec. operation of all open-reel tape recorders using metal particle tape. (See FIGURE 2.)

The combination of increased output from the tape and a reduction of the hiss level produced by the tape in playback allows us to contemplate an open-reel tape recorder operating at 15 in./sec. (half-track mode) delivering dynamic range figures exceeding 80 dB.

If we take the performance specifications already obtained by Tandberg's Model TD20A in combination with this improvement in dynamic range, we can anticipate the following performance:

Frequency response: 20Hz to 20 kHz ± 1 dB;
Dynamic range greater than 80 dB.

Figure 2. Playback equalization curves.——————— 50 μsec curve, according to NAB Standards (1963). — — — — — Recommended 10 μsec. curve, for metal particle tape (15 in./sec. operation).

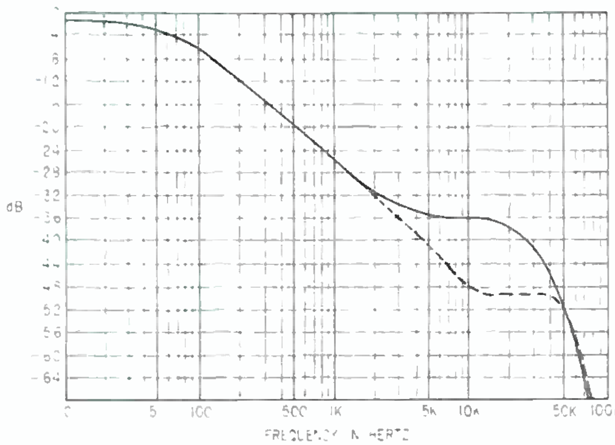


TABLE 1: COMPARISON TABLE—CASETTE TAPES

Tape	(Gauss) Retentivity	Coercivity (Oersteds)	Coating Depth (Microns)
Maxell UD XL I	1640	330	5.5
3M Master II	1500	550	5.5
Maxell UD XL II	1500	550	5.5
Metal Particle Tape (3M Metafine)	3300	1000	4.0

A prototype open-reel tape recorder outfitted with the necessary electronics and heads required to make it compatible to these new metal particle tapes carries a current retail price of $1,400.00 for the ½-track 15 in./sec. operation. If we allow for inflation and various modifications which are anticipated, we can realistically obtain these performance levels at a cost of $1,600.00-$1,800.00 by the time the tape becomes available.

METAL PARTICLE TAPE *VS.* DIGITAL FORMAT

Comparing these price/performance figures with some of the currently available digital formats appears in order. For example, Mitsuhishi Electric has demonstrated a pcm recorder with the following specifications: Frequency response: 20Hz to 20 kHz ± ½ dB; Dynamic range greater than 85 dB; Price: For two channels of audio $36,000.00 to $40,000.00.

A similar unit from Soundstream using a different system (16 bit *vs.* 14 bit in the Mitsuhishi) boasts 90 dB signal-to-noise ratio and costs $50,000 for four channels.

The 3M Company is leasing a 32-track mastering system, including a companion four-track mixdown unit using 16-bit audio-digital conversion. Frequency response is stated at 20 Hz to 20 kHz +0/−3 dB and signal-to-noise at 90 dB. The system, which has a tape speed of 45 in./sec., costs a mere $150,000!

MONEY-SAVING ELEMENT

Of course, in the multi-track format the absence of cumulative noise buildup afforded by the digital system is of no small consequence. What we should really conclude from all of this is that metal tape analog recorders will have clear advantages to the owner-operator of a small studio whose budget limitations pose problems in the procurement of high-performance results from two-channel mastering machines. These machines, and certainly similar 4- and 8-track versions, can offer the small production studio previously-unattainable performance levels at a fraction of the cost of their digital counterparts.

Certainly, development in both analog and digital areas of tape recording can be expected to continue at a rapid rate. While the problems of compatability posed by the adoption of new time constants for metal tape recorders cannot be overlooked, they are certainly nowhere nearly as complex as those presented by the total absence of any standard in the current digital formats. This lack of compatibility is a small price to pay for a dramatic improvement in performance.

It can be concluded that in the "cost be damned" world of superstar production, the expense of a complete digital system may be justified. (What's a few less Rolls Royces anyway?) But for those whose budgets are less exotic, the application of metal tape to professional equipment may well make dramatic improvements in the final product affordable. ■

Cross-reference Guide to Magnetic Tape Specifications

MANUFACTURER	AGFA		AMPEX					
TAPE NUMBER	PEM 468	PEM 526	631	632	671	406	407	GRAND MASTER
MAGNETIC PROPERTIES								
Coercivity (oersteds)	380	300	264	290	264	290	290	295
Retentivity (Gauss)	1060	1050	958	1100	958	1150	1150	1400
ELECTROMAGNETIC PROPERTIES								
Recommended Bias (dB)	3.5	6	—1.8	1.5	—3.3	3.0	3.0	3.0
Print-through (dB)	58	55	51	57	49	58	57	55
Signal-to-Noise Ratio (dB)	78	73.5	59.3	62.5	51.3	63	63	64.3
PHYSICAL PROPERTIES								
Base Material*	TP	TP	P	P	P	P	P	P
Base Thickness (mils)	1.18	1.41	1.42	1.42	0.75	1.42	0.88	1.42
Oxide Thicknes (mils)	0.63	0.63	0.42	0.40	0.22	0.50	0.50	0.50
Back Coating (mils)	0.07	0.04	none	none	none	0.05	0.05	0.05
Total (mils)	1.88	2.08	1.84	1.82	0.97	1.97	1.43	1.97
Standard Widths: ¼"	X	X	X	X	X	X	X	X
½"	X	X				X	X	X
1"	X	X				X	X	X
2"	X	X				X	X	X

*P—Polyester
TP—Tensilized Polyester

MANUFACTURER	BASF			MAXELL			MEMOREX		
TAPE NUMBER	DPR26LH	SPR50LH(L)	LGR30P	UD-XL50	UD-50	LN-50	GAMMA 60	GAMMA 90	QUANTUM 90
MAGNETIC PROPERTIES									
Coercivity (oersteds)	325	340	310	325	315	315	290	290	300
Retentivity (Gauss)	1200	1050	1050	1350	1200	1170	1350	1350	1525
ELECTROMAGNETIC PROPERTIES									
Recommended Bias (dB)	(Not Available in dB)			(Not Available in dB)			—1.0	—1.0	—1.0
Print-through (dB)	53	57.5	58	54	55	55	63	59	56
Signal-to-Noise Ratio (dB)	60.5	70.5	64	65	64	63	60.4	60.4	64.6
PHYSICAL PROPERTIES									
Base Material*	TP	TP	TP	P	P	P	P	P	P
Base Thickness (mils)	0.6	1.5	2.0	1.38	1.38	1.38	1.42	0.92	0.83
Oxide Thickness (mils)	0.39	0.63	0.5	0.49	0.49	0.49	0.4	0.4	0.4
Back Coating (mils)	0.13	0.13	0.13	0.08	none	none	none	none	none
Total (mils)	1.12	2.26	2.63	1.95	1.87	1.87	1.82	1.32	1.23
Standard Widths: ¼"	X	X	X	X	X	X	X	X	X
(inches) ½"									
1"		X							
2"		X							

*P—Polyester
TP—Tensilized Polyester

MANUFACTURER	TDK			3M					
TAPE NUMBER	AUDUA L	AUDUA LB	SUPERIOR S	176	206	207	208	209	250
MAGNETIC PROPERTIES									
Coercivity (oersteds)	350	350	280	320	320	320	325	325	380
Retentivity (Gauss)	1150	1150	1000	1000	1050	1050	950	950	1200
ELECTROMAGNETIC PROPERTIES									
Recommended Bias (dB)	1.9	1.9	(not available)	0	0	0	0	0	2
Print-through (dB)	54	54	52	not available	52	50	56	54	51
Signal-to-Noise Ratio (dB)	63	63	61	72.5	75.5	75.5	72.5	72.5	79.5
PHYSICAL PROPERTIES									
Base Material*	P	TP	P	P	P	P	P	P	P
Base Thickness (mils)	0.87	0.87	1.0	1.30	1.42	0.85	1.44	0.87	1.30
Oxide Thickness (mils)	0.47	0.47	0.5	0.40	0.56	0.56	0.40	0.40	0.65
Back Coating (mils)	none	0.04	none	none	0.08	0.08	0.08	0.08	0.08
Total (mils)	1.34	1.37	1.5	1.70	2.06	1.49	1.92	1.35	2.03
Standard Widths: ¼"	X	X	X	X	X	X	X	X	X
(inches) ½"				X	X	X	X	X	X
1"				X	X	X	X	X	X
2"					X	X			X

*P—Polyester
TP—Tensilized Polyester

COERCIVITY—(abbr. H_c)-measured in oersteds—is the magnetic field required to reduce the magnetization of a saturated magnetic specimen to zero. The coercivity is a direct measure of the bias current requirement of a tape. The coercivity value is obtained from a 60 Hz. B-H loop tester with a 1000 Oersteds field calibrated to that maintained by the National Bureau of Standards. The coercivity of representative studio tapes generally ranges between 280 and 380 oersteds.

RETENTIVITY—expressed in gauss (i.e., magnetic flux lines per cross-sectional square centimeter of tape)—is a measure of a magnetic tape's flux density after a saturation-producing magnetic field has been withdrawn. The long wavelength saturated output is directly proportional to the retentivity. The retentivity value is obtained from a 60 Hz. B-H loop tester with a 1000 oersted field calibrated to that maintained by the National Bureau of Standards.

Agfa-Gevaert, Inc.
275 North Street
Tetterboro, New Jersey 07608
(201) 288-4100

Ampex Corporation
Magnetic Tape Division
401 Broadway
Redwood City, California 94063
(415) 367-2011

Audio Devices
100 Research Drive
Glenbrook, Connecticut 06906
(203) 327-6500

BASF Systems
Crosby Drive
Bedford, Massachusetts 01730
(617) 271-4038

Maxell Corporation of America
60 Oxford Drive
Moonachie, New Jersey 07074
(201) 440-8020

Memorex Corporation
Audio Division
1700 Broadway
New York, New York 10019
(212) 541-7780

Sony Corporation of America
9 West 57th Street
New York, New York 10036
(212) 371-5800

TDK Electronics Corporation
755 Eastgate Boulevard
Garden City, New York 11530
(516) 746-0880

3M Company
Magnetic Audio/Video Products
Division
3M Center
Saint Paul, Minnesota 55101
(612) 733-0301

ROBERT K. MORRISON

Using Induction Loops

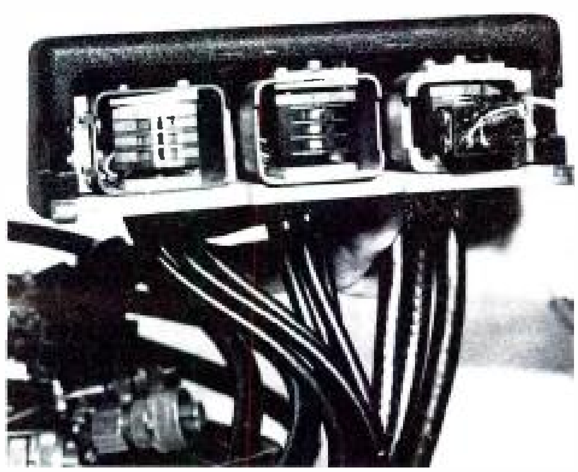
How to make induction loop measurements of a reproduce channel.

INDUCTION LOOP response measurements utilizing a single turn of wire, parallel to the reproduce head gap, are frequently mentioned in standards recommendations and the literature in general. Before describing the technique, and practical methods of performing the measurements, we should state what the test will and will not achieve.

WHAT TO EXPECT

Properly performed induction loop response measurements *will* provide data relative to the electrical characteristics of the system. Included will be useful data pertinent to head resonance, playback amplifier response, and core losses of a specific had. The technique will NOT provide data relative to spacing loss (i.e., tape-to-head contact), gap loss of the head itself, "head bumps" due to the physical design of the head, nor losses due to misalignment. The distinction between a "standardized" reproduce channel with an IDEAL repro. head, and a channel adjusted to vary from the ideal characteristic to compensate for the imperfections of a practical head must be understood. The common 7½ in./sec., 50 and 3,180 micro-second, NAB curve would call for an induction loop response showing a 13.6 dB rise at 15 kHz, referenced to 400 Hz, and a 3 dB drop at 50 Hz. In employing a practical head, there will usually be some gap loss and this must be compensated for, although the deviation from "ideal" in repro. heads is becoming quite small. A good head supplied for the purpose above might show a deviation of only a dB or two at the upper and lower frequency extremes. The present tendency with the shorter gap spacers being employed is to find most of the deviation at the low end—due to head

The induction loop in place on a playback head.



Robert K. Morrison is founder of Standard Tape Laboratory.

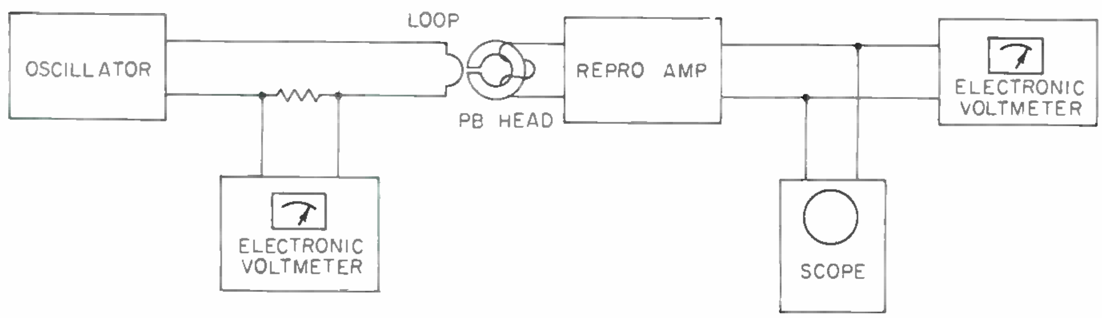


Figure 1. The method for induction loop measurement.

bumps resulting from core design shape. Some core loss is to be expected, but this will show up in the induction loop measurements.

MEASUREMENT TECHNIQUE

The following technique for loop response measurements may be conveniently employed in most laboratory or shop environments. In addition to the reproduce amplifier and playback head, you will need the following:

Two VTVM's.
A short piece of small-diameter enameled wire.
A resistor (10 ohms is fine).
An audio oscillator.
Leads to connect the equipment, as shown in Figure 1.

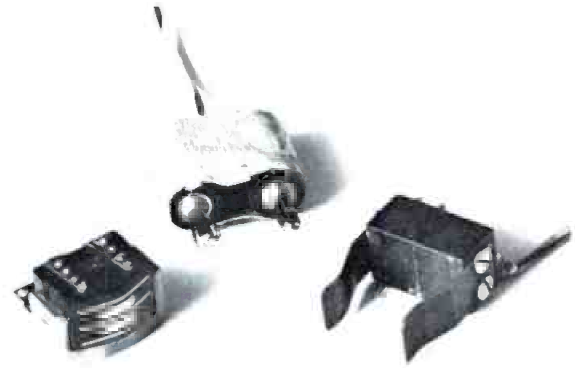
A single piece of wire is positioned up against the head with attention given to secure it in a parallel relationship to the gap. It should be as close as possible to the gap. Obviously, care should be taken not to scratch the head. and therefore, you may want to put a layer of masking tape over the head's surface and then secure the wire with another piece of tape. If loop measurements are to be made frequently, you will appreciate the convenience of a spring clip or holder for the wire, such as the one seen in the photographs. Such a device can be easily fabricated and quickly attached or detached. Since heads come in many sizes, you will have to make a loop holder to fit the type of head stack involved. Notice that the wire can be laid in a groove of plastic material in such a way to insure that the head surface cannot be scratched. A piece of masking tape can be permanently left on the holder to protect the head.

Some added considerations:

(1) The response is not affected by the "asimuth" relationship of the wire to the tape head gap, however maximum signal will result from careful placement as above.
(2) The usual audio oscillator will only provide a signal at 400 Hz of sufficient strength to produce a ZERO reading on about the −30 dB scale of the voltmeter which is connected to the output of the playback amplifier.
(3) It is best to make the measurement with the level control on the playback amplifier set in the normal position for two reasons: (a) Some equipment may vary slightly in response at different level settings. (b) The induction loop will show a rising response with frequency, and if the 400 Hz reference were set to ZERO on equipment having a time constant of say, 120 micro-seconds, the high frequency region of measurement could easily produce amplifier clipping resulting in a misleading reading. I have personally encountered two such cases resulting from the above problem: both happened in professional areas; one a laboratory, the other a large recording company's engineering facility. The best policy is to include a 'scope at the amplifier output and watch for any clipping. You may wish to measure a channel that has been adjusted to reproduce a test tape with flat response. Provided the tape is accurate, the result of a loop response test will indicate how much compensation was necessary to make up for gap, spacing, core, and geometric losses in the head.

Another possible use for the loop response test would involve the calibration of a reproduce alignment tape by means of a known reproduce head. By "known," we mean a head that has been measured carefully to determine its actual core, gap and contour deviations from ideal. With such a head connected to a repro. amp which has been corrected for these head losses, a reproduce alignment tape can be examined for agreement. We have found, incidentally, that the most reliable data result from use of heads which are made to be as near "ideal" as possible. One reason, other than the fact than any error involving a large correction factor usually results in a large error, is that heads departing from "ideal" by a wide margin often

Rear view of plastic block shows resistor and leads to voltmeter.



One turn of wire fits in a groove in the plastic block.

make measurements very uncertain. Best case in point would be the use of a 300 micro-inch repro. head to calibrate a tape's short wavelength recordings. The readings would be unsteady and the measurement, therefore, uncertain. The readings would be unsteady and the measurement, therefore, uncertain. There was a tendency, unfortunately, for some standards committees, in the past, to use components with gross deficiencies when determining measurements of recorded materials. Often the corrections, each with its own inevitable error of measurement, compounded to provide a mathematical treatise of many pages, representing an experiment that was probably unrepeatable. The best agreement and repeatibility of loop measurement tests as related to response tapes can be achieved by use of a repro. head as close to ideal as the state of the art allows.

SIMPLICITY OF THE LOOP TEST

A mid-frequency reference tone is supplied to the wire. (400 Hz is most often used for the reason that the major American standards committees have shown 400 Hz as the zero reference on their charts.) The level from the oscillator is adjusted to produce the zero reference on the voltmeter scale (actually about −30 dB as stated above). This meter is connected to the OUTPUT of the repro. amplifier. An additional voltmeter is bridged across the ten ohm resistor in series with the wire. The voltage drop is noted and all subsequent tones are fed to the wire at the same level. In this way we can be sure that the current through the induction wire is the same at all frequencies. Remember, in making any of these measurements that you are seeing the electrical response of the head, plus the cable, plus the amplifier. You can, by sweeping the oscillator, quickly determine the resonance of the system. The cable capacitance will often affect the resonance, so it is well to employ the SAME type of cable from head to amplifier as will be used in practice, when you make loop measurements.

Your attention is called to the fact that much confusion occurs when playback amplifier curves are compared to loop response curves. They are NOT the same, but are directly related. (How they relate will be found in another section of Morrison's book—Ed.) ■

Editor's Note:

The preceding article, **Using Induction Loops**, was taken from section seven of the **Standard Tape Manual** by Robert K. Morrison. Publisher: R. K. Morrison Illustrative Materials, 819 Coventry Road, Kensington, California 94707.

ALBERT E. HAYES, JR.

Audio Problem Solving with a Programmable Calculator

Here is a step-by-step guide to the calculation of an amplifier's signal-to-noise characteristics, using a desk-top calculator.

BACK IN MAY of 1977, author John Maxwell's article, *Noise of Sources*, led us step-by-step through the calculations required to compute an amplifier's signal-to-noise characteristics. More recently (November, 1978), a series of articles in **db** drew attention to the increased role of technology in freeing us from many of our step-by-step audio chores.

The November issue prompted a re-reading of Maxwell's article, with an idea towards working out a calculator program that would be of use to engineers confronted with the tedious, but necessary, task of duplicating Maxwell's work.

In his article, Maxwell computes the noise output of electret microphones over a 20 Hz to 20 kHz bandwidth, showing the difference in net noise output for differing values of load resistance. Another set of calculations provides the same type of information when a magnetic phono cartridge drives the preamplifier.

Maxwell's paper provides an orderly sequence for making the many calculations which are required over the bandwidth of interest. For the electret microphone calculations, he sums the microphone capacitance (C_m) and the stray capacitance (C_s), to find the total capacitance, C. This is shunted by a load resistance, R_1. From here, Maxwell finds the resistive component of the impedance [$R_e(Z)$]. using the formula: $R_e(Z) = R_L/(1 + \omega^2 R^2_L C^2)$.

The calculation is done for ten one-octave bandwidths. In each, the noise voltage is equal to $\sqrt{4kT(R)(BW)}$. (For more information on this, also see *Input Noise in Microphone Preamplifiers*, by Josef W. Dorner in the July, 1978 issue of **db**—Ed.) The total source noise is found by taking the square root of the sum of the squares of each of the ten noise voltage calculations.

In this article, Maxwell's formulae will be converted into a program that can be run on a modern desk-top calculator. The specific program listed below was done on a Hewlett-Packard HP-97 calculator. The same program will run on the HP-67 with simply a change in notation, and can be translated fo rthe HP-33E with a few significant changes. By following the program step-by-step, it is hoped that the reader will gain a better understanding of how the programmable calculator may be used for audio problem solving.

The program is presented in three columns; A, B, C. Column A is a tally of line numbers or "instructions." Each instruction is a key stroke(s), and these are listed in Column B. Where an instruction requires more than one key stroke, these are separated by a space in column B. Column C is a series of brief explanatory remarks, which are discussed in greater detail at the conclusion of the program.

The HP-97 programmable printing calculator used for the programs described in this article.

Dr. Hayes is a consulting engineer in Fullerton, CA.

With some changes, the programs may be run on the HP-67, and other even less expensive calculators, such as the HP-33E ($100.00).

All photos courtesy of Hewlett-Packard.

CALCULATOR PROGRAM

A	B	C
001	LBL A	enter first input ($=C_m$)
002	CLRG	clear registers
003	STO 1	store input in 1
004	RTN	continue program
005	LBL B	enter next input ($=C_s$)
006	STO + 1	add, store in 1 ($=C_m + C_s$)
007	RTN	continue program
008	LBL C	enter next input ($=R_L$)
009	STO 2	store in 2
010	2	
011	5	lowest bandwidth (=25 Hz)
012	STO 3	store BW in 3
013	3	
014	5	
015	.	
016	3	
017	5	
018	5	
019	3	lowest center frequency ($F_c =$ 35.3553 Hz)
020	ENTER	enter F_c,
021	2	and
022	×	multiply by 2,
023	π	and then by π,
024	×	to get $2\pi F_c$ ($=\omega$)
025	STO 4	store ω in 4
026	LBL 1	
027	RCL 4	recall ω from 4
028	X^2	square ω ($=\omega^2$)
029	RCL 2	recall 2 ($=R_L$)
030	X^2	square R_L ($=R^2_L$)
031	×	multiply ω^2 by R^2_L
032	RCL 1	recall 1 (=C)
033	X^2	square C ($=C^2$)
034	×	multiply $\omega^2 R^2_L$ by C^2
035	1	
036	+	add 1 ($=1 + \omega^2 R^2_L C^2$)
037	RCL 2	recall 2 ($=R_L$)
038	X⇄Y	invert X and Y, and
039	÷	divide, to get $R/(1 + \omega^2 R^2_L C^2)$
040	1	
041	.	
042	6	
043	5	(when the sign of the exponent is changed, this value is equal to 4kT)
044	6	
045	EEX	
046	2	
047	0	
048	CHS	change sign, to get 1.656×10^{-20}
049	×	multiply R_e by 4kT
050	RCL 3	recall bandwidth (BW) from 3
051	×	multiply 4kT(R_e) by BW, to get 4kTR(BW)
052	STO + 6	recall 6, add 4kTR (BW) and store in 6
053	2	
054	STO × 3	recall 3 (BW), multiply by 2 (=2×BW), and store in 3
055	1	
056	3	
057	0	
058	0	13,000 Hz is the highest BW of interest
059	0	
060	RCL 3	recall 3 (BW).
061	X>Y?	compare with 13,000
062	GTO 2	go to LBL 2 (@066)
063	2	recall 4, multiply
064	ST × 4	by 2, and store in 4.
065	GSB 1	go to LBL 1 (@026)
066	LBL 2	
067	RCL 6	recall 6 (= sum of the squares)
068	√X	take the square root of line 67
069	ENG	use engineering notation
070	DSP 2	display label 2 (=√x)
071	R/S	run/stop

In this program, the "labels" (LBL, A, B, 1, 2, etc.) indicate places where the calculator will process data input. Depending on the instruction following the LBL. the calculator will either wait to receive data from the user, or process data already in memory. And now, let's proceed through the program, step-by-step.

ANALYSIS OF PROGRAM

001-003 starts the program, clears the registers of all previously stored data, and stores the first input from the user, which in this case is the shunt capacitance, C_m. 004-006 inputs the stray capacitance (C_s), adds it to C_m, and stores the sum in register 1. In steps 007-009, the same procedure stores the load resistance, R_L, in register 2. 010-012 enter the width of the individual band for the lowest frequency segment (25 Hz), and this is stored in register 3.

The next operation, in steps 013-020 enters the center frequency of the lowest frequency segment (35.3553 Hz). (It should be noted that Maxwell used the arithmetic mean of 37.5 Hz, while here the geometric mean frequency has been used. The resultant differences are trivial, as we shall see.) Steps 021-025 convert the center frequency, C_f, from hertz to omega, by multiplying it by 2, and storing the result in register 4. 026 is a label to which we shall return later in the program. Steps 027-039 perform the necessary steps to calculate $R_e(Z)$, as specified by Maxwell.

Next (040-048), contain the constant, 1.656×10^{-20}, which is simply, 4kT, assuming a room temperature of T = 300° Kelvin (=27° C. or 80.6° F.) 049 multiplies 4kT by R_e. In steps 050-051, this product is multiplied by the bandwidth, recalled from register 3. At 052, the quantity in register 6 (=0, the first time around) is recalled and added to the current value of 4kTR(BW), and then returned for storage in register 6. 053-054 recalls the bandwidth stored in register 3 and doubles it, storing the new product back in register 3. 055-059 enters the highest bandwidth of interest, after which 060 recalls the bandwidth currently stored in register 3, and 061 compares the two. If the quantity in register 3 is in fact greater than 13 kHz, the calculator proceeds to the very next step (062), where it is directed to skip ahead to LBL 2 (Step 066). However, if the bandwidth is *not* greater than 13 kHz (in other words, X>Y is *not* true), the calculator skips step 062 and continues at 063.

At this point in the program (that is, the first time around), register 6 contains the value of the square of the noise voltage in the 25 Hz bandwidth between 25 and 50 Hz. The noise in the subsequent bands has not yet been calculated. Therefore, 063-064 recalls the bandwidth stored in register 4, doubles it, and stores it back in register 4. In effect, we have doubled the value of F_c in the equation $\omega = 2 F_c$.

065 sends the calculator back to LBL 1, at step 026. The new value of ω is recalled from register 4, and the calculations continue, as before. This time, at 052 there is already a stored quantity in register 6, so the new quantity is added to it, and the sum stored back in register 6.

The process continues, until finally step 061 indicates that X is greater than Y. Since X>Y is now true, the calculator advances to 062, where it is directed to skip to 066. 067 recalls the total sum of the squares of the noise voltages now stored in register 6, and the square root of this value is found in step 068. 069 converts this value into engineering notation. (In engineering notation, in the quantity 10^x, x is equal to a multiple of 3, a convenience for engineers who deal in terms of milli-, micro-, mega-. etc.—Ed.). Finally, 070 displays the answer, and 071 concludes the program.

If this program is run with Maxwell's sample figures; a 10 pF microphone capacitance, a 5 pF amplifier and stray capacitance, and a 1G (10^9) load resistance, the program runs about 30 seconds, and yields the result: 8.42 microvolts. This is somewhat larger than Maxwell's value of 7.9 microvolts for two reasons: as noted earlier, Maxwell uses the arithmetic center frequency of each segment as F_c, while our program uses the geometric center. Also, Maxwell did not use a full octave for his highest-frequency segment (12.8 to 20 kHz), while our program assumes a bandwidth out to the full 25.6 kHz.

PROGRAM FOR SECOND FORMULAE GROUP

Given below is a somewhat longer program for Maxwell's second set of formulae, which relate to the noise appearing in the output of a preamplifier when driven from a magnetic phono cartridge. This calculation is of course more complex, since both inductive and capacitive —as well as resistive—elements are involved.

Five inputs will be required. These are; LBL A = cartridge inductance; LBL B = cartridge resistance; LBL C = cartridge capacitance; LBL D = load resistance; LBL E = amplifier input capacitance. By studying the explanation of the first program, it should not be too difficult to decipher all 112 steps of this one. Good luck!

(Hint: If the number, 222.14, appearing in steps 019-024 is not immediately recognized, try comparing it to the results of steps 013-024 in the previous program.—Ed.) ■

PREAMP NOISE

				019	2	075	X^2	038	RCL 4	094	ST + 1
001	LBL A	057	1/X	020	2	076	×	039	1/X	095	2
002	CLRG	058	STO 0	021	2	077	RCL 0	040	+	096	ST × 6
003	STO A	059	RCL 8	022		078	X^2	041	1/X	097	2
004	RTN	060	RCL 9	023	1	079	×	042	STO 8	098	ST × 5
005	LBL B	061	×	024	4	080	X⇄Y	043	RCL 7	099	1
006	STO 2	062	RCL 8	025	STO 6	081	÷	044	1	100	3
007	RTN	063	RCL 0	026	LBL 6	082	1	045	+	101	EEX
008	LBL C	064	×	027	RCL A	083	.	046	RCL +	102	3
009	STO 3	065	−	028	×	084	6	047	÷	103	RCL 5
010	RTN	066	X^2	029	RCL 2	085	5	048	RCL A	104	X>Y?
011	LBL D	067	RCL 9	030	÷	086	6	049	×	105	GTO 4
012	STO 4	068	X^2	031	X^2	087	EEX	050	STO 9	106	GSB 6
013	RTN	069	RCL 0	032	STO 7	088	2	051	RCL 6	107	LBL 4
014	LBL E	070	X^2	033	1	089	0	052	×	108	RCL 1
015	ST + 3	071	×	034	+	090	CHS	053	STO 9	109	√X
016	2	072	+	035	RCL 2	091	×	054	RCL 3	110	DSP 3
017	5	073	RCL 8	036	×	092	RCL 5	055	RCL 6	111	ENG
018	STO 5	074	RCL 9	037	1/X	093	×	056	×	112	R/S

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People/Places/Happenings

• Three research managers of **CBS Technology Center,** Stamford, Conn., have been appointed to executive posts. The three are **Robert A. Castrignano,** named director of advanced television technology; **Abraham A. Goldberg,** promoted to associate director for advanced television research; and **Arthur Kaiser,** appointed associate director for advanced television development. All are senior members of the Technology Center staff, and their inventions have resulted in 39 patents.

• In a reorganization of its sales department, **Scientific Audio Electronics, Inc.,** of Los Angeles CA. has promoted **Warren Pompei** to director of sales, along with the appointment of **Andrew McKinney** as national sales manager. Elsewhere in the organization, **Barry Thornton** was named chief engineer, directing research and development of new products, while **Don Jackson** was appointed professional products applications engineer.

• After undergoing a $300,000 remodeling effort, **Jim Hodges' Buffalo Sound Studios,** of Fort Worth, Texas, is open for business. With the installation of a 24-track MCI recording system and new acoustical design, Buffalo Sound Studios will be offering production services for radio, television, film and other audio recording.

• **Charles David Tandy,** chairman of the board, president and chief executive officer of **Tandy Corporation,** parent company of the worldwide **Radio Shack** store chain, died in his sleep of a heart attack Saturday, November 4, 1978. Mr. Tandy, who took a small, family leather business and developed it into an international corporation, acquired the ailing Radio Shack chain, of nine stores, in 1963. He became the chief executive officer of the Radio Shack Division of Tandy Corporation, developing the operation into a network of more than 6,500 Radio Shack stores and dealers in the Western Hemisphere, with nearly 500 overseas stores operating under the name Tandy International Electronics.

• Responsibility for the long-range business planning has been delegated to Joseph Dash, promoted to the position of vice president, business development, CBS Records. Mr. Dash, who has been with CBS since 1969, previously served as director, business development.

• The newly created position of assistant national sales manager has been filled by **Richard McConser** of the **Micro-Acoustics Corporation.** Mr. McCouser's background includes sales management positions at BSR and Pickering.

• Joining **Radio Shack** as a divisional advertising manager, **Richard D. Myers III** will take charge of the major media advertising in an 11-state area covering the northeastern U.S. Mr. Myers was previously a major account supervisor for the Fort Worth Observer newspaper.

• Elected to the board of directors of **Astatic Corporation,** Conneaut, Ohio, **Leon P. Davis** was also appointed to the new position of general manager of sales, foreign and domestic. Mr. Davis joined Astatic in 1976 as manager-international marketing.

• Moving to the new post of senior engineer for the recorder care division of **Nortronics, Bruce Larson** will direct the development of production standards, quality control, new product development, and all phases of production engineering.

• Entering into an agreement with **Cecil Watts, Ltd., Empire Scientific Corporation** has been named exclusive U. S. distributor of the Watts record care products in the United States.

• An addition to recording services available in the northeast Colorado area is **Radiant Star Recording,** located at 4th and Cleveland Streets, Loveland. **Bruce Brunson** is the head man there. As well as offering all of the usual sound equipment, Radiant Star has a promotional adjunct, **Radiant Star Graphics,** headed by artist and advertising man **Ray Mickelic.**

• Moving up at **ADC Products** are **John Antanies,** promoted to western regional sales manager; and **Richard Van Overbeke** named district manager, western region. New field assignments went to **Warren Anderson** assuming OEM customer coverage responsibilities in the midwestern territory; and **Dennis Thompson** appointed southwestern OEM salesman.

• Functioning in a new capacity as director of marketing for the **Ampex Corporation,** magnetic tape division, **S. Erek Jenstad** will be responsible for all domestic marketing, sales, product management and marketing administration of the company's magnetic tape products.

• Several changes in top level executive responsibility were announced by **Shure Brothers Inc.,** Evanston, Ill., **Victor F. Machin,** formerly senior vice president of marketing and manufacturing at Shure, has been named executive vice president of personnel, marketing and manufacturing. **James H. Kogen** was named executive vice president of finance and engineering and **Meyer Langer,** vice president-finance. Elsewhere, **Bernhard W. Jakobs** was promoted to director of engineering and head of the Engineering Division; **Allen R. Groh** has been appointed manager, technical markets and product management; and **Michael R. Vehlow** has moved up to assistant sales manager-export sales.

• **Mordaunt-Short Ltd.** of Great Britain announced the establishment of their American subsidiary company, **Mordaunt-Short Inc.,** for the distribution, servicing and support of their products throughout the U.S. President of the company is **Michael C. Short,** managing director of the British parent organization; vice president and general manager is **Joel Schwartz;** director and vice president (technical) is **Michael Deadman;** and **Christopher R. Short** is director and vice president (administrative). Mordaunt-Short Inc. will operate from offices at 1919 Middle Country Road, Centereach, NY 11720, telephone (516) 981-0066.

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