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THE SOUND ENGINEERING MAGAZINE

MAY 1974 $1.00

The First

COMING NEXT MONTH

• In OPAMPS FOR MIXING, author Roy H. Trumbull explains in simple language how to construct a non-interacting mixer for radio broadcast (and even recording studio) applications. His discussion centers on the use of operational amplifiers that can permit a 40 input mixer with only 1 dB of interaction between gain controls.

And in A MIC PREAMP-LIMITER, Ting Barrow discusses an inexpensive operational amplifier design that can function as a mic preamp limiter. It uses an opamp-ldr design from Opamp Labs of Los Angeles and is easily assembled.

The postponed db VISITS ORTOFON will appear. In this picture/text article you will see the manufacture of disc recording heads, as well as other components including tone arms and phono cartridges.

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

ABOUT THE COVER

• Page 26 of this issue has a report on the Copenhagen AES Convention by John Woram. The cover illustrates one of the audio fames that belongs to that Danish city. This is V. Poulsen's original magnetic recording device made by him before the turn of the century. The magnetic head ran on the overhead screw trolley producing a recording or play from a wire wound on the cylinder. Actual playing time was on the order of a couple of minutes. The photo was taken of the unit on display at the convention.

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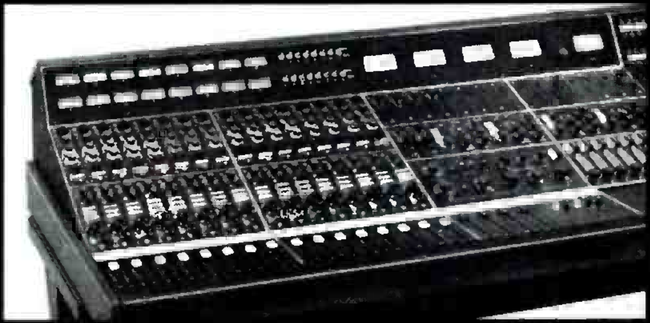

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letters

The Editor:

You perform a most useful service to the sound engineering community by publishing occasional tutorial articles. However, it seems to me that it is important that such articles use standard terminology, symbols and units, and that your editorial policy should be punctilious in this regard.

A case in point is the excellent article, THE DECIBEL, by A. Oscar Burke in the March, 1974 issue, in which centimeter-gram-second units were used. In *The International System of Units (SI)*, NBS Special Publication 330 (1972 edition), the standard unit of pressure is no longer the dyne (of the cgs system) but the newton of the metre-kilogram-second system, the force which gives a mass of one kilogram an acceleration of one metre per second. The corresponding unit of pressure is the pascal (one newton per square metre, N/m^2). However, the reference level for air acoustics has in fact remained unchanged in the current standard, reported as the American National Standard in *Preferred Reference Quantities for Acoustical Levels*, ANSI S1.8-1969, at 20 μPa (or 2×10^{-5} N/m^2). A further point is the use of a capital P for pressure; in American Standard *Letter Symbols for Acoustics*, ASA Y10.11-1953, reaffirmed 1959, the capital P is reserved for power and a small p is used for pressure.

These may seem to be small points, but the sooner we start using the current standards, if necessary in parallel with old ones, and particularly in educational articles, the less difficulty we will have later on.

Geoffrey L. Wilson
Associate Professor,
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Norman H. Crowhurst

THEORY AND PRACTICE

● Is language—English or any other —inadequate, or is it the way we people use it? Audio seems to be no more precise in its use of language than any other discipline. And a word that recurs to illustrate this is *linear.* What does it mean?

From its derivation, it is an adjectival form of *line*, usually by implication, a straight line. I still remember the days when, unless otherwise specified, the word *linear* had the implied noun, *frequency response,* attached to it. So a linear amplifier was one that responded uniformly to all frequencies.

This usage persisted, as I remember, even after equalization came on the scene, so that a system in which all the equalization was correct, according to what it was supposed to be, was linear. I suppose my point here is that in those days, linearity had nothing to do with distortion, in most people's minds. Linearity related to frequency response, and distortion related to what happened to waveform, at whatever frequency.

Back in those days, of course, transistors had not been heard of. There were various kinds of tubes, which seemed to be more efficient at cooking eggs than at producing audio output. So audio designers were really fighting the power battle quite hard in those days.

As well as stuffing extra grids into the tubes, to push up their efficiency, audio engineers were playing with different kinds of circuits. To distinguish between the way in which the circuits operated the tubes, particularly at the output stage, which was where power really counted, *class* designations were devised.

Designers of those days, not predicting that transistors would come along presently, sought to do something better with the inefficient tubes. In addition to having to heat the cathodes with quite a few watts, they found that the standing plate current when no audio was being delivered made possible several times the maximum audio that a pair of output tubes could deliver.

This was seen, by some enterprising designers, to be because both of a pair of push-pull output tubes had to be conducting plate current throughout the audio waveform. The plate current could go from its standing value, down to nearly zero, and up to about twice its standing value, for maximum audio output.

The reason for going to push-pull, so that one tube swung up in current when its mate swung down, had been to improve another kind of *linearity,* although at the time it had been regarded as reducing distortion. But the idea of *linearity of transfer* characteristic had begun to be mentioned, and thus the word linearity had begun to achieve a new meaning.

To give you some idea of what this meant, the maximum theoretical efficiency of such a push-pull output circuit was 25 per cent. That meant that to get 100 watts audio output, the plate dissipation of the output tubes

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would need to be 400 watts, exclusive of cathode heater power. As practical tubes were seldom better than 20 per cent efficient in this mode, an amplifier capable of delivering 100 watts audio (which would have been an extreme rarity) would have consumed a kilowatt, when you included heater power, power for the driver stages, and so forth.

The notion of *Class B*, introduced by designating the existing mode as *Class A*, improved possible efficiency quite a step. The idea was to bias each output tube so it conducted current during only one half of the audio waveform. One output tube handled one half of the audio waveform, and the other one handled the other half.

Nowadays, when solid state devices do that all the time, this idea does not sound like any great breakthrough. But in those days it was achieved with a considerable struggle. It was virtually impossible to design a power amplifier that did not use a rather husky output transformer to couple the audio output to the loudspeaker(s) it served.

You may still find some of the old tube amplifiers around. One of the best was the McIntosh. In it, the power transformer and the output transformer were about the same size, and accounted for more than 9/10th of the total weight of the amplifier. And that was a very marked improvement over most of that amplifier's predecessors.

Relative to use of the word *linear*, these high-efficiency amplifiers used the Class B way of getting more power from smaller tubes and, because each output tube did not amplify "linearly" as Class A had, we had another ambiguity creeping in.

The most efficient output tubes, just as tubes, were pentodes or beam tetrodes. By strapping various of the grids, except one, to either plate or cathode, such a tube could also function, must less efficiently, but much more linearly, in the sense of producing less distortion, as a triode. A given pair of output tubes might produce 50 watts as pentodes operated in Class B, or less than 10 watts as triodes operated in Class A.

Some rather smart engineers, whom some of us remember with a degree of affection and admiration, realized that those two modes of operation represented a sort of pair of extremes and that some compromise should be possible. So, with some skillful design work, they produced a special kind of output transformer, and a circuit to go with it, that operated pentodes or beam tetrodes in a sort of part way mode, between that of pentodes and that of triodes.

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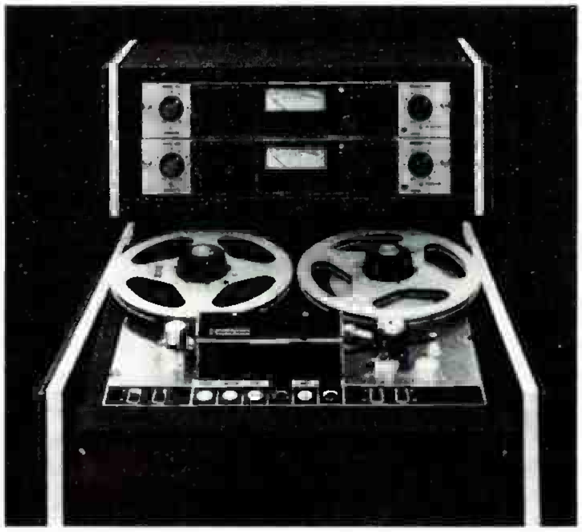

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The resulting circuit was called *ultra-linear,* because it achieved quite nearly the amount of power that pentode connection would achieve, with linearity, or freedom from distortion, not inferior to the Class A triode output. My point here is that this usage reinforced the application of the word *linear* to the over-all transfer characteristic, particularly how little the amplification distorted the shape of the wave. Before linearity came to describe this, other terms were used; usually frequency response was then said to be *flat.*

When transistors were invented, introducing a whole new world of *solid state,* it was a long while before they gained much acceptance for audio use, for a variety of reasons. They found their more immediate applications in new fields, not inhibited so much by what had gone before, mostly related to computer technology.

In computer parlance, such devices can be built into one of two kinds of computer (not to mention hybrids): digital or analog. In digital use, they worked essentially like the much more cumbersome mechanical calculators that went before them, by discrete number intervals. Analog used continuously variable quantities, requiring circuitry that could function with such variables.

Adoption of the binary number system for digital use meant that individual elements, transistors or whatever, within the system, either conducted fully or did not conduct at all. They were used strictly as *two-state* devices. All kinds of logic circuits were built up around this digital process.

In contrast, a computer where intermediate values produce some kind of intermediate output results rather than a set of either/or alternatives (no matter how many bits the latter might employ) needed its components, transistors, etc., to be operated in what was called a *linear* mode. While this was related in the sense of a transfer, to the last audio usage of the word we introduced, it was not quite the same thing.

In the early days of transistors, *linear,* in the computer sense, would not have been anywhere nearly as good as an audio man expected, which was one reason why transistors took so long finding their way into audio. But nowadays the boot is on the other foot. Linear, for computer application, refers to compound devices, often using a number of transistors on an integrated circuit chip, having a degree of linearity that would put the best performance ever achieved by a tube amplifier hopelessly to shame.

Viewpoints and definitions change. About twenty years ago, soon after I came to this country, I was invited to serve on an IRE (now IEEE) committee, one function of which was to review definitions. The chairman would read a definition, or have us do so to ourselves, and then ask if any of us saw any need of a change of wording to update it.

After a little while, I began to feel "antsy." So at one particular well-known definition (although I forget what it was) I summoned up my courage. I told them that, probably like them, I had learned this definition in engineering school, but did not understand what it meant, then or now, although I felt I used the word correctly from familiarity with its use. I suggested that if someone could explain what the definition meant to me, I would volunteer an opinion as to whether it needed changing.

That comment started a table round of confessions. It appears that nobody really understood the term, although each could parrot it, given the occasion. And until I spoke up, each felt that maybe he was the only one dumb enough to have difficulty with it, so kept quiet.

I had forgotten that incident completely until recently when, after taping a program in which I participated with a panel discussing facets of education, the director said he had heard a marvelous definition of an *intellectual*—"a person who has been educated beyond his level of comprehension."

That definition brought the experience to mind, as illustrative of it. I have since related the same definition to others I have met, in different professions and, without exception, it seems that our professions are loaded with people who fit that definition.

Recognizing that this is so is a big step toward changing it. It is high time that we abandoned this pseudo-intellectual snobbery, and started a move towards establishing something often talked about, "intellectual honesty," by the process of practising it. Admitting that some of our commonly used terms are pretty fuzzy in meaning to a lot of people and then endeavoring to clarify meanings is one way of improving communication among those who work in audio. ■

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Martin Dickstein

SOUND WITH IMAGES

Light and Lenses

• Except for some special setups, every projector, camera, telescope, microscope, and every pair of field glasses, eye glasses, and eyes makes use of a lens somewhere in its construction. In some cases, the lens spreads the light, while in others the light rays are concentrated. In each instance, though, light is bent, the amount and direction depending on the shape, and construction of the lens and the incident angle of the light. Photographers and audio-visual specialists are pretty well aware of which lenses do what and when, what the various terms describing lenses mean, and when a particular lens will be best for a specific purpose. Whether you are in, or close to, the audio-visual field, it might be well to review some refresher information and maybe have some new facts come to light (no pun intended).

Before getting into lenses, and how they work, it is necessary to recall a few things about light. Light is defined as the radiant energy capable of affecting the eye to produce vision. Although the total spectrum of radiated energy is rather wide, the range that light covers is quite small. The full range of radiant energy actually extends from a wavelength of 10^{-14} (a fraction consisting of a 1 over a 1 followed by 14 zeros) to 10^{7} (10 million) cm. The color spectrum visible to the eye is in the very narrow band, extending from 0.4 to about 0.7 *microns* (indicated with the Greek letter mu [μ] and equal to 1/10,000 of a cm.) Another term used frequently to measure wavelengths in the range of light is the *angstrom* which is equal to 10^{-8} cm. per angstrom unit and indicated by Å. Light is in the 4,000 to 7,600 Å range. It might be of interest to note that within this band there is maximum visibility at 0.56 microns, or just about at the yellow line of the rainbow. Similar to the Fletcher-Munson curves for the ear, there is also a standard luminosity curve which shows that the eye responds to colors from the violet/ultra violet line (0.4 microns) to the deep red (0.7 microns) in a curve resembling a single humped hill and looking like an average distribution curve in statistics.

Although light can be seen, just what it is can still raise a bit of discussion. Sure, it travels at the presently accepted maximum speed of the universe of 186,000 miles per second, but it has been found that light requires two different ideas to explain how it acts. One theory was that light consisted of particles (photons) and the other that it moved in waves. Both are used to explain different phenomena, but it has just been proven that light is also electromagnetic in nature and will bend as it passes a gravitational field. Normally, light travels in a straight line, it can be reflected, diffracted (with a narrow grid grating) and it can be refracted, or bent. It is the last characteristic that is of interest when considering lenses.

Since the calculated speed of light is normally assumed to mean travelling through a vacuum, any other medium would slow light down. Materials are classified by an index number which indicates the relationship of light speed in vacuum to the other material. For example, glass, depending on its composition, has an index somewhere between 1.5 and about 2.0. This would mean that light travels at about 1.5 to 2.0 times as fast in free space as through glass. When a ray of light hits a flat piece of glass at some incident angle, then, the light will bend toward the norm or axis perpendicular to the glass, and then speed up again as the ray goes out the other side. Water has an in-

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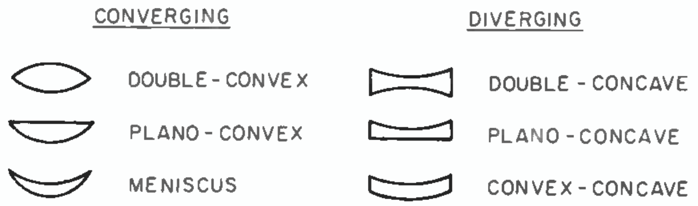

Figure 1. Different types of lenses.

dex of 1.33, which would indicate why a straight object like a pencil looks bent when stuck in a glass of water. (CHART 1)

It was the same principle of refraction which allowed Newton (famed for supposedly having an apple hit him on the head while he was sitting under the tree) to break up white light with a prism into the familiar rainbow. It is also this same phenomenon which allows the eye to see. The eye is a very complex lens, through which light passes. As you read this, six tiny muscles move each eye across the page. Others control the size of the opening through which light passes to compensate for the brightness of the light. The image is focused (by other muscles) inside the eye and is then carried by 130,000,000 nerve connections to the brain. The image inside is actually upside down, characteristic of a lens, but the brain has learned in early infancy that the object is not really upside down, so it compensates automatically. The brain also realizes that although the image is focused inside the head, the object is actually outside and again compensates, automatically. If the muscles become inefficient and the eye can't focus sharply, other lenses (spectacles) can be added to the seeing system to reestablish proper image focusing.

All projectors make use of several lenses in combination to allow sharp focusing of the image on a screen. Lenses generally come in six shapes as shown in FIGURE 1. With *convex* meaning "belly out" and concave indicating "belly in," the six different lenses can be identified easily. (FIGURE 2) Rays of light entering anywhere but directly on the center axis will be bent out of line at an angle depending on the curvature of the lens. The same will be true when the ray exits from the lens, but the direction of bending will now depend on the shape of the other side.

In addition to their shape, lenses can also be defined according to what they do to rays of light. If the rays come together as they leave the lens, the lens is the *converging* type and the focal length is positive, while the *diverging* lens has a negative focal length. The former is typical of the convex type and is used most frequently.

Chart 1. Some typical materials and their relative indices of refraction.

Air	1.0003
Carbon Dioxide	1.0004
Water	1.3330
Diamond	2.417
Glass (crown)	1.48 to 1.61
(flint)	1.53 to 1.96
Ice	1.31

The quality of lenses is judged by their ability to pass light evenly throughout their surfaces, their sharpness, the evenness of their focusing capability, and their ability to pass color without distortion. A characteristic of poorly made lenses is that the image will vignette, or fall off at the edges, because all the light is not coming through evenly, but is being cut off by poor construction of the lens at the ends.

Some words that are well known by most people in their applications are probably vague in definition. Here are some for quick reference. These are not all the terms used in optics, not by a long shot, but a brief review of these common terms might be clarifying.

Aperture—
A number designating the ability of the lens to pass light.

Back focus—
Distance from the rear of a lens to the focal plane.

Depth of Field—
Distance between the nearest and farthest points within which all objects will be in focus.

C-mount—(16mm & T.V.)—
The lens mount with 1-inch outside diameter, 32 threads to the inch, with a 17.5 cm. distance between the flange of the lens to the focal plane.

f/number—
Light-passing capability given in a number determined by dividing the focal length by the diameter of the axial beam. The lower the number, the greater amount of light is passed.

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Circle 40 on Reader Service Card

AUDIO FREQUENCY ANALYZER

• Tunable band pass, band stop, low pass, and high pass filters can be push-button selected in the Type 2121 frequency analyzer. The unit features active filters wtih four bandwidths, selectable between one percent and ⅓ octave, which can be tuned through the frequency range from 20 Hz to 20 kHz. When connected to a condenser microphone, the analyzer can be used as a sound level meter and, connected to a vibration transducer, vibration analysis can be performed. The voltage measuring range is from 10 uV to 300V rms. Other features include an A-weighting network; automatic frequency sweep when controlled by a level recorder type 2305 or 2307; interchangeable meter scales.

Mfr: B & K Instruments, Inc.
Circle 42 on Reader Service Card

AUDIO LEVEL OPTIMIZER

• A unique gating circuit in Model 220 inhibits compression release in the absence of an input signal and is claimed to eliminate background noise present with conventional limiters. This automatic gain device, which features selectable peak limiting and average compression functions, is designed for am, fm, and t.v. broadcasting. A frequency selective function is optional. For dealing with extended program interruptions, the user may have Model 220 hold gain indefinitely at the previously compressed value, hold gain for ten seconds and release, or hold gain for ten seconds and fade. Resumption of the program restores normal operation.

Mfr: Inovonics, Inc.
Price: $680.
Circle 41 on Reader Service Card

PROFESSIONAL AUDIO RECORDER/REPRODUCER

• Motion sensing on the AG-440C transport eliminates the problem of switching from fast forward-rewind to play. Edit control on the unit releases transport brakes, eliminating handling of the tension arm. Newly added sapphire guides and an improved flutter idler reduce skew, improving tracking. Automatic switching is incorporated in the Sel-Sync mode; the output switches automatically from monitoring Sel-Sync to monitoring input when a channel being reproduced in Sel-Sync is put into record. Switch-controlled two line output impedances, 600 ohms or 150 ohms, are incorporated along with a plug-in etched board; meter sensitivity for +4 dBm or +8 dBm output line is selectable by a switch. Space for a fourth head is provided for a four-track stereo head, single track head, or any other special purpose record or reproduce head. Head assemblies are easily replaced with full access for editing, cleaning or demagnetizing. AG-440C is available in full-track, two-track, and quarter-track configurations for ¼-inch tape and a four-track configuration for ½-inch tape. Portable or console models or unmounted machines for rack installations are available. AG-440-8 is an eight-track capstan-servoed version that handles 10½-inch reels of one-inch tape. All parts are easily accessible for maintenance.

Mfr: Ampex Corporation
Price: $2,585-$9,950
Circle 43 on Reader Service Card

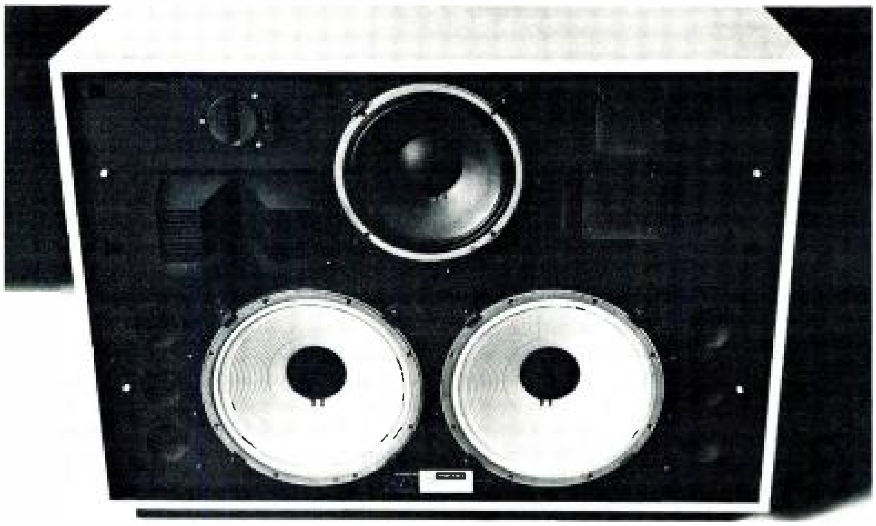
DIGITAL DELAY SYSTEMS

• Delta-T 102, with a dynamic range of 90 dB, is claimed to minimize the constant critical adjustments necessary to avoid undesirable low and high level effects which commonly plague digital delay devices offering a 55 to 75 dB dynamic range. The unit is capable of providing high quality audio signal delays of up to 320 ms per delay unit. It contains one to five delay outputs, each independently adjustable on the front panel; a 5-position led headroom indicator verifies correct operating settings; it is of fully modular construction. Additional slave units may be cascaded for long delay requirements with no degradation of audio output. According to the manufacturer, the proprietary processing techniques utilized in the series will create a system having a 15 bit dynamic range at a cost level of present 10 and 12 bit systems. The system consists of a main frame unit into which up to eight delay (memory) modules and up to five output modules may be inserted. A fail-safe bypass option provides a direct path from the input connector to each output when power is turned off or removed from the main frame, making unnecessary the need for an external bypass panel for handling emergency situations. A remote console option is also available. Completely linear performance from the system noise level up to the limit level is claimed, insuring maximum fidelity with wide dynamic range sources. Delta-T has been found useful in large auditoriums, permitting multiple speaker locations to be acoustically synchronized. In recording studios, it allows the simulation of theater acoustics by introducing delays of various lengths which are fed back to the mixing console, both directly and through reverberation devices.

Mfr: Lexicon

Circle 44 on Reader Service Card

Nobody ever made a monitor that could match this sound.



Type of System	4-way
Components	(2) 15" low frequency loudspeakers (1) 12" midrange loudspeaker (1) High frequency compression driver with horn lens (1) Ultra high frequency compression driver
Frequency Response	30 to 20,000 Hz ± 3dB
Sensitivity (SPL at 30' lmW)	46.5 dB
Power Output (SPL at 10 ft. in a room volume of 2000 cu. ft. with 1/2 rated power input —150 watts)	110dB
Crossover Frequency	250, 1100 and 9000 Hz
Size	35"x48"x20"
Net Weight	243 lbs (110 kg)
Configuration	Bi-amplification only
Price	Utility finish shown $1314 Walnut finish $1464

The 4350. Three years ago JBL's technical staff was asked to produce the best studio monitor that technology and artistry could create. That was their total assignment. Considerations of cost and monitor size and studio application were secondary. The search was for a sound. The name was 4350. Its birthday was April 13, 1973. And, from the day it was born, it was the best sounding studio monitor money could buy:

A virtually flat frequency response from 30 to 20,000 Hz. Minimum phase shift throughout the entire band pass. Extraordinary response to onset and transient signals. Carefully controlled, semi-diffuse dispersion pattern throughout the frequency range. Uniform sound characteristics from *ppp* to *fff* dynamic markings. Extremely low transducer distortion within the recommended dynamic range values of more than 90dB. High sensitivity for maximum conversion efficiency.

But, wait. A spec is not a sound. Come hear the 4350 and see how far sound can go.

Circle 22 on Reader Service Card

James B. Lansing Sound / Professional Division / 3249 Casitas Avenue, Los Angeles 90039

Until now.

	The 4340/41	The 4332/33	The 4330/31
Type of System	4-way	3-way	2-way
Components	(1) 15" low frequency loudspeaker (1) 10" midrange loudspeaker (1) High frequency compression driver with horn lens (1) ultra high frequency compression driver	(1) 15" low frequency loudspeaker (1) High frequency compression driver with horn lens (1) Ultra high frequency compression driver	(1) 15" low frequency loudspeaker (1) High frequency compression driver with horn lens
Frequency Response	35 to 20,000 Hz ± 3dB	35 to 20,000 Hz ± 3dB	35 to 15,000 Hz ± 3dB
Sensitivity (SPL at 30' lmW)	44dB	44dB	44dB
Power Output (SPL at 10 ft in a room volume of 2000 cu ft with 1/2 rated power input—37.5 watts)	101dB	101dB	100.5dB
Crossover Frequency	250, 1250 & 9500 Hz	800 and 8500 Hz	800 Hz
Size	38"x24"x20"	30"x24"x20"	30"x24"x20"
Net Weight	179 lbs (81 kg)	121 lbs (55 kg)	96 lbs (44 kg)
Configuration	for bi-amplification or with high level network	for bi-amplification or with high level network	for bi-amplification or with high level network
Price	to be announced	to be announced	to be announced
Availability	June 1974	June 1974	June 1974

Four monitors. Virtually one sound. A matched set: you could record on one, play back on another, mix on a third and master on a fourth.

Four monitors. Their only differences are acoustic output, cost and size.

Hearing is believing. Come hear what you can do.

JBL

DON DAVIS

Impedance Matching for the Sound Engineer, part II

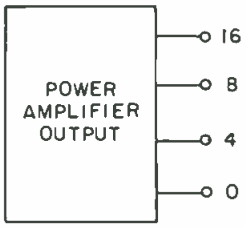
This is the concluding segment of this work begun in the last issue. It concludes with further information of basic value to every audio man that is involved with interfacing of different components.

When involved in the everyday matching of a loudspeaker to an amplifier, knowledge of where the *lowest* point is in the impedance curve becomes important. One major manufacturer of musical instrument loudspeakers deliberately quoted a higher value of zeta by two-to-one to sound, as if their loudspeaker was more sensitive than one of their competitors, who had an honest Z specification.

Ask yourself, is the higher output of one loudspeaker you hear really greater resulting from sensitivity, or is the impedance rating phony?

Unfortunately, just the connection of a loudspeaker with a specified zeta to a power amplifier with the same impedance tap available is not as straightforward as it might appear. What if you want a four woofer system? For example, suppose the four woofers are 8 ohms each (a common case nowadays due to transistor amplifiers). Two of them are in parallel = 4 ohms and four of them in parallel = 2 ohms. But, your amplifier has only 4, 8 and 16 ohm taps. By connecting to the 8 and 16 ohm taps (no connection to the common or "0" tap) you get approximately 1.4 ohms, which is safely below the 2 ohms required, yet still close enough to deliver adequate power to the loudspeakers. Connecting across the 4 ohm and 8 ohm taps gives less than 1 ohm. Now connect sixteen 16 ohm loudspeakers or eight 8 ohm loudspeakers in parallel without the need of 70 volt transformers.

Another approach for twenty-plus dollars is to buy a high quality autoformer and "step up" the 2 ohms back to 8 ohms. Figure 14 details all the available impedances at the output of a conventional amplifier output transformer and all available impedance ratios a typical high quality autoformer allows.



Z_H = HIGHER Z TAP
Z_L = LOWER Z TAP
Z_X = Z ACROSS TAPS

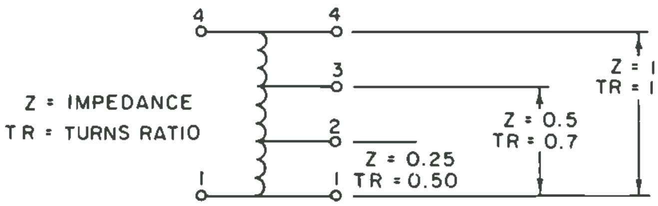
$$Z_X = \left[\sqrt{Z_H} - \sqrt{Z_L}\right]^2$$

NOTE: DCR $\leq .05 Z_X$

AVAILABLE IMPEDANCES FROM TYPICAL AMP.

CONNECT TO	IMP.
0 & 4	4Ω
0 & 8	8Ω
0 & 16	16Ω
4 & 8	0.686Ω
8 & 16	1.373Ω
4 & 16	4Ω

(A)

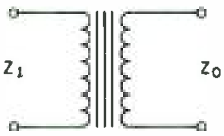


	T.R	IMP.
TERM. 4 TO TERM. 3	0.3	0.09
TERM. 4 TO TERM. 2	0.5	0.25
TERM. 4 TO TERM. 1	1.0	1.0
TERM. 3 TO TERM. 2	0.2	0.04
TERM. 3 TO TERM. 1	0.7	0.5
TERM. 2 TO TERM. 1	0.5	0.25

(B)

Figure 14. Calculating and matching output impedances at (A) and autoformers for impedance matching at (B).

(COURTESY CECIL CABLE, CECIL CABLE & ASSOC.)



$$Z_I = \left[\frac{\text{TOTAL AMPLIFIER POWER}}{\frac{\text{POWER TO SPKR}}{} + \left(\text{POWER TO SPKR} - \left(\frac{\text{POWER TO SPKR}}{10\ \text{EXP}\left(\frac{\text{INSERTION LOSS}}{10}\right)}\right)\right)}\right] \times \text{AMP } Z$$

EXAMPLE

AMPLIFIER'S POWER OUTPUT = 200 WATTS
AMPLIFIER'S OUTPUT IMPEDANCE AT 70 V = 25Ω
EACH LOUDSPEAKER CONNECTED TO 25 WATT Z_o TAP

IF INSERTION LOSS WERE = 0 dB THEN:

$$Z_I = \frac{200}{25} \times 25 = 200\Omega$$

$$\frac{Z_I}{\text{AMP } Z} = \#\text{ OF UNITS} = \frac{200\Omega}{25\Omega} = 8 \text{ UNITS}$$

IF INSERTION LOSS WERE = 2 dB THEN:

$$Z_I = \left[\frac{200}{25 + 25 - \left(\frac{25}{10\ \text{EXP}\ \frac{2}{10}}\right)}\right] \times 25 = 146.09\Omega$$

$$\frac{Z_I}{\text{AMP } Z} = \#\text{ OF UNITS} = \frac{146.09\Omega}{25\Omega} = 5.84 = 5 \text{ UNITS}$$

Figure 15. Accounting for the insertion loss of a 70-volt transformer.

IMPEDANCE MATCHING 70 VOLT LINES?— THAT'S RIGHT.

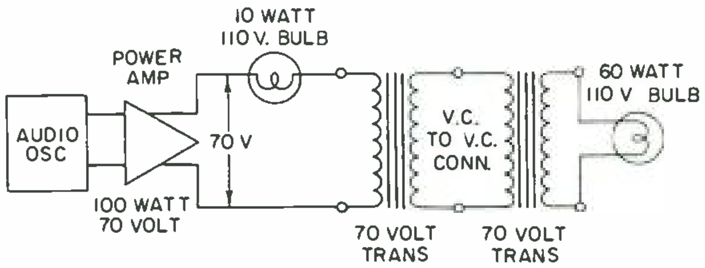
We are taught in our innocence that if we use the magic 70-volt system all that needs to be done is to ascertain the total power available from the amplifier and be sure not to exceed it when we add on each transformer and assign so many watts to the voice coil attached to its secondary. Just pick power on the primary and voice coil impedance on the secondary and keep adding them up until all their powers equal the total power available. A panacea? Unfortunately, no. 70-volt distribution systems have garnered a reputation for poor quality out of all proportion to the simple reasons why this occurs. First of all, this simplified method forgets to account for *possible insertion losses* of the transformers themselves.

FIGURE 15 details an example where a 2 dB insertion loss drops the available units that can be connected from 8 to 5. (Obviously, you can't hook on 0.8 of a unit.) Usually line losses are ignored as well. Therefore, it is almost positive that connecting an impedance bridge to a 70-volt system will result in reading an impedance *lower* than the rating of the amplifier. This is why the low impedance, no transformer, method mentioned above is attractive where you buy heavier copper instead of transformers.

REACTIVE TRANSFORMERS

As if things weren't bad enough, the majority of 70 volt transformers offered are of poor quality and highly reactive at lower and higher frequencies. An eye opening test is to take any two identical transformers you commonly use and wire them "back to back" from voice coil to voice coil. Connect one of the 70-volt windings to the 70-volt output of a 100-watt power amplifier. Connect the other 70-volt winding to a standard 110 V a.c. 60-watt light bulb. Put a small 10-watt bulb in series with the line coming from the power amplifier. Connect an audio oscillator to the input of the power amplifier. Setting the oscillator to 1,000 Hz, adjust the amplifier gain until the light bulb lights up to just below normal brightness (70 volts). The small bulb will either not light or be very dim.

Figure 16. The construction of a transformer truth box.



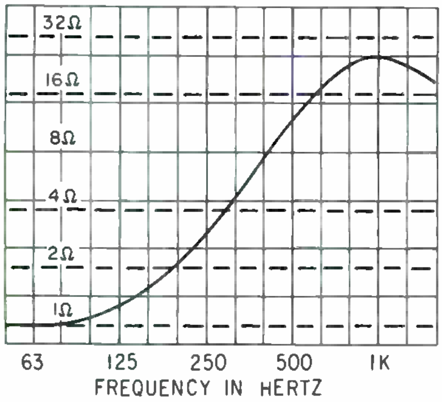


Figure 17. What can happen with certain transformers.

Figure 18. A 70-volt distribution illustrating typical impedances encountered.

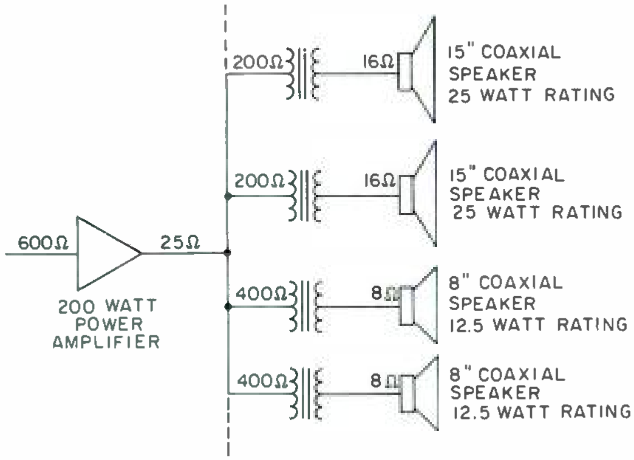
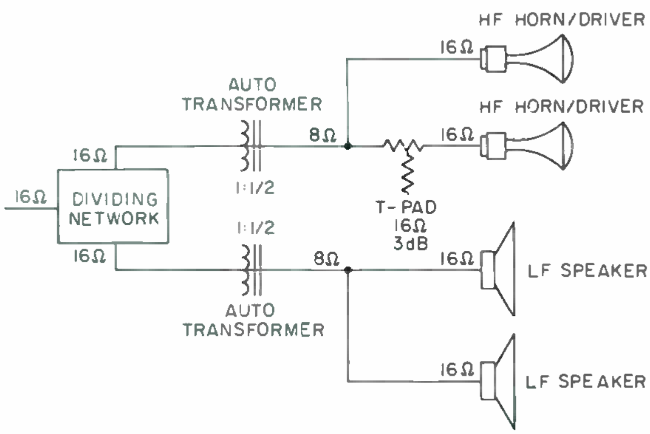


Figure 19. Handling typical crossover network termination.



Now, sweep the audio oscillator down in frequency. As the frequency lowers, the large bulb will go out (no power being delivered to the load) and the small bulb will glow brighter and brighter until it may burn out. (The transformer's reactance has caused the equivalent of a short circuit of the amplifier's output.) See FIGURE 16 for the details of this fascinating demonstration.

At about this point, you begin to appreciate what these transformers are doing to the amplifier every time the program material contains any bass power. That this condition is all too prevalent is shown in FIGURE 17, where the impedance by frequency of a nameless but popular 70-volt transformer is concerned. If the author's experience is any guide, some poor amplifier manufacturer is being blamed by the users of these transformers for making unreliable amplifiers that burn up too easily. The only safe recourse for the amplifier manufacturer is to raise the cost of his units to the level where he can afford to build in the capability to work into a short circuit without damage. Much design time and money is wasted in this manner because sound engineers won't, don't, or can't measure impedance correctly.

FIGURE 18 illustrates a typical 70-volt distribution sys-

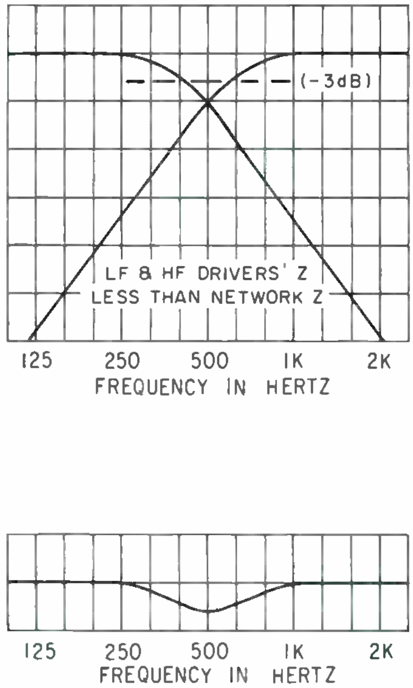


Figure 20. The resultant difficulties of using an autoformer wrong.

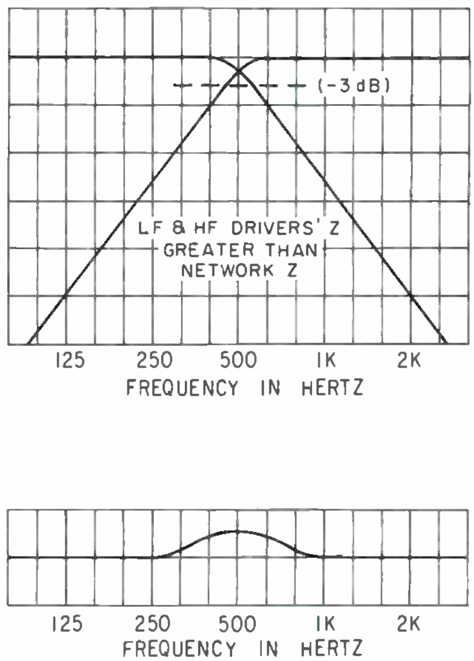
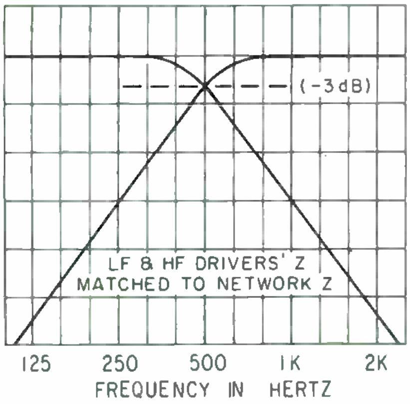


Figure 21. The same problems as in Figure 20.



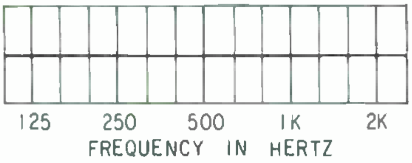


Figure 22. The same problems as in Figures 20 and 21.

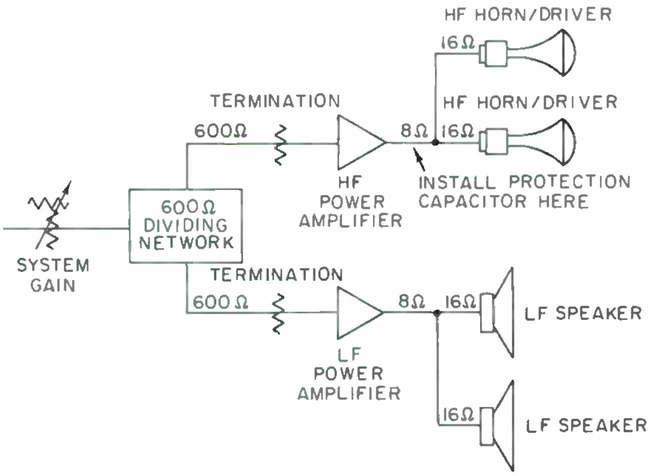


*Figure 23. The handling of typical bi-amplification network terminations. *The typical value for a 250 Hz rolloff = 50 μFd.*

tem and indicates how the powers chosen are actually impedance choices. In high quality transformers, the insertion loss is compensated for in the windings; therefore, the loudspeaker actually receives the power indicated. In most cheap units, the power indicated on the label is not the power received, hence the dB-SPL falls lower than calculated. This means that each transformer draws slightly more power from the line than is indicated and that the final impedance will be too low if an attempt is made to add up powers equal to the amplifier's power.

MATCHING CROSSOVER NETWORKS TO DRIVERS

Still another area of unhappy impedance experiences is that of failing to insure that each leg (high frequency leg and low frequency leg) of a crossover network is properly terminated. (See FIGURE 19.) All too frequently, the autoformers are used as level adjusters rather than as impedance matchers, with the resultant difficulties chronicled in FIGURES 20 and 21, as compared to the desired result in FIGURE 22.

BIAMPLIFICATION SYSTEMS

FIGURE 23 represents a typical biamplification system. Some hard won rules are:

1. Be sure the input to the passive 600 ohm crossover is correctly built out.
2. Don't forget to put a passive level control in front of the line level crossover network because the amplifier gain controls are no longer available for that purpose—they are now "balance" controls.
3. Don't forget to provide protection against low frequencies out in the high frequency driver line about one octave *below* the crossover frequency of the 600 ohm passive network used back in the link circuit. This is often a simple capacitor of the non-polarized, oil-filled motor starting variety. This saves the high frequency drivers if catastrophic amplifier failure occurs.

MINIMUM LOSS MATCHING PADS

FIGURES 24, 25, and 26 give, in full detail, the construction of minimum loss matching pads for unequal impedances. FIGURE 24 shows conventional minimum loss pads for matching 500 ohms to 200 ohms; FIGURE 25 illustrates the design of an improved impedance correcting circuit for matching impedance when internal output impedance is higher than load impedance. And, FIGURE 26 gives the design for the reverse situation. If a loss greater than the minimum loss calculated for these pads is desired, then a conventional loss pad may be added to them.

Ralph W. Townsley's exceptionally fine book on this subject is a must for any serious student of impedance matching and passive networks: *Passive Equalizer Design Data*, published by Tab Books.

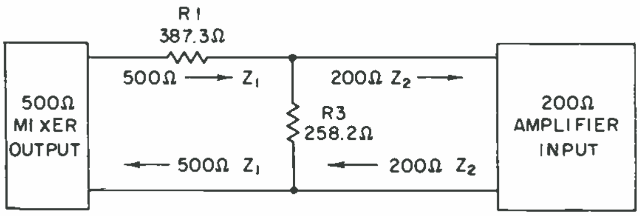
HYBRID TRANSFORMERS

Telephone companies, motion-picture dubbing console constructors, and knowledgeable sound engineers use hybrid transformers to obtain impedance matching to long telephone lines, studio lines, etc. FIGURE 27 illustrates the useful properties of these units.

Hybrid transformers allow interesting signal divisions and combinations while maintaining impedance matching between differing circuits.

A signal arriving at the lower left termination of the schematic in FIGURE 27 will be transferred to the upper load and none of this signal will appear in the lower right termination. If the signal arrives at the lower right termination, it will be transferred to the upper load also and none of it will appear at the lower left termination. In order to obtain these characteristics, the balancing resistor connected to the center point of the transformer winding must be set to the proper value, relative to the upper termination. (In the case of long transmission lines with complex impedances, precision balance networks can replace the balance resistors. Impedances of 300, 600, 900, 1200, etc., are routinely handled by readily available hybrids.)

To better understand the operation of this device, let's have a signal originate from the lower left and assume the impedance looking into 11-12 to be exactly equal to the value of the 600-ohm balancing resistor. If this is so, then the voltage drop from 12 to 11 will be exactly duplicated across 9 to 7, which would *seem* to induce a voltage in the circuit of the lower right termination. This is not the case, however, since this voltage is exactly equal but opposite in phase to the drop across the balancing resistor. Therefore, *no voltage is available to cause current flow* through the lower right termination. One-half the voltage (−6 dB) is lost in the resistor; therefore, the signal being transferred to the upper load is at −6 dB.



$(Z_1 > Z_2)$

$$R1 = Z_1 \sqrt{1 - \frac{Z_2}{Z_1}} \qquad R3 = \frac{Z_2}{\sqrt{1 - \frac{Z_2}{Z_1}}}$$

LOSS = 8.96 dB

$$dB = 10 \text{ LOG } \left(\sqrt{\frac{Z_1}{Z_2}} + \sqrt{\frac{Z_1}{Z_2} - 1} \right)^2$$

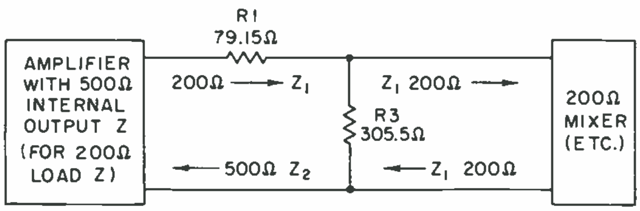
Figure 24. Conventional minimum loss pad for matching 500Ω to 200Ω.

In the case where the signal comes into the hybrid through the upper termination, the two lower loads can be considered in series and consequently, no voltage appears across the balancing resistor. Therefore, there is no voltage loss in transmission. However, because of the equal division of the upper signal between the lower right and the lower left loads, each will receive one half the power or − 3 dB less than the original.

CONCLUSION

I have touched upon the basics of impedance measurement, calculation, matching, and transformation. I have not covered the real complexities that a professional transmission engineer, for example, wrestles with. But I have dealt with the areas of greatest aggravation for the average sound engineer. It is hoped that this start into the

Figure 25. An impedance correcting pad for matching impedance when internal output impedance is higher than load impedance.



$(Z_2 > Z_1)$

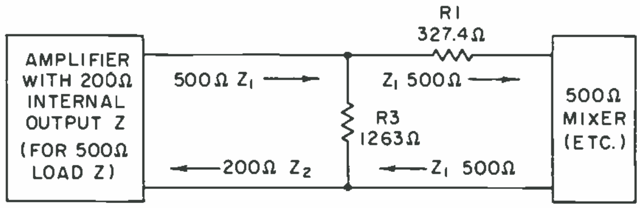
$$R1 \quad \frac{Z_1}{\sqrt{\frac{Z_1 + Z_2}{Z_2 - Z_1}} + 1} \qquad R3 = Z_1 \sqrt{\frac{Z_1 + Z_2}{Z_2 - Z_1}}$$

PAD INSERTION LOSS = 4.38 dB

$$dB = 20 \text{ LOG } \frac{\left(\frac{Z_1 \cdot R3}{Z_1 + R3} \right) + R1}{\left(\frac{Z_1 \cdot R3}{Z_1 + R3} \right)}$$

MISMATCH LOSS = .88 dB

$$dB = 10 \text{ LOG } \frac{(Z_1 + Z_2)^2}{4 Z_1 \cdot Z_2}$$



$(Z_1 > Z_2)$

$$R1 = Z_1 \sqrt{\frac{Z_1 - Z_2}{Z_1 + Z_2}} \qquad R3 = Z_1 \left(1 + \sqrt{\frac{Z_1 + Z_2}{Z_1 - Z_2}} \right)$$

PAD INSERTION LOSS = 4.37 dB

$$dB = 20 \text{ LOG } \frac{Z_1 + R1}{Z_1}$$

MISMATCH LOSS = .88

$$dB = 10 \text{ LOG } \frac{(Z_1 + Z_2)^2}{4 Z_1 \cdot Z_2}$$

Figure 26. An impedance correcting pad for matching impedance when internal impedance is lower than load impedance.

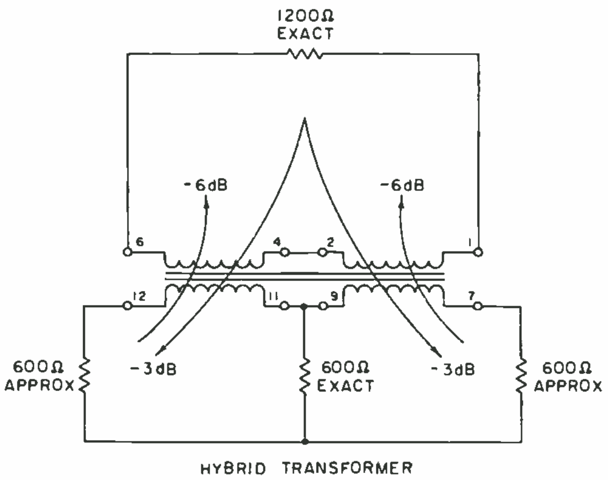


Figure 27. A hybrid transformer.

subject will help many engineers and technicians to take the big step and get involved. You won't run out of interesting, useful, and fascinating material with which to work. ■

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JOHN WORAM

The AES Convention in Copenhagen

The 47th AES Convention was held in Copenhagen, Denmark this past March. This is a report on the European audio equipment shown.

THIS MAGAZINE has always tried to keep its readers informed on the latest goings-on in the audio world, and when it was announced that the 47th Audio Engineering Society convention was to be held in Copenhagen, Denmark, it didn't take much effort to convince myself that it was my solemn duty to attend. After all, how often does one get to take a business trip to Copenhagen? These opportunities don't come along every day you know.

For many of us, the convention began at New York's Kennedy International Airport, where passengers are sorted, crated, and shipped to all parts of the world in a style reminiscent of a bad day at the Chicago stock yards. Nevertheless, the A.E.S. had arranged a package deal—round trip air fare, six nights in the hotel, and breakfasts; all for $410! At that price, I'm surprised the entire USA membership wasn't on board. Anyway, we all survived the departure lounge and were soon on our way.

What with jet lag, culture shock, and fatigue, I was quite unprepared for my first encounter with the Danish audio industry. As we moved toward the baggage claim area, a few announcements came over the airport p.a. system. Yes, I know that every airport has a p.a. system, but this one is really wierd! I don't know what sort of nut designed it, but you could understand every word that was spoken. What a strange sensation!

Perhaps we should send some good old American know-how over there to show them the right way of doing things. Everyone knows you're not supposed to understand airport announcements. It takes the romance out of flying

John Woram is our regular monthly columnist and our associate editor. His column will reappear in its usual place next month.

The Tore Seem (Norway) console.

One of the several Triad consoles shown.

The Lyrec 2-inch tape deck

The Philips custom console built for Scottish t.v.

when you know just when and where your departure is.

Well, I suppose it's a valid approach, but it'll never catch on in this country.

The convention site was the modern Hotel Scandinavia, which certainly had some off-beat ideas about how to treat American guests. The hotel staff actually pretended that our arrival was not an imposition on their time. There were widespread rumors of chambermaids smiling and saying good morning. Even more puzzling, the hotel restaurant served real food. Of course the real shocker came on the last day, when I noted an overcharge on my bill for a meal I didn't remember having. The desk clerk apologized, and said it must be an error, for I should certainly know best how many meals I had. Now what sort of way is that to treat a paying guest?

American visitors got a chance to see a lot of equipment that is not exhibited here. For instance:

TAPE RECORDERS

From Denmark, the Lyrec Company displayed their 2-inch multi-track studio tape recorder. The transport is quite compact, and appears to be very well engineered. Sorry I can't be a little more specific, but this machine and most of the other items mentioned here are new to me. I suggest writing to the manufacturers for more specific information. The addresses are listed at the end of the column.

The Schlumberger tape recorder? I'd not even heard of this outfit before, yet there they were with a tape recorder, turntable, and recording console. The tape recorder looks impressive. The transport is built on a cast aluminum machined deck which appears quite solid. There's a small amplifier and speaker built into the deck frame which should be great for quick edits, cueing, and such. The standard model is full track only (?) but is available in half-track format on request.

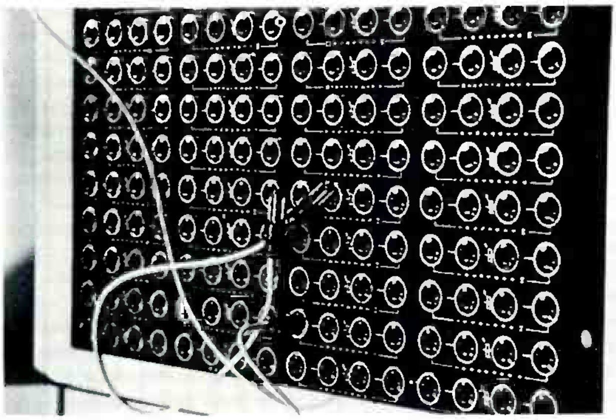
CONSOLES

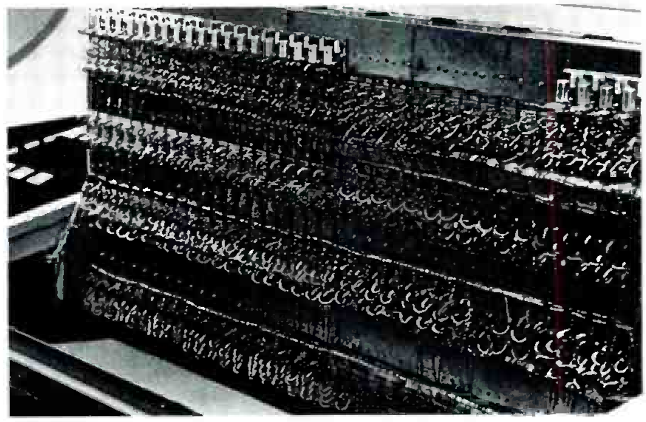
Philips brought in their 40 channel console, custom built for Scottish TV, Glasgow. Despite the complexity, the console is quite compact, with a wrap-around frame construction that gives the operator a fighting chance to stay in touch with the console extremes.

The Helios people—also known for their wraparound consoles—had some modules on display at their booth. In addition, the Helios-equipped Island Studios mobile van was on hand just outside the hotel. Helios has placed their equipment in many notable London studios (and elsewhere of course) and I hope that before too many moons, I shall get a chance to see, and report on, some of them.

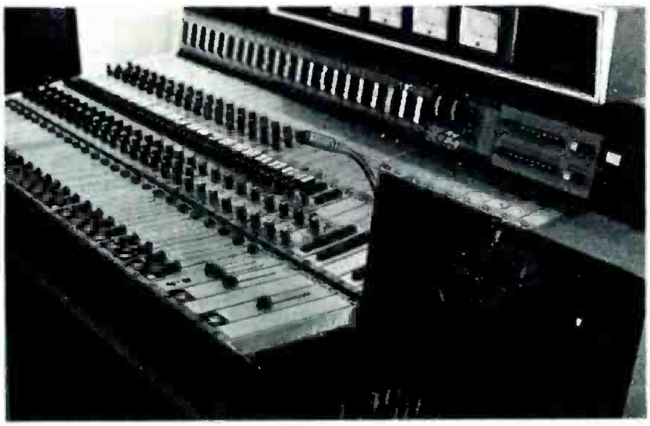
The T.E.A.M. mobile van was also on the lot. This one features a 54-in.(!), 16-out A.P.I. desk. A.P.I.'s Lou Lindauer tells me that negotiations are under way to send the van to Poland this summer for the Sopot Jazz Festival. I've heard reports of this annual event, which seems to be one of the important eastern European happenings. Lately, the festival has apparently expanded to include equipment displays too. (If these words are reaching anyone connected with this, or similar exhibitions, we'd like to hear more about your activities.)

Speaking of festivals and such, the Lord Mayor of Copenhagen invited us to a reception at the Town Hall. And when I say "us," I mean the whole convention!!





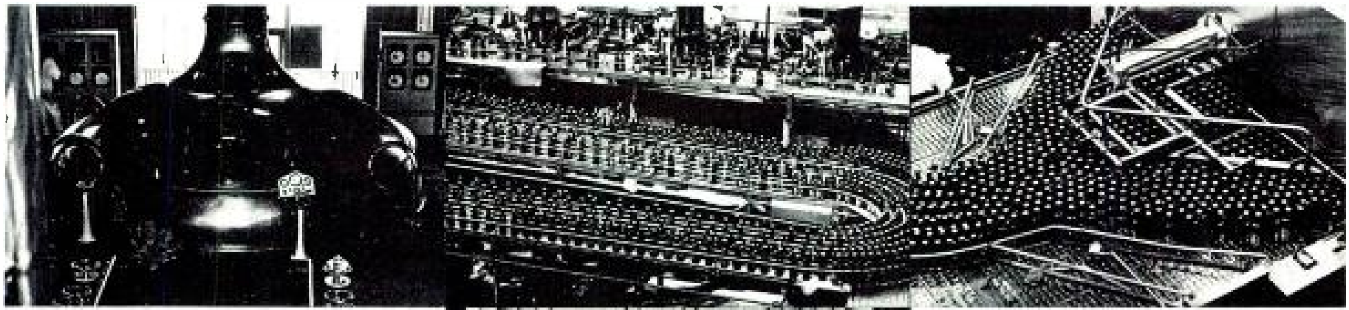
In this view of the Italtel patch bay, you can see the sophisticated patch system used. The adjoining photo shows the underside wiring.



The Schlumberger console with its interesting patch bay.

This is a completely automated B & O turntable with a straight-line tracking arm.

View at the Carlsberg brewery. This was an A.E.S. tour spot!



The elephants hold up the main gate to the brewery and have given their animal name to one of the beers produced here.

That's right! Busloads of us. We were transported to Town Hall and treated to a smorgasbord that stretched as far as the eye could see (or the stomach could travel). And lots of Beer too. Note the Capital B—this was BEER! No wonder the Danes pay such high taxes. I wonder what New York's Abe Beame will do for us this fall?

And of course, who could visit Copenhagen without making a pilgrimage to the Carlsberg breweries? Not us, that's certain. We spent an interesting afternoon touring the plant and then were invited to conduct an extensive a-b test of the various Carlsberg potions. All in the interests of audio science, of course.

Meanwhile, back at the convention. . . .

The Norwegian Tore Seem Company's 8-in, 4-out console was quite compact without being crowded. Judging by the module controls, the console offers quite an extensive range of equalization. One interesting module is called the Discjoker. (I wonder if Wolfman Jack knows about this?) Not the invention of a prankster, it is intended as an override device for d.j.'s and others who must interrupt with commercials, station announcements, and whatever. Even in Norway.

Certainly not compact was the Italtel console. Even the patch bay was larger than life. We took a look underneath the console at some excellent wiring and cable dressing work.

From England, Trident Audio was on hand with two consoles, their series A and B. On the A series, the meters may be switched from p.p.m. to v.u., which should be of help to the v.u. man who is trying to get used to using p.p.m.

Elsewhere, there were some interesting new developments in meters. NTP showed a wide variety of peak program meters. L.e.d. and conventional readouts are available, and they also have a 24-in/4-out video display unit on the style of the well known Audio Devices Vue-Scan.

The Knick Company likewise displayed a selection of l.e.d. meters.

Of course, many of the well known American show exhibitors were also on hand, but we'll be reporting on them after the Los Angeles convention.

Unfortunately, I didn't get to hear many of the papers, but one should be noted here. *Magnetic Recordings as Evidence in Law*, by Hugh D. Ford (pre-print f-6). Mr. Ford presents a well prepared study of the art of detecting the tampered tape. Of course this sort of thing never happens here, but nevertheless, his paper is most informative. It is available from the A.E.S. as a pre-print, and I trust it will be published before too long in the journal.

A SHORT DIRECTORY OF EXHIBITORS

a/s Lyric Electro-Acoustic Equipment
12, Hollandsvej
DK—2800 Lyngby, Denmark

Schlumberger Instruments et Systems
B.P. 69
92 Rueil-Malmaison, France

Philips Broadcast Equipment Corp. (US office)
One Philips Parkway
Montvale, New Jersey 07645

Helios Electronics Limited
161 High Street, Teddington
Middlesex TW11 8HT, England

Tore Seem A/S
Kirkeveien 71
N- 1344 Haslum
Norway

Italtel s.p.a.
Piazzale Zavattari 12
20149 Milan, Italy

Trident Audio Developments, Limited
4/10 North Road, Islington
London N. 7, England

NTP N. Tonnes Pedersen a/s
44, Theklavej DK - 2400
Copenhagen NV, Denmark

Knick Electronische Messgerate
D-1 Berlin 37
Beuckestrasse 22
Germany

db Visits—
Audio Designs & Mfg.

It's really not a long flight from N.Y.'s La Guardia Airport to Detroit, Michigan, home of Audio Designs. The factory is located in one of those inevitable industrial park areas that seem to be everywhere around inner cities.

Audio Designs has always been in the Detroit area, but their beginnings in 1966 were more humble than their present position as a leading manufacturer of consoles and console equipment.

It all commenced with Robert Bloom and 700 square feet in a store front in Detroit. That was 1966. From the beginning, the goal was to create innovative designs in custom console and ancillary equipment. Soon after the store front days, Bob and his small crew moved to a 5,000 square foot plant and began the increased manufacture of custom consoles, each made to the specifications of the final user, but using pre-built standard component elements. By the summer of 1972, the product acceptance had become such that a new plant was sought, and found, that now offers 15,000 square feet of manufacturing and office space and employment has risen to a staff of forty people. The most recent executive addition to the company occurred recently when Murray Shields joined Bob Bloom and Audio Devices. Murray was formerly with Eastern Sound in Toronto, and there is more than a bit of Canadian speech pattern to be heard when he talks.

Audio Devices reports a good business year just past. Sales are up 38 per cent over the previous fiscal period in 1973, a pattern that is typical of recent growth trends of the company. Iterestingly, much of the recent growth has accelerated faster from the broadcast (particularly t.v.) and sound reinforcement fields than from recording studio sales.

THE PRODUCTS

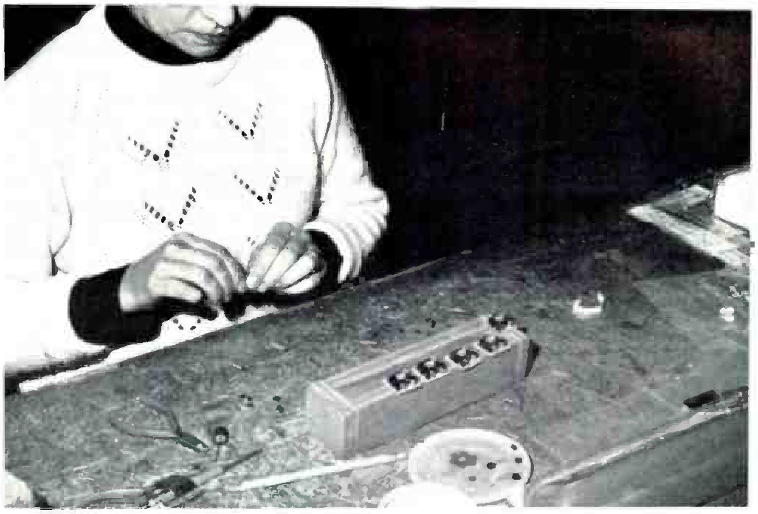
The console business as it presently exists is mostly sales as stock units but about 30 per cent is modified stock. On occasion, Audio Designs still will produce a thoroughly custom console. A typical price for a 24-in/16-out stock unit is $42,000.

Consoles can be equipped with a variety of products that are also sold as separate components. Among these are the Slidex faders, which require no cleaning and have no appreciable backlash, the Audex switching system which takes assignment switching out of the input module, a noise suppressor (model 301), four-band equalizer module, Vue-Scan—available with up to 28 channels of display on a 16-inch video c.r.t.—and, upcoming, a limiter module.

With this much already in the line, a growing business in componentry is being reported. Vue-Scan, in particular, seems to have surprised the company in the large degree of its acceptance and sales.

A final comment: consoles are, after all, highly personal systems. Many fail in their goal because, while well engineered, they cannot be well operated by human beings. The human engineering aspect of console design is important to this company. It was created by a man who has been a mixer.

Every company must have an r&d department. Audio Designs is well equipped.



Audio Designs manufactures its own operational amplifiers, here shown at an intermediate stage of production.

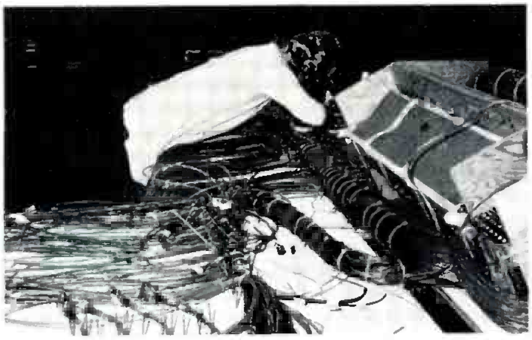
Operational amps are tested both before and after being sealed in potting material; as shown here they have already been encapsulated.

The beginnings of any product (in this case an operational amp) start in the company's design department.

A modified assembly line system is used for modules. Each individual station is responsible for the major assembly.

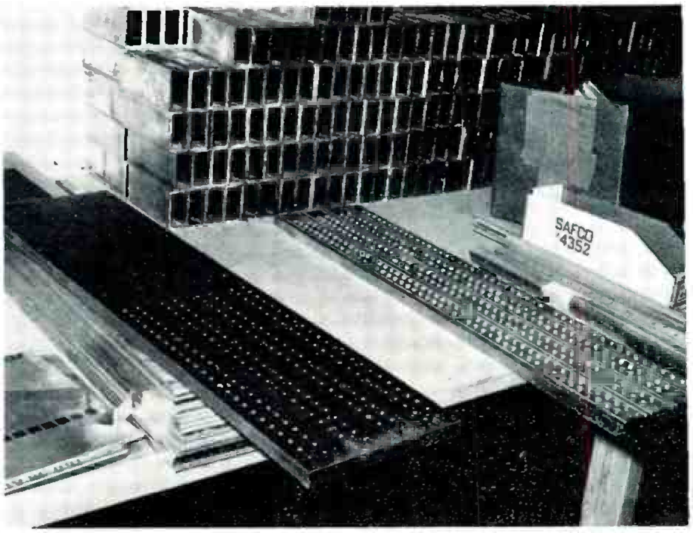
Audio Design's extensive machine shop. Most of the metal work in components and consoles is done here.

Three views of the innards of a console under manufacture.



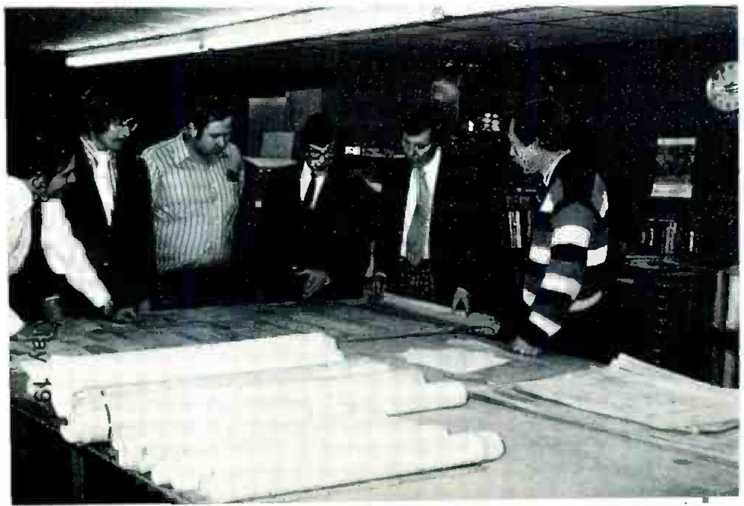
The main cabling is pre-assembled on a jig and then wired in with a check and recheck system. A lot of wire goes into a big console.

Consoles are assembled into wooden cabinets. The company threfore has an extensive woodworking shop.

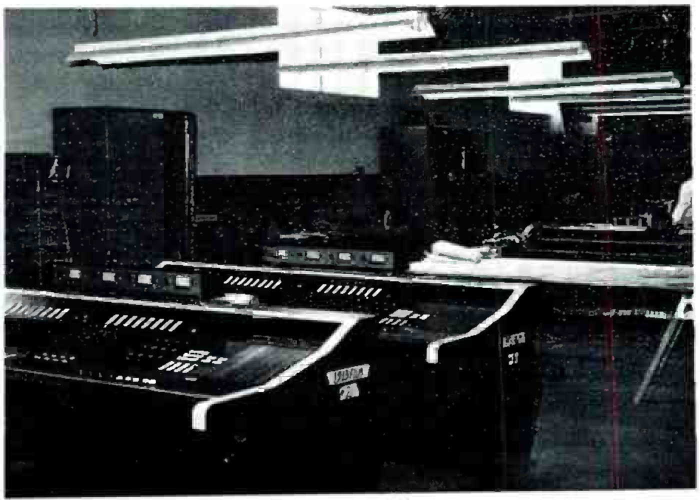


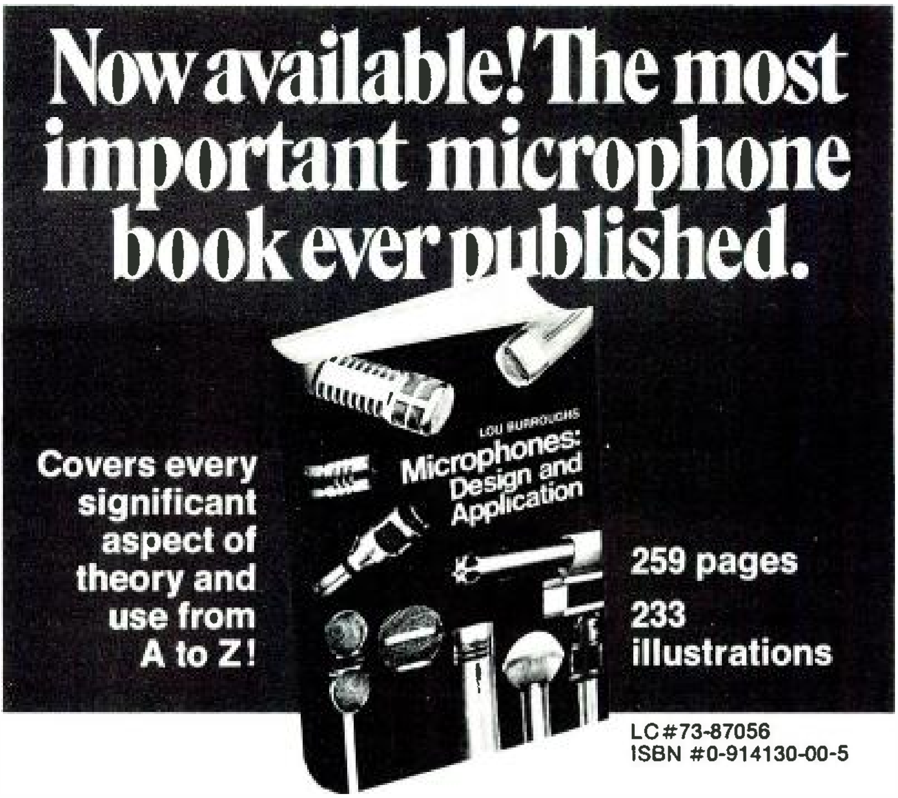
These heavy metal frames will eventually be milled out to form the backing for patch bay systems in consoles.

The executive crew. Among those present are Bob Bloom at the extreme left and sales manager Murray Shields at second from right.



Finished or nearly finished consoles awaiting final checkout before packaging and shipment.





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PEOPLE, PLACES, HAPPENINGS

• Mexican high fidelity speaker system manufacturer, **Romex Vega,** has done a turnaround on its original intent, to supply high fidelity products to the Mexican market, to whom U.S. products were virtually unobtainable due to high duty costs. Today, Romex Vega announces that it is exporting its products to the United States through its American subsidiary, **Inercontinental Marketing, Ltd.** of Baldwin, N.Y. The original offering of speaker systems will eventually be enlarged to include amplifiers, fet pre-amplifiers, and tuners.

• A recording seminar, directed at those who wish to increase their competence in the audio field will be held at **Gilfoy Sound Studios, Bloomington, Indiana,** during the week of June 10. Topics covered will be the history of magnetic recording, limitations of magnetc tape, microphones and transducers, studio acoustics, studio personnel, audio consoles, monitors, noise reduction, enhancement devices, tape editing, multi-track recording, multitrack mixdown, and a session on phonograph records. The sessions will consist of lectures, demonstrations, or the observation of actual 16-track recording sessions. Saturday and Sunday will be reserved for individual 16-track mixdown, wherein each student gets a chance to realize his or her own mix from the master tape recorded during one of the class recording sessions. The seminar fee is $100.00. Inquiries should be sent to Gilfoy Sound Studios, Inc., 1130 W. 17th St., Bloomington, Indiana 47401.

• Stepping up from the position of executive vice-president, **Donald R. Beall** has assumed the position of president of **Collins Radio Co.,** of Pittsburgh, Pa., a subsidiary of **Rockwell International Corporation.** He replaces **Robert C. Wilson,** who has moved to the **Memorex Corp.** as chairman of the board, president, and chief executive officer. Mr. Beall joined Rockwell in 1968 as executive director, financial planning, in the corporate offices. Later, he served as vice president, finance and executive vice president of the company's electronics group before joining Collins Radio.

• **James W. Hegadorn** has been appointed assistant sales manager of the public address, sound, and intercom products of the **Bogen Division of Lear Siegler, Inc.** He will provide technical assistance to distributors and sales representatives, product analysis and assistance in new product concepts. Mr. Hegadorn, who has been affiliated with Bogen's sales department for seven years, was formerly employed by **Nidisco, Inc.** in their sales department.

• **Walter F. Gips, Jr.,** president of **Gulton Industries, Inc.** has been named a director of the **Metex Corporation.** Prior to the merging of **Luminator, Inc.** with Gulton Industries, Mr. Gips had served as chairman of the board of Luminator, with whom he had been associated since 1951. Prior to that, he was assistant to the vice-president of sales of **U.S. Plywood Corp.** and had served as a member of the **Harvard Business School** faculty.

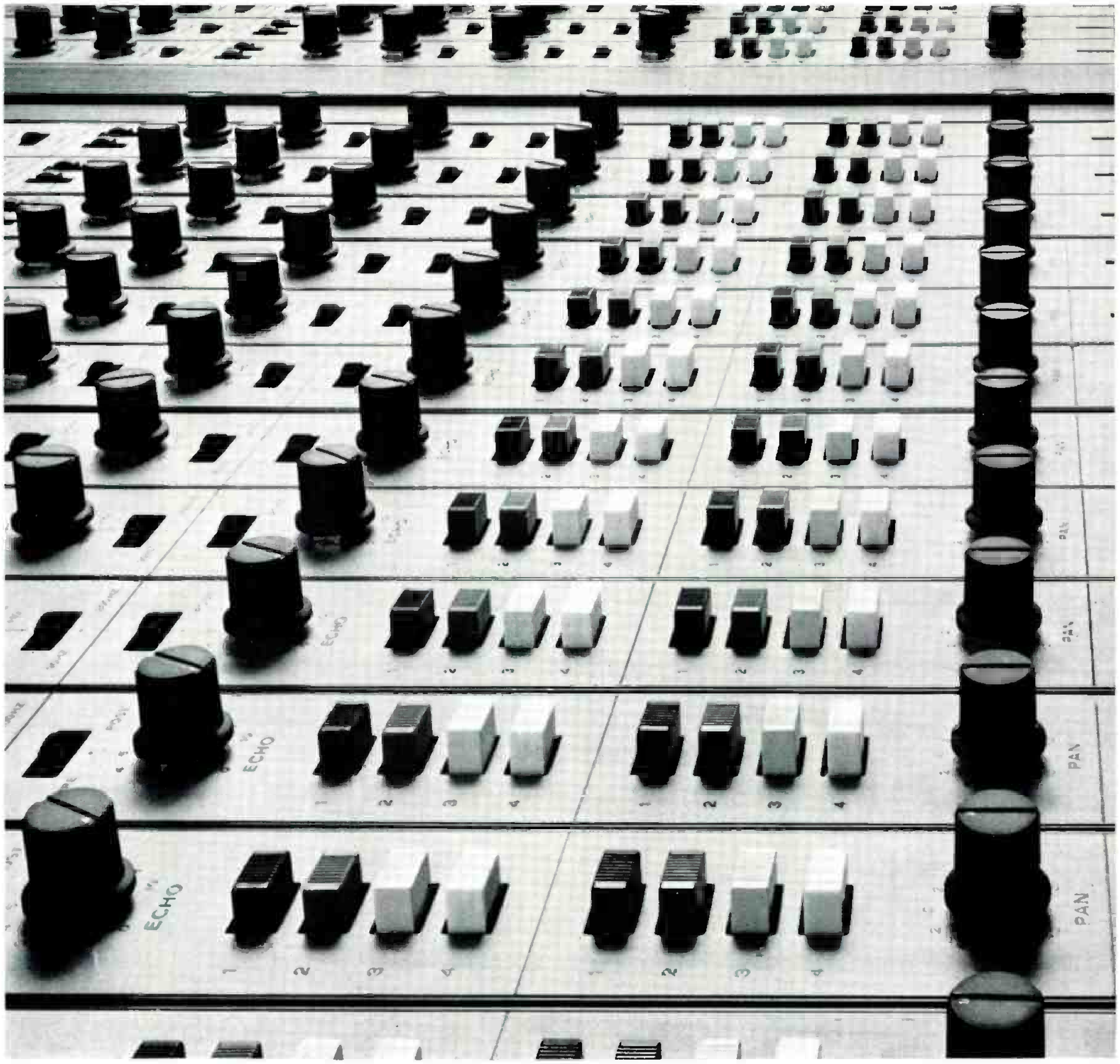
• **Sound 80, Inc.** of Minneapolis, Minn. and **MCI,** of Ft. Lauderdale, Florida, have entered into a licensing agreement on Sound 80's design of the PBE Multi-Track Tape Lock-up System, which MCI will manufacture and market world-wide. This system puts a sync pulse on one channel of each of two 16-track tape machines. When the machines are rewound, they can be stopped somewhere close to one another, and as soon as the two are put into play, the one machine will find the other and lock precisely in sync.

• The **EVR** system will shortly be marketed in Taiwan by the newly-formed **EVROC Corporation,** Taipei. EVROC will import EVR players and cassettes for both sales and rental and will acquire local programs from private and public sources in Taiwan for transcription into EVR film-cassette form. Agents for EVROC are **Nippon EVR Ltd., Videonet International, Inc., Hitachi Ltd., Mitsubishi Electrical Corporation,** and **Teijin Ltd.**

• New officers have been elected by the **Society of Broadcast Engineers,** which recently marked its tenth anniversary. Reelected to executive positions were **James C. Wulliman, WTMJ Stations, Milwaukee,** president. **Glenn H. Lahmann, KDKA, Pittsburgh,** vice president; **Robert Truscott, WITI-TV Milwaukee,** secretary-treasurer. Members of the board of directors who were reelected include **Albert H. Chismark, Broadcast Division of Meredith Corporation, Syracuse, N.Y.; Edwin T. Karl, WSNL TV, Suburban Broadcasting, Central Islip, N.Y.** New board members include **James Grinnell, ABC Television, Chicago; John Lyons, WWRL-AM, Woodside, N.Y.; William Orr, WBNS Stations, Columbus, Ohio; Bart Paine, College of Medicine, University of Arizona, Tucson, Arizona;** and **Robert Wehrman, WIIC-TV, Pittsburgh, Pa.** Directors remaining in office to complete the second year of their terms are **Steven deSatnick, WCVB-TV, Needham, Mass.; Robert W. Flanders, McGraw-Hill Broadcasting Co., Indianapolis, Ind.; Eugene Hill, Kaiser Broadcasting, Oakland, Calif.; Charles Morgan, Susquehanna Broadcasting Co., Avoca, Pa.**

• **Tom Jennings** has been named president of **Wald Sound,** a subsidiary of **Verit Industries,** Sun Valley, California. Mr. Jennings replaces **Peter S. Wald** who has assumed the position of chairman of the board of Wald Sound. Prior to joining Wald, Mr. Jennings served as a marketing consultant to **ESS, Inc.** He has also worked as a marketing consultant for **Toshiba** and had spent six years as president of **JBL International.**

• Enlarged facilities will be available for the use of customers at **Bill Rase Studios** of Sacramento, California, which is moving to new quarters in May. The producton house will include cassette/reel duplication, two studios with adjoining control rooms, film editing and filing, video taping—both mobile and in-studio—and a complete recording facility. On the sales end, products available will include Pentagon duplication systems, Crown International tape machines and amps, Superscope cassette loaders, TASCAM and Soundcraftsman products.



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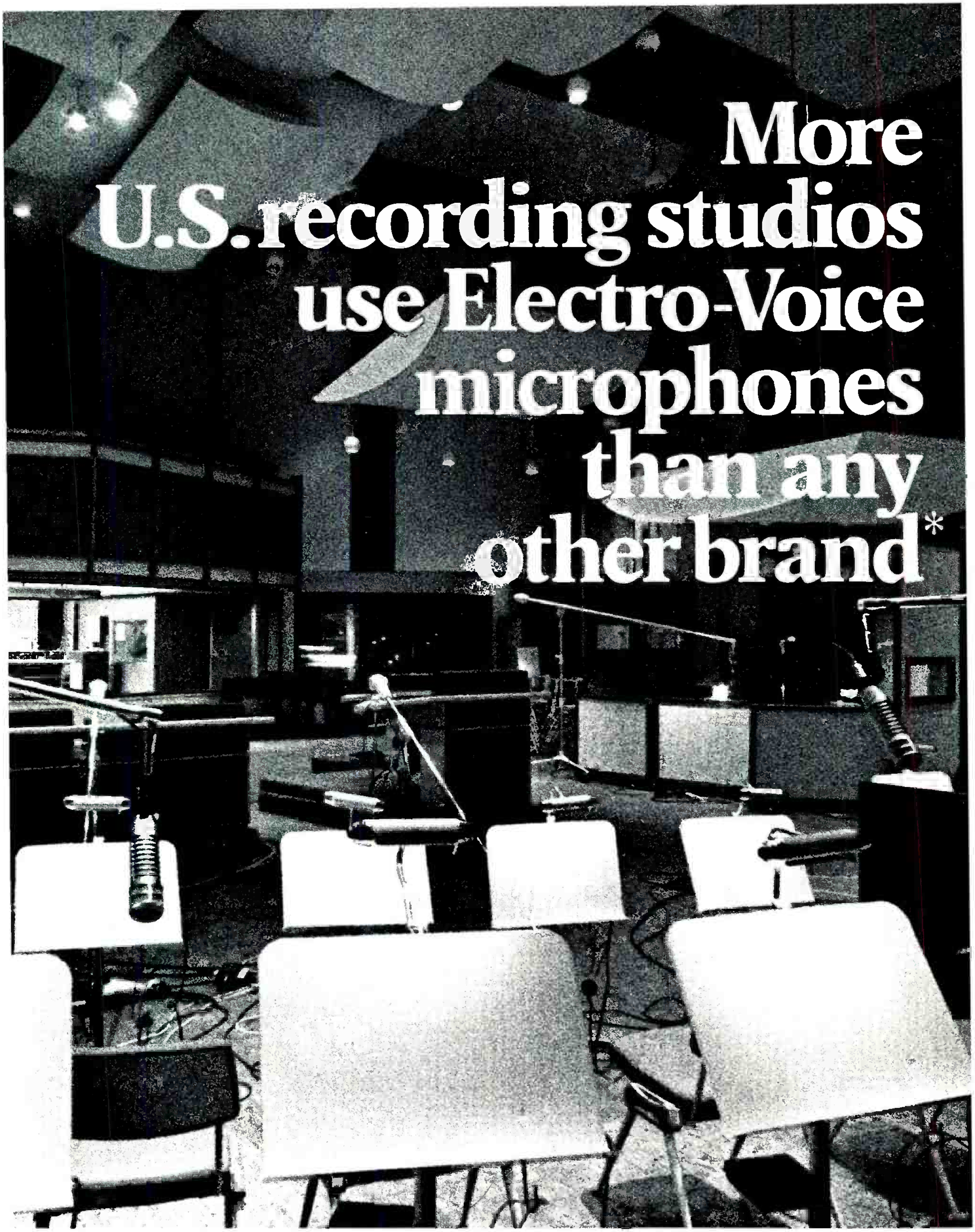

Model RE20 Recording Cardioid Dynamic Microphones photographed in the studios of Glenn Glenn Sound, Hollywood, Californi

*Based on a study of all 680 U.S. recording studios listed in the 1973 Billboard International Directory of Recording Studios.

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