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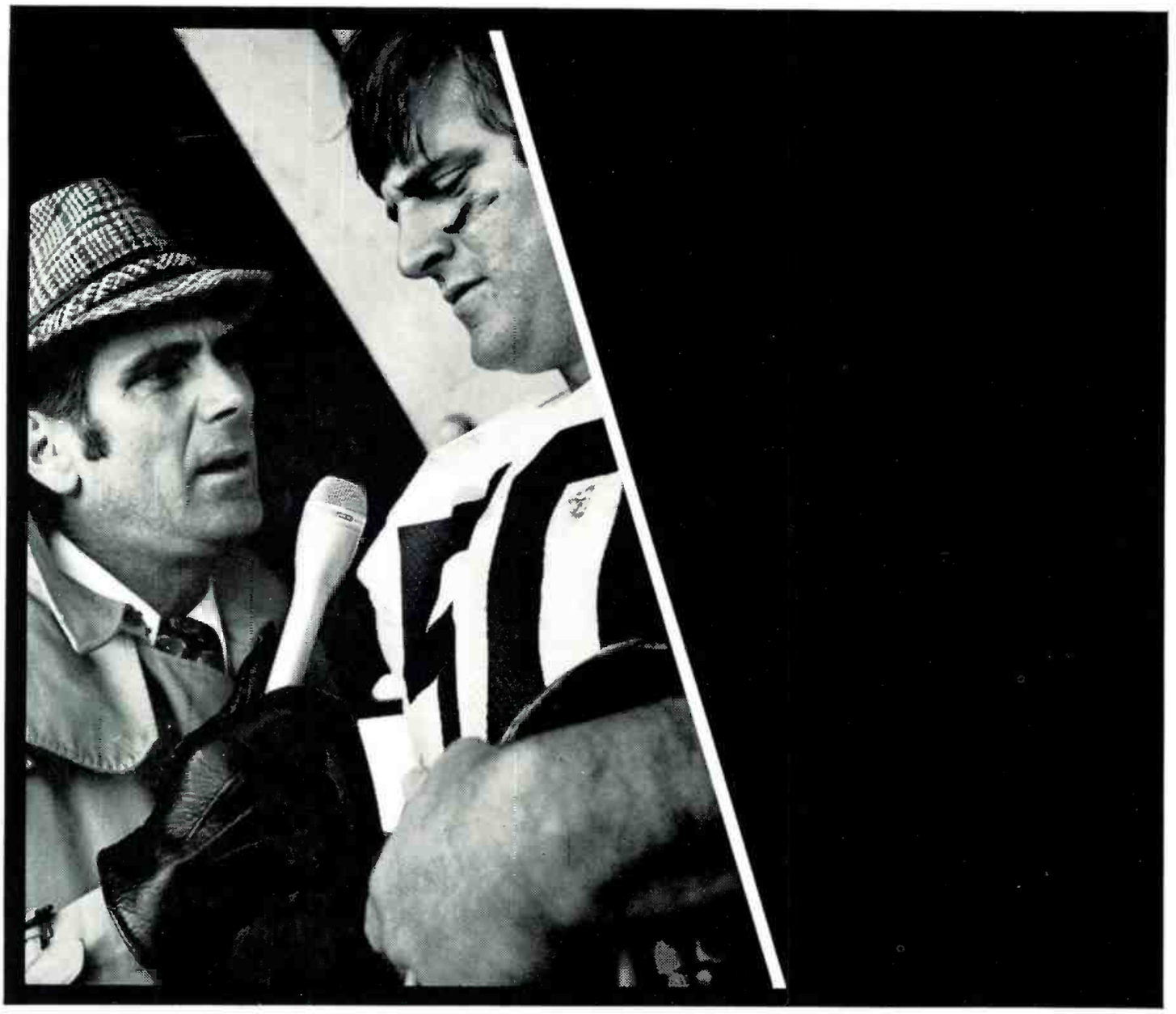
THE SOUND ENGINEERING MAGAZINE

NOVEMBER 1973 $1.00

TRANSFORMERS



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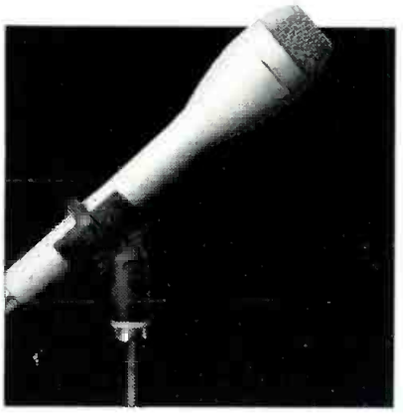

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COMING NEXT MONTH

● Robert E. Berglas appears in our pages for the first time with a description of a most interesting and useful product—to wit: AN FET AUDIO MIXER WITH LED GAIN LEVEL DISPLAY. This article will set you thinking on many aspects of your mixing chores.

Back in the September issue we promised an article on Caribou Ranch, that ultra successful studio seemingly buried in the wilds of the Colorado mountains. Associate editor John Woram did the original visit and has written the article with photographs he took and some more new ones taken by editor Larry Zide. You'll find out why a group such as Chicago has sought them out.

And there will be our usual contributors: Norman H. Crowhurst, Martin Dickstein, and John Woram. Coming in **db**, The Sound Engineering Magazine.

ABOUT THE COVER

● This is an issue on transformers, and once again we have given Bob Laurie our art director a free hand. Transformer-related articles begin on page 26.

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THE SOUND ENGINEERING MAGAZINE
NOVEMBER 1973 VOLUME 7, NUMBER 11

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

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John M. Woram

THE SYNC TRACK

● In the July issue, I rambled on about recording sessions that become exercises in technology, rather than musical experiences. I sometimes wonder what will happen when I stray into the music-versus-technology routine, since, as a "technologist" (whatever that is) I suppose I should be campaigning for more tracks, bigger consoles, and automated coffee breaks. Anyway, I'm glad to say that the mail reaction was quite favorable. Apparently there are a lot of studio engineers who have had similar misgivings.

To quote one letter; "It seems conductors and players have lost confidence in their ability to judge balances in a studio—perhaps because the musicians have so often been directed to play in un-naturally isolated groupings and/or with headsets on."

Ah, yes; the earphone syndrome! They're usually handed out as a matter of routine, with little or no thought of whether they're really needed. Lately, there are one-ear phones, to allow the musician to hear the live studio sound with at least one free ear. But what

advertisers index

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THE SOUND ENGINEERING MAGAZINE

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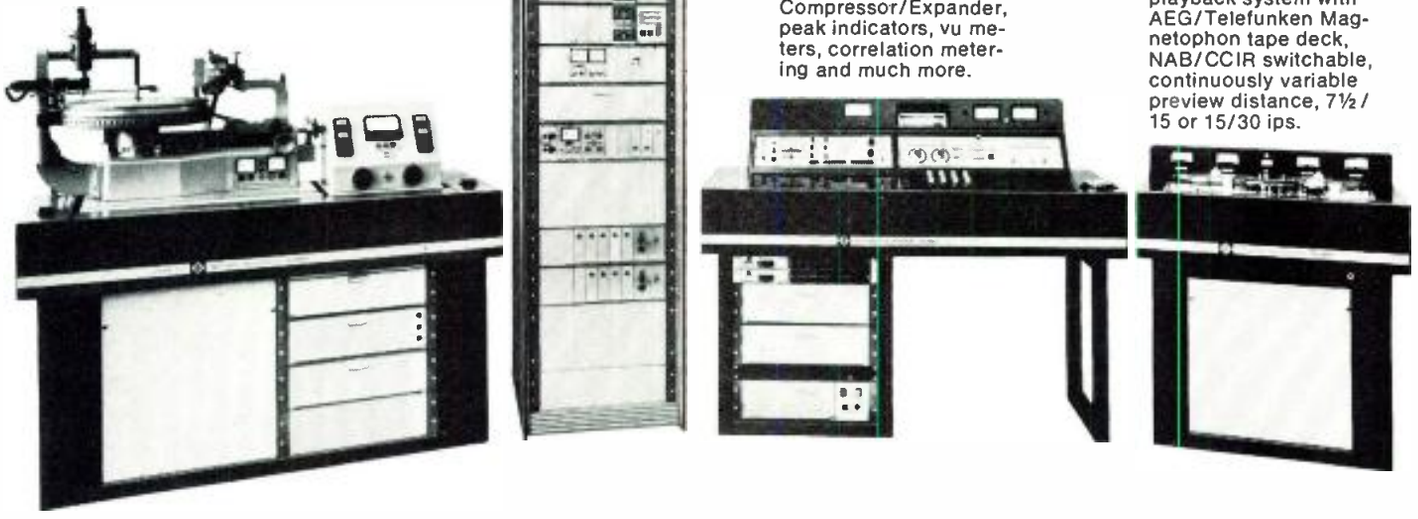

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about a no-ear phone? In other words, *leave the things on the shelf!* (It should be understood that I don't recommend trying this on a sweetening or overdub session.)

I was on a session some time ago that just wasn't going very well. The musicians were having a lot of trouble with the earphone balance. First there was too much keyboard, then not enough. Next it was the drums, later the bass was distorting, and on, and on. After a while, I was doing two sessions; one for the cue feed, another for the tape. Since I'm not very good at this, I eventually turned the cue feed off, explaining that it had burned out. I would send for another one, but in the meantime, may we try it without earphones?

Well, at first the electric guitar player complained he could not hear the acoustic. So, the acoustic was moved in a little closer, and the electric amp turned down a bit.

Now wasn't *that* a technological break-through! Each musician could hear the others, and balance himself accordingly. Needless to say, the session got a lot better very quickly. The musicians were able to function as musicians, and not as highly trained recording machines, firmly wired into place via the miracle of the headset.

Oversimplified? Perhaps, but the point is that good musicians play a lot better as artists than as technicians. Which—sort of—brings us around to a recent meeting of NARAS, the National Academy of Recording Arts and Sciences. The title of the meeting was, *Honest Music vs. Technology.*

The panelists, and audience, exchanged opinions on the proper role of technology. A few said that technology had gone too far, and they were distressed at the amount of tampering that goes into at least some modern recordings. Maybe its my paranoia surfacing again, but there seemed to be some present who thought that technology—all technology—was evil. Of course, what they really meant (I hope!) was that some of the modern "advances" were quite unnecessary, and that science must not intrude upon art.

I think that's about what I said in the July column, so perhaps we all agree. Or at least we do at meetings such as this. But what about at the next recording session, when the acoustic guitar is being drowned out by the brass? There are at least half a dozen ways to overcome the problem.

- Overdub the guitar, later.
- Shove the guitar into an isolation booth.
- Overdub the brass, later.
- Find out who wrote the chart, and fire him.
- Blame the engineer.
- Ask the musicians to make the necessary adjustments.

Chances are, the last listed item will not even occur to anyone, and if the engineer suggests it, he'll be suspected of copping out. As one letter put it, "Many producers assume the engineer who does not plant a forest of microphones before beginning every session is just too lazy."

No doubt there are some lazy engineers around, but when circumstances dictate it, a competent engineer should be able to set up, and control, a large number of microphones, and whatever else is needed to satisfy the requirements of the session. But when some other—more artistic—solution would be more to the point, then the engineer should expect the others involved to do their part too.

So much for this aspect of technology. On another front, both NARAS and the AES had recent meetings on quad. This time, the NARAS meeting was in Chicago, at Sound Market Studios. Jim Cunningham and I were the speakers, and the audience came loaded with questions about the various contending systems, and about quad itself. Most if not all the audience were in-

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dbx new RM 157 tape noise reduction system provides four channels of simultaneous record and playback with 30 dB more noise reduction than competitive professional systems, yet is priced only slightly above the better consumer noise reduction systems.

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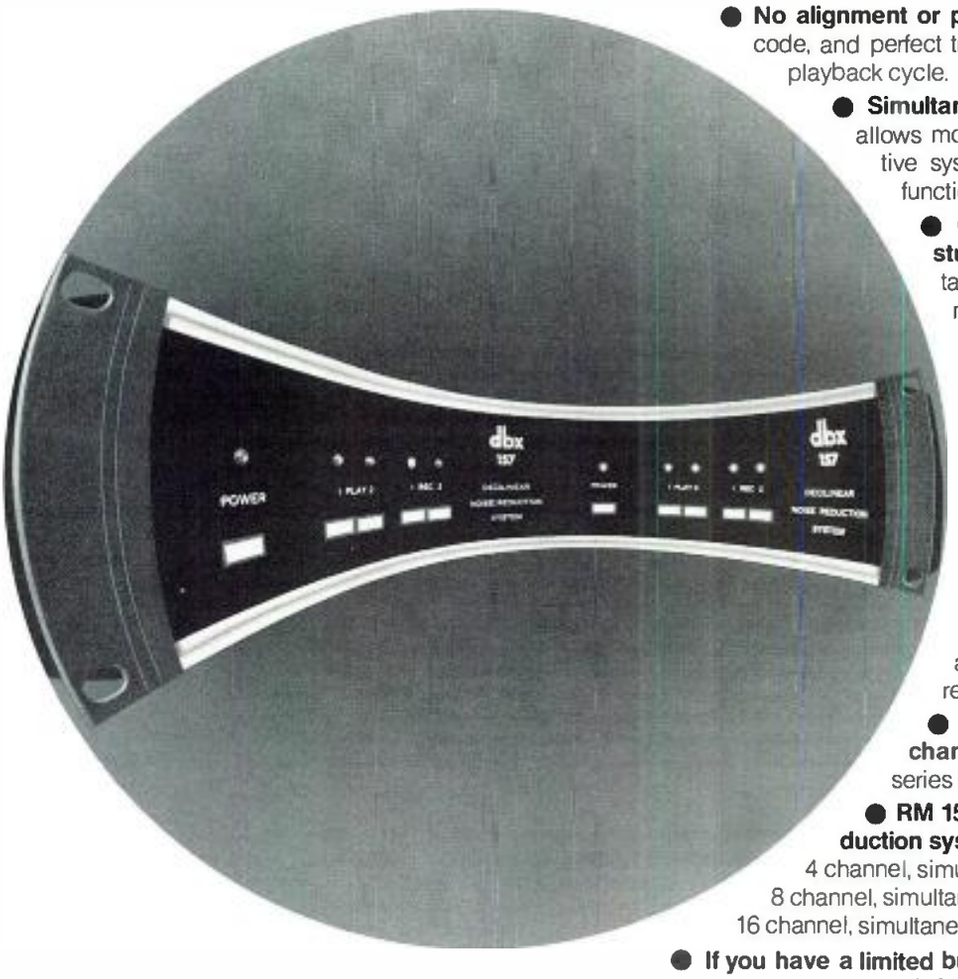
- **No alignment or pilot tones are necessary** for accurate code/decode, and perfect transient tracking through the complete record and playback cycle.
- **Simultaneous record and playback on each channel** allows monitoring off tape during recording. (Most competitive systems do not perform both record and playback functions simultaneously.)
- **Complete compatibility with dbx professional studio noise reduction systems** assures that master tapes made with the RM 157 can be played back, mixed down or further processed at any of the many studios now using dbx noise reduction.
- **Freedom from coloration of the sound** permits ping-pong or sound-on-sound recording through several generations without audible deterioration.
- **RM 157 is convenient to use for remote recording** as it occupies only 3½" of rack space, weighs 15 pounds and consumes only 10 watts of line power. Inputs and outputs are single-ended and terminated with RCA type phone jacks for ease of connection to semi-professional preamp/mixers and recorders. No pilot tones for level matching are required; just plug it in and record.
- **Expansion of system capability to 8, 16 or 24 channels** can be accomplished within the same model series by adding more RM 157 four-channel units.
- **RM 157 simultaneous record and playback noise reduction system prices are:**

4 channel, simultaneous record and playback (shown)	$1,100.00
8 channel, simultaneous record and playback	2,200.00
16 channel, simultaneous record and playback	4,400.00

- **If you have a limited budget,** switchable record OR playback models 152 and 154 in this series start at $161.00 per channel.

dbx professional tape noise reduction systems for all types of recording applications are available from professional audio dealers or the factory. For full product information and list of local dealers, contact:



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dustry members, yet there was still a lot of uncertainty about technical details. Imagine the confusion the general public must be experiencing!

The November meeting of the New York section of the Audio Engineering Society was on the subject of quad mixing. Panelist Tom Dowd neatly explained the mono—stereo—quad progression in terms of a file of Indians; musical Indians at that! In the mono days, the Indians were in a single file, one behind the other, with solo Indian in front of course. Enter stereo, and the Indians arranged themselves from side-to-side, still in single file, and with the soloist in the middle. And now, with quad, the tribe is at last able to break ranks and stand wherever they please. Of course there are certain spots that are still taboo, and any Indian standing on one of them will be instantly swallowed up by that old meanie, mono. But, as so many technical papers have instructed us, anyone who would stand in a forbidden area (center rear, for example) must be some kind of wierdo anyway.

Getting back to the meeting, there was some discussion on the amount of tailoring required to prepare a quad mix that would be playable in mono. Each panelist had his own methods for coping with the 4:1 problem; however I remain distressed by the attention given to this common denominator. I can't help recalling those old Westminster Lab records. The accompanying booklet said that, "For technical reasons, this record is pressed at a lower volume than most recordings. Please adjust volume control accordingly." The booklet then went on to say that the record would also probably sound a lot better on a top-quality system. If memory serves, the discs cost more than the standard product of the day, and contained not much more than half the amount of music found on other discs The idea was to present the best quality that the state-of-the-art could deliver. Of course there were no compatibility problems, since it was pretty much a mono world at the time.

I wonder what would happen if some of this philosophy were applied to quad? What about mixing down from sixteen directly to an encoded two track tape, while monitoring in the decoded mode? And the hell with what it sounds like in mono. This is the kind of thinking that drives marketing people bananas, since everyone knows that the great masses demand mediocrity. (If you don't believe that, take another look at your car.) But still, wouldn't it be fun if someone would put out quad records designed for the person who has just spent a lot of money on a quad system, rather than for the person who has not bought a quad system? But I guess that's being illogical.

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All models have complete internal protection. IM distortion is better than 0.05% from 0.01 watt to full power. All units mount in a 19-inch rack. Three year warranties cover parts, labor and round-trip shipping.

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All models are designed to work 18 hours a day, 7 days a week for 10 years with three head replacements. Modular construction and plug-in circuit boards mean fast, easy field servicing. These precision instruments will make clean, accurate recordings years after the economical semi-pro decks are retired. All models handle ¼-inch tape and 7-inch and 10½-inch reels. All mount in 19-inch racks. Standard speeds are 15, 7½ and 3¾ ips. There are individual record, erase and play heads for 1 to 4 channels. Over 40 standard models are available with numerous professional accessories.

CX822 Mastering Recorder
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integral mixing facility simplifies setup ■ same tape transport system and meter monitoring as CX822 ■ two mic or line inputs per channel

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SOME FUTURE MEETINGS

In New York City NARAS
Scoring for the Film
December 6th at 6 pm
Reeves Sound
304 East 44th St.

In Boston

The Boston section of the Audio Engineering Society has begun holding regular meetings. Boston members of the AES will automatically receive meeting notices. If you live in the Boston area and are not yet a member, drop the acting secretary of the Boston section a note, and you will be placed on the mailing list. The address is:

Dave Chanda
14 Greenview Street
Apt. 5
Framingham, Mass. 01701

In Europe

The 47th convention of the AES is scheduled for March 26-29, 1974 at the Hotel Scandinavia, Copenhagen. Anyone interested in a charter flight to Copenhagen should drop a note to the Editor, **db** Magazine. If there is sufficient response, a round trip from New York will be organized. ■

OVATION/SANSUI EMBARK ON MAJOR PROMOTION CAMPAIGN

Glenview, Ill. — Dick Schory, President of Ovation Records, and Hiroshi Tada, Executive Vice President and General Manager of Sansui Electronics Corporation, have announced plans for a major national multi-media promotion and advertising campaign to get underway this fall.

Across the country thousands of dealers will be involved in a massive educational program, telling the public what is special about Sansui's QS. They will explain that only records encoded in QS have the capacity to give you sound sources from any area within a 360° sound field and that receivers with vario matrix offer more realistic 4-channel than any other decoding system.

The exciting campaign will feature a cooperative effort on the part of Ovation Records and Sansui in terms of national advertising with Ovation artists and Sansui 4-channel receivers and amplifiers. The entire Ovation and Black Jazz catalog which includes such artists as Bonnie Koloc, Heaven & Earth, and Willie Dixon, is recorded with the QS encoder. Ovation is the only record manufacturer exclusively producing 4-channel discs.

Other aspects of the campaign will feature dealer 4-channel clinics and seminars, promotions with banners and demonstrations of 4-channel showing 2-channel and mono compatibility. In-store demonstrations will be supported by attractive posters both of the Ovation artists and new posters created especially for Sansui's 4-channel campaign. Buttons will also form an integral part of this ambitious marketing concept.

MAJOR AUDIO CRITICS HAIL QS VARIO MATRIX

New York, N.Y. — Comments from the audio press have been enthusiastic about Sansui's vario matrix circuitry. Noted critic Bert Whyte describes his auditioning the QS system in the August, 1972, issue of *Audio* Magazine this way:

"A discrete quadraphonic tape was played for us, and then A/B-ed with a disc cut with the Sansui QS encoder and decoded through a new type decoder. The results were startling. With both pop and classical selections, there was very little apparent difference between the tape and the disc. Localization and separation were very accurate and stable. Ambient material was as effectively reproduced as 'surround stereo.' There seemed to be little of the diffuse 'amorphous' feeling typical of much matrixed quad sound. . . . it must be reckoned as a matrix system with great potential . . ."

International acclaim has also been accorded the QS vario matrix. Britain's famed *Hi Fi News* described its impression this way in its May, 1972, issue:

"Undoubtedly the most convincing and interesting demonstration was the Sansui, who had arranged comparison between QS Mark II [vario matrix] and QS using special recording. . . . The QS II [vario matrix] system seemed effective; unanomolous discrete rear images, somewhat spreadened but definitely behind, were consistently detected."

Julian Hirsch, director of the famed Hirsch-Houck labs, in his September, 1973 Popular *Electronics* article on QS vario matrix, said:

"Having listened to a demonstration of the system in operation both at the Audio Engineering Society, N.Y. convention and elsewhere, we can testify that the Sansui QS Vario Matrix appears to provide a fully 'discrete' sound character, with no evidence of the side effects sometimes experienced with gain-controlled matrices."

And *Billboard* magazine's Claude Hall was quoted in June, 1973's *BM/E* as saying:

"SQ with logic is 500 times better than stereo and the QS with vario matrix is 700 times better than stereo."

VOX BOXES GO QS MATRIX

New York, N.Y. — Vox Productions has joined the growing list of record manufacturers producing discs encoded in QS. The company is set to release a famous Vox Box of The Complete Chopin Music for Piano and Orchestra performed by the Utah Symphony under Maurice Abravanel; the set will carry Vox catalog number SVB 5126.

According to a company spokesman, several dozen other new albums in QS are scheduled for release over the next six months. One of the most anticipated is likely to be the Complete Tchaikowsky Symphonies. Vox has joined over 30 other companies around the world, including 18 in the United States, who utilize Sansui's QS matrix to produce records with the greatest creative freedom for the artist and recording engineer and that can be enjoyed by more home listeners than any other 4-channel system.

Other manufacturers producing QS encoded discs include: ABC/Dunhill, A&M, Audio Lab, Audio Treasury, Barclay, BASF, Black Jazz, Bluesway, Blue Thumb, Canyon, Command/ABC, Crown, French Decca, Impulse/ABC, Jockey, Kilmarnock, King, Longines Symphonette Society, Minoruphone, Ode, Ovation, Project 3, Pye, Quad Spectrum, RTV/ERA, Teichiku, Telecast Marketing, Toho, Tokuma-Onko, Tumbleweed, and Toshiba-EMI.

QS Regular Matrix (RM)

First in Hardware
First in Software

New York, N.Y. — The QS/RM 4-channel matrix can be found on more pieces of high fidelity equipment than any other 4-channel system. Over 58 manufacturers are now making more than 242 models with QS or RM decoding positions.

To match the hardware story, QS has surpassed all other 4-channel systems in record production as well. Over 30 companies around the world have produced over 496 albums in QS. That includes over 166 records manufactured by 18 companies in the United States. U.S. artists represented by these companies include such names as Carole King, Joan Baez, B. B. King, Bonnie Koloc, SunRa, Willie Dixon, Beverly Sills, Gato Barbieri, Enoch Light, Dick Hyman, Pharoah Sanders, John Coltrane, Count Basie, Tony Mottola and 101 Strings. More and more manufacturers are using the QS matrix because of its unique engineering freedom and the fact that more consumers can buy more equipment capable of decoding QS Regular Matrix.

KLOS GOES QUAD

Los Angeles, Calif. — KLOS-FM, ABC's top rated station in Southern California and a national leader in the 18-34 market, has just completed its first series of regularly scheduled 4-channel broadcasts.

The 13 week series sponsored jointly by Pacific Stereo and Sansui Electronics Corporation has impact far beyond the high expectations of the sponsors or the producers. The impact was so great that a second 13 week series is planned starting in the next few weeks.

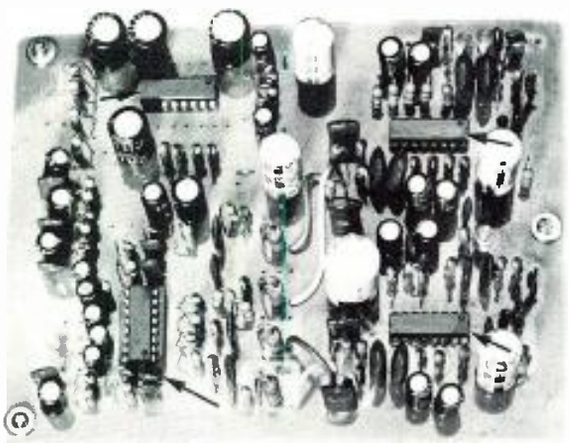
KLOS used a QS encoder and ran all their programming for the quadraphonic segment through the encoder. This included all types of tapes and discs. The listener at home with a mono set received the FM signal with no change and no dilution of quality, while the FM stereo listener actually got a program with an enhanced stereo effect and the listener with a QS or other decoder, had FM 4-channel sound with all its nuances and subtleties brought into his listening room.

Response to the series was enthusiastic. KLOS reported phone calls and letters requesting information on 4-channel and 4-channel broadcast, while local audio dealers reported a noticeable increase in traffic through their stores and specific increase in interest in 4-channel products by all manufacturers.

WSHE in Miami, Florida, the leading rock station in the Miami-Ft. Lauderdale area, has just purchased a QS encoder and plans to go 24-hour Quad by mid-November. "We believe 4-channel is the most exciting broadcast development in many years and the wave of the future," commented WSHE's owner, Gene Milner. "We're looking forward to being the first in our market with it."

SANSUI INTRODUCES IC CHIP QS VARIO MATRIX 4-CHANNEL DECODER

Woodside, N.Y. — Sansui Electronics Corporation has announced a major breakthrough in 4-channel audio technology. After years of experimentation and development, the Sansui QS vario matrix decoder has been reduced to three different IC chips. Two of the three chips are currently in production and available, while the final chip will be available in quantity by early February, 1974. The IC chips will be manufactured in Tokyo by Hitachi.



Sansui is aggressively pursuing a two-stage licensing policy of the chips and vario matrix decoder. Step one is giving chips, information and technical assistance to any audio manufacturer requesting them. This is intended to aid the industry in experimentation with what Sansui believes to be the greatest single advance in 4-channel technology since the introduction of the QS matrix itself in 1970. Step two is licensing of commercial production of QS vario matrix decoders.

The IC chip version of the vario matrix decoder is a huge stride for a number of reasons. The concept of IC's provides tremendous economy in terms of simple component costs, but also in adjustment and "tuning" costs. Conventional discrete component decoders had to be adjusted for maximum performance, the current IC chip QS vario matrix is set to operate at peak performance from the time of manufacture.

Economy is one major aspect of the new IC units. "Universality" is the second major area of importance. With the proliferation of several matrix systems, there has not been one decoder that could adequately handle more than one system. The new IC chip QS vario matrix can and does. It provides a full 20dB separation in the QS mode and excellent separation on all SQ records.

Another exciting aspect of the new vario matrix technology is the synthesizer. Previously, so-called synthesizers added ambient sound available on most conventional stereo records, to the rear channels and "created" a 4-channel effect. With the new IC chip vario matrix decoder, a 2-channel signal is fed through its own encoding process and then decoded. The resulting signal is a "surround" effect with real directionality on three sides. Music is no longer just enhanced, instruments are spread around a panorama, but appear to be fixed and have position and direction. Since a majority of record collections are still primarily stereo, and since many 2-channel discs will never be released in 4-channel, the new development adds a new dimension to 4-channel, rather than being just a large technical leap.

With the new IC chips plus associated discrete components, a manufacturer can build a Universal decoder and synthesizer for less than $12, which means that a decoder could be available to the consumer at a price anyone interested in 4-channel can certainly afford.

Since Sansui incorporated the vario matrix in its QRX receiver line in January, 1973, sales have risen dramatically and consumer response has been overwhelming.

Martin Dickstein

SOUND WITH IMAGES

VidExpo '73 and AES

● With all the conventions that have been taking place in the last few months and those still to come, it might be well for us to start each coverage with a brief description of the sponsors to avoid confusion for those who might not be familiar with some of the organizations.

First, from September 4 to 6, at the Plaza Hotel in New York City, *Billboard Publications* sponsored **VidExpo '73.** Among the publications that sponsored this convention and exhibit were *Billboard*, the international news-weekly on music-records-tape-video; *Merchandising Week*, the home electronics industry news-weekly; *Videnews*, the biweekly video newsletter; *High Fidelity*, the monthly hi-fi magazine; and *Photo Weekly*, the photo industry's only weekly business paper.

In conjunction with VidExpo '73, the International Industrial Television Association had a meeting of the North Atlantic Region on the topic, *Management of the In-House Television Production System.* It took place on September 4 and covered subjects of great interest to the more than seventy users, specialists, and interested visitors who are involved with use and application of video equipment and services in government, industry, and educational facilities. The people then gathered in small groups to discuss, with experts, subjects of mutual interest such as video in training and information, cost effectiveness, and budgeting.

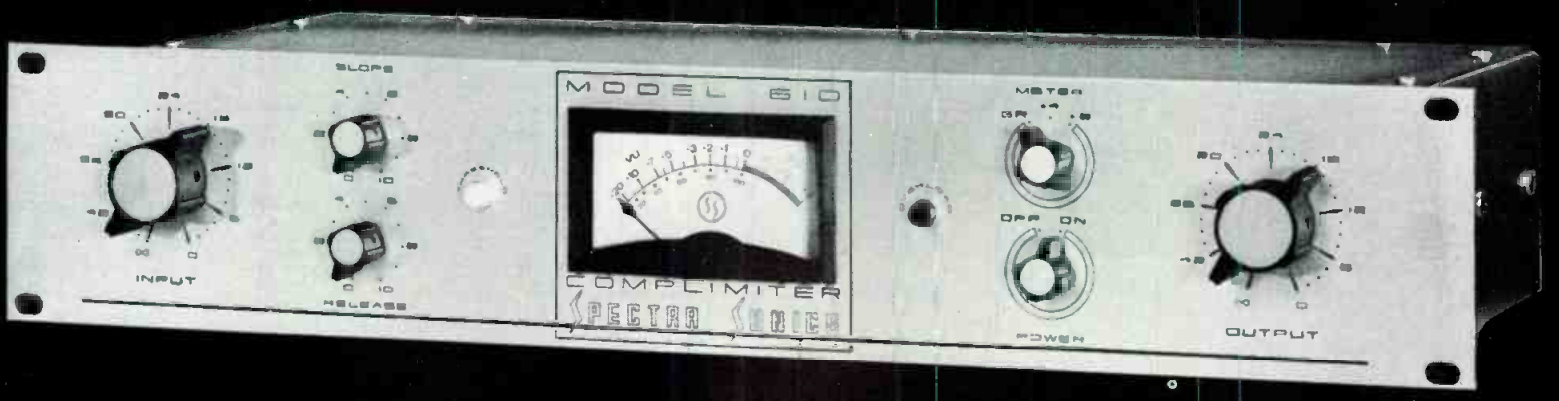
At the VidExpo '73 convention itself, nearly 2,000 visitors were offered a series of talk-and-discussion sessions beginning with *How Management Is Using Video Networks To Improve Communications.* The moderator of the session, Mr. Warren Wille, Information Services Manager of Dana Corp., told about his company's retrieval system, which distributes the latest information from a variety of input sources to as many as twenty-five individual locations, throughout offices and conference rooms at company headquarters. Inputs include slides, graphics, video tape, live camera pickups, character generator information, magnetic video discs and tapes, and a computer memory. Similar installations have also been made at three other locations.

In the insurance field, the session was told by a representative of the Insurance Company of America, that they started with 65 ½ inch EIAJ machines (reel-to-reel) and are now using 1 inch facilities and ¾ inch Umatic machines. Marketing information and employee news is distributed in offices in both this country and Canada.

The other two speakers at this meeting, one from IBM and one from the Chase Manhattan Bank, told of how their respective companies make use of video. IBM now has well over 600 ¾ U machines in field locations, headquarters, and various division labs and plants. Salesmen, executives, and employees are all informed by t.v. At the bank, video is used to inform employees and banking and security groups elsewhere in similar

Figure 1. This is the origination studio of Trans-World Communications. Each of the seven cities in which the company operates has an identical control point which transmits current motion pictures to all the hotels hooked to the system. The "mini-computor" in the foreground transmits the selected features to the guest's room within 33 milliseconds of receiving the order.

NUMBER!



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PERFORMANCE: The SPECTRA SONICS Model 610 "COMPLIMITER"™ can accomplish, independently or simultaneously, limiting and compression functions with performance that is unequalled by most *linear amplifiers*. The minimal noise inherent in this system assures a low threshold of -40dBM and permits an input sensitivity substantially greater than other systems. Through the use of the most advanced circuitry, the Model 610 "COMPLIMITER"™ has the fastest attack time (100 nanoseconds to 2 microseconds). The "COMPLIMITER"™ allows undistorted recording and transmission at levels that are measurably higher than those commonly in use. In tape recording, for example, this "limiting only" mode eliminates approximately 6dB usually set aside for tape overload protection.

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Other sessions discussed the subjects of *How Business is Using Video to Improve Employee Performance, An Up-to-the-Minute Look at Many Ways Government Agencies are Utilizing Video,* and *Education—Does the "Entertainment" Concept Really Work?*. In the other two conferences, topics under scrutiny included *Specialty Applications in Advertising, Medicine, Hotel Pay/Free T.V., and Cable T.V.* and *Home Entertainment —What Does the Consumer Really Want?*

At the Specialty session, Dr. H. J. Barnum, of the J. Walter Thompson Advertising Agency, spoke of his company's branching out into the medical field and producing software for the continued education of practicing physicians. More than 150 doctors are involved in this country and overseas in the preparation of material to be recorded and distributed to members of the American Academy of Practicing Physicians. The agency's function is in the production of the software and making masters which can be reproduced in any medium. The present plan is to produce 48 modules, each consisting of a video tape, accompanying text, and demonstration kit, available for a small monthly fee to the subscribing physicians. The ultimate purpose is to raise the standard of knowledge in physicians. Incidentally, the cost of the project's production will be covered by advertising in the cassette, text, and demo kits of the package.

Dr. George Rowland, Chairman of the Commission on Education of the American Academy, then explained that the organization was founded in 1947 to keep family doctors up to date and that physicians are required to pass National Board exams every six years in order to specialize. All members are also required to spend 150 hours in three years for reeducation. For the package he will receive, the physician may need a cassette player, a film or slide projector; these could either be owned or rented by the doctor. Dr. Rowland said that there were 35,000 members of the Academy and that over 100,000 physicians receive the organization's magazine. Question and answer periods followed.

Figure 2. General Electric's large screen television projector created images visible to large groups of visitors who wished to see the best of the in-house productions presented at the VidExpo 73 conference.

Before we discuss the exhibits, or at least some of them, let's mention that the excerpts taken from the talks and discussions of some of the meetings were selected only to provide a sample of what took place and not to compare or show preference in any way. The same is true of the choices of exhibits and equipment mentioned.

$1890

You pay for what you need

If you're seriously into music or sound reinforcement you want more than hi-fi products can give you. But full professional studio gear costs an arm and a leg, and you pay for a lot of things you may not really need.

That's why there's a TASCAM Model 10. It's an 8-in, 4-out mixing console, and it's just $1890.

With the Model 10 you get what you have to have. Without sacrificing a single necessary function.

Each input module gives you mic and line attenuation, three bands of peak and dip equalization (two with frequency selection), pre- and post-echo send and receive circuitry, pan function, and a unique straight-line fader.

Each of the four submasters has a meter control switch (line/echo), independent monitor level control, echo receive level control, and a straight-line fader. You also get a master gain module and 4″ VU meters with LED peak indicators. Plus pre-wired facilities for up to four additional input modules and other optional accessories including talkback, remote transport control, quad panner, and headphone monitor.

That's what you need and that's what you pay for. Some things, however, you may or may not need, and we leave that choice up to you. For instance, the basic Model 10 is high impedance in and out, but studio line impedances are available optionally. You'll probably want low impedance mic inputs, but you may not need all low impedance line inputs. So we don't make you pay for them. You can order any combination of high and low input/output impedances according to your application.

Details and specs on the Model 10 are available for the asking. At the same time we'll tell you about our new Series 70 Recorder/reproducers.

We've got what you need.

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Circle 24 on Reader Service Card

Circle 21 on Reader Service Card

Circle 32 on Reader Service Card

Figure 3. This control unit, offered by Audiotechniques and shown at AES provides special effects lighting, has front panel fuses, on-off switches, individual and group controls, and volume-like sliders for separate intensity control of each circuit.

Since it is not possible to mention all of them, only some will be mentioned, and some representative equipment will be described.

Among the exhibitors of hardware, there were Image Communications/Norelco showing the vcr with various features such as electronic editing, remote control, and frame lock; JVC, with several models of ¾ inch and ½ inch video machines, color cameras, and monitors; Martin Audio, showing Sony video equipment; Panasonic exhibiting its full line of video equipment, including both ¾ U and ½ inch recorders; King Instrument Corp. showed an automatic video cassette loading unit, an 8-track splicer, and an 8-track winder, and a computer cassette loader; and Sharp Electronics showed its complete video system using a ½ inch EIAJ compatible video cartridge recorder.

Hitachi demonstrated its Magnetic Disc memory device which can record and reproduce up to fifteen individual still pictures from any source, including a camera, vtr or t.v. receiver. Fifteen magnetic heads are used and images can be recorded in sequence, or at any time interval, which can be set from 0.1 seconds to 225 seconds. The playback time can also be set to any speed from 0.2 secs. to 64.5 secs. The disc can be stored for future playback or shown on a standard t.v. set and then reused. The horizontal resolution of the system is given as more than 350 lines in B/W and better than 250 lines in color. Synchronization is possible with an outside audio source if desired, and the unit will automatically record or playback continuously, if preset in this manner, or will provide a still image on any of the fifteen recorded pictures. The disc is 100 mm. in diameter and rotates at a speed of 3600 rpm.

One part of the session featured a playback of selected in-house productions from various industrial and educational sources. For the registrants, this feed was available at the conference on a large screen or in their

hotel rooms through a setup provided by Trans-World Communications, a division of Columbia Pictures Industries. Trans-World has, since 1968, provided closed circuit entertainment and communications services to hotels in the U.S., Canada, and the U.K., and is now installed in more than 30,000 hotel rooms. Televention services are also provided to large conventions, and Tele/Theater services are available (for a fee) to provide three channels of entertainment in color, including motion pictures, live sporting events, and special affairs.

At the conference itself, visitors could see the same program material as that fed to the hotel rooms on a large screen. The image was projected by a G.E. large screen t.v. projector utilizing a new single electron gun and single optical axis light valve. This system eliminates convergence and registration problems usually found in most 2- or 3-gun systems. The unit consists of a projection head assembly with pan and tilt adjustment on a control and electronics pedestal. The head contains a sealed beam Xenon lamp as the source, the sealed light valve, and the projection lens. Images up to 20 feet in width are possible and can be used either for front or rear screen operation.

The week after the VidExpo conference and exhibit took place, the Audio Engineering Society had its convention. Most of our readers are familiar with this organization; the sessions and exhibits are covered in these pages. However, at this session, there were several additional items that might be of interest from a visual standpoint.

At the exhibit, which ran from September 10-13 at the Waldorf Astoria Hotel in N.Y.C., Audiotechniques, Inc. of Stamford, Conn. displayed two items of a visual nature. One was a Lightmaster made by Zero 88, in London, England. This unit is a lighting effects synthesizer and control unit which, through plug-in modules and front-panel controls, can provide sequence flashing, random flashing, ten variations of flowing light, and can convert sound to activate the connected lights. The other device is called a Dream Screen. Music, or any other sound, is converted to changing light patterns which vary in shape, intensity, and color. A control box, through which the sound is fed and converted, allows for presetting or changing any of the variables. The unit can also operate by itself without any audio input at all. At present, screens come in three sizes—6′ x 4′, 4′ x 3′, and 3′ x 2′.

The other visual effects were created at a special meeting which took place in the evening of September 11. Under the heading *Look What they've Done to My Song, Ma!*, the AES offered a look at the past, present, and future of recording and displayed equipment from the Edison era to the modern multi-track tape recorder. Aural effects were pre-recorded; one such was a 16-track musical selection written specially for the meeting and recorded on a synthesizer by Walter Sear. Along with the sound from the sixteen speakers set up around the room, two special projectors were set up at the rear of the room to illuminate the ceiling and the walls of the room while the music was playing. The effects from one unit resembled the more common oil-and-water-overhead projector combination but with much more interesting and varied effects. The other provided changing light and moving shapes which were mixed with the effects from the first unit. The projectors are called Meteor Majors and are available through Meteor Lighting in Syosset, N.Y. The units come with various attachments which can be fastened to the front of the projector without the use of any special tools. The latter effect was created by the Rotating Cassette attachment, and the former by their Liquisplode unit which consists of a small

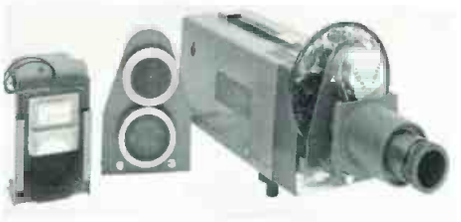


Figure 4. This special effects projector was used at the AES Convention for the highly successful production of "Look What They've Done to my Song, Ma!". The attachments provide differing effects.

tank with separate compartments for the two liquids, agitated by a tiny pump.

Before closing this coverage, let us remind you of the upcoming conventions for which we can only ask you to remain tuned. We hope you can attend some of these if only to meet old and new friends whom you may not have seen or heard from recently, or since last year at the same convention. We met many friends at each convention, like Joel Tall after whom the Edi-Tall block for tape editing is named, John Woram and Larry Zide who each had an important part to play at the special meeting of the AES Convention we talked about, and many more. You might even meet old and new business contacts, which is what conventions are all about!

Obviously, this preview can cover only a very small smattering of all the hard- and software that can be seen or information that can be acquired at these conventions. We hope that, at the very least, we whet your appetite for more details on subjects, opinions, and equipment. For example, we hope you will be able to attend the **Day of Visuals,** sponsored by Audio/Visual Communications and the National Visual Communications Association. This one day session on November 29 will take place at the Roosevelt Hotel in New York City and is designed for all who are involved in any way at all with audio/visuals. The morning sessions will provide an overview of the a/v field, with novel uses for various a/v techniques, a pair of talks on *New Imagery Technology,* including the video cassette and the latest on new video transmission systems. The afternoon will be divided into two meetings, each in three sections. One session will be on *A/V Managing* and the other on *Creating the Presentation.* Then there will be a final joint meeting to close the conference. Every moment will be productive; even the luncheon will feature a talk by the producer of the film, *Let the Good Times Roll,* including tips on film editing, sound techniques, and illustrative film clips.■

Picture Gallery—43rd AES Convention

ONCE AGAIN, it is time to show what our camera saw as it travelled an AES Convention. This one took place on September 10 to September 14 at New York's Waldorf-Astoria Hotel. Each new show seems bigger and better and more well run than the one that came before.

This picture gallery presents as many views as space permits us to show. This is by no means all that there was to see. If you want information on the products shown send in the number indicated with a circle around it—on the card to be found at the back of this issue. Information will be sent you directly from the manufacturers.

VIEWS AROUND THE SHOW

The grandson of 36 grand from Audiotronics is a compact 18 in, 4 out console design. Circle 59 on Reader Service Card.

Modestly budgeted radio stations will want to know more about the CCA packages. Circle 67 on Reader Service Card.

Fairchild Sound demonstrated this broadcast console for t.v., custom built for KLFY-TV. Circle 53 on Reader Service Card.

Full quad mixdown is only one of the features of Spectra-Sonics 24 in, 24 out console. Circle 62 on Reader Service Card.

It was a rare moment indeed when we were able to get an unobstructed view of the Neve console. Circle 72 on Reader Service Card.

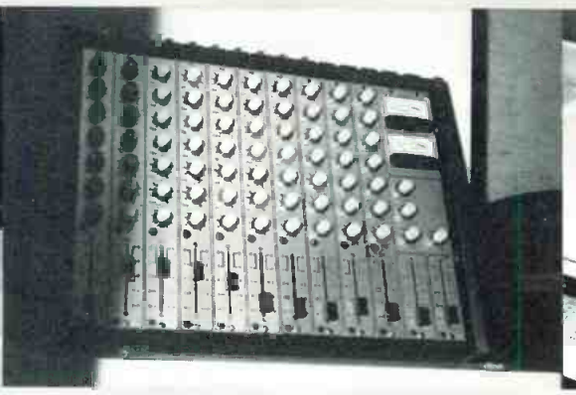
Mom's Wholesome Audio is the name given to Gately distributed p.a. mixers. Circle 78 on Reader Service Card.

At the MCI booth, their big board was constantly being demonstrated. Circle 70 on Reader Service Card.

Among the best looking consoles at the show was this RCA BC-100 series unit. Circle 77 on Reader Service Card.

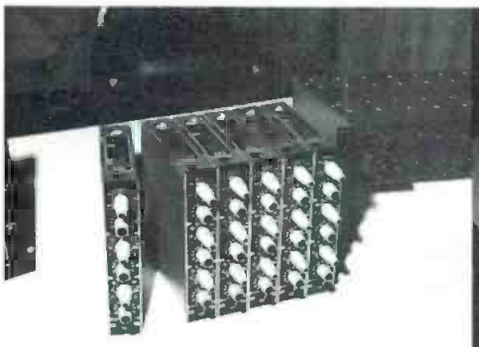
Sescom offers a range of microphone splitters and combiners to the industry. Circle 50 on Reader Service Card.

These various components combine to create the Automated Processes memory mixdown system. Circle 71 on Reader Service Card.

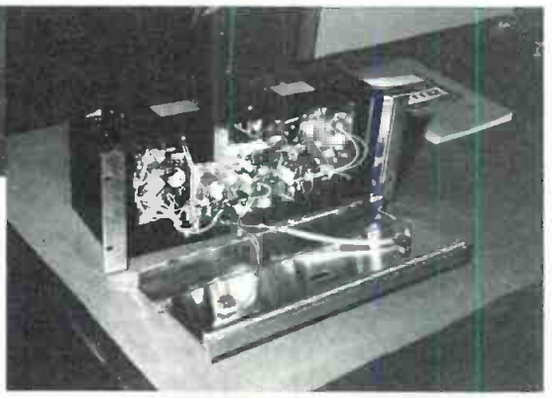


This Allen and Heath 6 in, 2 out portable mixer was demonstrated by Auditechniques. Circle 56 on Reader Service Card.

Noise reduction at reduced per channel cost is provided by the dbx 157, shown as two units. Circle 58 on Reader Service Card.



These small modules incorporate the ITI Paramatrix equalizing system for console installation. Circle 65 on Reader Service Card.

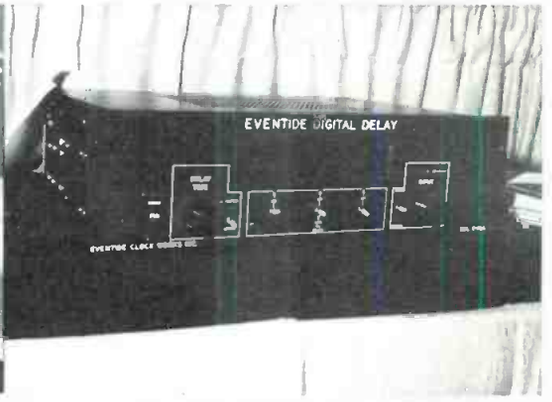


With the front panel dropped, the Crown DC-300A amplifier shows its innards. Circle 60 on Reader Service Card.

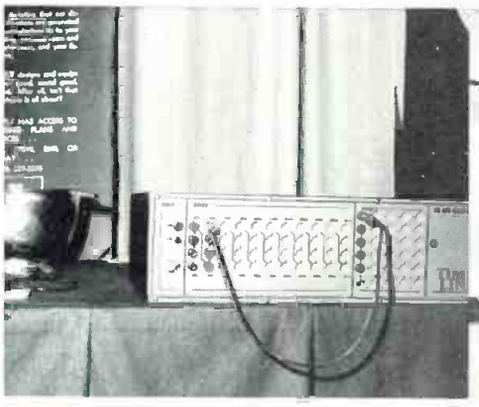
The sign on Allison Reasearch/ Automated Processes' "memories little helper" says it all. Circle 66 on Reader Service Card.

Shure Brothers offer this portable gated compressor for recording and broadcast use. Circle 73 on Reader Service Card.

The Dolby 364-E2 film equalizer and noise reduction unit is for optical tracks. Circle 68 on Reader Service Card.

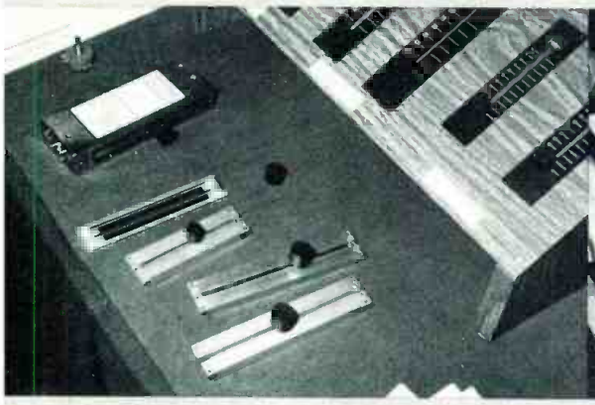


Eventide Clockworks' digital delay line is now available in a less expensive version. Circle 57 on Reader Service Card.



The Pandora Timeline can supply a wide range of delay times via card additions. Circle 69 on Reader Service Card.

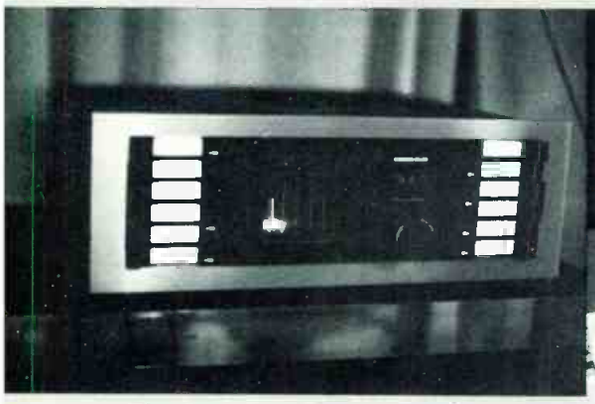
UREI's electronic crossovers permit you to create your own monitor speaker systems. Circle 61 on Reader Service Card.



Almost any configuration can be used with the proper Waters fader control. Circle 74 on Reader Service Card.

This ultra-sophisticated operating deck for 2-inch tape is made by Exedit. Circle 64 on Reader Service Card.

We've shown this big Stephens before, but now you can have all forty tracks of it in a portable. Circle 51 on Reader Service Card.



The Sequerra tuner was being demonstrated as the ne-plus-ultra f.m. receiver. Circle 76 on Reader Service Card.

Ferrograph came up with a new machine featuring 10½ inch reel capacity and Dolby-B. Circle 75 on Reader Service Card.

The newest version of the Scully recorder is offered in several formats including ½ inch, four track. Circle 54 on Reader Service Card.

Pentagon makes this cartridge loader as an accessory to its line of duplicators. Circle 63 on Reader Service Card.

A surprise of the show was captured by ReVox with this new semi-pro ¼-inch machine. Circle 55 on Reader Service Card.

These ultra compliance drivers give the Bose 800 its particularly uncolored sound character. Circle 52 on Reader Service Card.

There will be more new products as seen at the AES Convention in the December issue.

Norman H. Crowhurst

THEORY AND PRACTICE

● Over the years, my correspondence has brought me many examples showing the contraposition of credibility and authority. The curious thing is that many people mistake one for the other, and lose both! Let me illustrate from these experiences.

The first time that I remember having the distinction brought to my attention was almost thirty years ago, soon after my second book was published. It was entitled *Amplifiers* and has long since been out of print. One thing it addressed was the proper use of load lines to estimate or calculate amplifier performance.

About that time I gave a lecture at the Royal Society of Arts, in London, where the British Sound Recording Association met, on the design of passive and active types of equalizers, all of which was pretty new at that time. In those days, most people considered themselves lucky to hear anything at all, and only the most advanced purists were concerned about equalization.

After the lecture, a young man came up to ask a question about something I had said in the lecture, about which he was sure I had made a misstatement. I noted a copy of my new book tucked in his outside jacket pocket, so assumed he knew I was the author. When I started to reiterate what I had said in the lecture, in a little more detail; he pulled my book from his pocket.

He started to prove I must be wrong, because on page so-and-so, this book said—and he proceeded to read it to me. Maybe my wording was not as well chosen as my later efforts, but he was misinterpreting one sentence, without reading on to get what qualified that statement in the next sentence. Because I remembered what I had written, I suggested he read the next sentence.

Then he saw two things: one, that I had been correct in what I had said in my lecture; and two, that I was also the author of the book, a fact he had not connected until that moment. And what amused me at the time was the fact that he was prepared to accept his misinterpretation of what I had said in print more readily than his misinterpretation of my spoken word. In my mind, I dubbed that, "the authority of the printed word," and it certainly does influence many people. If something is in print, it must be true.

Later, I ran into more instances of similar things. Long before I started writing this column, my technical articles had often attempted to resolve contradictions and misunderstandings. I remember several in which I tried to straighten out a popular misconception about cathode followers.

Some textbooks quite correctly showed this circuit functioning as an impedance changer. What they usually did not show was that the peak output signal current could not exceed the standing plate current of the tube. Nowadays, a similar property inheres in an emitter follower, and again, the peak signal current cannot exceed the standing collector-emitter current of the transistor.

But in those days, every time I wrote such an article—and in one of them, I suggested the reader set up the circuit and measure the results for himself—one particular reader would write in and contradict me, on the authority of a certain textbook, widely used in technical college courses of those days.

Of course, he was misquoting the textbook, or at least quoting it out of context, and he persistently refused, apparently, to set the thing up and check it out. To him, the textbook said the opposite of what I said and the *textbook* must be right!

When we first came to this country, I secured a job as chief engineer of a well-respected company in the audio field, where I had several engineers working with me. Two of these were freshly graduated from college. Since I had held a similar position in my native England, the difference between the preparation these two had received and what I could have expected of their counterparts in England was quite noticeable. But I said nothing.

When I assigned them a simple measurement project, they did not have the faintest notion where to start. Under these circumstances, the usual procedure would be to lay out instructions for them in a,b,c fashion, and then leave them to it. But I realized from my teaching experience that it would be quicker in the long run to take a little time training them to think things through for themselves so they could use their own initiative after a bit.

So I would ask them just what they had to measure, how to isolate the variables, and so forth, until they could figure this all out for themselves, without any help. Thus it was that one of them came to me, after less than six months of this work, and told me he had learned a zillion times as much about engineering by working with me these few months than he had learned from his degree course in engineering at a university whose name I will not repeat.

In the years that followed that incident, in a great variety of ways, I have encountered the same complaint relative to virtually every college that provides what the catalog advertises as an engineering education. Some are obviously worse than others and there are a few good professors scattered around from whom an engineer here and an engineer there gets a really good start. But the whole situation rather disgusted me.

So I set about finding out what was wrong. When I talked to people at colleges and universities, the professors complained that they knew what I meant, but they were really doing the best they could with the poor "material" (meaning students) that came to them from high schools. I will not take space here to detail my studies, back down to kindergarten level and back up again, trying to pin down where the bad things happen.

Of course, as my more recent anal-

yses have shown, the error is not confined to any one level, but to certain systemic problems that have made the whole of what passes for education in our country today a pretty useless effort. And one that is getting more so with each passing generation. And my writings about the matter, in this column and elsewhere, have been getting attention and not a little agreement, if rather little action, as yet.

In fact, I was beginning to think that my accumulating grey hairs must account for the fact that I no longer get letters from readers anxious to contradict me, but that everyone seems to confirm what I say, from different vantage points. Then I got one that really gave me a chuckle. For one thing, it reassured me that I do not have that many grey hairs yet. But it was the irony of it that made me chuckle.

You see, it came on the notepaper of the university whose name I did not repeat a little earlier, from a professor who said he was interested in what I have to say but that he cannot agree with me Now wasn't that interesting and ironic?

To illustrate my point a little further, let me quote from my own column, as it appeared in the July issue. There the following sentence appeared:

The good teacher's capability can be summed up as knowing how learning happens, in a variety of different human beings, and being competent at causing it to happen.

Some seem to think that says it pretty well, and straightforwardly. But you see, people who can read that sentence and get its simple meaning are not trammeled with an education in education. Any person who has received an education in education will see certain unstated synonyms in that sentence, that the rest of us do not see.

First, "knowing how learning happens" is kindergarten language for Educational Technology. Next, "in a variety of different human beings" translates to Comparative Psychology, and finally, "being competent at causing it to happen," translates to Motivation. So let us see how a trained educator would read that sentence:

The expertise a good teacher needs can be obtained from courses in educational technology, comparative psychology and motivation.

No kidding—was that what I said? Most educators would insist it was, till they were blue in the face! But let me point up, if I can, the differences that I see.

I thought I was saying how you would recognize a good teacher, should you ever see one. Before anyone rises to that, let me say that I know there are some, because I have met them, but such a misinterpretation is apt to make me a little salty! And I can assure you there is no guarantee that a student teacher, sitting through the three courses named, would end up as a good teacher. If there was, we would have no problems.

We could enumerate the kind of content you would find in courses on educational technology and comparative psychology, but I can assure you that it would have little bearing on helping a teacher to become competent at causing learning to happen.

But most interesting to me is how educators think of motivation. Usually that is in the counselor's bailiwick. Johnny is not motivated too well. So the counselor sees him. "What do you want to be when you get out of school, Johnny?"

Resisting the temptation to say something like, "One of Hell's Angels," maybe Johnny says that his Dad wants him to become an engineer.

So the counselor goes over to the rows of filing cabinets and selects the

drawer with an E on the front. Masses of brochures from engineering schools show that their prerequisites include various amounts of math and other subjects in which Johnny is not doing too well. "So you'd better work on those subjects, Johnny," concludes the counselor.

That is the educator's notion of motivation!

Frankly, I do not believe that would have motivated me in my own school days. And I doubt whether it would have motivated Thomas Edison, Alex Bell, Albert Einstein, or any of the men who have contributed significantly to human advancement. If we had had the benefit of that kind of motivation a few decades ago, we would never have had electric light, the telephone, or a great many other modern devices and conveniences we take for granted today.

What motivated them was curiosity —the simple desire to find out about things. But these educators stifle that. Students may only find out what they are programmed to learn. And all that gobbledygook that mathematics educators stuff into "new math" textbooks would give anybody mathematical indigestion! Not to mention other pieces of the fragmented curriculum structure. ■

you write it

Many readers do not realize that they can also be writers for **db.** We are always seeking good, meaningful articles of any length. The subject matter can cover almost anything of interest and value to audio professionals.

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GEORGE ALEXANDROVICH

Balanced and Unbalanced Lines

What are the relative values of using each method? Are transformers the answer, or are alternatives appearing on the horizon? The author answers these, and other questions.

I BELIEVE that all simple solutions are ingenious. No exception was the discovery of the balanced line, or principle of balancing electrically a circuit in order to cancel or eliminate an unwanted signal. There has never been another solution which could improve upon this method of handling the problem.

The problem of interference first arose many years ago when it became necessary to find a means of making a transmission line impervious to outside interference, such as lightning discharge, high voltage line interference, or radio-frequency noises. At that time our airway, our inner space, was not electronically polluted. There were no large electro-generating plants, no radio or t.v. stations,

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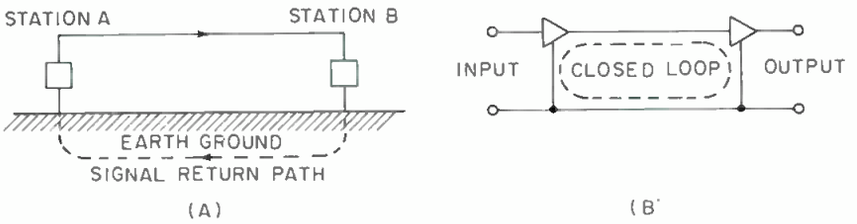


Figure 1. An unbalanced line. (A) is the physical representation and (B) the schematic one.

no radar sites, no electric shavers or toothbrushes, pocket calculators or satellites. If in those days someone had a field strength meter and wanted to test it, he would have been out of luck; his meter would have read *zero*.

This doesn't mean that Mother Nature didn't know about electricity. Far from it. The human body, for example, is the most complicated electronic machine imaginable. Small electrical impulses are circulated through our bodies and coordinated by the world's most sophisticated computer with its gigantic memory bank—the brain. Our world has been designed harmoniously, intended as a beautiful, clean, utilitarian creation where everything has its place and order. But man, with his interference, which he calls *progress*, has distorted this natural design. And this leads us, in our need to repair our own meddling, to our principle of balanced lines and how they are used.

Let us look at the principles of power transmission first, following with a review of balanced and unbalanced lines. Don't let the term *power* throw you; theoretically, transmission of any sort of signal involves power. Radio and light waves carry power. If this were not so, we wouldn't be able to see the light or to receive radio transmissions.

There has to be a closed loop to achieve a transmission of power. In a flashlight, two wires are needed to light the bulb. The same requirements hold true for telephone lines. Sometimes in military applications single wire is used for a telephone network, but the return path to complete the electrical loop is through the ground. (See FIGURE 1 for illustration.) A single wire transmission line, with the ground as a return path, is a great antenna for picking up radio waves. This single wire picks up random electrical fields surrounding it and mixes them with the original signal being sent through the line, thereby causing interference. Since one side of such a line is the ground potential and the other is *hot*, we call such lines *unbalanced*. (See FIGURE 1.)

In order to isolate such a line from external interferences, shielding techniques as shown in FIGURE 2 are used. The shield usually consists of a metal jacket over the hot lead in the form of thin foil or wire braid. Adequate insulation, depending on the application, is used between the wire and the shield. In this case, the determining factors are the voltage breakdown point and the wire-to-shield capacitance. The shield is usually tied to the ground in one or several places, providing a short circuit to the ground for all external fields which normally would be picked up by the wire. In the rf applications where interference signals may be of very high frequency, long ungrounded shields may present a high enough impedance at those frequencies and may create sufficient voltage drop across its ungrounded portion to be ineffective. That is why in some older types of radio mixing boards or audio systems all shields are left exposed and are tied into one solid bundle or cable with grounding points all along its length.

But unbalanced lines and the aforementioned shields cannot stop magnetic fields from being induced into the line. Magnetic shielding can be used, but it is not practical, not only from the standpoint of cost, but also because of the weight and space required, not to mention the added difficulty of handling the wire.

Speaking of shields, think of all the wire used for telephone networks. Millions of miles of thinnest wires are being used today, taking too much space and costing a fortune. Since there are no simple ways to completely shield and protect unbalanced lines from all types of interference—accomplishing transmission of low level signals economically over long distances—a method of balancing the line was invented. Needless to say, a shining example of a user of balancing technique is the telephone company, where all standard short and medium range transmission lines using wire (some lines are connected by micro-links) are balanced.

In order to balance the line, both sides are adjusted to carry identical, but opposite-in-sign electrical information with respect to the ground. In other words, we can say the signal in both wires are 180 degrees out of phase and equal in amplitude to each other. The easiest method of balancing the line is to use balancing transformers at each side of the line, as shown in FIGURE 3.

Transformer windings are usually made with center taps, which are grounded at each end of the line. Wires or conductors of such balanced lines are usually kept close to each other. You can notice them in modern cables as a pair of twisted wires. In older types of installation on telephone poles, both wires ran parallel to each other.

The idea behind the balancing is that any external field produces the identical interference in two wires, and with identical strength (amplitude) and phase. Since the balancing transformer on the receiving end would only allow signals from both lines which are opposite in phase to pass, it would reject all signals appearing with identical phase in both sides of the line. This brings us to a very important condition in balancing the line—the electrical symmetry with which the balancing transformer has been manufactured. It should be obvious that if both halves of the transformer windings are not identical, the difference in signal strengths produced across both halves of the winding will be added to the original signal being transmitted, as an interference signal.

In order to make a correct decision when to use balanced and when to use unbalanced lines, let us look into

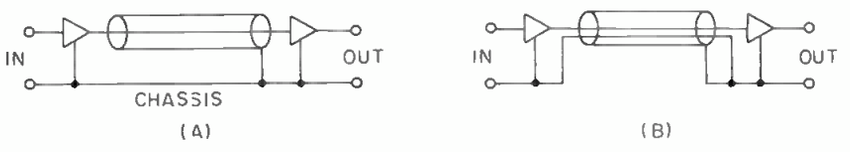


Figure 2. Shielded wire can be used in differing ways as a carrier of unbalanced audio. At (A) a single shielded wire is shown, while at (B) a double conductor shielded wire is shown.

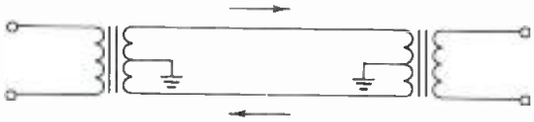


Figure 3. Balancing a line using transformers at each end.

the advantages and disadvantages of each.

Balanced lines are obviously less sensitive to external interference but require transformers which are costly, bulky, and can also pick up external magnetic fields themselves. Unbalanced lines are more susceptible to noise pickup, but are more economical to use over shorter distances, even if you have to use shielded wire. Much more care needs to be exercised, in using unbalanced lines, to relating the two pieces of equipment so as not to create ground loops. (Let's not leave anyone baffled by the term *ground loop*. It is a condition that occurs when the ground wire interconnecting two devices, amplifiers, or systems has a current flowing through it.) This current comes from dissimilar ground potentials caused by poor grounding of the equipment in the first place. The differential current is superimposed on the signal traveling through the unbalanced line—one side of which is a ground wire—causing interference. If this parasitic current is pure d.c., it will have no adverse effects on most audio circuits, but if it is of audio frequency, it will be most undesirable. (For instance, 60 or 120 Hz.)

The advantages of balanced lines are overwhelming for long transmission hauls because they don't require shielding. In the old pole-to-pole system, the interwire capacitance, as well as the capacitance of the line to ground was low, but in modern cables it is high and requires frequent signal boosting along the route—which incidentally achieves better balance. Transformers have been a dominant component in balancing lines, although they have limitations in power handling capability and are deficient in frequency response, noise distortion minimizing, and phase control. Because of interwire capacitance, copper losses, inductance of the lines and quality of the transformers and transducers used, it has been found that we cannot expect telephone line response to extend below 300 Hz and above 3,000 OHz.

Although unbalanced lines are impractical over long distances, they are very convenient and economical for use in compact systems where they don't impose limitations such as those found in balanced lines. It is desirable to do without transformers in these instances, even if transistors have to be called upon to perform functions ordinarily served by transformers. This is because of factors such as reversal of phase, voltage amplification, impedance matching, signal mixing distribution, and even balancing and unbalancing. In some instances, it might be simpler to use a transformer for the task of reversing a phase than using a phase reversing amplifier with power supply and all the trimmings. But if you are planning a system, it may be simpler to make an effort to design the transformer out of it.

In making a decision as to which type of line to use, consider the length of it as well as the signal strength expected to be present. You should develop an arbitrary set of your own rules, guided by the design parameters you have to meet and the available technology. If microphone lines are involved, consider only balanced lines and using a transformer. You not only want to provide good balance and isolation, but more and more mics today are phantom powering, which means that the primary of the mic input transformer carries the potential for the microphone amplifier. The reason I said *potential* is because there is no current through the primary, since it is balanced and current through both sides of the line is not being transmitted to the secondary of the transformer. The reason for this is that it is d.c. and that there is a cancellation of currents in the primary. The only place where I would dare to use an unbalanced microphone line is in the talkback circuit, where the amplifier may be only inches away from the mic and the quality of the signal is not critical. In the case of patch bays, where you may be called upon to interconnect systems with unknown grounds and phases, there is only one sure way—balanced lines throughout.

As I have mentioned, the trend today is to get away from transformers because of many reasons. One of these is the rapidly increasing miniaturization of equipment. This has been lagging in the technology of transformer design, which has not kept pace with the developments in the solid state semi-conductor field. Ways have to be found to replace big bulky transformers with tiny chips that will do the job many times better than the hunks of iron and wire we now have. Already, circuits have been designed which replace inductors completely. Although in some instances today we say that the transformer is an ultimate element of the component, the day may come when the last lamination will be discarded and only powdered iron miniature laminations may remain.

Another instance of bypassing bulk for miniaturization is evident in the practice of substituting switches for unwieldy patch bays. One of the major t.v. networks is converting their master grid, consisting of a couple of dozen racks full of patch field, to several racks full of solid-state switches combining rf and audio signals by means of multiplexing them on the common high frequency carrier, then delegating them, distributing them, and separating them again. Analog-to-digital conversion, like a contagious disease, has spread over all the facets of the electronic field, affecting not only the technological side of our lives, but the traditional ways in which we used to do things!

Getting back to transformers for a second—I think the reason why we feel it is time for the obsolescence of the transformer as we now know it is because it is still essentially the same as it was back in the 1930's. There have been no successful modernizations of the transformer principle except for improvements in winding and assembly. This produced some reduction in size and upgrading in performance. Frankly, the transformer works great for the function it has been designed to serve. But it has to convert electrical current into a magnetic field and then back to an electrical current of different voltage. Solid-state devices don't have to do this. The advent of operational amplifiers has provided a new outlet for the imagination of electronic engineers, who can develop circuits offering balanced feed and input, which could be nulled for perfect balance at a fraction of the cost of a transformer. One disadvantage of transformers—which actually appears as an advantage to a majority of audio engineers—is that because they are imperfect in their transfer characteristics, they act as filters, cutting off the extremes of the audio spectrum. This property of the transformer still makes it attractive. I suppose there's a nostalgic element here; engineers identify the passing of the transformer with the loss of something familiar, like the phasing out of the horse and carriage. But judging by the speed of technological development, the disappearance of the transformer may come before we know it. ■

ARNOLD SCHWARTZ

Transformers

Here, you will find out what transformers are and what they do. And you will discover how one manufacturer designs and tests their transformers.

An interesting approach to transformer operation is to start with a generator driving an ideal iron-core inductance. An ideal inductance has two important characteristics. First, the coefficient of coupling is unity. This means the magnetic flux due to the electrical current is totally linked to all the turns through the magnetic core material. In a real inductance there is less than 100 per cent flux linkage. Second, in the ideal inductance, it takes zero current to magnetize the core. In all *but ideal* conductances, it takes some small amount of current to magnetize the core. As expected, the generator will see an inductive load, see FIGURE 1(A). By

Arnold Schwartz is a former columnist for **db**. *He is president of Micro/Acoustics Corporation.*

connecting the generator from the center tap to one end, and a resistor from the center tap to the other end, see FIGURE 1(B), we convert the iductance to a transformer. The inductive current in each half of the inductance is out of phase and cancelled. The generator will see a purely resistive load if the coupling coefficient is unity and an ideal core material is used. Later on we shall see the effect of less than unity coupling and a less than ideal core material. The electrical connection at the center tap need not be made, see FIGURE 1(C), leaving only the magnetic coupling between the two windings. FIGURE 1(D) shows the transformer in its more conventional representation.

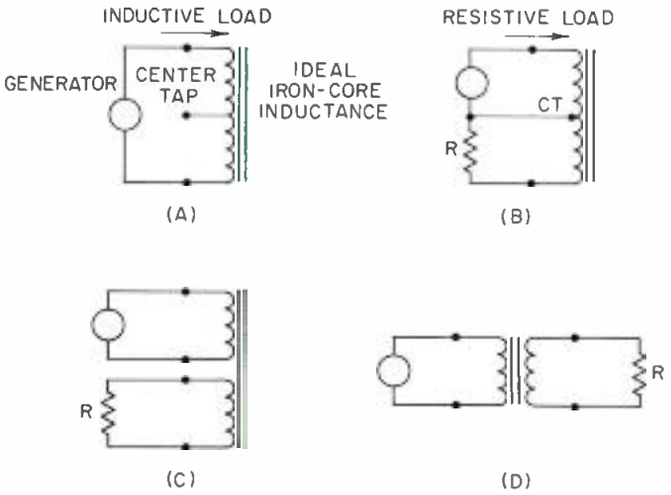


Figure 1. An ideal iron-core inductance connected as a transformer. At (A) a generator driving an inductive load is seen. (B) shows a generator driving a resistive load. At (C) the electrical connection is eliminated, while at (D) a conventional transformer representation is shown.

IMPEDANCE, VOLTAGE, AND CURRENT TRANSFORMATION

Transformers in audio signal circuits are used for a variety of purposes, including isolation, impedance matching, voltage transformation, and current transformation. Voltage, current, and impedance changes are a function of the turns ratio, but in all cases the power in the primary circuit equals the power in the secondary. We therefore have the well known transformer equations:

$$E_p I_p = P_p = P_s = E_s I_s$$

$$\frac{N_p}{N_s} = \frac{E_p}{E_s} = \frac{I_s}{I_p} = \sqrt{\frac{\xi_p}{\xi_s}}$$

P = Power
N = Turns
E = Voltage
I = Current
ξ = Impedance
subscript_p = primary
subscript_s = secondary

These equations are set down in the form of a nomograph (FIGURE 2) which can be used more easily to determine the ratios of primary to secondary turns, impedance, voltage, and current. The current and voltage ratios are expressed in dB. Very often a transformer or circuit specification will only list one of these items, but with the nomograph of FIGURE 2 we can determine the remaining primary and secondary relationships. Take the case of a transformer used to match a 150-ohm line (primary) to a 600-ohm line. The impedance ratio is 4:1. We enter the

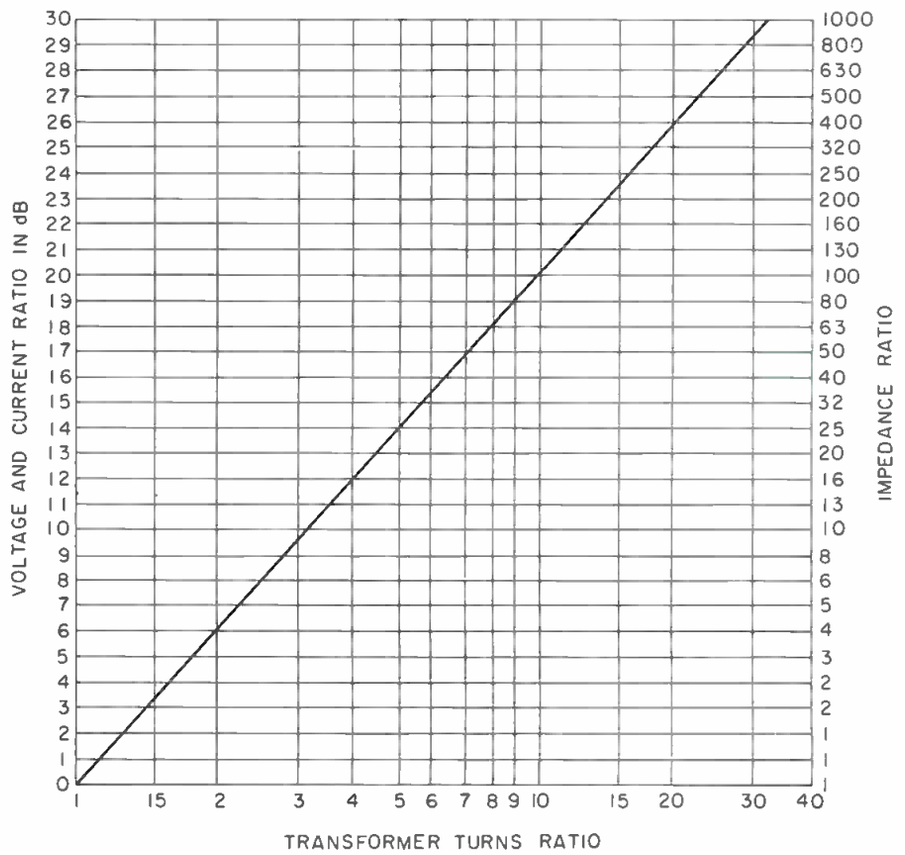


Figure 2. A transformer nomograph.

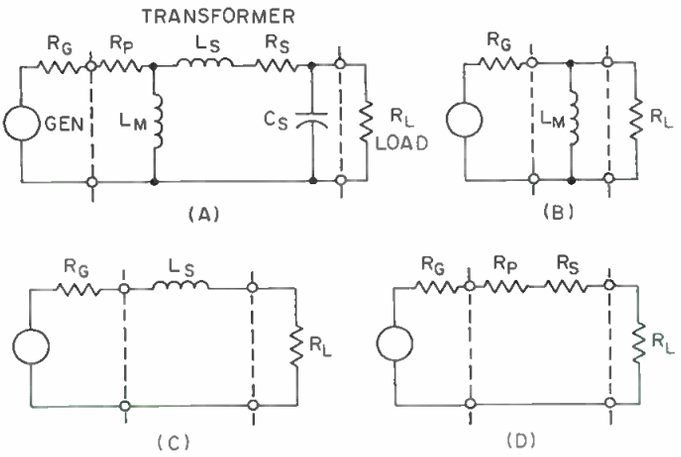


Figure 3. At (A) a simplified equivalent transformer circuit is shown, (B) is a low-frequency equivalent circuit, (C) a high-frequency equivalent circuit, and (D) is an efficiency equivalent circuit.

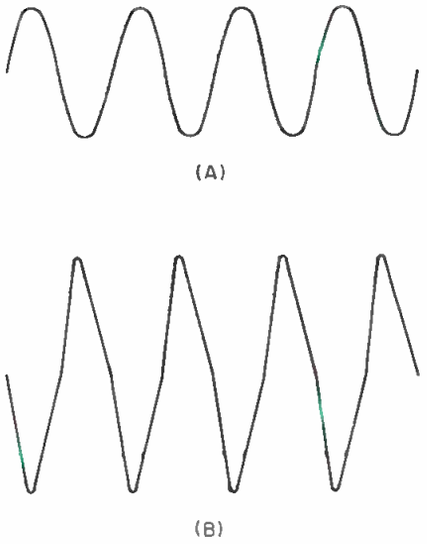


Figure 4. (A) The output waveform below maximum power capability is shown while at (B) we see the output waveform when the core is saturated.

nomograph at the right hand side, where the impedance ratios are shown, at the indicated ratio of 4. Going to the left on that horizontal line, we intersect the voltage ratio scale at 6 dB—which is the voltage gain and also the current loss in the secondary. To find the turns ratio we note where the horizontal 4:1 impedance line intersects the sloping line; we then drop down vertically from that point to the turns-ratio scale at the bottom of the nomograph. We intersect this scale at 2, so that we know the turns ratio is 2:1. The secondary has the larger number of turns since it is a step-up transformer.

As a second example, we can start with a known primary to secondary voltage gain of 10 dB. We enter the nomograph on the left hand side at 10 dB, and going to the right on that horizontal line, we intersect the impedance ratio scale at 10, which means that the secondary impedance is ten times that of the primary. The turns ratio is found as in the first example and is slightly less than 3.2:1 (actually 3.17:1). The nomograph can also be used to convert voltage or current ratios into the dB equivalent.

TRANSFORMER FREQUENCY RESPONSE

Up to this point, we have assumed a perfect transformer. Since the perfect transformer does not exist, we have to consider how the actual transformer deviates from the ideal, and how this affects the circuits in which we employ it. The simplified equivalent circuit of an actual transformer with a 1:1 turns ratio is shown in FIGURE 3(A). Resistors R_p and R_s represent the d.c. resistance of the primary and secondary winding, respectively. L_m is a shunt inductance which is present due to the magnetizing current, i.e. that current which is required to produce flux in the core. This small amount of current needed to magnetize the core is 90 degrees out of phase with the load current, which is why it appears as a shunt inductance. The smaller the magnetizing current, the higher the value of L_m. L_s, or leakage reactance, is there because the coupling coefficient is less than unity, and represents the imperfect cancellation of inductive currents discussed above in reference to FIGURE 1(B). L_s is in series with the load current. The shunt capacitance C_s represents the stray capacity existing between the windings. The quantities R_p, R_s, L_m, and C_s, in conjunction with the source and load impedance, determine the band width of the transformer.

LOW FREQUENCY

If we consider the low frequency end of the band, we can further simplify the circuit by eliminating L_s, whose series reactance at these frequencies is negligible, and C_s, whose shunt reactance at these frequencies is very high. If we lump R_p and R_s with the generator and load resistance respectively, we have the circuit shown in FIGURE 3(B). The low frequency limit of the transformer response is determined by the following formula:

$$F_{LC} = \frac{\frac{R_G R_L}{R_G + R_L}}{2\pi L_M}$$

F_{LC} is the low frequency cut off where the response is the 3 dB down. At frequencies below the 3 dB point, the response rolls off at 6 dB per octave. As the generator or load impedance is increased, the low-frequency cutoff will increase and the low frequency response will be attenuated further.

If the transformer is to go down to very low frequencies with a given source and load impedance, then the core material must require as little magnetizing current as possible, which is equivalent to increasing L_m. The larger L_m, the lower the low frequency cut off.

HIGH FREQUENCY

At high frequencies, the reactance of L_m is large and we can ignore it in the transformer high frequency equivalent circuit. We also make the simplifying assumption that C_s is small enough to ignore so that we arrive at the high frequency equivalent circuit of FIGURE 3(C). The high frequency limit of the transformer is determined by the following formula:

$$F_{hf} = \frac{R_G + R_s + R_p + R_L}{2\pi L_s}$$

F_{hf} is the high frequency cutoff and the response is 3 dB down at this point. At frequencies above the 3 dB down-point, the response rolls off at 6 dB per octave. In this circuit, as the generator or load impedance decreases, the

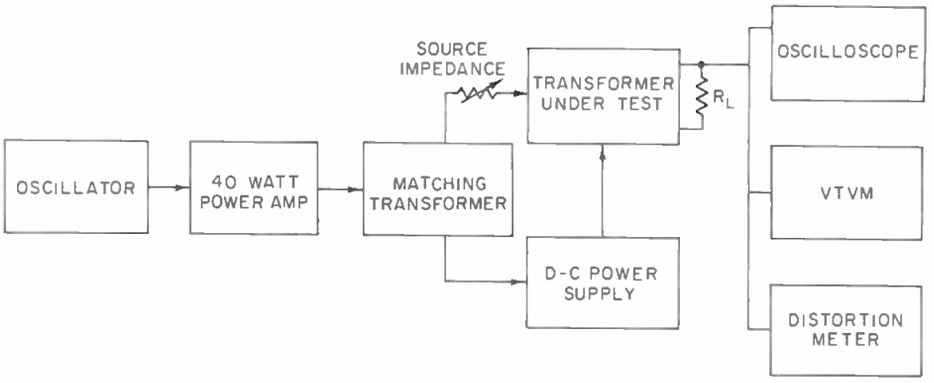


Figure 5. The transformer test setup as used at United Transformer Company.

high frequency cutoff will decrease and the high frequency response will be attenuated further.

TRANSFORMER EFFICIENCY

The effect of the primary and secondary d.c. resistance is to lower the transformer efficiency. FIGURE 3(D) shows the equivalent circuit as it relates to input/output efficiency in the midband. Part of the power intended for the load is dissipated in resistors R_p and R_s. When source or load impedance is below the rated value, efficiency will drop. Engineers at the United Transformer Company (UTC), one of the leading manufacturers of transformers, explained to me during a visit there that typical losses in a well designed transformer amount to about 1 to 1½ dB —or we can say that transformer efficiency is about 90 to 85 per cent. UTC design engineers stated that it is well within the state-of-the-art to build transformers with higher efficiencies, but that size and other economies dictate a compromise design with moderate losses.

MAXIMUM POWER AND DISTORTION

An important limitation on transformer operation is the allowable maximum power level. FIGURE 4(A) shows the output waveforms of an audio transformer in the midband at a level below its maximum capability. When the power level of the transformer is exceeded, the core will saturate (the change in flux is not directly proportional to changes in current) and cause distortion. For a given power level, the flux density increases proportionally as the frequency decreases, so that core saturation is more of a problem at the low end of the transformer pass band. FIGURE 4(B) shows the output waveform of the same transformer when the core is driven into saturation, and severe waveform distortion is evident. Therefore, as power level requirements increase, the amount of core material must increase. Very small transformers can only handle moderate power levels, while larger transformers generally are capable of larger power handling capacities.

TRANSFORMER TESTING

At UTC, a standard laboratory transformer test setup is maintained to check the quality of production items and to evaluate new designs. A block diagram of this test setup, which is used to measure response and distortion, is shown in FIGURE 5. An oscillator is the signal source, and the 40-watt amplifier provides power gain. The matching transformer is also used as a d.c. return path for the power supply which is available for those transformers operating with unbalanced d.c. A variable resistor provides the correct source impedance. Output measuring devices include an oscilloscope, a distortion meter, and vtvm.

A well designed transformer, that is, one designed with a sufficiently wide frequency range, operated below core saturation and properly shielded from hum pick-up, will provide smooth frequency response (equivalent to a high quality amplifier) and extremely low distortion.

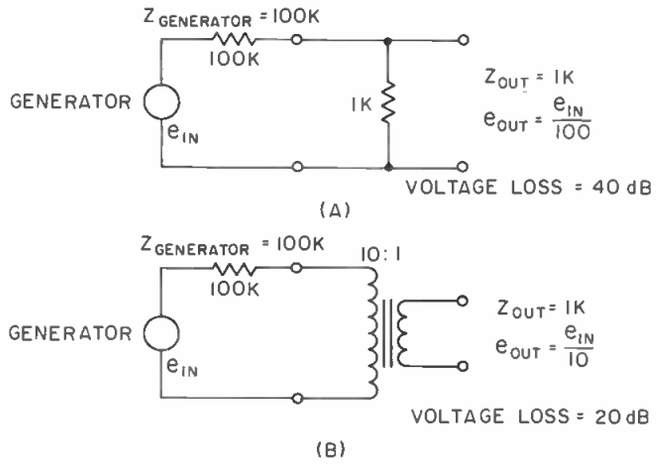


Figure 6. Impedance matching. At (A) a resistive network, and at (B) a transformer.

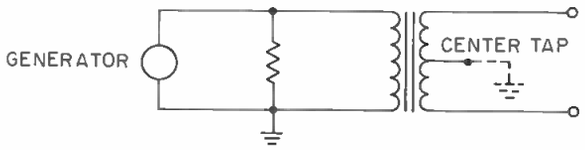


Figure 7. A transformer used for isolation.

EXAMPLES OF TRANSFORMER CIRCUIT APPLICATIONS

Gain. One of the most common uses of transformers is to step up voltage in a circuit. For example, some types of microphones have low output voltage and low output impedance. By using a step-up transformer, one having a primary-to-secondary turns ratio of 3.17:1, we can provide a 10 dB voltage gain. The secondary impedance will increase to ten times that of the primary impedance.

Impedance Transformation. Very often we wish to go from a high impedance circuit to a low impedance circuit. A transformer will accomplish this with the minimum possible loss. If we want to reduce the output impedance of the circuit shown in FIGURE 6(A) from 100 k to 1 k by means of a resistance network, the ouput voltage will be 40 dB down from the generator voltage. If we use a transformer with a primary-to-secondary turns ratio of 10:1 to change the impedance, then the output voltage will be down only 20 dB from the generator voltage (FIGURE 6(B)). By using a transformer for impedance transformation, we provide minimum voltage loss, and actually no power loss, at the low impedance output terminals.

Isolation. If we wish to isolate a circuit or a transmission line from ground, then the transformer, because it employs magnetic coupling, is an excellent choice. In the circuit of FIGURE 7 we have a signal source with respect to ground. If we wish to eliminate the ground reference, then a 1:1 isolation transformer is used. If we wish to provide a source which is balanced with respect to ground, then we can ground the center tap of the secondary. ■

STEVEN F. TEMMER

Wide-Band Subminiature Audio Transformers

A great deal of attention must always be paid to each element that goes into the makeup of a transformer. But when miniaturization is demanded extra attention must be achieved. This article explains the manufacturing steps used by Beyer to achieve quality and small size.

TRANSFORMERS have been used for many years as coupling devices between the stages of amplifiers. Their unique properties make them amenable to a great variety of uses and some interesting designs have evolved. The increase in transformer utilization has inspired new developments in soft-magnetic material technology and refinements in the manufacture of wire. This has improved transformer performance, but the increased complexities of situations where transformers are used has led to the necessity of new designs, especially miniaturization.

Steven F. Temmer is president of Gotham Audio Corporation.

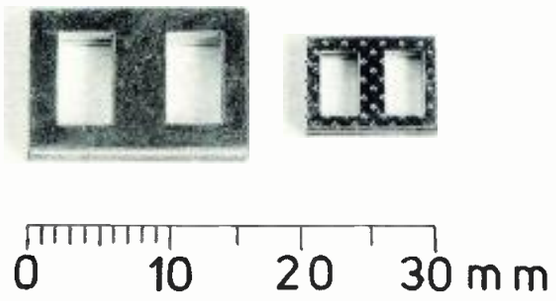


Figure 1. Two sizes of lamination stacks showing the unbroken frames.

This has required ingenuity, especially in dealing with laminated core construction, which is used in transformer production because it represents a practical and economical method of manufacture, especially if a wasteless core stamping method is used. The conventional method used for assembling the laminated core, however, results in a splitting of the magnetic circuit, which in turn makes it impossible to increase further the effective permeability of the core—the permeability converges toward a certain limit, thus determining the inductivity constant of the iron core.

There are three possible ways of overcoming this and improving the inductivity: enlarging the cross-section of the core, shortening the magnetic circuit, or increasing the cross-section of the coil. But, since these factors are inversely related to each other, the solution must be found in a compromise. Logically, the ultimate method would be to increase the number of turns combined with a decrease of the wire gauge. This, however, entails an increase in the insertion loss, which cannot be tolerated beyond a certain limit when involving input transformers between the microphone and the first transistor. In addition, the increased capacitance of the coils reduces the high frequency response, thus setting a limit for the turns ratio.

All these considerations have led to a completely new concept in the production of studio quality miniature transformers at Beyer. Permeability was the critical factor. As pointed out above, the permeability of the core cannot be increased with split cores, even if the permeability of the material itself were to be increased. The only remaining possibility would be a gapless core circuit. The use of a gapless ring in toroidal transformers is nothing new, but in view of the difficulties encountered in winding such transformers, economic reasons mitigated against their use.

In these miniaturized transformers, the conventional laminated core has been retained but now it consists of gapless individual laminations only. We just stamp two windows into each lamination to make space for the coil. These laminations are stacked to form a core with a square cross-piece. Around this cross-piece we glue together two halves of an injection-molded plastic bobbin, forming a complete bobbin onto which the wire is wound. The wire ends come out of the coil on one side without reinforcements and are then soldered to leads which are threaded through the space remaining betwen the circular bobbin and the square core cross-piece. A special plastic wedge prevents the leads from accidentally being pulled out. Finally, the transformer is impregnated and enclosed in two mu-metal cups.

The specifications achieved with this system are quite impressive. By using laminations 16 mm long by 11 mm wide to form a core cross-section 4 mm by 3 mm and 17,000 turns of 25 μm wire on the bobbin, an inductance of 4,000 H can be obtained. If this is divided into a primary and a secondary winding, it is most eminently suitable for use as a microphone input transformer. With a turns ratio of 1:15, it has a primary inductance of 5 H, and a frequency response from 30 to 15,000 Hz with a maximum deviation of -0.5 dB at the extremes of the curve. In production, the measured values are around -0.3 dB. The dimensions of the whole transformer, complete with mu-metal casing, are only 16 mm in diameter by 20 mm high. (0.65 inches x 0.8 inches.)

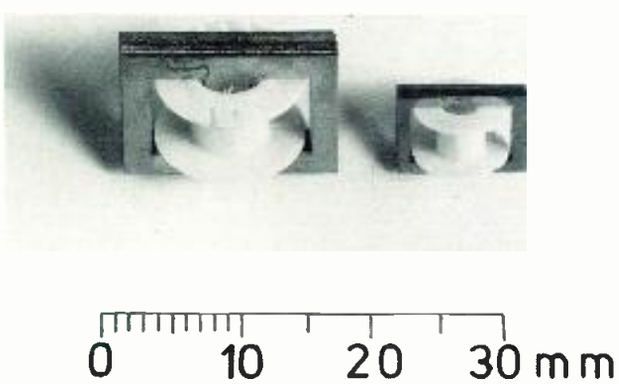
Here is a second example to further illustrate the quality achieved. A transformer was made for a 600 ohm line with a maximum input voltage of 8.8 volts (+21 dB) and a frequency range of 30 to 15,000 Hz. To keep magnetic induction low, the inductance was brought to a maximum. Thus, the input inductance was 1,500 H and the required standards of -0.5 dB at the extremes of the frequency response range were maintained. The turns ratio was 1:1 and the outside dimensions again were 16 mm diameter by 20 mm high. Additionally, these transformers were imbedded in silicone rubber within their mu-metal cases to make them shock and climate proof.

A similar design with a turns ratio of 1:1 was made to serve as an isolation transformer to be used as a d.c.-free coupling between a.c./d.c. television sets and tape recorders. In this case, a high insulation value was imperative. By means of a vacuum-impregnating process, a rating of 2,000 V was obtained.

These two are only random examples of the application of this principle; Beyer employs this unique design in the manufacture of hundreds of transformers to meet the individual requirements of original equipment manufacturers. In the course of further development, we have been successful in making a still smaller transformer than the one described above. This unit, whose laminations measure only 9.5 mm in length and 7 mm in diameter, represents, most likely, the smallest mass-produced transformer in the world.

The bobbin measures 7 mm (outside diameter) while the dimensions of the core cross-piece are 2 x 2 mm² (80 mil x 80 mil). With these sub-miniature transformers it is possible to attain a turns ratio of 1:20 and a fre-

Figure 2. The coil forms have been glued together on the lamination stacks.



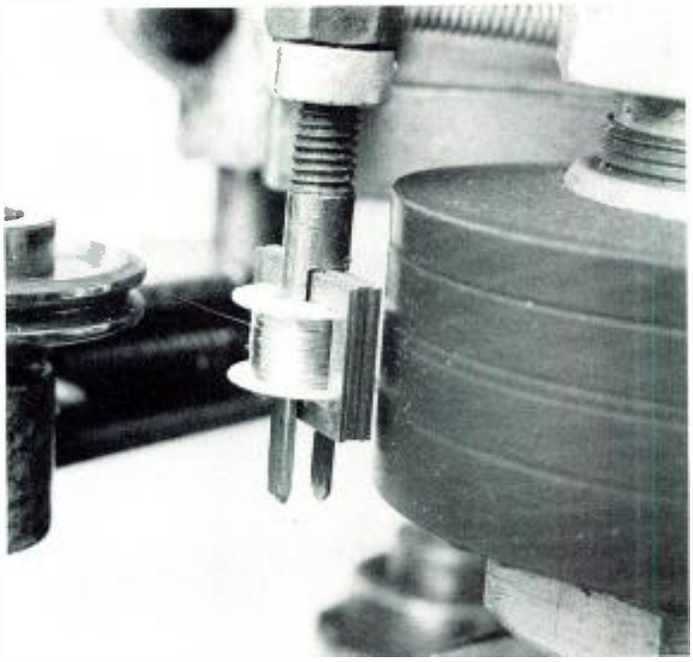


Figure 3. The winding process is shown. The laminations are held stationary while the coil form is friction driven by the rubber wheel at the bottom. The wire comes from the back of the winding machine.

quency response with a loss of three dB at 35 Hz and only one dB at 20,000 Hz. Because of its small dimensions, (its mu-metal case is 12 mm long and 10 mm in diameter) this transformer can be built into the shell of a connector. In keeping with the prevailing cost-saving technique of designing preamplifiers with high impedance inputs, it is possible to produce a dynamic microphone which has this transformer built into the end of the cable. This results in optimum frequency response combined with the absence of induced interference. The transformer is wound with lacquered copper wire with a diameter of 20 μm, or 0.0008 inch. This represents, at least for the present, the practical limit for economical production while maintaining the required specifications. Theoretically, using this winding process, it would be possible to employ 15 μm (0.0006 inch) or even 10 μm (0.0004 inch) wire.

The production methods used in making a transformer of such unique design are, naturally, unconventional. The stamping of the core laminations is done quite simply. The strips for making the laminations are supplied by the manufacturer in the desired width, under the trade mark Hyperm 900. Only two windows have to be stamped out and proper lengths cut. All this is done by means of a fully automatic stamping tool, which minimizes waste. The laminations are manufactured of either 0.35 or 0.2 mm high-alloy metal with 78 per cent nickel content. Special care is taken to assure that the sheets are even and free of burrs.

After being washed and stacked in special containers, the stamped laminations undergo a heat treatment which varies with the specific metal charge in order to obtain the maximum permeability of the material and the core. Present techniques have made possible permeability figures of about 50.000, measured at 50 Hz, in material with an initial permeability of 0.3979 A/m. Since the frequency limitation of the laminations is relatively small, higher values are achieved at 20 and 30 Hz. This is beneficial to the low frequency response of the completed transformer: because its inductance varies with frequency, a reduction in inductive reactance results in a lowering of the specific resonant frequency of the transformer. This

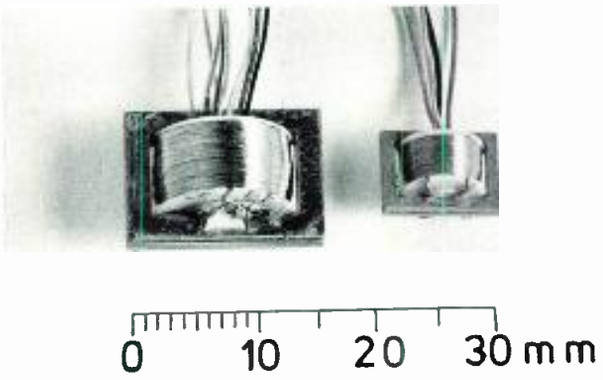


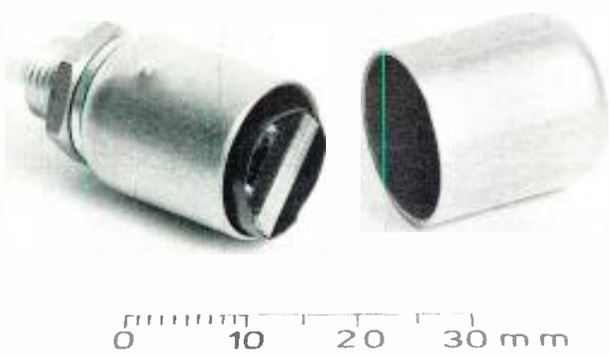
Figure 4. The fully-wound transformer showing the leads soldered to the coil ends.

is why the transformer is not evaluated by its inductance at 800 Hz.

Following the heat treatment, the laminations are sorted according to their tolerance and glued together to form core-packs consisting of eight single laminations of 0.35 mm each. Core laminations with such high permeability values need to be handled with utmost care and the laminating process must be carefully controlled to assure that no excessive tensions occur within the core material. After the two halves of the bobbin are glued together around the prepared core's cross-piece, the bobbin must be checked to see that it spins freely. The transformer is placed in a special vise on the coil winding machine and friction rollers spin the bobbin while the core remains stationary. The wires are threaded through lateral slots in the bobbin and a collar placed on the body of the bobbin to assure that the necessary distance from the corepack is maintained and to prevent the wire from being sheared off. The copper wire is fed from a supply spool located overhead, with constant wire tension within the limits prescribed for the particular wire maintained; since the supply spool need not be driven, breakage of the wire is avoided. Using this new winding process, ten to twenty thousand turns on the secondary side are not uncommon. A spot of lacquer keeps the ends from unravelling. The leads, which emerge very close together, are run out according to a specified plan to avoid any mixup. Because the leads are very short, special solder containing copper must be used to minimize alloy formation on the hair-thin copper wires.

Finally, the transformers designed for normal use are given a protective coat of lacquer, while an additional vacuum impregnation is given to those designed for higher safety requirements. The transformer is then installed in a double-walled, high quality mu-metal shell to protect it

Figure 5. The transformer is inserted into a mumetal shielding can and the leads are brought out through the threaded stud at the bottom.



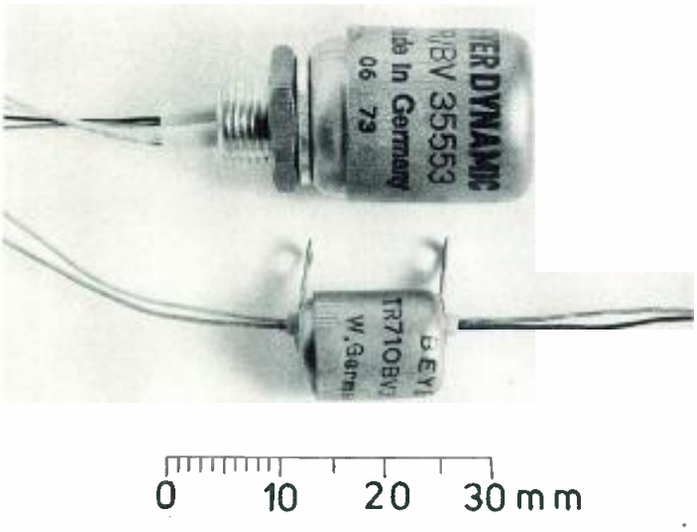


Figure 6. The models TR-145 (at the top) and the TR-710 (below) fully assembled, and showing the relative size of each.

from interference caused by stray magnetic or a.c. fields to the extent of about 70 dB. This mu-metal case may have a threaded stud at one end (type BV-35) to permit single hole mounting with the wires threaded out through its center or solder lugs may be attached to each end, allowing installation like a condenser on a terminal board. This mounting is known as the BV-35L version. The entire unit may also be encased in injection-molded plastic with a seven-pin miniature tube header (BV-36) or a standard 0.2 inch grid printed circuit header. (7-pin = BV-37; 8-pin = BV-38; 9-pin = BV-39) Most transformers sold today for o.e.m. applications are of the PC board mounting type.

With low turns ratios of up to 1:15, these transformers will cover a frequency range of 20 Hz to about 20,000 Hz. If the turns ratio is higher, the capacitance of the connecting elements—wire entry, leads, etc., and, to a small extent, the capacitance of the winding, will become effective. This is why, for the higher frequencies, the reactance of the transformer becomes capacitive. It must be borne in mind that, with a turns ratio of 1:30, the capacitance of the secondary side appears on the primary side mulitplied by a factor of 900; this may impose a considerable load on the source.

Even though all the particulars regarding sub-miniature transformers have not been touched upon here, the design engineer will readily recognize the possibilities inherent in this unique method of transformer construction. There is still much room for the improvement of such characteristics as permeability, wire gauge, and manufacturing precision. Some soft-magnetic materials are already available which may enable an even higher permeability of the core. A doubling of the present permeability value possible of 50,000 Oe will allow an increase in the number of turns and, thereby, an improvement in low frequency response. Better methods of reducing mechanical strain in the core lamination process will permit the use of thinner material. This, in turn, will allow a further increase in the frequency range of the sheet metal. The use of ceramic materials may also prove advantageous in the future. With the improvements already achieved and those contemplated, specifications, using miniature and sub-miniature transformers, will be expected in applications previously deemed impractical or impossible. ■

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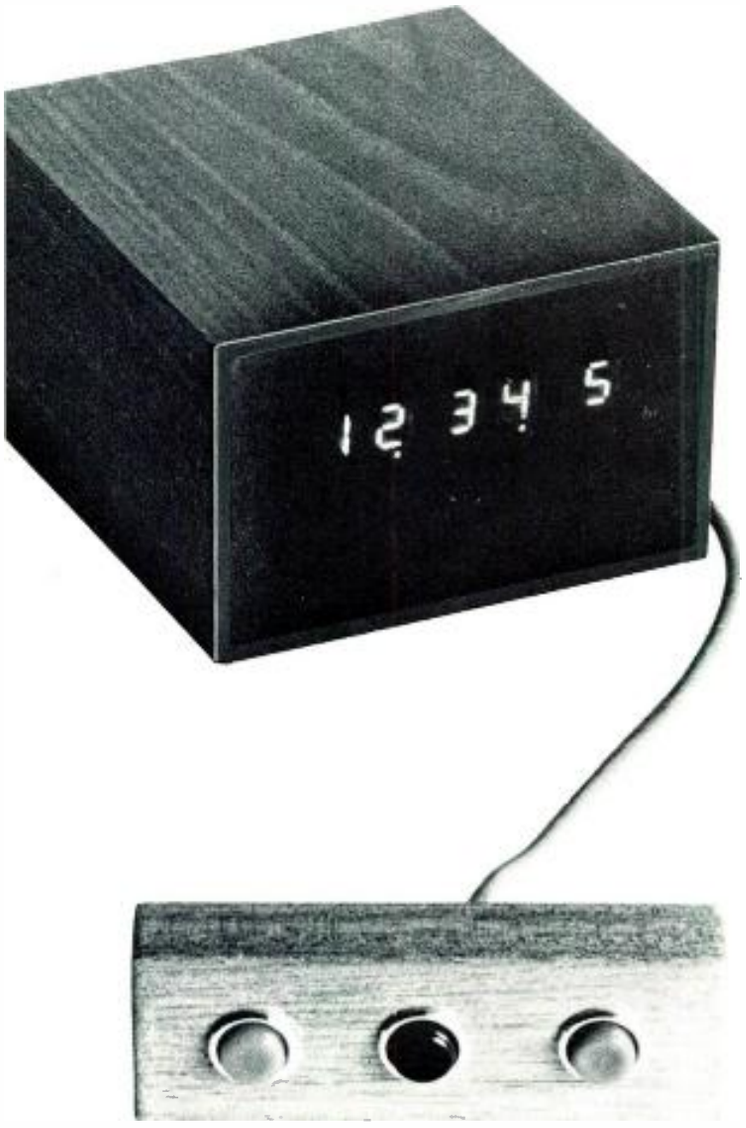
● **Lawrence J. Scully,** formerly president of **Scully Recording Instruments Company,** has announced the formation of **L. J. Scully Manufacturing Company** in Bridgeport, Conn. The new company will concentrate on the development and production of professional audio devices for the recording and broadcast industries. A number of new items are being produced—an extended play tape reproducer designed for broacast automation; a preview head tape reproducer for tape to disc transfer applications, which will accommodate all current automatic feed systems including the JVC Quad discrete system; and a new recording lathe to be introduced in late fall. Joining the new company in management and engineering capacities are **Jerry Scully, John Curtis, Dan Politi,** and **Richard Havanec.**

● The appointment of **Andrew P. McClure** as vice president, manager of sales, has been announced by **Schafer Electronics Corporation,** Goleta, California, suppliers of broadcast automation systems. Mr. McClure has been involved in sales activity and direction at Schafer for the past year. Before joining Schafer, he was account manager at **Xerox Corporation.**

● **G. Curtis Kline** has been appointed director of marketing, Norelco Sound Systems, at **Philips Broadcast Equipment Corp.,** Montvale, New Jersey, a subsidiary of **North American Philips Corporation.** Kline will direct the marketing of commercial and professional sound systems, color broadcast television equipment, closed-circuit t.v. systems, the Norelco VCR video cassette recorder, and security products, including Saferay x-ray detection systems. Before joining Philips, Kline was the New York City manager for the **Edison Voicewriter Division** of **McGraw-Edison Company.**

StopClock

A New, Accurate, Digital Timing Instrument for Recording Studios, Broadcasters, and Other Demanding Applications



Timekeeper is proud to introduce a new inexpensive *Electronic* StopClock—a compact instrument featuring an easily-read visual display.

Only 5⅛″ wide x 3¼″ high x 5½″ deep, it uses modern digital circuitry to provide accuracy of a very high order with exceptional long term stability. The large ⅜″ high, seven-segment numerals can easily be read from a distance of more than 15 feet. Maximum count is one hour (59:59:9).

Three remote-mounted push buttons are used for manual control: START, STOP, and RESET. These buttons may be placed in a console, operating desk or any convenient location. The clock may be remotely located in the equipment, or on a desk or table. (A mounting flange is provided.)

Operation is similar to any conventional stopwatch. The green button starts the clock; the red button stops it. The black button resets it to zero. These may be depressed in any order, or all at once, without damage to the clock. If it is desired to start the clock by releasing a button rather than depressing one, the green and black button are pressed simultaneously. When the black button is released, the clock will start automatically.

The accessory plug on the rear panel may be used for all remote operations. All BCD information is available at this plug for accessory units such as digital printers, slave units, etc.

The Model T-1 is supplied for 120 volt 60 Hz operation, in an attractive simulated walnut grained enclosure with a red lucite face. However, 120-volt 50 Hz operation is available at no extra charge if so specified at the time you place your order.

The Model T-1 is priced at $185.00. As with all Timekeeper products, it is fully guaranteed to meet with your complete satisfaction, or your money will be promptly refunded. It is guaranteed for one year against any defects in manufacturing.

The Timekeeper Electronic StopClock is a must. More than a high quality timer—it provides the added convenience of full visual display, high accuracy and stability plus operational flexibility. Order one soon. You will be delighted with it.

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P.O. Box 835, Great Neck, N.Y. 11021

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On the other hand,
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*4' on axis with just 50 watts, with optional SEQ Active Equalizer. Response without equalizer, 40-18,000 Hz.

Both monitor systems share the same mid-range and high frequency speaker components. Both have tweeter protector circuits built in to save the systems from inadvertent damage. The Sentry IVA uses a dual-speaker, horn-loaded bass end for efficiency. The Sentry III uses a single speaker in a vented enclosure for extended range.

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