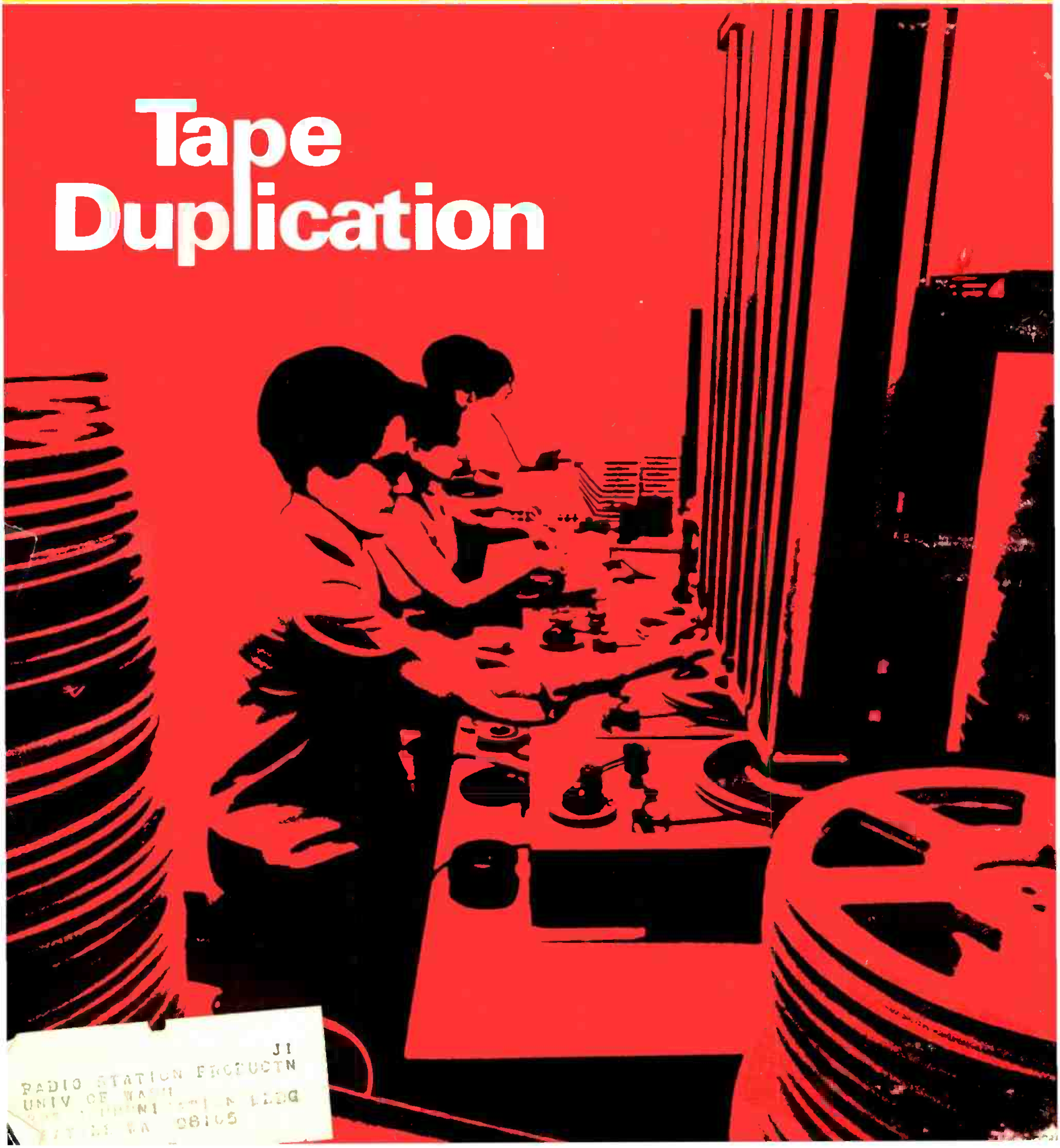
THE SOUND ENGINEERING MAGAZINE

db

NOVEMBER 1970 75¢

Tape Duplication



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COMING NEXT MONTH

• In December we will have a double-barrelled issue. Main theme will be the recording studio with three articles specially devoted to this topic.

Don Davis has written a paper that describes the methods and advantages of Acousta-Voicing Studio Monitors.

New Concepts in Studio Equipment Design by R. N. Andrews details devices developed to make the lot of the recording engineer at RCA easier.

A picture/text interview with John Eargle, chief engineer of Mercury Records gives the reasons why an Audio Designs' multi-channel console has been added as the main control unit for Mercury in New York. Included will be a series of photos that show the tribulations of placing a giant pre-built console high in a modern office building.

The Teldec video disc has burst like a bombshell on the audio/visual-home entertainment scene. We have commissioned columnists Arnold Schwartz and Martin Dickstein to take detailed looks at the system in their respective columns. In addition, writer Edward Tatnall Canby discourses on the implications of this exciting development to the professional audio community.

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

ABOUT THE COVER

• This view along a tape-duplicating facility has been created from an original photograph kindly supplied by GRT Corporation. It's all by way of telling you that this issue's special theme is Tape Duplication and the story begins on pg. 26.

db

THE SOUND ENGINEERING MAGAZINE

NOVEMBER 1970

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a note from the publisher

Many of our readers with a keen eye for graphics will note that this issue contains a number of changes. Our Art Director, Bob Laurie, has completely redesigned the cover format with an eye to a contemporary, exciting presentation that is in keeping with the feel and flow of the audio world. We hope you like this design concept and the ones that follow.

Internally we have made other changes in headlines, type faces and other details which bring an overall improvement to our general appearance.

We hope that our readers find these purely mechanical changes make their reading of **db** more pleasant and enjoyable.

Due to a sudden and completely unforeseen wildcat strike at our printers, our October issue was delayed about two weeks before reaching the Post Office. This unavoidable delay is most regrettable and we have made strenuous efforts to get back on schedule with alternate sources of printing. We now have this under control and henceforth should maintain our regular schedule—and with some luck improve upon it.

Robert Bach, *publisher*

advertisers index

letters

A number of correspondents have had difficulty in locating the integrated circuit mentioned in Walter Jung's September article, An IC Line Amplifier. Mr. Jung writes:

The manufacturers and their respective part numbers (for the TO-5 style, industrial temperature range unit) are as follows:

U5R7723393 (uA723C)	Fairchild
S5723L	Signetics
SG723CT	Silicon General
VA5R72339 (VA723C)	Varadyne
RC723Q	Raytheon

Check your local distributors for stock on the above. If not available locally, you will surely be able to obtain units through one of the large national industrial distributors. You may have to ask for the 723 *regulator*, however.

Walter G. Jung
Rockville, Maryland

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.

Are you doing something original or unusual in your work? Your fellow audio pros might want to know about it. (It's easy to tell your story in **db.**)

You don't have to be an experienced writer to be published. But you do need the ability to express your idea fully, with adequate detail and information. Our editors will polish the story for you. We suggest you first submit an outline so that we can work with you in the development of the article.

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It can be prestigious to be published and it can be profitable too. All articles accepted for publication are purchased. You won't retire on our scale, but it can make a nice extra sum for that special occasion.

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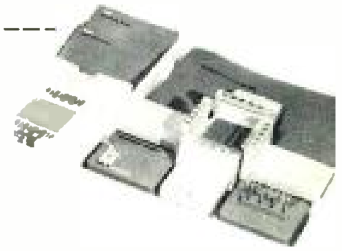

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George Alexandrovich

THE AUDIO ENGINEERS HANDBOOK

• The advent of solid-state technology radically changed the thinking of circuit designers. Amplifiers shrank to the size of a match book with performance exceeding that of their vacuum-tube counterparts. Circuits and design approaches changed accordingly. Appearance on the scene of the operational amplifier with its extremely high input impedance and low output impedance all but made obsolete impedance matching between amplifier stages. Contrary to classical textbook examples which use transformers almost everywhere, today's circuits are especially thought of to eliminate as much iron as possible. After all, transformers and impedance matching don't lend to microminiaturization techniques in manufacturing circuit assemblies. It is simpler to put hundreds of transistors on a single chip than to reduce the transformer to half size and maintain its performance. Besides transformers continue to rise in cost while integrated circuits cost less and less.

The subject of using transformers was brought up because textbook mixing networks (and many in actual use) are designed to transfer maximum power by matching impedances. However, modern operating techniques of sound mixing demand mixing-network performance that is not possible using matching techniques. As an example: in multitrack recording you may want to split signal between two channels without increasing crosstalk between them. In matching the circuits you will experience level loss due to division of available power. This is a serious drawback with modern mixing techniques. It is not uncommon to find systems where more than twenty mics are being used, and with capabilities to handle many more. This means that the mixing network should be capable of combining some thirty inputs. Thirty sources mean insertion loss of the mixing network of 29.7 dB. If one is lucky enough to have zero level feeding his mixing network then the output of the mixer is high enough not to worry about noise. But most of the time output of the mic preamp which is zero is reduced to -15 or -20 dB level by the mic fader. This signal is then fed into the mixer. Now your level is -50 dB. Add a few inputs and slightly lower the gain with the fader and you have a noise problem. It's not that noise will start bothering you, but your mixing network booster amp will be the limiting factor in generation of noise.

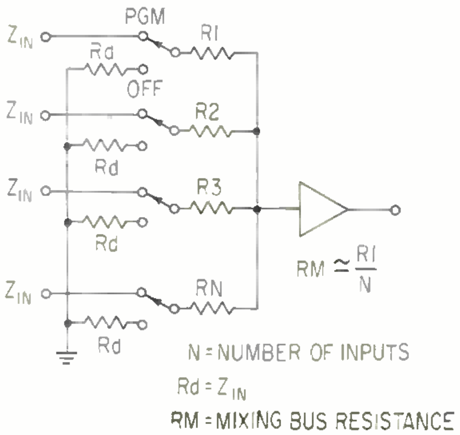

Figure 1. A conventional mixing circuit.

Before we get to methods of correcting this condition I should remind you that, whether you use 600-ohm mixing resistors in the network or 1 megohn, the insertion loss is the same—only combined impedance of the mix changes. For example ten 600-ohm resistors will produce a bus resistance of 60 ohms while 10 k ohm resistors will produce 1000 ohms. The difference between these two values is that you can connect several 10 k resistors to the same source to feed several mixing networks while it would be impossible to do this with 600-ohm mixing resistors.

In order to eliminate any possibility of the mixing network worsening our s/n figure, we must find a way to prevent signals from dropping too low. Our first reaction might be to put a booster amp after each input fader, so as to feed zero level into the mixing network. This is fine, but for thirty inputs it means thirty booster amps. Why not split the

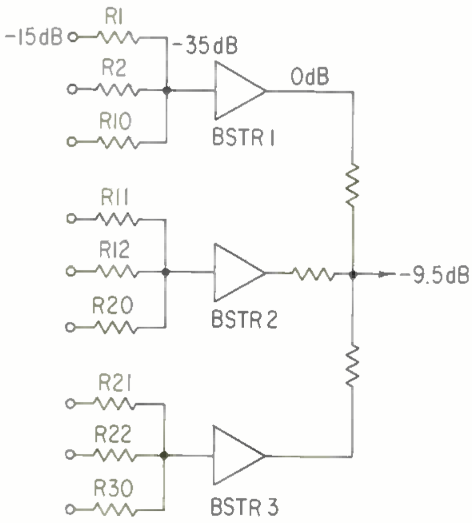

Figure 2. This is the method for the reduction of mixing losses.

mixing network into groups of ten inputs. Each group will now have its own booster amp which feeds into a combined mix of three boosters. Each booster—with a gain of 35 dB—will bring the level to 0 dB, then in mixing it with other two levels loss will only be 9.5 dB. This level is just high enough to feed into the submaster fader where another 15 dB loss is generated. Output of the fader (submaster) is now -24.5 dB just right for the line amp (or program amp). See *Figure 2.*

When you mix so many signals from so many sources into one channel, crosstalk between channels is of no consequence. All signals meet anyway in the same bus. But what if you have to split signal between the two channels while maintaining interchannel leakage down to -60 or -70 dB. In matching networks crosstalk is at -26 dB below the level of the source (for ten inputs) and 36 dB for thirty inputs. There are basically two ways of solving this problem without using an isolation amplifier for each split feed.

One way is to apply active mixing using a summing amplifier. This device, available as an i.c., is adjusted for unity gain by applying heavy negative feedback. Input impedance (apparent source resistance) is very low. As seen from *Figure 3*, connections to the input are made in the conventional way—with one exception: when switching out any or all inputs, dummy load resistors are not needed to keep the impedance of the bus constant (such as in *Figure 1*) because amplifier input impedance is usually much lower than bus impedance.

As the number of inputs increases, mixing resistors have to be made larger than shown, if amplifier input resistance is fairly high, otherwise good crosstalk figure will not be realized. If mixing resistors are 10 k each and the op amp input is 100 ohms then crosstalk is about 60 dB regardless of the impedance of the sources. Making the mixing resistors larger would affect mixing losses of the network. One has to strike a happy medium for optimum operation of the circuit.

There is also another way to achieve low crosstalk—a bridging mixing network. This circuit resembles conventional mixing network but uses a fairly large value of mixing resistors. It could be used only in systems that are physically compact and properly laid out, with levels feeding a mixing network of not lower than -10 dB. Although this network produces mixing loss typical to a conventional network, it offers cross-talk levels exceeding 80 dB regardless of the impedance of the source or mixing amplifier input. The only requirement is that any inputs disconnected from the source should be grounded. Because mixing resistors are usually in the 100 k ohm range, and whether they are connected to a source with resistance of 0 or 600 ohms or not, (only 0.5 per cent of the total resistance) does not change the impedance of the mixing bus. All inputs in this mixing network are truly bridging their respective sources, so even if as many as twenty channels are fed from one source, combined loading on this circuit is only 5 k ohms. Again, loss of this network depends on the number of inputs the circuit is designed for. But the most importank aspect of this combining network is the ability to offer channel

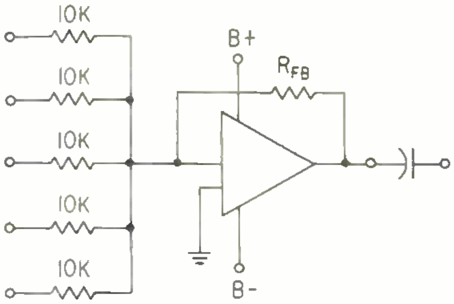

Figure 3. A block diagram of an op amp mixer.

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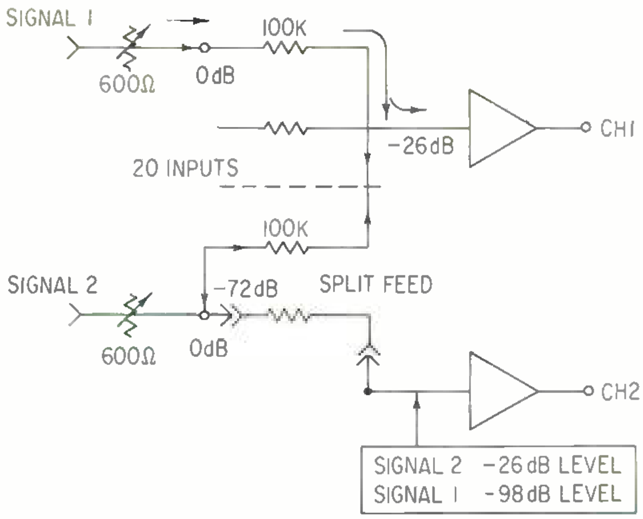

Figure 4. The crosstalk between channels.

isolation. Let's see what it takes for signal from one channel to reach another.

Let us say that a source of 600 ohms feeds a mixing resistor of 100 k (See *Figure 4*). The mixer is designed for twenty inputs. Level of the mixing bus is at -26 dB. In order to reach another channel, signal has to travel through the mixing resistor, forming a voltage divider with the source impedance feeding the second channel. Since this path offers a loss of 46 dB, combined crosstalk is at -72 dB. If we were to assume that source impedance may be lower than 600 ohms when using (for example) an amplifier with output impedance of 10 ohms, then crosstalk would be 86 dB.

True value of a mixing network offering little or no crosstalk shows in the monitoring circuits, where it is desirable to have a mix of all channels at once. Communication circuits found in multipath mixers benefit greatly from bridging mix nets.

In contrast to what has been discussed is the subject of broadcast production consoles. The time has come when designers of boards have to take a hard look at the techniques used in mixing. Most stock consoles cannot accept more than one channel without changing the impedance of the mixing bus, thus affecting the level at the same time. This was acceptable for many years when production techniques did not require anything more elaborate. But for the cost of a few resistors and attendant assembly time, the same boards can double up as recording and production consoles, thus saving money. How many boards are there that don't use any mixing resistors? If someone decides to use modern transistorized amplifiers with the same circuit he is in for a surprise. The first time he will switch in two channels, signals from both channels will be shorted out, because of the low output impedance of the amplifiers.

It is my feeling that within a few years we will be working with boards using not only the latest solid-state devices but that new trends in active summing of signals will develop into equally new technology, perhaps using multiple stages of mixing and amplification and isolation—so to be able to mix any number of circuits with no degradation of signal or increase in noise. ■

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ARNOLD SCHWARTZ

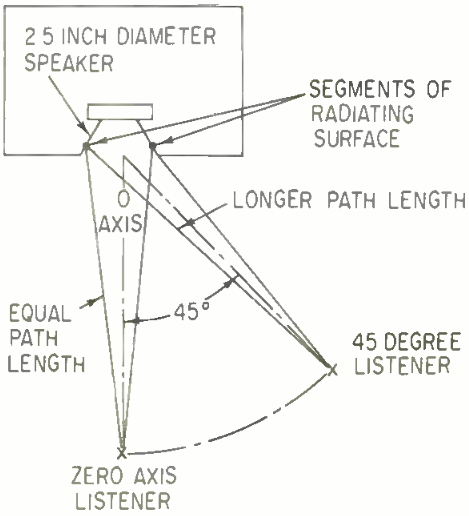
THE FEEDBACK LOOP

• Recent trends in speaker system design have indicated an increasing awareness of the problem of directional characteristics. Virtually all realistic speaker response curves published are on-axis, anechoic measurements. The prospective buyer in the high-fidelity show room usually stands directly in front of, and quite close to the speaker he is evaluating. This position enables him to hear the on-axis response, and the closer he gets to the speaker the more he tends to eliminate room characteristics from consideration. When the speaker system is in use at its ultimate location, whether in the studio, listening room, or at home, directional characteristics have a profound effect on sound quality.

DIRECTIONAL CHARACTERISTICS

Directional characteristics deal with the radiation of the higher frequencies as a function of angle. These characteristics are also referred to as the high-frequency dispersion characteristic. We can demonstrate directional characteristics by considering the action of a speaker mounted in an infinite baffle. In practice, in the high-frequency range that we are considering, a closed box is a close enough approximation to an infinite baffle. *Figure 1* shows a speaker with an effective radiating surface of 2.5 inches diameter mounted in a closed box. The zero axis is the center line perpendicular to the plane of the baffle upon which the speaker is mounted.

Figure 1. Path length difference and speaker directional characteristics.



ON AXIS

We will now observe the effect of two symmetrically placed segments of the speaker's radiating surface on a listener situated on the zero axis (on axis). The acoustical energy from each segment will travel the same distance to the listener and arrives there in phase (see *Figure 1*). The energy from each segment will then add directly. This in phase condition will hold true for all frequencies.

OFF AXIS

We now locate the listener the same distance from the speaker but at an angle of 45 degrees off the zero axis (see *Figure 1*). The acoustical energy from the left hand segment arrives slightly later than the energy from the right hand segment due to the longer path length of the former. This delay corresponds to a phase shift of approximately 147 degrees when we drive the speaker at a frequency of 4,400 Hz. Now when the energy combines the total acoustical power will be -11 dB down relative to the power found on the zero axis. By integrating the effect of all the segments comprising the total area of the speaker diaphragm we would be able to find the acoustical output at 45 degrees relative to the zero axis. Of course, the simple and direct way of measuring output is to use a microphone. *Figure 2* shows the 45 and 60 degree outputs (as a function of frequency) of the speaker relative to the zero axis output. We can see the high frequency attenuation at these angles, amounting to -5 dB at 10 kHz, and -11 dB at 60 degrees at the same frequency.

POLAR RESPONSE

Directional characteristics are usually displayed in the form of polar response. In this type of display we select a single frequency and plot the relative output as a function of angle (see *Figure 3*). The polar response provides a "picture" of the speaker radiation pattern. As fre-

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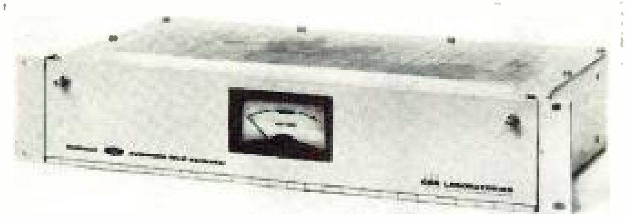

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quency increases the pattern becomes progressively narrower for our 2.5 inch diameter speaker.

In the typical speaker system the high-frequency radiation is assigned to a small speaker which has, among other advantages, a broader radiation pattern at high frequencies than larger diameter speakers. Nevertheless, even relatively small speakers have polar patterns that become narrow at high frequencies because of the phase shift due to path length difference. It should be noted that when more than one tweeter is mounted in the same plane, a common practice with some manufacturers, the polar response becomes even narrower than it would otherwise.

DIRECTIONAL CHARACTERISTICS AND THE LISTENER

How does the narrowing of the radiation pattern affect the listener? When he is located very close to the speaker, as is the case of an engineer at a console where the monitor speakers are within a few feet directly in front, he is in the *near field*. He hears mainly the directly radiated sound. Energy that is reflected off the walls and other surfaces is only of secondary importance. Now, if the speakers are directed towards the listener he will hear the zero-axis response, and will not notice any losses due to deficiencies in the polar response. If the listener moves off the zero axis he will notice a change. Since woofer and mid-range speakers, by virtue of their size in relation to their operating range, usually have broader polar characteristics he will not notice any change in the low and mid frequencies. High frequencies, however, will be attenuated due to the relatively narrow polar patterns.

When the listener is located at some distance from the speaker, as might happen in a studio listening room or at home, he is in the *far field*. Regardless of his position with respect to the zero axis, what he hears will be determined mainly by the total polar output of the speaker system. The room characteristics will average out the total energy radiated at each frequency, and what the listener hears may be at some variance from the near field-zero


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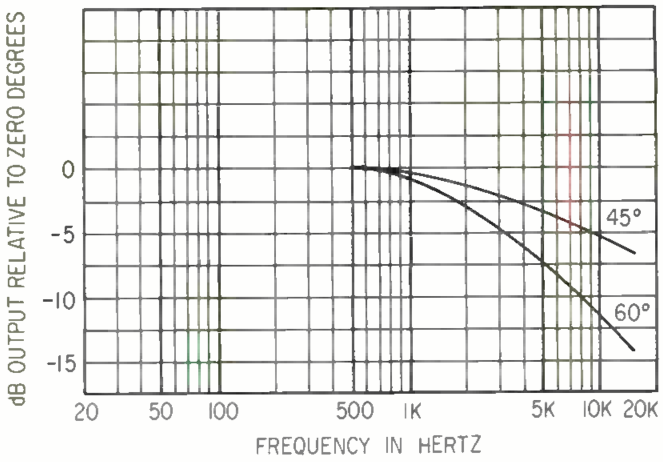


Figure 2. The response of a 2 1/2-inch speaker at 45 and 60 degrees relative to zero degree output.

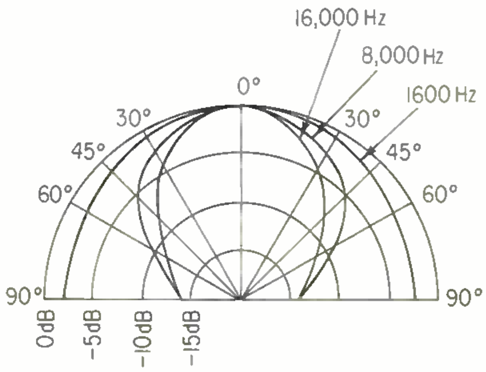
axis response. Once again the narrower polar pattern of the high-frequency speaker, as compared to the broader patterns of the low and mid range speakers, will cause an over-all loss of high frequencies.

The distance from the speaker to where the reverberant field predominates over the direct radiation depends upon the dimensions and other acoustical properties of the room. Use of room equalization now current is more closely related to compensating for irregularities in total power output of the speaker at various frequencies than to the room response.

Speaker system designers use different approaches to overcome the narrow polar patterns at high frequencies. Included in these approaches are tweeter design, tweeter mounting in more than one plane, use of reflected sound to disperse high frequencies, and acoustical networks. A somewhat different approach to the problem involves the use of auxiliary high-frequency speaker systems which have broad or omni-directional patterns. They utilize a number of high-frequency speakers mounted in different planes so that the polar responses are combined to provide an omni-directional radiator.

To the critical listener, whether he is evaluating a recording in the studio, or at home, speaker directional characteristics can have significant effect on sound quality. ■

Figure 3. The polar response of a 2 1/2-inch diameter speaker.



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PROFESSIONAL STUDIO EQUIPMENT

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Specs	15ips	7½ips
w. & fl.	0.06%	0.09%
f. resp. ±2dB	40Hz to 30kHz	20Hz to 20kHz
S/N	-60dB	-60dB

CX822

Crown tape recorders and reproducers are available in 42 models with almost any head configuration, including 4 channels in-line. Patented electro-magnetic brakes maintain ultra-light tape tension and never need adjusting. They are made by American craftsmen to professional quality standards, with industrial-grade construction for years of heavy use.

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Claimed by its pro audio owners to be the finest professional tape recorder value on the market today - price versus performance ■ Frequency response at 7½ips ±2dB 20Hz-20kHz, at 3¾ips ±2dB 20Hz-10kHz ■ Wow & flutter at 7½ips 0.09%, at 3¾ips 0.18% ■ S/N at 7½ips -60dB, at 3¾ips -55dB ■ Facilities: bias metering and adjustment, third head monitor with A/B switch, sound-with-sound, two mic or line inputs, meter monitoring same as CX822, 600Ω output ■ Remote start/stop optional, automatic stop in play mode ■ $895 for full-track mono deck as shown, $995 for half-track stereo deck

SP722

Ideal reproducer for automation systems ■ Meets or exceeds all NAB standards ■ Remote start/stop optional, automatic stop in play mode ■ $595 for half-track stereo reproducer

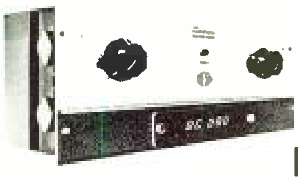
STUDIO MONITOR AMPLIFIERS

D40

Delivers 40 watts RMS per channel at 4Ω ■ Takes only 1¾" rack space, weighs 8½ lbs. ■ IM distortion less than 0.3% from 1/10w to 30w at 8Ω ■ S/N 100dB below 30w output ■ $229 rack mount

D150

Delivers 75 watts RMS both channels at 8Ω ■ IM distortion less than 0.1% from 1/10w to 75w at 8Ω ■ S/N 100dB below 75w output ■ Takes 5¼" rack space, weighs 16 lbs. ■ $439 rack mount



DC300

Delivers 300 watts RMS per channel at 4Ω ■ IM distortion less than 0.1% 1/10w-150w at 8Ω ■ S/N 100dB below 150w output at 8Ω ■ Lab Standard performance and reliability ■ "As close to absolute perfection as any amplifier we have ever seen" - Audio magazine, 10/69 ■ $685 rack mount

Circle 24 on Reader Service Card

John M. Woram

THE SYNC TRACK

• In the last month's column, *Figure 6(B)* showed that, as the program level feeding a limiter decreases, the system gain increases. Since low-level program is accompanied by tape hiss, the listener may be distracted by the sudden increase in hiss as the system gain rapidly rises during the quieter passages of music.

Obviously, the less hiss, the less of this type of distraction—which is just one more argument for a noise reduction method such as the Dolby system. With a Dolby'd tape, sudden changes in system gain will not be quite so distracting. Another Dolby dividend is that you probably won't need as much limiting in the first place, since the quieter passages are now more audible, due to the lower noise level.

Although the Dolby system is a great tool, it does not make musical decisions, and if the musical content suffers because of sudden gain increases, other steps must be taken. For one thing, a longer release time may be selected on the limiter. (Unless otherwise noted, all references to limiting, or limiters, apply equally to compression and *vice versa*.) Release time is generally defined as the interval required for the system to return to constant gain (on many commercial units—to about 2/3 recovery) once limiting ceases. The longer the release time, the more gradual (and therefore less apparent) the gain increase. A disadvantage of a longer release time is that when an occasional short percussive sound causes limiting, the system will take a relatively long time to recover when the percussive sound ceases. In selecting a release time, the musical, and hiss, content must both be considered to determine the proper setting.

EXPANSION

Some units have a so-called expansion feature in addition to limiting and compression. Expansion might be defined as a compression ratio of less than 1, such as shown in *Figure 1*. In the expansion mode, the dynamic range of the output is larger than that of the input—just the opposite of compression. As a complement to limiting, expansion may restore some sense of dynamic range to the program. However, care must be taken so that expansion does not begin below the residual hiss level. As input level increases, expansion ceases, and limiting begins.

To digress a little further into hiss, Allison Research demonstrated their KEPEX system at the recent Audio Engineering Society Convention in New York City. Among other things, it seems the KEPEX may be set up as a gating device. Once a signal falls below a predetermined level, the KEPEX shuts that microphone or track off, thereby eliminating extraneous low-level noise in the case of a mic, or hiss on a finished tape. This feature might be considered as a possible complement to fast release times on a limiter. Once the program level falls below a pre-set level, the KEPEX should turn the system off, thereby preventing the limiter from raising the hiss

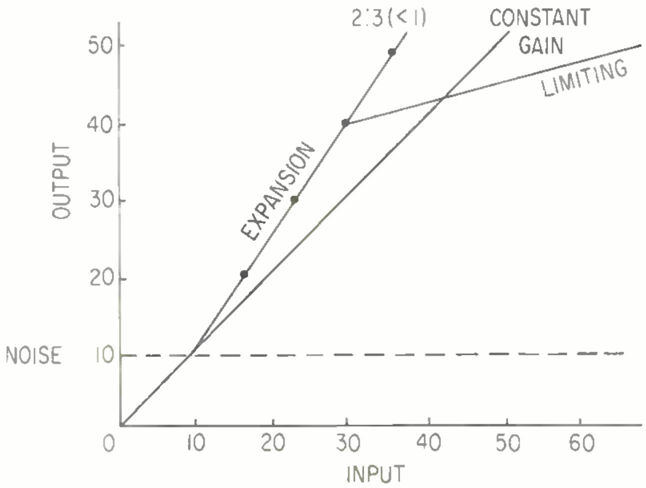


Figure 1. Expansion can be defined as a compression ratio of less than 1.

Neve

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One of the recent examples of Neve craftsmanship designed and built to the requirements of Cine Tl Studios Ltd., London.

This console incorporates 26 full mixing equalized input channels each with microphone and line inputs. There are eight output tracks with three mixed down groups for stereo and mono mastering, six echo groups, studio foldback, and an impressive list of built-in equalizers, compressors and other signal processing devices. A comprehensive communications system links the Studio floor, balance engineer, projection room and the producer.

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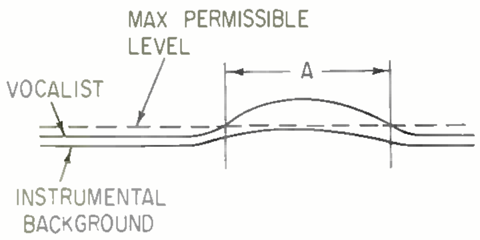

Figure 2. One problem in tape mastering is keeping the vocalist in proper perspective to the instrumental background.

level. (The KEPEX seems to have a multitude of other applications too, which I'll try to uncover for a future column.)

SELECTING A LIMITER/COMPRESSOR

Readers in the market for a limiter or compressor are referred to the guide published in last month's issue on pages 33-35. Remember that compression ratios must be referred to their various thresholds before they can be compared to each other. On a more practical note, find out if the controls you will be using are conveniently located. Some units have one or more controls on the *back*. If these controls are important in your application, you're going to be in big trouble if you rack mount the units.

Most of the newer limiter/compressors have a stereo interconnection, which is important in tape-to-disc work, as well as in tape copying, etc. This provision allows two limiters to be coupled together so that when one track of a stereo tape requires limiting, the other track is limited by the same amount. Without this feature, a sudden limiting action on one track would cause an apparent shift in sound towards the other track if its level remained unaffected.

One recurrent problem in tape mastering is keeping the vocalist in proper perspective to the instrumental background. Consider the typical situation pictured in *Figure 2*. Levels have been adjusted so that the vocalist remains somewhat above the instrumental background. At certain times however, the singer rises still further above the background, and the maximum safe level is exceeded, as at (A) in *Figure 2*. Now if the vocal track only is limited, it may become buried in the background at these points. Yet it may not be musically desirable to limit the entire program by *x* dB.

An arrangement such as shown in *Figure 3* may be possible, if three limiters are available. One of them (X) is inserted in the vocal track; the other two (Y) and (Z) are stereo interconnected and inserted in the mixed-down background tracks. The control voltage from limiter (X) is brought out to potentiometer R^1. Varying R^1 will cause different amounts of limiting at the vocal limiter and the stereo pair. For example, a voltage that will cause 6 dB of gain reduction at (X) will only reduce (Y) and (Z) by 3, dB, and so on.

Note that the control voltages from the stereo pair regulate a voltage controlled *amplifier* in the vocal track, as well as their own gain reduction sections. With proper regulation, an increase in instrumental level will cause gain reduction in the stereo pair, and amplification in the vocal track. Yet, if the vocal track approaches maximum permissible level, the vocal/instrumental combination is reduced according to the R^1 setting.

Experimenters are warned that I have not yet tested this set-up, since it is a little on the involved side.

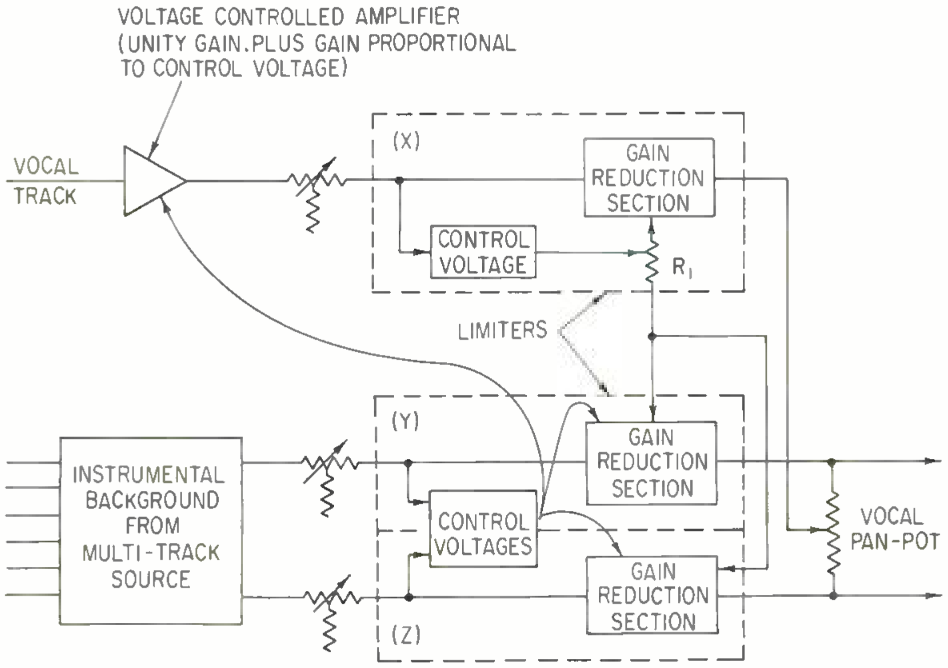

Figure 3. This arrangement, using three limiters can solve the problem brought up in Figure 2 and the text.

NEW DEVELOPMENTS

In a recent AES paper [1] a limiter is described that features a delay line in the signal chain. By delaying the program (imperceptibly, about 150 microseconds) the limiter has time to react and cause gain reduction before the arrival of the signal at the gain-reduction section. It is claimed that this innovation eliminates the distortion problems associated with limiters having some finite attack time.

And in a Philips technical bulletin describing the PYE 5752 limiter, another unique control system is described. Grossly oversimplifying their description, the unit features a high-speed switching (on-off) device operating on the duty-ratio principal. The greater the off-time, the more energy is removed from the original signal. Further processing removes the switching pulses, leaving an attenuated output that possesses the same wave shape as the input.

These are but two new approaches to creating the definitive limiter/compressor. In the future, I hope to be able to discuss the recent progress in automation (once I figure it out—don't wait up). Some of this progress utilizes advanced limiting concepts—some of it minimizes the need for extensive limiting. In any case, it should go a long way toward reducing some of the problems that have so far attended wide dynamic range programs.

REFERENCES

[1] *A Wide Dynamic Range Limiter and Program Conditioner:* David E. Blackmer (consultant) and Saul A. Walker, Automated Processes, Inc. AES Preprint Number 757 (M-4).

[2] *Sound Sense—PYE 5752:* Philips Broadcast Equipment Corp.. One Philips Parkway, Montvale, New Jersey 07645.

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NORMAN H. CROWHURST

THEORY AND PRACTICE

• Input matching, particularly of microphones or pickups to amplifiers, has been discussed before, if not in this column. From the professional viewpoint, where each component is viewed as an entity, the matter is usually confined to that of selecting ideal impedances, or at least ones that match—or correspond.

Thus, from this viewpoint, a line-impedance microphone needs an amplifier with a line-impedance input, and enough gain for microphone, rather than merely the correct impedance, which could be intended to accept a telephone line level as input. A high-impedance microphone must be connected to a high-impedance microphone amplifier input, and a low-impedance mic to a corresponding low-impedance input.

That is a simple matter of matching—by numbers—that does not require any knowledge of the circuits involved inside the microphone or amplifier, to achieve the desired end. Here we plan to discuss the "inside" details a little more. There is also the question of ideal impedance for various purposes, including the method of connection used with each, such as concentric cable, shielded twin, etc.

Back in the days of tube amplifiers, the input that mattered to the tube amplifier was voltage input to the grid. A high impedance microphone or pickup would be connected directly between grid and ground, using a single shielded (concentric) input cable (*Figure 1*). Any other impedance would yield lower voltage output for a unit of the same power-conversion efficiency. So to achieve maximum gain, as well as the best possible signal-to-noise ratio from the tube, an input transformer was used to step the impedance up to a high value to suit the grid.

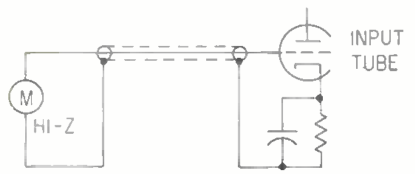


Figure 1. The old tube circuit provided a voltage input to drive the grid.

The advent of transistors changed this. The important input is no longer signal voltage, unless the transistor is of the field-effect type. In the latter case, the situation is not unlike that discussed for tubes.

But the other, ordinary type transistor essentially amplifies current. True, operated grounded base, it can be considered a voltage amplifier, at constant current, but this is still different from the tube or fet situation, in which the impedance presented by the input is high: the emitter-to-base impedance of a transistor is quite low.

However, most transistor circuits use the base as input, not the emitter, for a variety of reasons, not the least of which is a supply problem for grounded base: emitter and collector need supplies of opposite polarity. Using base as input can have either the emitter or collector essentially grounded, with the other as the output electrode of the input stage.

Grounded collector (*Figure 2*) provides zero voltage amplification (with apologies to those persons who tell us that various standards do not acknowledge the term *voltage amplification*—how else would you say that?), but amplifies current, thus changing impedance as well as providing gain. This is the emitter-follower circuit, analogous to the old cathode follower of tube days.

There are differences from, as well as similarities to, this older circuit, that we have discussed before. The main one is the fact that the impedance connected in the emitter output from the stage is presented at the base input, multiplied by the current gain of the stage.

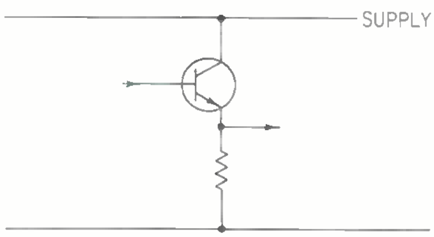


Figure 2. A transistor circuit using grounded, or common collector, provides only current gain, like the cathode follower of tube circuits.

Thus, if the emitter-connected impedance is 1,000 ohms, the base input impedance looks like beta times this. If beta is 100, base input impedance is 100k, unless the biasing arrangement upsets the value.

The other input configuration is grounded emitter—or something closer to that than grounded collector. Usually, the emitter will have a much lower resistance value connected between it and supply than that between collector and the other supply terminal (*Figure 3*).

Now comes the question of optimizing this circuit. The input stage has to meet two requirements that in some degree conflict: it must provide a satisfactory input load for the microphone or pickup connected to it; and it must provide the maximum possible gain, to raise signal as rapidly as possible above a level where, from circuits and other sources, noise constitutes a hazard.

Idealized theory tells us that maximum power—and thus by implication level—transfer occurs when source and load impedance match. Thus, the microphone or pickup impedance should be identical with the input impedance provided by the base-to-ground connection of the transistor circuit, in its operational condition. But practically, it is never as simple as that, whatever your professor may have told you in school.

In the old tube circuit, we could never match the grid input impedance in the power-matching sense, because the grid takes virtually zero power, requiring a voltage at no cur-

(continued on page 25)

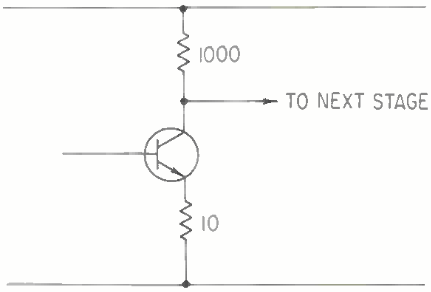


Figure 3. An essentially grounded emitter circuit uses a much lower value emitter resistance than collector resistance, and takes the output from the collector.

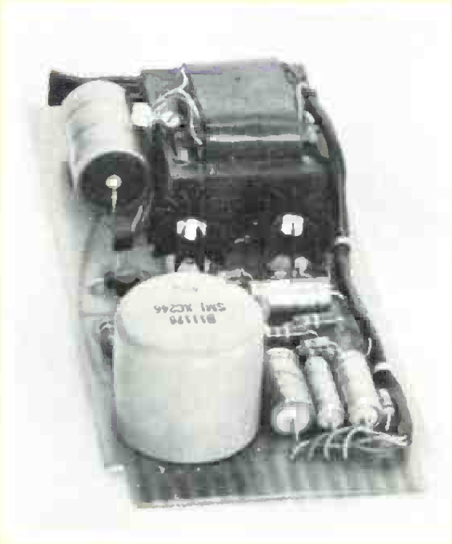
NEW PRODUCTS AND SERVICES

Stereo Ribbon Mic

• This well-known ribbon microphone is once again available in the United States since the Danish manufacturer is now directly represented in this country by a subsidiary. Model BM5 is two separate microphones plugged together to make a stereo unit characterized by wide dynamic range, low distortion, and smoooh extended response. The two elements can be rotated up to 90 degrees relative to each other with the angle indicated on a calibrated scale. A music/talk switch is included for close work because of the inherent tendency of ribbon mics to over-emphasize low frequencies when used at distances less than 3 feet. A table stand is included.

Mfr: Bang & Olefsen
Price: $99.95
Circle 42 on Reader Service Card

Amplifier/Preamp



• Model 1109 is the vanguard of a new series of amplifier and equalizer modules. The 1109 is 600/150 ohms bridging input with dual 600-ohm outputs. Gain is adjustable through a 20 dB range and, depending on input strapping and termination will range from 30 to 56 dB. Output power of each of the outputs is +24 dBm and if they are paralleled, +27 dBm can be achieved. Noise is within 2 dB of the theoretical limit. Power requirements are either +24 to 30 V d.c., or 15 V d.c. The board is a 2 ¾ by 6-inch glass epoxy card with gold plated contacts that mate with a standard 15-pin connector.

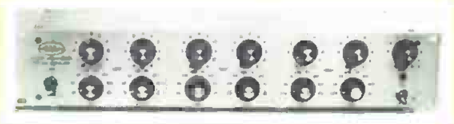
Mfg: Universal Audio (UREI)
Circle 2 on Reader Service Card

Audio Control Center

• The M63 Audio Master is a frequency-equalizing audio control center for both recording studio and broadcast applications. The unit will convert the output device to a remote amplifier—with equalization—in broadcast stations. it will equalize music and program material in broadcast and recording studios, function as a frequency shaper to reduce feedback and enhance sound quality in reinforcement systems, and provide audio control and monitoring facilities in multiple mixer applications. Bass and treble controls along with variable high-pass and low-pass filters and a volume control give the unit its capabilities. It accepts two high-level inputs, and has outputs for headphones, 600-ohm balanced line, high/low impedance mic level, and auxiliary high impedance, high level. For monitoring applications, the unit has an illuminated vu meter.

Mfr: Shure Bros., Inc.
Prcce: $160.00
Circle 40 on Reader Service Card

Program Equalizer



• Low frequency shelf boost and cut is variable up to 15dB at 30, 60, 80, 120, 150, 200, 300, and 500 Hz. Mid range peak boost and cut is variable up to 10 dB and covers the discrete frequencies of 250, 350, 500, 700, 1000, 1400, 2000, and 3000 Hz. At the high frequencies, boost and cut is again 15 dB and the frequencies are 2.5, 4, 5, 6.5, 8, 10, 12, and 15 kHz. Input and output is 600-ohms transformer isolated. Noise is 80 dB below +4 dBm. Distortion is 0.2 per cent at +23 dBm maximum output. The unit fits a standard rack mount, is a.c. powered (20 watts 50 or 60 Hz), and takes 3 ½ inches of panel height.

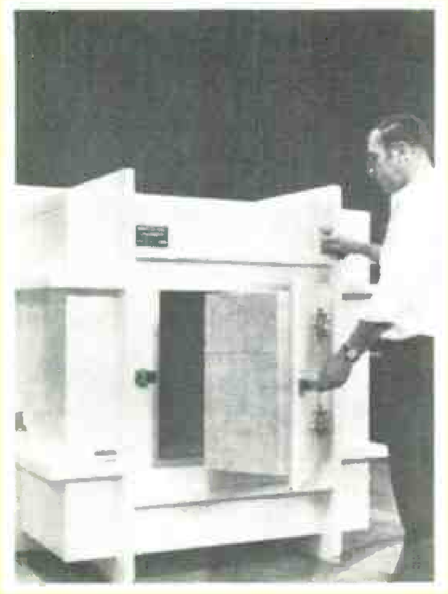
Mfr: Martin Audio Corp.
Price: $575.00
Circle 39 on Reader Service Card

Monitor Speaker

• The A-50 aperiodic loudspeaker has dual-spectrum damping—a new design that is claimed to both extend low frequencies while providing effective damping. These dual benefits are achieved by using two high-compliance woofers and two airtight cabinet compartments connected through an acoustical resistance. A non-inductive crossover network directs frequencies above 1 kHz to a separate hemispherical soft-dome tweeter. The cabinet itself is free-standing and slim-line with dimensions of 28 by 21 ½ by 10-inches deep. The grill clotch is Velcro secured.

Mfr: Dynaco, Inc.
Price: $179.95
Circle 36 on Reader Service Card

Portable Anechoic Chambers



• This new line of portable chambers has been designed to facilitate the study of the acoustic properties of small mechanical equipment, devices, as well as the calibration of microphones. These series P chambers offer performance that is achieved within a sound attenuating cabinet (including the access door) that is lined with pre-tested An-Eck-Oic wedges. In addition, the floor system is non reflecting. Cabinet section joints are splined to prevent acoustic leaks. A sound absorption level of between 99 and 100 per cent therefore is easily maintained within the chamber. Eight standard models are offered with free-field volumes ranging from 25 x 25 x 25 inches to 69 x 69 x 69 inches. Cutoff frequencies are 150, 200, or 250 Hz.

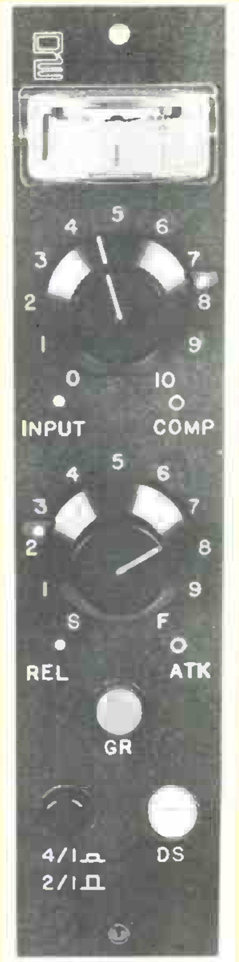
Mfr: Eckel Industries, Inc.
Circle 1 on Reader Service Card

Strip Chart Recorders

• These new recorders use a linear servo motor pen drive to achieve utmost reliability. They are only 3 ½ -inches high so they conserve rack space, yet have a versatile chart drive and viewing system. Adapting the linear motor to a chart recorder results in a drive system that has only one moving part —the motor/slider/pen assembly. Because the entire radial field of the motor is produced by a permanent magnet, the motor consumes little power and has virtually no internal temperature rise. The motor can be driven continuously off scale with no noise and no damage to the recorder. The slanted chart viewing system provides easy access to the chart as it is either rolled up or torn off. Two models are available: The model 7123A/B uses 10-inch chart paper and has a less than 1/3 second full-scale response, while the model 7143A/B takes 5-inch paper and has a full-scale response of less than ¼ second. Input ranges from 1 mV to 100 V, single span, are specified by option. Chart speed is also determined by option choice as is the option of electric writing.

Mfr: Hewlett-Packard Co.
Price: Model 7123—$750;
Model 7143A—$695.
Circle 4 on Reader Service Card

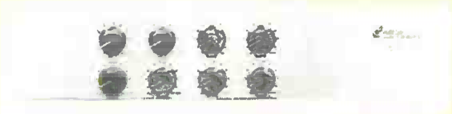
Modular Compressor



• Model Auto-Mix 2B offers the two most useful compression ratios for modern music recording and dialogue. These are the ratios of 2:1 and 4:1. Continuously variable attack time is provided. This permits deliberate use of slow attack times. There are also ten curves of de-essing which function on either ratio. Separate input and compression controls achieve a 90 dB s/n at all compression conditions. For custom installations, all controls may be remotely controlled. Power requirements are 28 V d.c.bi-polar regulated. At full rated putput 30 mA are required. A 36-pin p.c. connector is provided.

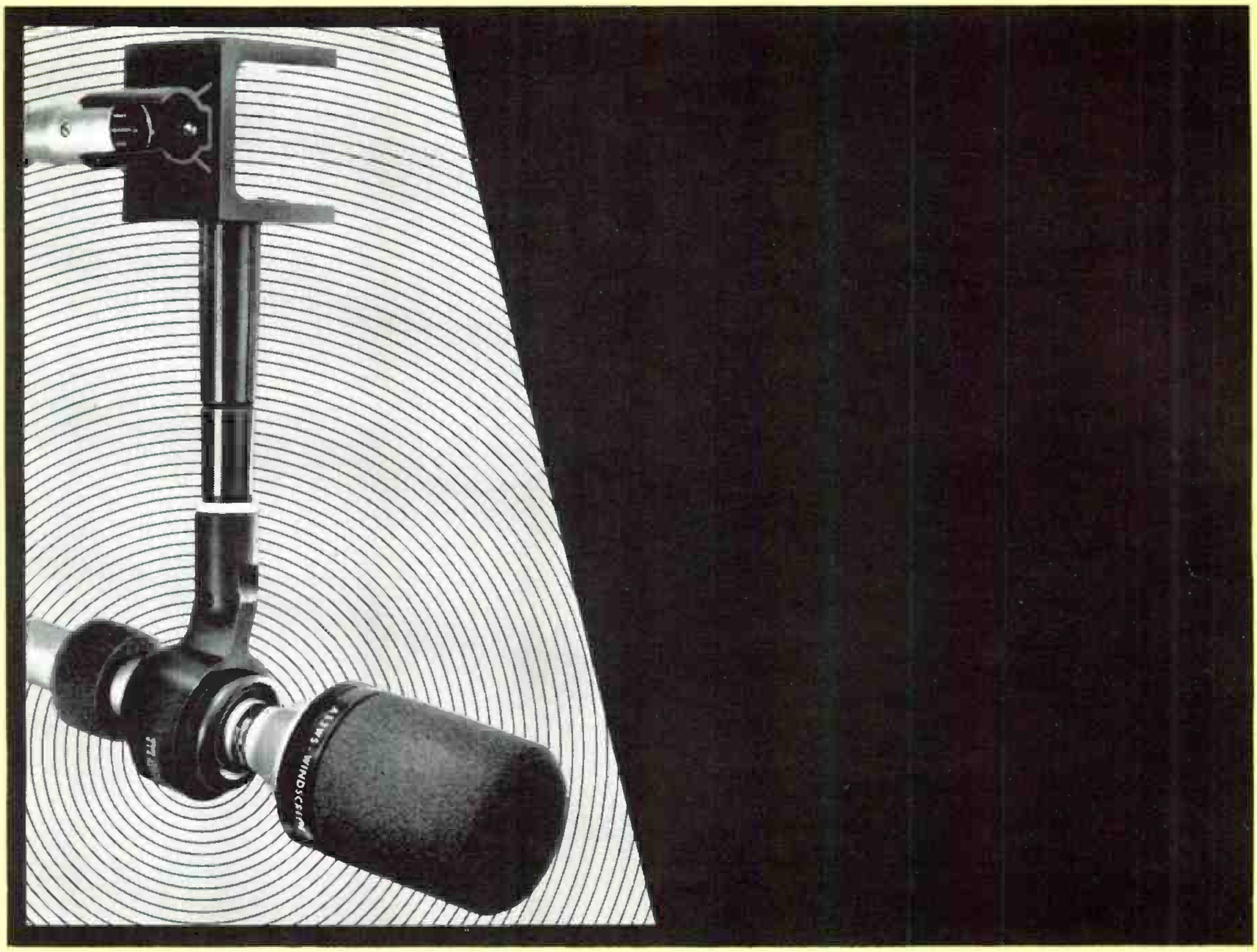
Mfr: Quad-Eight Electronics
Price: $250.00
Circle 5 on Reader Service Card

Equalizers



• These are two models, similar looking, of a new equalizer designed to work with this company's EM-7 echo mixer. Model PEQ-7 is a four-channel peaking type equalizer. It features two low-frequency peak frequencies (40 and 100 Hz) and five high frequency peak frequencies (1.5, 3, 5, 10, 20 kHz). Boost or cut at the selected frequency can be inserted in steps of 2, 4, 6, 9, and 12 dB. The unit has integrated circuits and has zero insertion loss. It plugs directly into the EM-7 system. The second model, EQ-7B is an i-c version of this company's EQ-7 shelfing type equalizer, it features zero insertion loss, extremely low noise (86 dBm) and an equalization cabability of 15 dB at each of the frequency extremes. This unit also can be plugged directly into the EM-7 mixer.

Mfr: Gately Electronics
Circle 43 on Reader Service Card



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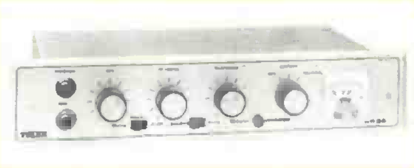
SHURE

Circle 27 on Reader Service Card

Spectrum Analyzer

• This sophisticated audio measuring device is basically a swept frequency spectrum analyzer operating from 10 Hz to 50 kHz with a 10 Hz resolution. A 1.0 volt signal is available on the front panel which tracks the local oscillator and permits frequency-response measurement of amplifiers, filters, loudspeakers, and microphones, as well as attenuation and isolation in circuits and components. The local oscillator and the sweep generator can be swept either in a linear mode for display on the 7 x 10 cm crt or in a log frequency display for expanded lower-frequency analysis. The model 710/801 is battery-operated and covers the frequency range of 10 Hz to 50 kHz.
Mfr: Systron Donner Corp.
Price: $3250.00
Circle 37 on Reader Service Card

Record Preamp



• Model RP-84 is a versatile professional record and playback preamplifier specifically designed for magnetic tape recording and playback with standard NAB calibration. The all solid-state unit can be used with either two or three-head tape transports and includes an a-b monitor switch. An equalization selector switch and a slow/fast speed switch match the unit to any tape transport operating from 1 7/8 to 15 in./sec. Bias adjustment provides optimum record level and an over-all frequency response of 30-18,000 Hz, 3 dB at 7 ½ in./sec. The preamp can be used with quarter-, half-, and full-track head configurations and provides mixing of mic and line inputs. It has a high-impedance phone jack, vu meter, record light, and record interlock. The bias oscillators of several preamps can be synchronized for multi-channel applications.
Mfr: Telex Communications Div.
Price: under $145.00
Circle 44 on Reader Service Card

Ready-To-Use Console

• Up to 28 inputs and 16 outputs in a console measuring only four feet in width are provided by this new entry. It is delivered fully wired and ready to operate. The concept behind the design is a fully modular console using plug-in components that will never become obsolete as the studio's requirements grow. The console can be expanded in capabilities through the simple expediency of addint this company's plug-in wired modules. Modulite volume level indicators are used that offer a virtually instantaneous following of the audio envelope with a sequencial pattern of colored lights.
Mfr: Altec Lansing Div.
Circle 38 on Reader Service Card

Effects Catalog

• One of the wildest, most interesting catalogs to come to our attention is the 120 page catalog entitled *World Wide Sound and Music Library* of Cinema/Sound International of New York City.

We guarantee that you won't put it down once you start leafing through its contents of sounds. It is rich in its completeness. As an example there are 39 types of Farm Animal Sounds ranging from piglets snorting to a cattle stampede complete with hooves, rumble, moos, and bellows. There must be over 400 automobile sounds of every description and this is only through A!

Also included is a series of tapes of Fairs, Festivals and Celebrations recorded around the world from Northern Ireland to Nigeria, from Norway to Singapore. A large number of American events are also covered—such important holidays as the International Brick and Rolling Pin Throwing Contest in Stoud, Oklahoma and the always touching Watermelon Festival held in Hampton, S.C. But don't go away. A section is devoted to News Events, Historic Voices, Campaign Songs plus Musical Listings. The news events date from original wax recordings of pre-1910 vintage (Robert Peary and William McKinley, etc.) to the present. You can select the only known recording of Lenin, or hear Alf Landon, or Princess Elizabeth saying good night to British children, etc. This section is topped off with a Library of Campaign Songs, Incidental Music and Historic Voices. All in all it is a most imposing task, well done, extremely well documented and indexed and probably the world's largest sound library.

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(continued from page 20)
rent—or so little as to be meaningless as a measure of power level. In that condition, the objective was to achieve the best, or maximum voltage transfer, consistent with achieving a satisfactory frequency response or other performance criterion.

In the transistor circuit, similarly, the objective becomes that of achieving the maximum current transfer consistent with similar other criteria. While the transistor, admittedly, comes nearer to being a power amplifier than does the tube, because it can amplify both voltage and current components of signal, pure matching theory does not apply without modification. The fact remains that the transistor is basically a current amplifier—it uses essentially current input, just as the tube uses voltage input.

As the tube achieves matching by assigning an impedance to the grid, which may be realized by use of an external grid resistor, so the transistor achieves matching by modifying the base input impedance to suit. When the emitter is actually grounded (no resistor between emitter and ground) the base input impedance is low and quite non-linear. So an emitter resistor is needed to linearize base input impedance.

Thus, if the transistor of *Figure 4* has a beta of 100, using a collector resistor of 1,000 ohms, and a bias resistor of 100k from collector to base, bias is stabilized so collector current maintains a collector voltage close to half supply voltage as operating point. If the following stage input impedance is 500 ohms, the collector load is 333 ohms (1,000 in parallel with 500).

So the feedback fraction, for signal, is 333/100,000, or 1/300. With a beta of 100, this reduces gain to 3/4, or 75, of which 2/3, or a current gain of 50, reaches the following stage. This is virtually fixed, regardless of the emitter resistor value, which will merely change the input impedance.

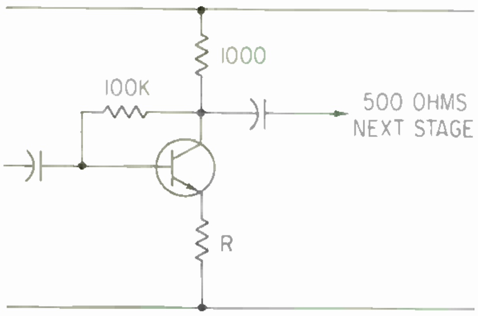

Figure 4. Detailed consideration of this circuit illustrates relationships in transistor input circuits.

As the working gain of the stage is 75 (this transistor has no means of knowing that only 2/3rds of this reaches the next one) the impedance reflected by the emitter resistor into the base circuit will be 75 times the value of the resistor chosen. This is what determines matching.

Now assume that a microphone has a purely resistive impedance of 600 ohms: an emitter resistor of 8 ohms will cause the amplifier input to match this. Current gain will be 50, and voltage gain 41.7. Assume the microphone, for a certain sound input, generates 6 mV signal, open circuit. It will deliver 6/1,200 = 5 microamps input signal which, multiplied by the current gain of 50, will pass 250 microamps signal to the second stage.

Now, halve the emitter resistor, to 4 ohms: now the input current from the same signal will be 6/900 = 6.67 microamps, to produce 333 microamps at the second stage. Clearly the *maximum* signal will occur when the emitter resistor is removed altogether (zero value) so the microphone feeds into a short-circuit.

Then the only linearizing effect on the base-emitter input impedance will be the resistance of the microphone itself. In other words, the amplifier will provide fairly linear *current* amplification, but quite nonlinear *voltage* amplification, under this condition. If this is good enough then it is the condition that achieves maximum gain.

The emitter resistor will serve to linearize input, so the microphone feeds into a more linear load resistance, instead of a very non-linear (almost short-circuit) impedance, but it will reduce power gain a little.

For the same reason encountered in earlier input matching problems, it may be desirable to make the load impedance higher than the theoretical ideal match. The microphone or pickup impedance may include an inductive component, in which case matching into too low a load value results in loss of higher frequencies.

This loss is not irretrievable and it is predictable, based on the relative inductive component of the microphone's internal impedance. So it may be possible to achieve higher gain, and better signal to noise level, by matching into something close to a short-circuit, and then using a carefully designed high-frequency boost later, to equalize for the high-frequency loss.

This must be offset against any possible non-linearity that occurs due to operating the transistor with zero input impedance (or close to it). True, at the low levels utilized by microphones (or even pickups), the distortion produced by this non-linearity will be low.

The choice will be—or should be—dictated by working dynamic range. Low-level pickup will mean that distortion is less likely to be a problem, which noise is more likely to be. So short-circuit matching (or something approaching it) will achieve best results for this purpose.

High-level pickup will mean that distortion assumes greater importance, while noise is less likely to be a factor. So an appreciable value of emitter resistor will help linearize input, with our prejudicing signal-to-noise ratio, in this case.

NORMAN H. CROWHURST

Tape Duplicating —A Status Report

Tape duplicating for the mass market has become big business. In this state-of-the-art report, the author limits his look to that equipment designed for high-output production of tapes. A future report on small-run duplicators is in preparation.

THE UPSURGE IN AUDIO today is tape—particularly cassettes and cartridges. And by upsurge, I mean mass market, not the small-time high-fidelity fan thing that has gone on for decades. This kind of market inevitably attracts entrants, for in such quantities there is money to be made.

The basic engineering problem attached to producing inexpensive tape cartridges and cassettes in quantity is quite different from the problems that plagued the development of the disc industry a few decades ago. The disc record always was a natural for setting up dies and knocking them out by the million. The problem with tape is that virtually every copy has to be made an inch at a time from the master—however fast the inches may be made to pass.

Before this became a problem, tape needed material that would allow at least reasonable quality recordings to be compressed into a smaller space/time relationship, which is analogous to the progress made from the early 78s to modern LPs of various speeds, all much lower than 78, and with many more grooves to the inch, in disc recording. With each medium, that advancement came through development.

To get a mass-produced, inexpensive tape package, the problem remained to find a means to impress program on the copy tapes at a cost commensurate with the materials. For commercial output has now become a quantity/time problem. Return on investment, and consumer price, inevitably reflects the answer to the question, "How many can we turn out, within a given time?"

Primarily this was a matter of transferring the program to the copy tapes, from a master or sub-master recording. But as this process was accelerated, by making a greater number of copies at a faster rate of transfer, the cost bottle-neck quickly moved down the production line. Next thing, more people were needed to package them in cassettes and cartridges: this became the new limiting cost factor.

Speeding up the transfer of program onto the copies required basic technological development. But packaging was more in the production engineer's customary field. However, another problem, still related to this fact that the program must be transferred, inch by inch, instead of at one "bump", as discs are, was quality control: getting and keeping the reject rate low and, above all, keeping the rejects off the market, as far as possible. For nothing has a worse effect on future sales potential than an appreciable percentage of duds getting out!

A disc can be given reasonably good visual inspection in a few seconds, to achieve virtually 100 per cent quality control. To thoroughly check individual tapes equivalently would necessitate someone sitting and listening to every tape sold, all through: an obviously non-economic requirement!

Those are the basic problems of the tape producer. But to produce, he needs duplicating equipment, and that is what this article is all about, along with questions of philosophy of the people and companies in the business, how they go about solving the problems, and so forth.

Of course, duplicating is not new. The first physical problem is how to get more than one copy made each time the master tape is run through the playback heads, in the purely mechanical sense. The electronics end is relatively simple. The master tape output can always feed a bus (at whatever level, that is a matter of choice) that in turn energizes any desired number of recording heads for making copies. But how do you make sure all the tape speeds are correct—identical—as the transfer is made?

In the early days, the late Robert Marshall developed a very fine machine that solved this problem purely mechanically: a machine used by Dubbings Electronics for many years. It had a single master capstan, that rotated solidly, driving master tape and all the copy tapes on the same shaft. It was a solidly-locked mechanical synchronization.

Bob had his problems making all the transports work, to avoid subsidiary problems such as tape flutter and its associated ills, but he was a fine mechanical engineer, and he finished up with a good machine, that occupied much less floor space than the newer master-slave sets that have since monopolized the field. So why is everybody using these master-slave sets, electrically or electronically coupled, today?

The basic reason for this choice is similar to the problem the airlines have: the planes are only earning their keep—amortizing their cost—when they are in the air;

*Norman H. Crowhurst is an engineer, an author, and a teacher. He is a regular columnist with **db** Magazine.*

The problem with tape is that virtually every copy has to be made an inch at a time . . .

in the same way a duplicator is only paying when it is running, actually transferring program from master tape to copy tapes.

The time taken to load the system up is virtually down time. So is time taken to rewind the master, ready to make another run. True, the latter operation can be performed on a separate machine, freeing the duplicator for only forward motion. But even that involves extra handling.

A vital step, and one now universally accepted for duplication of tapes for cassettes and cartridges, is the use of an endless tape bin for handling the master. By this means, as soon as one pass is completed, the beginning is there ready to start the next, with absolutely no waiting. The master can run through and through and through, endlessly, without wasting any more time than is needed to provide leaders on the finished tapes, according to the type of container—cassette or cartridge—used for the finished product.

Looking at the tape in a bin, running, it seems a miracle it does not get hopelessly tangled—all those loops, wriggling and squirming, as it goes in one side and comes out the other. While it operates well most of the time, variation in bin design shows that problems have occurred.

Design of the bin varies. Some use glass fronts so the tape can be seen at a glance at any time. Some are vertical, some sloping. Some use suction or air pressure to keep tape from bunching so it jams round the intake, where it passes through the transport.

Loading the bin uses slightly varying procedure, from machine to machine, but is basically simple and essentially the same. The lead end is anchored at the point where it enters the transport, while live tape from the storage reel is fed through the transport into the bin, until the whole program to be duplicated is in the bin. Then the two leader ends are spliced together, and the master is "ready to go".

When a run is finished, the splice is undone (it uses a tape to facilitate this) and the master is once again wound onto its storage reel.

With this procedure available, it becomes merely a matter of making sure that, for most of the time at least, this endlessly repeating master is making a maximum number of copies. To achieve this, the tape load in the slaves, each of which receives program from the same master, can be reloaded, one at a time, without stopping all the other slave machines. Down time is fractionalized.

Say it takes an expert reloader 20 seconds to remove a finished roll of tape, with however many copies on it, and reload the machine with a fresh roll of tape. And suppose the one master is feeding a dozen slaves. This way, each slave machine is down for only 20 seconds, every so many copies. The other way, where the master is stopped and restarted, assuming only one operator, all the slaves are down for 12 times as long, or 4 minutes, plus any time needed to prepare the master for another run.

What this 4 minutes means, of course, is relative. If the reload was needed only once an hour, it is not bad. But if a reload is needed every 10 minutes, the 4-minute break time begins to represent a considerable loss. And this relationship depends on how many copies are run at a time, and how fast.

Most of the tapes made play at 1-7/8 or 3-3/4 in./sec. Let's assume a particular tape plays 30 minutes per track, some are longer than that. They can be recorded at 30, 60, 120 or 240 in./sec., which represent 16, 32, 64, or 128 times the slower playing speed of 1-7/8 in./sec. This means the tape will take just under 2 minutes, 1 minute, half a minute, or 15 seconds, respectively, to record each cassette- or cartridge-full of tape.

The master tape may or may not be physically the same as the copies made from it. Most master tapes are wider, such as 1 inch, allowing wider tracks and better signal/noise ratio than can be achieved on the copies. Many masters also play at higher speed, 7-1/2 or 15 in./sec., for copies that will play at 1-7/8 or 3-3/4 in./sec. This means that the master machine must run at from 2 to 8 times the speed of the slaves in making the transfer, so the ratio of the transfer speeds is the same as the ratio of the normal playing speeds.

For example, if the master plays at 7-1/2 in./sec. and the copy at 1-7/8 in./sec., the master machine may run at 240 in./sec. and the slave at 60 in./sec., both 4:1. Or speeds of 120 and 30 in./sec. would serve. *Table 1* shows available speeds on equipment shown to the writer by six manufacturers when he was collecting information for this article. These should not be taken as final, because this is a rapidly changing field, and the table merely shows the state of the art a few months ago, as you read this.

A dozen or so such units of recorded track may be transferred onto a continuous roll of tape by each slave machine at one loading, later to be divided and put into individual cassettes or cartridges. Assuming an even dozen are made in each roll, the loading will take from 24 minutes down to 3 minutes, according to the transfer speed used. This begins to put the whole transfer operation into perspective.

That covers the mechanics of transferring tracks from master to a number of copies, via slave machines. It does not yet get down to the details of how 4- or 8-track tapes are produced, whether all at once, or in successive passes through the machine. Both methods are used, by different people. Nor does it resolve many minor problems, both mechanical, electronic, and a combination of both, that can arise.

Some of the slave machines come with inter-changeable heads and electronics to go with them, so that various types of tape can be made on the same set of machines, after appropriate modifications. While the

TABLE 1

Maker	Master Speed				Slave Speed			
	240	120	60	30	240	120	60	30
Ampex		X	X	X			X	X
Electrosound		X					X	X
Gauss	X	X	X		X	X	X	
GRT	X				X	X		
Otari	X	X				X	X	X
Vega	X	X				X	X	

Table 1. Transfer speeds on current model tape duplicators

Speeding up the transfer of program onto the copies required basic technological development . . . the program must be transferred, inch by inch, instead of at one "bump", as discs are. A problem was quality control: getting and keeping the reject rate low and, above all, keeping the rejects off the market, as far as possible.

usual practice will be to run as long a run as possible of one type, or catalog number, before changing to another, in order to reduce down time while such changes are being made, for many operators of duplicating equipment, working under pressure of customer orders, flexibility at high speed is an asset.

Some machines make a feature of being able to switch from one type of production to another in a matter of seconds. Of course, the precise time depends on the simplicity of the operation involved, the familiarity of the operator with the necessary operation, and the degree of readjustment, if any, needed to align the new mode.

This discussion leads to the choice of philosophy for integrating the record heads with the electronics that drive them. Some prefer to have a high-level (power) bus that provides enough energy, both audio and bias, which must be in the region of several megacycles to correspond with normal bias at playing speed, to feed all the slaves that will be used, in such a way that disconnecting individual slave units does not influence the level fed to those remaining connected.

Others prefer packages with an attached printed-circuit board so that the electronics for driving the heads can be pre-adjusted to suit the particular head on which they are assembled, and fed from a line-level bus.

Still others prefer to have separate electronics for each head in the system, but to mount all the electronics at a central adjustment location, rather than having them distributed in proximity to individual heads.

There are pros and cons for each method. For one-person operation, it would seem that the choice rests between the power bus or the integrated package arrangement. In either case, the adjustment is local to the individual heads, and need not interfere with the setting of any other slave machine. These methods have the further advantage that the transmission level avoids susceptibility to spurious pickup, such as hum.

The foregoing comments apply to producing quantity outputs of tape in cassettes and cartridges. However, reel-to-reel tape is not dead, by any means, nor is it likely to be. So all duplicating machines make provision for reel to reel, by eliminating the master bin—and they need the reels for loading and unloading the bin, anyway—and providing regular, rather than bulk reels on the slaves.

On the other hand, reel to reel can also be made by bulk process, using the bin and making a number of runs on each slave using bulk size reels, the tape from which is later cut up for individual market size reels, just the same as for cassettes and cartridges.

Having transferred program from the master tape to however many slaves are working at once, each producing however many runs of the program at a loading, you have spools and spools of multiple-unit tapes coming off the duplicator, and needing to be packaged in cassettes or cartridges at corresponding handling speed, if a bottle neck is to be avoided.

This leads to various approaches to automation in loading the section of prerecorded tape into their cassettes or cartridges and packaging them, on down the line. Few if any production lines are yet completely automated, as this is being written. But the ingenuity of the more progressive designers is rapidly moving in that direction. In complete automation, ideally, raw tape would feed in at one end, and packaged cartridges or cassettes would come out the other, already quality checked and packed, ready for shipment.

Automatic loading of cassettes or cartridges can be performed very quickly by using tape markers that trigger the machine when a run of program is completed. These markers are inserted by the master, between the end of one run and the beginning of the next.

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A 250 Hz tone, for example, recording at 240 in./sec., will be just about 2 Hz at 1-7/8, and thus inaudible at playing speed: the tape player just will not amplify such a frequency. The audio being recorded is transferred at 128 times the playing frequencies, which will be in the kHz range and up, and thus inaudible, or well beyond the audio range, when run through a head at 240 in./sec.

Thus a 250 Hz or similar keying tone can easily be picked up in a high-speed winding operation, and at the same time it will be completely inaudible on the finished tape, when it runs at its normal playing speed. The tone triggers an automated cutting device and/or whatever else is needed, with or without an operator's aid, to start another cartridge or cassette being loaded with the next run of tape.

Quality control can mean various things. One thing to look for is drop-outs on the tape. This can occur, due to weak spots in the tape coating, or due to failure to maintain absolutely uniform contact pressure while the tape crosses the recording head at the high transfer speed.

To minimize the latter, several duplicating machine manufacturers use two capstans, one before and one after the heads, with the shortest possible linear distance between them. As well as eliminating drop-outs due to varying tape pressure against the heads, this also minimizes scrape flutter.

Gauss Electrophysics employs an interesting method of maintaining uniform tension through this short but important distance of high-speed moving tape: both capstans are driven by synchronous motors, but the lead capstan is very slightly larger than the following one. This causes the lead motor to be dragged slightly below synchronous speed, while the trailing one is pulled

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slightly ahead of synchronous speed, the force created by this (electrical, not physical) slip controlling the tension of the tape as it passes over the heads.

Other aspects of quality control need to check for drop-outs due to variations in tape quality, perhaps, or to verify that recording quality is up to snuff. Variations in tape quality, for effective control purposes, must be checked continuously, virtually 100 per cent—at least on sample runs.

One way to do this is to provide the slave(s) with playback heads, that monitor the program impressed continuously, checking its level against the recording level a split second earlier, when the same point on the tape passed the recording head. This is only a level check, but it can be made highly reliable.

Checking for quality of recorded program involves listening to spot checks on the tape, and can only really be performed as a sampling operation. Of course, the more other checks that are provided, the less likely is any variation in quality of recorded program to escape detection.

As in any recorder, change of bias setting, or any other deviation, electrical or electronic, can interfere with quality. So output from each recording slave should be quality checked every so often.

Another quality control check concerns cartridges particularly, where a fault can occur that will impair the running of the tape, not necessarily due to any defect in the recorded program or associated with it. This could cause the tape to hang up at some point in its rotation through a playing machine.

One test for this performs a 100 per cent check on cartridges in batches, without listening to them. It uses the sub-audio key tone to determine when the whole tape has gone by and alerts the operator if any cartridge in the batch fails.

Practically all the manufacturers have made flexibility a key feature of design, so that each machine can be rigged to do the maximum variety of jobs. However, while one manufacturer aims at flexibility with his own line, to achieve change you need different units from that manufacturer's line; others aim at maximum compatibility, so individual units from that manufacturer can be used in combination with as many of his competitor's systems as possible.

Some manufacturers have devoted their attention to producing a duplicating system, or some particular part of it, for sale to people in the duplicating business. Some of these have designed improved cassettes or cartridges, yielding better handling of the tape, primarily intended for use in their own facility, but having it available, they find a market for that too, to other duplicating houses.

The name with the background in the business is, of course, Ampex. Their machines were successful, from the first, because of their solid design: they are durable. As several of the newer companies were started by, or

There are pros and cons for each method. For one-person operation, it would seem that the choice rests between the power bus or the integrated package arrangement.

Automatic loading of cassettes or cartridges can be performed very quickly by using tape markers that trigger the machine when a run of program is completed.

else hired, personnel formerly with Ampex, it is only natural that most of them perpetuate the same notion of ruggedness in design. That is as the fundamental principle taught in the school from which they graduated. One might even say they are over-engineered.

Of course, over-engineering for this kind of work is a good "fault". Failing to hold up can be a far more costly fault, so it is better to have a truly great margin of safety—a machine that will produce good, though not perfect output, even when it is persistently abused—than to try to engineer for some sort of economic optimum. The economics come in the time/material relationship of production materials, not in the tools used—the equipment.

We referred earlier to the choice between making 4 to 8 tracks (or even more, when they can squeeze more onto the tape) all at once, and making them tracks (that's for stereo) at a time, requiring more than one pass through the machine. Doing the whole operation at once, putting on all the tracks in one pass, saves time, but requires more electronic equipment and greater precision in the total adjustment, for perfect alignment, although most of this precision is cared for in the multitrack head.

On the other hand, making more than one pass enables greater focus to be placed on individual track quality, minimizes cross-talk problems within the head assembly, but imposes another problem: that of getting all the tracks to start and finish coincidentally, or closely enough so that parts of one or other run do not get chopped off in the packaging. This can be achieved by using the same keying codes, put on during the first run, as control to synchronize the starts on successive runs.

This connects with the problems of start and stop, mostly the starts. How soon can the machine come to speed, and synchronize with the master machine, already running? This depends on the type of drive, and it also sets requirements: the tape transport handling mechanism must control tape movement to correspond. Different machines use different types of mechanism to absorb speed changes and settle the whole mechanism down to uniform movement.

Different kinds of motor are used for all purposes, by different manufacturers. For the synchronous drive, some use servo motors, that enable all the slaves to be phase-locked to the master, with the theory that any deviation from synchronism, or any speed change due to supply variations will, in this way, affect every capstan, master and slave, in identical fashion.

Others use synchronous and closely identical drives for master and slaves, so that uniformity depends on this identity.

Then for the feed and take-up spools (which are involved on the slaves but not in the master bin) again different types of motor may be used. A high-slip induction motor can provide fairly constant torque, and thus close to uniform tape tension. On the other hand, a d.-c. motor offers some advantages in controllability.

Some manufacturers have devoted their attention to producing a duplicating system, or some particular part of it, for sale to people in the duplicating business. Others are themselves in the duplicating business.

For quality recording, head quality and the electronics that feed the heads are important. Otari has introduced a unique design using heads of ferrite material, which they claim to be superior and much longer wearing than conventional heads. Most of the manufacturers, who do not use a power level bus, have switched to the use of etched-circuit boards attached to or closely associated with the heads they serve, on which are mounted amplifiers, equalizers, and necessary trimming features.

These are just some of the facets of the ongoing research and development in the field. Far more things can happen to magnetic tape than meet the eye. For example, have you ever noticed that tapes deteriorate with keeping, quite apart from such obvious defects as print-through?

For some time, it has been felt that magnetic tape can be made wear-proof. Mechanically it can. Disc records can wear out, but tapes (even master tapes) can deteriorate by being stored for a long time. Apparently a slow longitudinal demagnetization occurs, especially at high frequencies, where wavelength is short.

For this reason a new recording sounds brighter, sharper, than one that has been stored for some time. This cannot happen to discs, unless they are played, to wear the high frequencies off. However, tape and other research is being conducted, to find ways of overcoming this problem. Meanwhile the more immediate problem is that of issuing the best possible new tapes, to which there are many more problems than we have space here to treat in depth.

One reason for versatility, and for different emphases in the design philosophies used, is the increasing variety of uses for tape. Car stereo, home stereo (which may use the same cassettes or cartridges interchangeably), and various portables, all use conventional program material, of the entertainment variety.

However, there are big customers with nationwide distribution and little customers not so widely known, who may require correspondingly big and little runs on their catalog numbers. So choice of quipment may vary, according to whether the duplicating facility is likely to be making all short runs, all long runs, or a mixture.

For short runs, versatility in making the necessary changes in minimum time is as important as producing quantity at maximum speed, or maybe more so. For long runs, which means large quantities, maximum operating speed, saving every second on the production line, is probably the most important single criterion, with many facets. For mixed runs, the best of both is sought, or maybe some compromise will be needed.

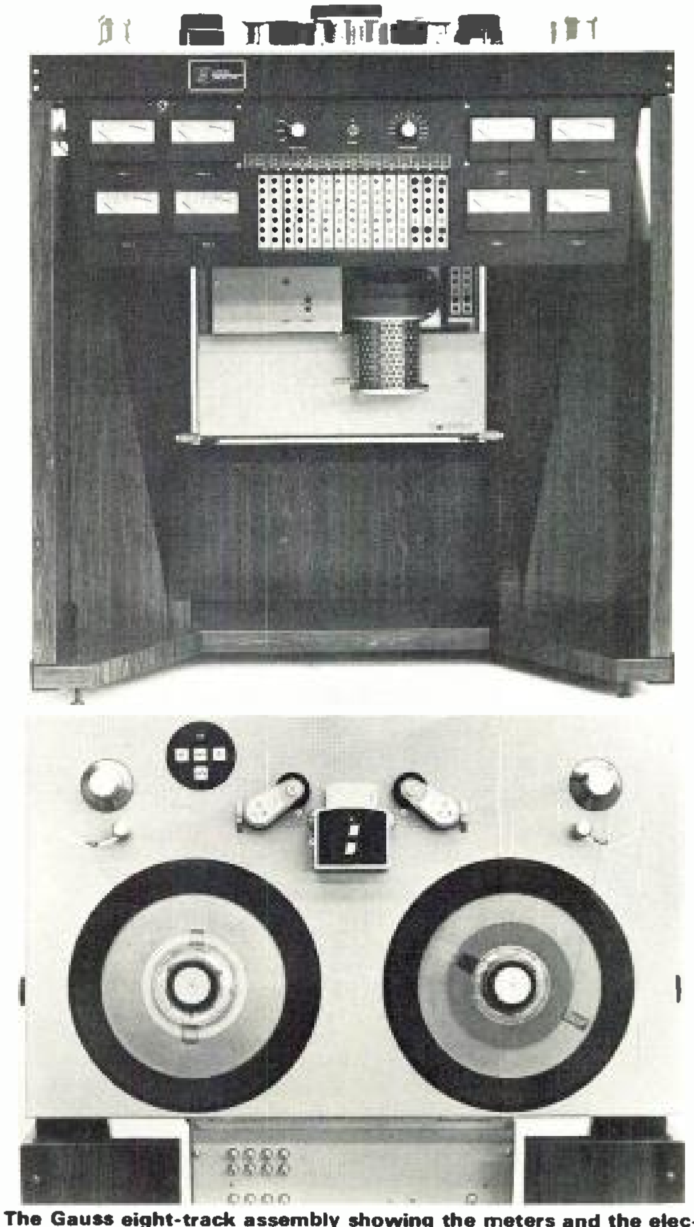
But entertainment media of one kind or another are far from the only uses for recorded tape today. Talking clocks, language and other teaching tapes, functional tape units for an almost endless variety of process controls, the field is endless. ■

A Guide to High-Volume Tape Duplicating Systems

THE FOLLOWING LIST and specifications should not be taken as a total guide to the market. Rather, this represents information available to us at press time on models and manufacturers. In this rapidly developing industry, it is to be expected that new equipment and manufacturers exist beyond this list. We will report on them in subsequent issues.

GAUSS ELECTROPHYSICS

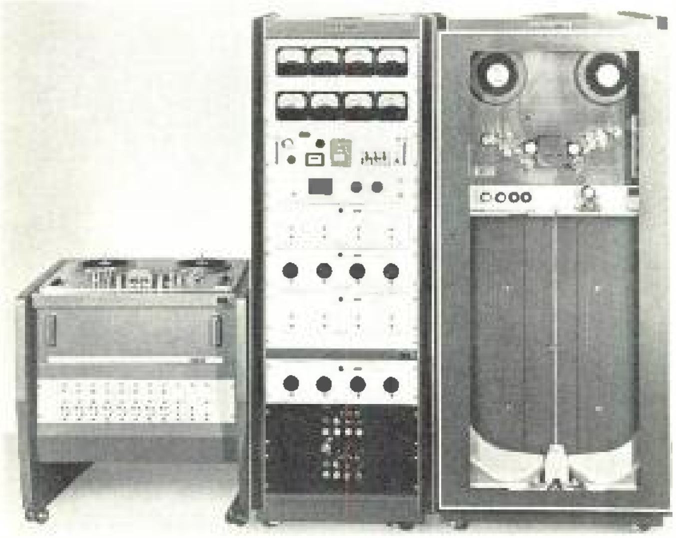
Series 1200—is a high-speed system with the master using reels of tape operating in a closed-loop system using a dual capstan drive with two direct-drive synchronous capstan motors. Servo systems control tape tension. Up to eight tracks are fed from ¼-, ½-, or 1-inch wide tapes. The slaves take 14-inch reels and ¼-inch or 150-mil wide tapes. *Circle 92 on Reader Service Card.*



The Gauss eight-track assembly showing the meters and the electronic part of the controls. In the top view of the transport the closed-loop double capstan system is clearly seen.

OTARI OF AMERICA

High Speed (32:1) Duplicators—Endless loop masters (with bin) are available in models using 1-inch tape and eight tracks, ½-inch tape and four tracks, and a convertible model that uses both. In the same way, slaves are available that use either cassette or cartridge configurations, with a model that is convertible to either. Other configurations can be had on special order. Monolithic crystal ferrite heads are used and are stated to provide five to ten times the normal life of laminated ferrite heads. *Circle 95 on Reader Service Card.*



Otari's basic system including the bin master with its clear front, the electronics rack, and one slave with its plug-in electronic modules below.

GRT CORPORATION

GRT 260 System—The master is a continuous loop transport with a bin that accepts up to 1200 feet of tape. An 1800 foot bin is under development. Eight tracks on the one-inch tape are fed to the slaves loaded with ¼-inch tape for cartridges, on the 202 model, or 150-mil wide tape on the 200 model cassette slave (four tracks, of course). Either slave model takes 14-inch tape reels. *Circle 93 on Reader Service Card.*

An actual installation of the GRT-260 system with five slaves. The solid-front tape bin is below the transport of the master, with some control electronics above.

(continued on page 38)

MARTIN DICKSTEIN

A Mini-Fair Comes to New York

The super displays shown at recent world's fairs are now appearing in industrial displays. Here is one that was recently opened to the public in New York City. It uses mechanical devices, sound systems and controlled projectors to provide startling effective information.

"HAVE YOU BEEN THROUGH THE MILL?"

This is the eye-catcher being used to attract attention to the fact that a new public exhibit, billed at the "world's largest permanent slide projection show," has opened in New York City—a simulated textile manufacturing mill right in the middle of the tourist attraction area, on one of the main thoroughfares, and within easy reach of the walking populace or the area lunch-hour crowds.

Back in 1967, when Burlington Industries made plans to house most of its corporate and merchandising divisional headquarters under one roof, thought was also given to the best way to provide the public with an inside view of how textiles and related products are made. In 1968, construction started on a 50-story building now known as Burlington House after the major tenant.

Early in 1969, when 21 of the company's 31 divisions began moving into 15 floors of the building, space was left adjacent to the building's main lobby for an exhibit area. The dimensions were 35-feet wide, over 200-feet long and 4 stories high at the center portion. The type of display that would be suitable for this area was considered and static presentations of any kind were immediately rejected as not being vital enough.

Fashion shows, the usual project for a textile or clothing material producer, were considered too limited in scope and appealing to only a small segment of the public. In order to tell the story of the world's largest and most diversified manufacturer of textiles and related products, and also the world's largest user of textile fibers (nearly 900 million pounds of 40 different natural and man-made kinds), it was decided that the exhibit should demonstrate how actual machinery used in mills produced the many end products the company made and the uses to which these products were put in everyday living. This was a rather large order, considering that Burlington has 135 plants in 14 states, employs 86,000 persons in its worldwide operation in 9 foreign countries, passed the 1.75-billion dollar sales mark last year, and has grown to this large operation from a company which began in 1923 in one plant in Burlington, N.C., working only with rayon and cotton.

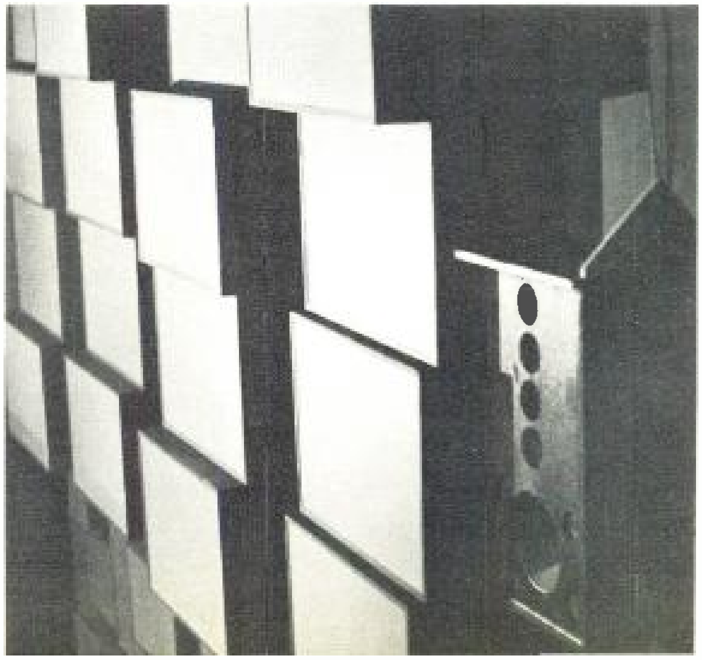
The firm of Chermayeff & Geismar, design consultants to Burlington on past occasions, was given the project, and after about five months, plans were ready for approval. One plan that was considered was to have the machinery actually produce their regular products to enhance the realism of the mill, which the public does not get to see under ordinary circumstances. There was nothing wrong with this idea, except that it was just not feasible from a logistics viewpoint. There was no easy way to bring in the raw materials and remove the manufactured items what with parking and traffic difficulties in the middle of the city.

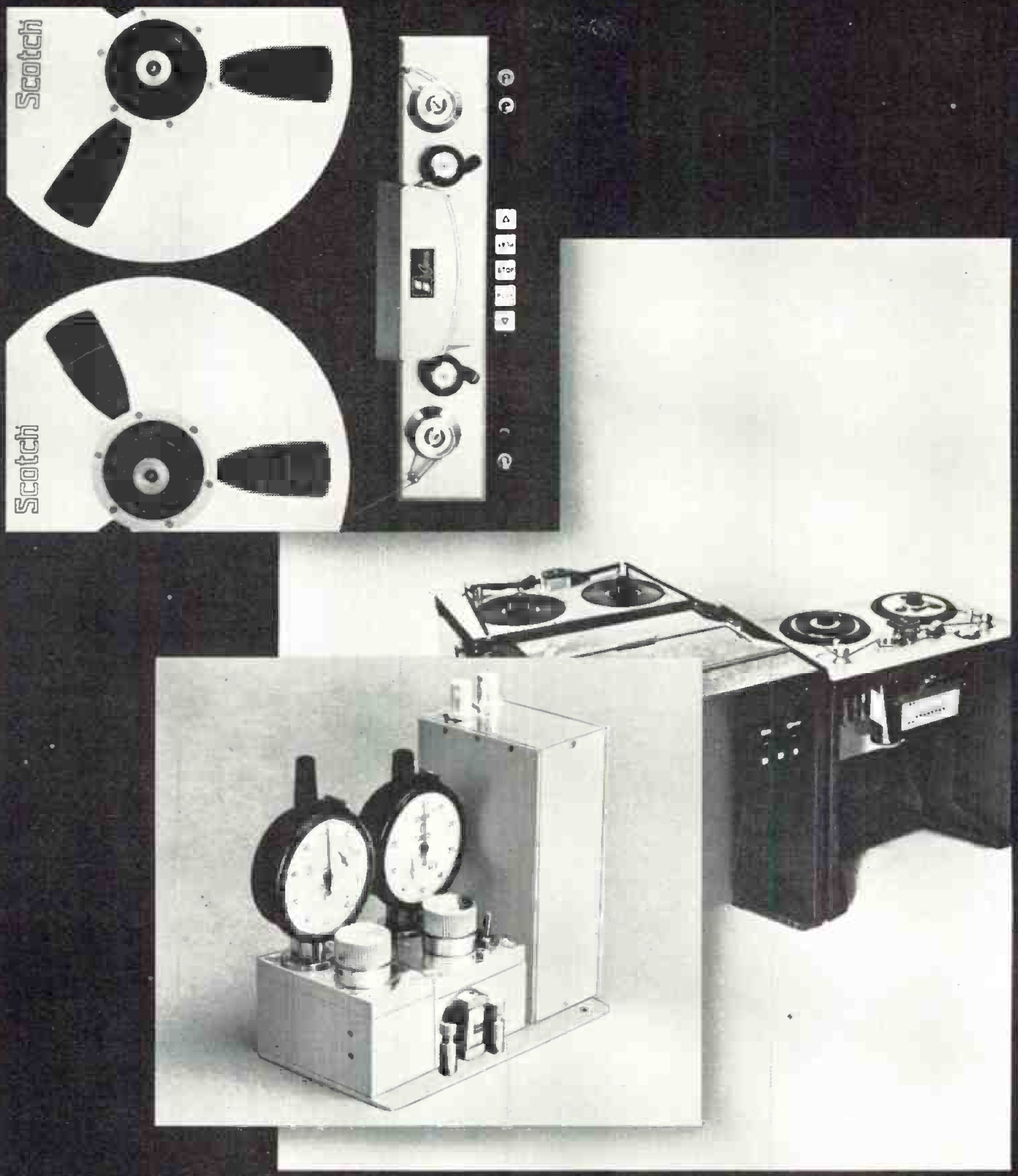
The final plan, then, was to have a raw materials display in which the sources of the basic fibers would be presented, followed by a machinery area in which the actual mill equipment would operate but not produce, and finally an exhibit to illustrate the end-uses of the products, textiles and materials.

For implementation of the project, the consultants

*Martin Dickstein is a columnist with **db** Magazine. As a free-lance audio/visual consultant he was involved in the assembly of the project he describes.*

Figure 1. The rear-projection screens. Sizes range from that of a small tv set to 4 1/2 by 6 feet, and the assembly rises to the ceiling. Note the speaker unit on the right. In actual use it is covered by a black cloth and is not seen.





PLAY-CHECKERS
FOR GAUSS FIDELITY

Tape duplication fidelity was just a buzz word until the Gauss 1200 Series made the scene. Gauss' Model 1250 Reproducer offers strict quality control verification of tapes duplicated in either 1/7″ or 1/4″ widths. It permits examination of the tape in *real* time.

Gauss' Model 1270 permits visual functional measurement of the tape duplicator throughout the duplicating process, thus permitting examination of the tape *at duplicator speed.* As play-checkers, they're necessary *all the time.*

They're quality standards *set* by Gauss.

by Gauss

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Circle 29 on Reader Service Card

called on the talents of Paul Seiz, currently director of the Museum of Performing Arts at Lincoln Center in N. Y., as associate designer. The total past record of this combination of talents includes such formidable design projects as the U. S. Pavilions at each of the N. Y., Montreal, and Osaka World's Fairs.

The concept that the visitors are entering a fair-like exhibit begins as they mount the steps at the front of the building. A modern fountain, built in what looks like a tree of pipes in a square-shaped pool, creates a ball of spray which falls into the pool, which in turn empties continuously into a lower and larger square pool.

The audience enters through a revolving door in a front wall of glass to the entry lobby of the exhibit. Here, on one wall, is a Burlington family tree made up of hundreds of cones of yarn and indicating, on discs within the spool arrangement, the names of products or divisions of Burlington . . . such well known names as Lees Carpets, Klopman Fabrics, Adler Socks, and Globe Furniture. The entire display is white on white.

The visiting guest then walks under six large rotating psychedelically painted (black and white) fabric pattern rollers onto a slowly moving "sidewalk," which will carry him through the rest of the exhibit. This moving walkway is 208-feet long and is the longest of its kind east of the Mississippi River.

The first exhibit area presents the sources of 6 of the raw materials—wool, cotton, rayon, nylon, polyester and glass fiber. The sound heard through ceiling speakers located over the ramp is electronic music creating the effect of gurgling liquids as though to indicate that the next step is a chemical process leading to materials for the manufacturing machines to use in their phase of the mill operation.

From here, the visitor is led into the largest section of the exhibit areas, the manufacturing plant. Production machinery is set up on three levels to demonstrate *spinning*—the rewinding of packages of yarn onto bobbins: *dye vats*—for quantity dying of yarn spools: *warping*—winding yarn from a number of yarn packages onto a large beam for the weaving or warp knitting processes: *circular doubleknit machines*—for production of doubleknit fabrics from natural and man-made yarns: *hosiery knitting*—producing pantyhose, women's hosiery, men's and children's socks: *hosiery boarding*—a process for shaping hosiery and socks under high temperature and pressure; *Jacquard loom*—weaving of tapestries, brocades, damasks, etc. from a punch-card programmed system: *Sulzer loom*—weaves fabrics at high speeds without a shuttle: *Raschel knitting machine*—produces warp knit fabrics with lacy and open effects as well as smooth surface patterns: and *tufting*—production of loop and cut pile fabrics for carpets, rugs, and bedspreads.

To enhance the effect of size of the mill area (40-feet high), the walls of this area are all mirrored so that the expanse of the actual size, as viewed from the moving ramp, is an illusion of immense proportions.

Mirror-walls also permit the viewing of rear sections of the machinery as well as the machines located on the lower level and also under the moving ramp.

As each of the machines makes its own sound and the total din of the area, under normal circumstances, would be almost unbearable, each of the machines is

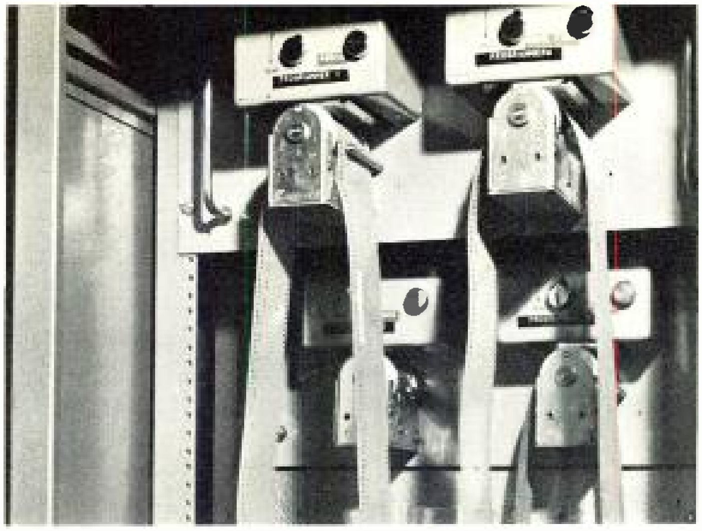


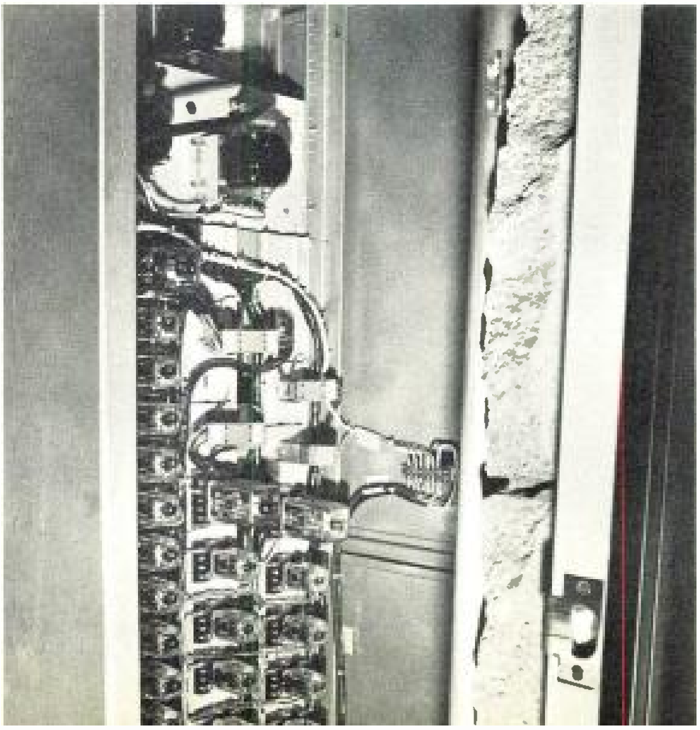
Figure 2. The control programmers for the slide projectors.

damped to decrease the sound it makes during movement as much as possible. Some of the units were modified to reduce the actual sound made to almost a complete silence. The true sound of each machine is then reproduced through specially selected sound columns for the high frequencies and bass speakers for the lower frequencies, both of which are located in the vicinity of the machines but disguised. The sound is then programmed so that only one machine sound is heard at any one time and a flashing arrow indicates which machine's sound is being reproduced.

It was found to be unfeasible to stop and start the individual machines as the sound was heard, and the method presently being used is quite effective, in spite of the fact that all the machines are moving continuously but only one sound is heard. The only machine not programmed for sound reproduction is the dye vat unit. This machine operates independently. As the cover lowers and the spools descend into the dye, steam (created by dry ice being lowered into water) rises from the inside of the unit and as the lid hits a microswitch on the way down, a hiss sound is heard.

The next part of the exhibit is most as what would be expected at a modern fair display. The entire length of the wall of this diorama is made up of a total of 69

Figure 3. The control relays located in the programmer rack behind the four projector control units. Above the relays you can see the motors for the programmer units as seen in Figure 2.



rear-screens *(Figure 1)* ranging from about the size of a small TV set to about 4½ by 6 feet and extending from slightly below the walkway all the way to the ceiling.

The screens are placed so that some are at the wall surface, others are slightly in front and others still farther forward toward the viewers. The display is divided into several sections. One segment, shows figures made of different parts of the body dressed normally but arranged to create a human that is quite unreal but amusing. Another section shows a chair with diverse covering material patterns while adjacent screens show various patterns or blowups of the material. Still others show windows with patterned curtains or athletic activities in which material is used for different purposes. The last section displays logos or labels of Burlington or subsidiary companies. For a more dramatic effect, each segment is programmed separately to change projectors that carry related images in a uniform pattern. The music, is called *Mill Rock* and is distributed through three specially-designed speakers placed at ear level on the moving ramp and spread across the width of the exhibit area and hidden in the black wall between screen boxes.

The exit area has 6 more "fabric" rollers revolving over the heads of the visitors as they step off the moving sidewalk. In the lobby, visitors are shown a map with pins indicating the locations of Burlington offices and plants, facts and figures about Burlington and its divisions on continuously rotating closed-loops of material moved by revolving rollers to simulate the operation of computers.

The total result of the Mill presentation is the multisensory experience of following the production of textile and related materials from source through manufacture to final use in every-day existence. The techniques used to present this brief (8½ minutes) tour of the mills are modern and unique. The rear screen projection area is the latest and largest industrial application for a permanent exhibit since the technique was first used at a recent World's Fair.

Figure 4. These lamps pin point a projector lamp that has failed. Switches below the lights are to preset programmers for continuous (normal) operation, or for one cycle after which the programmer is automatically stopped by a punch in the tape in the last channel.

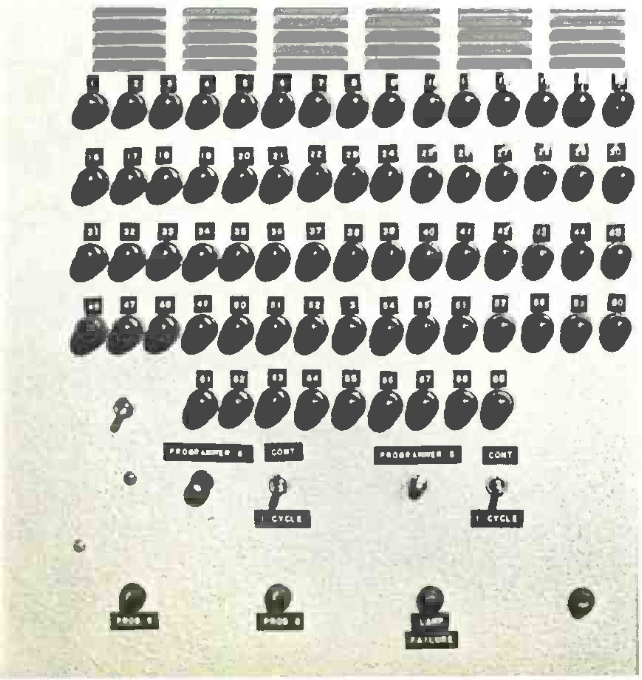


Figure 5. The author is seen starting one of four amplifiers/tape decks. Each amplifier has a monitor speaker which can be cut off by the switch below it. During the check-out period at down time, test levels are set.

As the visitor leaves the rear of the exhibit, and walks around the building on the side street, he is presented with a further experience, visible only from outside the building. Nearly 200 different colored fabrics are mounted in 175 squares, each four feet by four feet, and with a total of over 1,000 blinking lights bordering the squares. The center of this wall of fabric is left open so that persons looking into the exhibit area can see the machinery. The solid portions of the wall are used to block off the light from the outside from the raw materials and end-use areas of the exhibit.

The Mill opened on Sept. 10, and will remain open indefinitely. The display is open to the public each Tuesday through Saturday, from 10AM to 7PM. Admission is free.

All the control and sound amplification equipment is

Figure 6. Backstage at the Mill in the projection area. Note the perforated steel platforms on which the projectors are mounted.

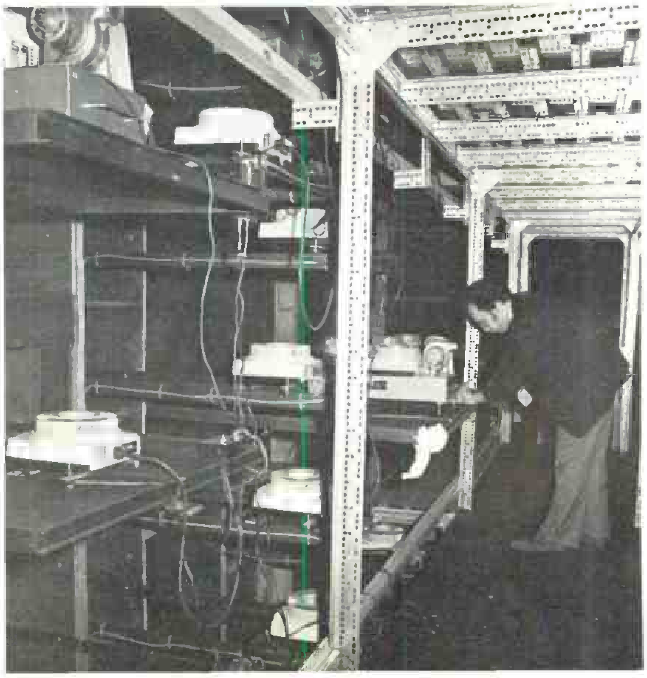


Figure 7. One of the standard projectors. Note the microswitch mounted at the zero position on the unit. At the right is the control box.

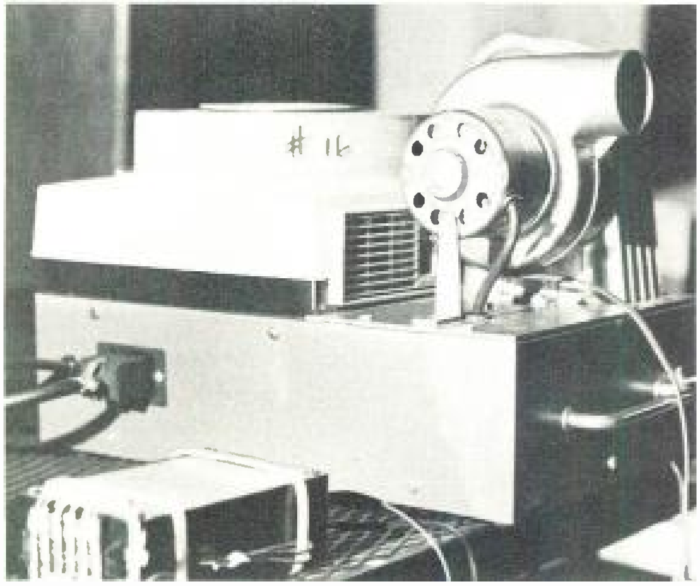
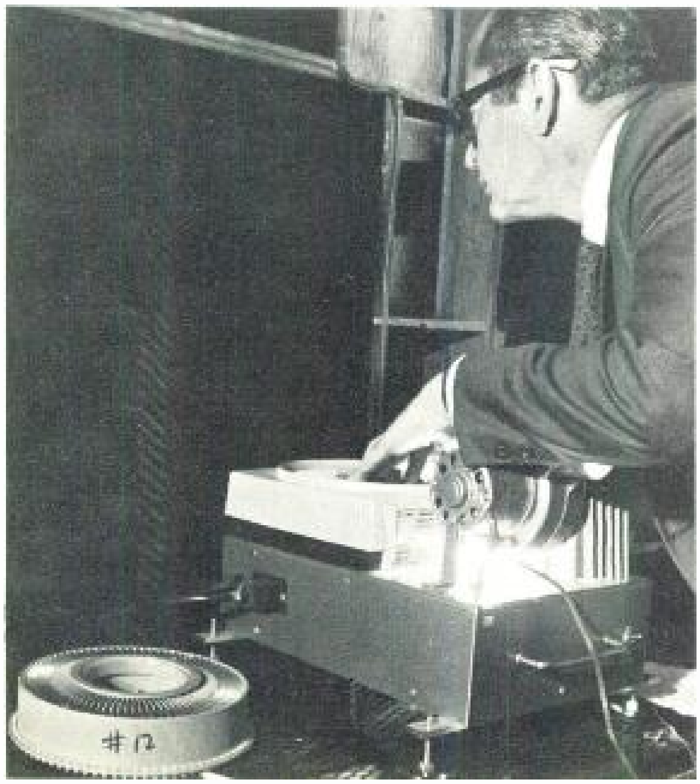


Figure 8. A projector modified by the addition of a Xenon Eight source. The added blower and projector are mounted on the remote of the power supply.

Figure 9. Technical director Stan Goldstein is shown adjusting the alignment of a projector with an SMPTE slide.



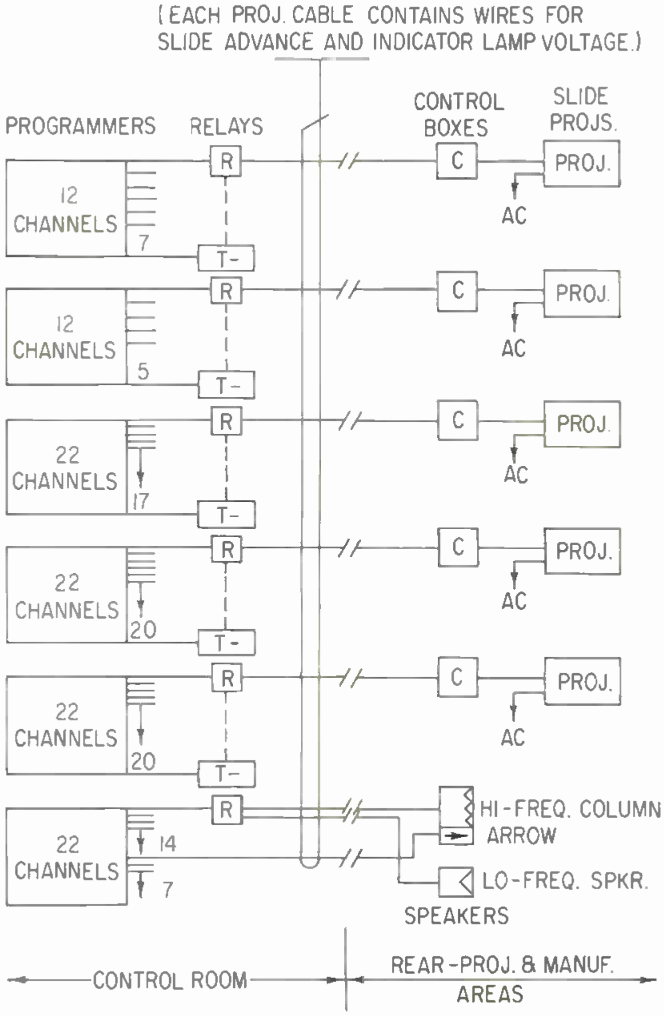
housed in six metal racks located in a small room adjacent to the rear-projection area. Two of the racks contain the six projection and sound distribution control programmers *(Figure 2).* Behind the four programmers in one of the racks are the relays used in the projector and sound control system *(Figure 3)* including the larger T-Bar relays at the top of each of the rows of smaller relays. The hinged door on the other programmer rack has mounted on it indicator lamps *(Figure 4)* which show when a slide projector has lost its source of illumination.

The other four racks contain all the audio equipment *(Figure 5)* which originate and amplify the sound and music for all the display areas.

As the machines are quite large, and each working part of the unit created a different sound, it was decided to record the sound in two parts, one take for the operating sound and one for the motor or chain drive. The recordings, made by Frank Lewin of Demeter Music, Inc., were made with a directional microphone on a full-track Nagra at 7½ in./sec.

The tricky part came in the dubbing of the original single track sounds to two-track tape for use at the exhibit. The rhythm of each sound for each machine had to be matched carefully with the other half of the total audio of the working machine. In the playback, the high frequencies are fed to a sound column located close to the machine, and the lower frequencies are fed to a bass speaker hidden near the part of the machine which created that sound originally. The level of each sound is

Figure 10. A line diagram (simplified) showing typical projector, sound, and indicator-arrow control circuits.



balanced against the other so that the composite sound effect is as realistic as possible. In the projection portion of the exhibit, modern rock music written and recorded by Entermedia Futures, Inc. is distributed through flat response speakers as shown in *Figure 13*.

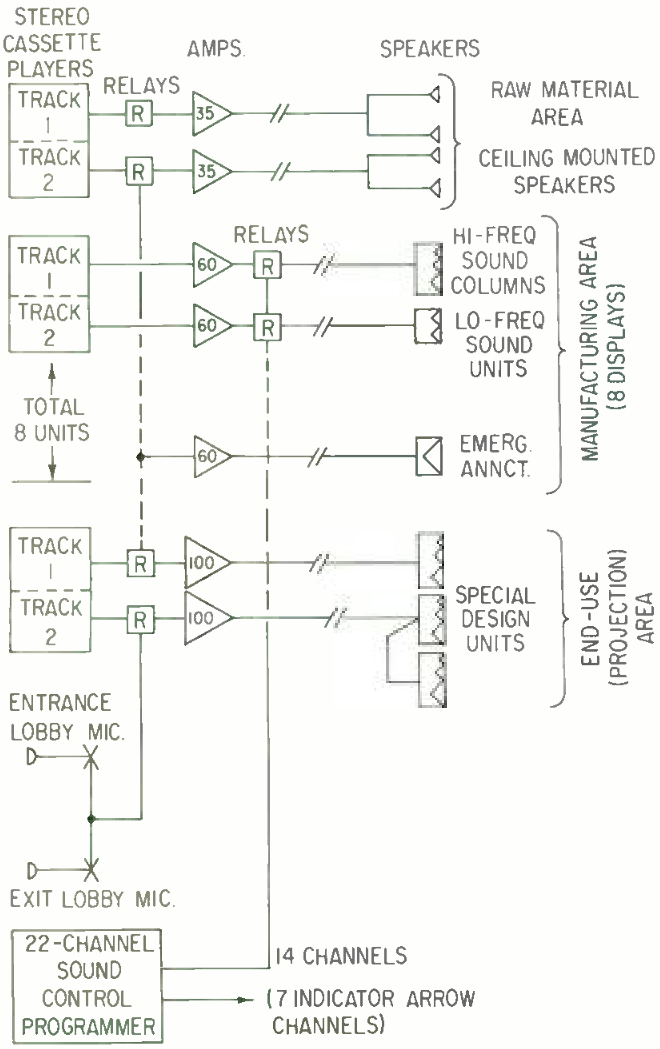
As in all public display areas, emergency precautions are required for the safety of the visitors, and, incidentally, to assist in preventing damage to any of the display items. For this purpose, a page system was installed with push-to-talk microphones in each of the lobbies. These use relays and the existing amplifiers in the first and third areas, and a separate amplifier and speaker in the machinery area.

Schools, church groups and other organizations are invited to schedule guided tours of the Mill. For this occasion, a wireless microphone system, with speakers overhead directly over the moving walkway, permit a guide to stand at the machinery and describe the operation of a typical mill.

It is Burlington's hope that they have provided the visitors to the exhibit with an entertaining and interesting display of how a mill works. Creation of good will, greater interest and closer association of the audience for the various subsidiaries and products of Burlington as well as a brighter aspect of the outside of a big business building on a busy side street are also among the desires of Burlington. The company that does more with fabrics than anyone else in the world has also created the latest and largest spectacle of its kind anywhere, and right in the center of fun city.

We wish to express thanks to Mr. Larry Carr of Burlington; Mr. Gene Demick of Bergen Expo Systems, audio-visual supplier and now maintaining the operation of the exhibit's a-v facilities; Mr. Bill Merrill of Porto-Vox Enterprises, Inc., audio and control equipment supplier; Mr. Bob Vogel, audio-visual engineer; Mr. Ron Gold of Rinzler/Arden Agency and the technical staff and guides of the Mill for their invaluable assistance. Photographs are by Burlington, Joseph Getzoff, and Leo Lowenthal.

Figure 11. Projector control and lamp indicator circuits typical of incandescent lamp slide projectors.



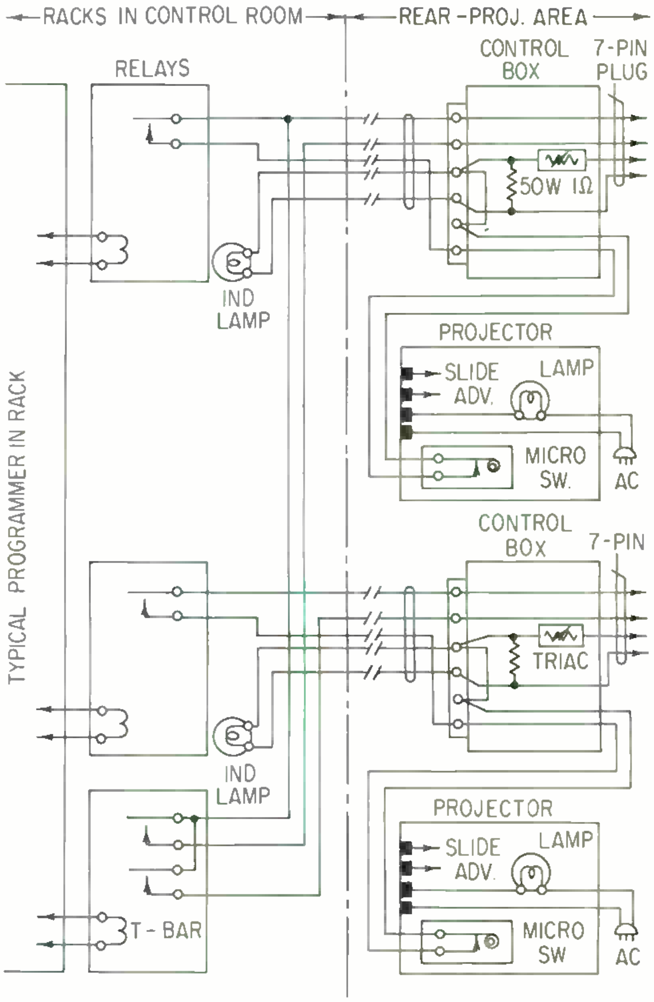
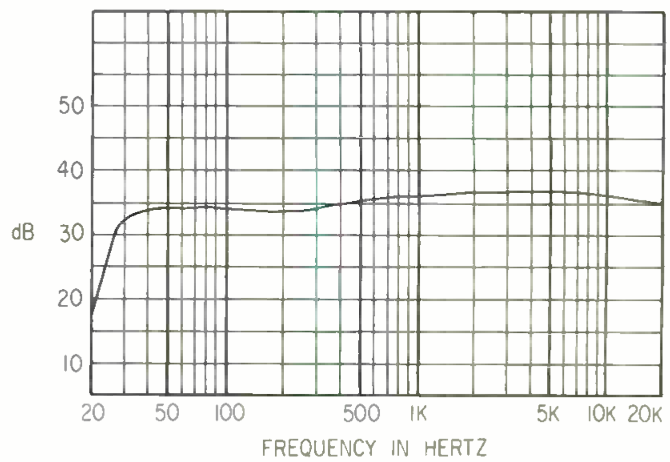


Figure 12. A simplified single-line diagram of the sound operating system. The wireless microphone system is not shown.

Figure 13. The frequency response in s.p.l. of the music speakers used.

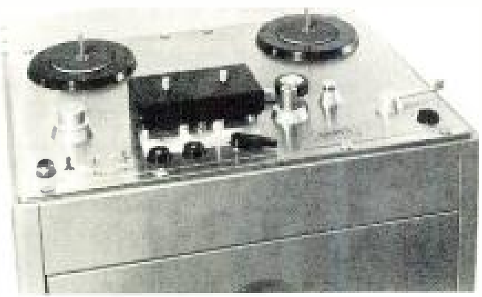


(continued from page 31)

AMPEX

Series 3200—Uses a flexible building-block principle. It starts with a master unit/console and one slave and is expandable to a maximum of ten slaves. The master uses tape on reels (no bin) which may be run backwards for no-rewind copies. Up to 14-inch reels can be used, ¼-inch tape, for duplicating full, half, or two-track mono tapes. Two-track and four-track stereo versions are available. *Circle 90 on Reader Service Card.*

Series BML-200—is a high-speed duplicator system for multichannel cartridges, cassettes, and reels. The endless-loop bin master can drive ten to twenty slaves. These slaves are field-convertible between cartridge and cassette formats. The master takes eight tracks on 1-inch wide tape; the slaves will reproduce these eight on 250-mil wide (¼-in.) tape or 150-mil wide tape (cassette) with four tracks. The slaves tape 14-inch reels, while the master bin will hold 1200 feet (about 30 minutes playing time per program track. *Circle 91 on Reader Service Card.*



The Ampex BML-200's bin slopes and has a transparent front. Electronics are below, including a pump and the power supply. The slave unit deck can have guides and heads interchanged.

ELECTROSOUND

Series 4000. High speed duplication from a reel-type master and slave system that takes up to 14-inch reels on either master or slave transports. The masters also have a bin for endless-loop operation. Plug-in head assemblies facilitate the shift from cassette to cartridge duplication operation. A complete line of tape processing accessories is also available. *Circle 94 on Reader Service Card.*

The Electro Sound master's bin permits the tape to be seen.

VEGA ELECTRONICS

Model 5000—Continuous loop master (up to 1200 feet in the bin) uses 1-inch tape for four- or eight-track operation. Reels for storage can be up to 10 ½-inch in diameter. The slaves take ¼-inch tape for eight-track recording (cartridge) and 150-mil wide tape for four-track cassettes. Up to ten slaves may be ganged for operation. A special bin is available for up to 1800-foot master operation. *Circle 96 on Reader Service Card.*

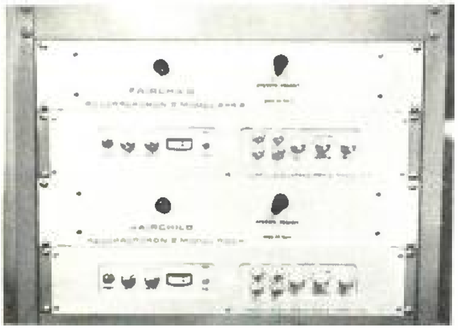
A Vega master, electronics rack, and five slaves. The tape-loop rack is below the transport, while the master electronics are in the adjoining rack.

Picture Gallery N.Y. AES Convention

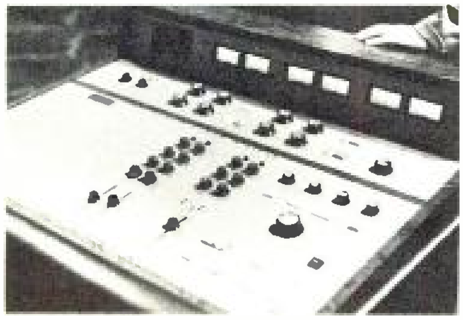
THIS AND THE FOLLOWING pages contain the new and almost new products found at the New York AES Convention's exhibition. The Hotel New Yorker was host to this largest convention between October 12th and the 15th.

Each photo is keyed with a reader service number. Simply circle the appropriate number(s) on the reader service card at the back of this issue and you will receive further information directly from the manufacturer.

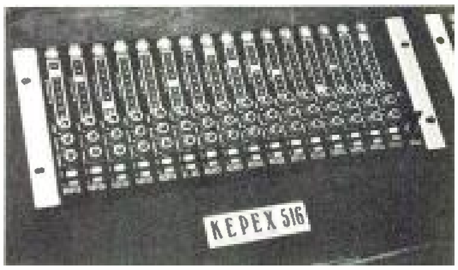
Audio Designs' RMC-1721 remote console is priced at $14,750. *Circle 76 on Reader Service Card.*



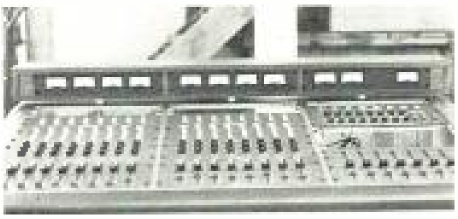
In a table-top rack, the **Fairchild** 659A Reverbertron II system. *Circle 73 on Reader Service Card.*



Westrex has a console that fully controls their Diskmaster mastering system. *Circle 75 on Reader Service Card.*



Kepex had a far-out demo booth in which they demonstrated their keyable program expander. *Circle 87 on Reader Service Card.*



Gately Electronics put this console together with their modules. *Circle 50 on Reader Service Card.*

Suburban Sound components combine to form "instant consoles." *Circle 89 on Reader Service Card.*

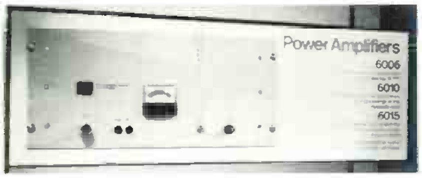
This **Langevin** console has nine channels in and four out. *Circle 78 on Reader Service Card.*

Quad-Eight came to the show with this new console. *Circle 85 on Reader Service Card.*

The **Spectra-Sonics** console has 20 channels in for 8 channels out. *Circle 88 on Reader Service Card.*

Electrodyne's most recent console has 16 channels in and 8 out. *Circle 86 on Reader Service Card.*

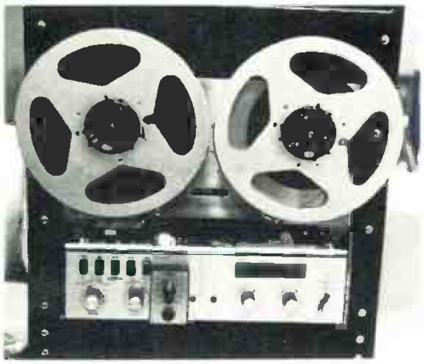
From **Scotch**, a new mastering tape, type 207 with improved characteristics of noise. *Circle 53 on Reader Service Card.*



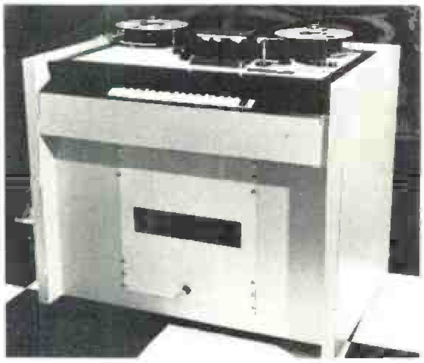
For sound reinforcement, **JBL** showed their model 6015 150-watt amplifier. *Circle 68 on Reader Service Card.*

UREI had the model 1109 amp/preamp card unit among its many items. *Circle 70 on Reader Service Card.*

A tiny condenser microphone, **Sony-Superscope**'s ECM-50 tie-tack model. *Circle 61 on Reader Service Card.*

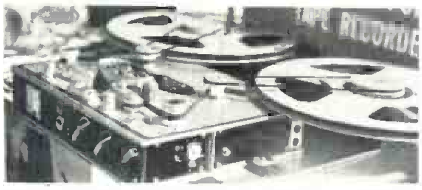


ReVox A-77 machines can now be ordered with plug-in adjustable drive speed control. *Circle 64 on Reader Service Card.*



Scully—the new 16 track model 100-16, available for the low price of $13,750. *Circle 55 on Reader Service Card.*

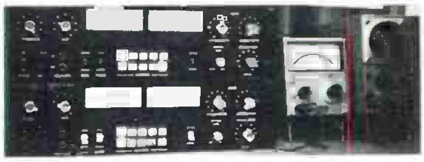
A first showing of the **Norelco** professional 3¾ in./sec. cassette recorder. *Circle 57 on Reader Service Card.*



The little battery-portable stereo **Stellavox** with big 10½-inch reel adapters. *Circle 79 on Reader Service Card.*

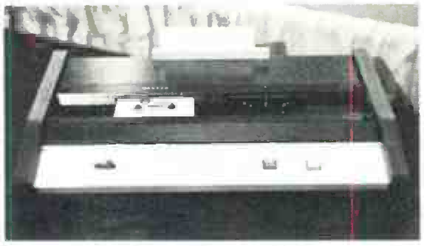
The new thin **Dolby** 360 tape noise suppression system fits between Scully modules. *Circle 52 on Reader Service Card.*

Four tracks on ¼-inch tape from **Ampex** on their new AG-500-4 model. *Circle 71 on Reader Service Card.*



Automated Processes showed a radically new limiter, compresser, expander system, model 500. *Circle 84 on Reader Service Card.*

Shure dramatically demonstrated the effectiveness of their isolation mounts for microphones. *Circle 58 on Reader Service Card.*



Pentagon showed the C120 system for cassette-to-cassette small-run duplicating. *Circle 74 on Reader Service Card.*

Caddco has a large variety of studio console accessories in plug-in configurations, "A Series." *Circle 81 on Reader Service Card.*

How do you pick up sound without noise?

Pick up the new RE50 and the new RE85 quiet microphones.

Model RE50 omnidirectional dynamic $120 list. Model RE85 lavalier dynamic $133 list. Less normal trade discounts.

Introducing two microphones that aren't "microphonic". That are unexcelled for hearing air-borne sounds, but shrug off contact noises. The new hand or stand RE50 and the lavalier RE85 dynamics.

Small, light, and just barely larger than the smallest microphones of their type. Yet both use a unique double-wall construction that is more effective in reducing microphone noise than any other we have tested.

Let's look into the RE50 first. A cutaway shows that inside each RE50 nestles the familiar 635A, case and all. It's shock-mounted at top and bottom to the outer case. Even the connector is isolated from the actual microphone. And the problems of mass and resonance have been worked out (with the aid of our computer) so that contact noises and cable rustling never reach the Acoustalloy* diaphragm.

The result is remarkable isolation from all but air-borne sound, even in hand-held applications where microphone movement is uncontrolled. And when you add the extra protection of the built-in Acousti-foam* blast and pop filter, this is one of the quietest omnidirectional microphones you can find. Yet response, output level, and polar pattern are essentially the same as the 635A (one of the most popular professional microphones of all time).

But if noise can be a problem with hand-held and stand microphones, it is a plague to lavalier types. Clothing rustle, cord noise, and accidental contact with hard surfaces are common troubles. Except with the new RE85. Again, we have created a microphone within a microphone. But we've gone even farther. A special low-noise grille, for instance. And even the hard, smooth paint finish was chosen to reduce small rubbing noises.

The result is virtually noise-free operation even with inexperienced performers. And at no expense to sound quality. Like all E-V lavaliers, output of the RE85 is peak-free and natural. Each RE85 comes complete with neck cord, tie clip, and a belt clip to help control the cable. The RE50 is supplied with a Model 300 stand clamp.

Both the RE50 and the RE85 are now available at your E-V microphone headquarters. In this noisy world, it's a relief to know that help has quietly arrived.

*E-V Trade Mark

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686 Cecil Street, Buchanan, Michigan 49107

high fidelity systems and speakers • tuners, amplifiers, receivers • public address loudspeakers • microphones • phono cartridges and stylii • aerospace and defense electronics

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PEOPLE, PLACES, HAPPENINGS

• Two announcements from **BASF Systems** tell of the opening of a new distribution center for the use of central warehousing and shipping. The location is their present Crosby Drive site in Bedford, Mass. The recently completed 40,000 square foot building features special air-conditioned storage for temperature sensitive tape, an office area, and six loading docks. The second announcement tells of the election of **Thomas Dempsey** as vice president of marketing and sales. Mr. Dempsey has been with BASF for the past six years. He was named marketing manager in 1969, after having served as national sales manager for BASF audio magnetic products.

• **Emanual Weintraub,** executive vice president of **Sterling Electronics** has announced that **Albert J. Marron** is the newly-appointed president of **Magnetic Windings Company** of Easton, Pa. The present president, **Bernard J. Beauregard,** is retiring. Mr. Marron brings to Magnetic Windings the experience of being the recent president and a director of **Hamilton Industries, Inc.** of Atlanta, Ga. Prior to this he was the general manager of **Teleflex.** Magnetic Windings manufactures electronic transformers and coils.

A new exchange visit of professionals in the audio/music field is now being organized for a May 1971 trip to the Soviet Union and other Eastern countries. The exact date of leaving is May 8th. You will visit these countries and meet your work counterparts. You will see studios and broadcast facilities that do things differently from your way. The sponsors of the trip are the **Citizens Exchange Corp.** (a non-profit, non-political organization). Co-sponsors are **db Magazine** and **Billboard.** It is expected that the Editor of db, columnist **John Woram**, and **Radcliff Joe** of Billboard will be along.

What does it cost? How long will it be? Present cost is established at $1068 which will be held until March 30th. This is an all-inclusive cost—air transport, hotels, meals, etc.—you will need very little pocket cash unless you are a souvenir grabber of large proportion. (It is anticipated that there will be a $100 increase in cost after March 30th—so it pays to subscribe early.) The duration of the trip, starting from New York, will be three weeks, with return to New York.

Write to the Editor for more details on this exciting Audio/Music Exchange Trip. Write: **The Editor, db Magazine, 980 Old Country Road, Plainview, N.Y. 11803.** Or you may contact the CEC directly at **10 West 46th Street, New York, N.Y. 10036.**

• **CCA Electronics Corp.** has purchased its present headquarters and manufacturing facility in Gloucester City, according to the announcement by **Bernard Wise,** CCA president. In his statement, Mr. Wise said that the purchase of the building increases the company's potential to 50,000 square feet of manufacturing, warehouse, and executive office space in a single, economic location. Heretofore, the company had been using only about half the building. In this facility, the company manufactures its complete line of professional broadcast transmitters. CCA also manufactures, through two subsidiaries—**QRK** and **Rek-O-Kut**, both in Fresno, California, amplifiers, tonearms, and turntables.

• **Ralph Gittleman** has been appointed vice president-commercial products at **Melcor Electronics Corp.,** a subsidiary of **Newton Electronic Systems, Inc.** In this new position he will be responsible for the Melcor line of professional broadcasting and recording studio components and new commercial products. Mr. Gittleman, a co-founder of Melcor, was previously vice president of marketing. Prior to founding Melcor he was computer section manager of the **Maxson Electronics Corp.** in New York. He also held various engineering positions with the **American Bosch Arma Corp.**

• **Carl Holder** has been appointed to the new position of new products development manager for **Audio Devices** according to an announcement from **William Goldstein,** v.-p. marketing and sales. In his new position, he will be responsible for the conception of new product development, from the exploration of new ideas, products, and applications—through technical development. He has been with Audio Devices for three years and was previously in research and development engineering. Prior to joining Audio Devices he was with **RCA** in their magnetic products division.

• At the recent meeting of the **National Council of Acoustic Consultants,** the following officers were elected: president—**Vincent Salmon** (Menlo Park, Calif.); vice-president—**Kenward S. Oliphant** (San Francisco, Calif.); secretary-treasurer—**O. L. Angevine, Jr.** (East Aurora, N. Y.). Three directors were also appointed. They are **Vincent D'Aprile** (Kingston, N. Y.); **Robert Lindahl** (Trenton, Mich.); and **Darial C. Fitzroy** (San Rafael, Calif.).

• **Robert D. Carrell** has been appointed director of **Superscope's** new tape duplicating division, according to **Joseph S. Tushinsky,** company president. Carrell will be responsible for organizing and managing the new facility located in San Fernando, California and will report directly to the president. The division's primary function will be to duplicate in all configurations the total output of Superscope's recording division. Special educational material and custom duplicating services are planned for a later date.

• **Peploe, Inc.** has announced the purchase of the **Janszen** speaker division from **Neshaminy Corporation.** The Minneapolis, Minnesota based electronics firm will continue and augment the speaker line, including the electrostatic elements found in most models. Peploe also owns **Electronic Industries, Inc.,** a firm in the music field: and **RTR Industries, Inc.** a westcoast speaker manufacturer. Peploe itself manufactures prototype printed circuitry and commercial airline products. Neshaminy Electronics will continue in its manufacture of components for the computer market.

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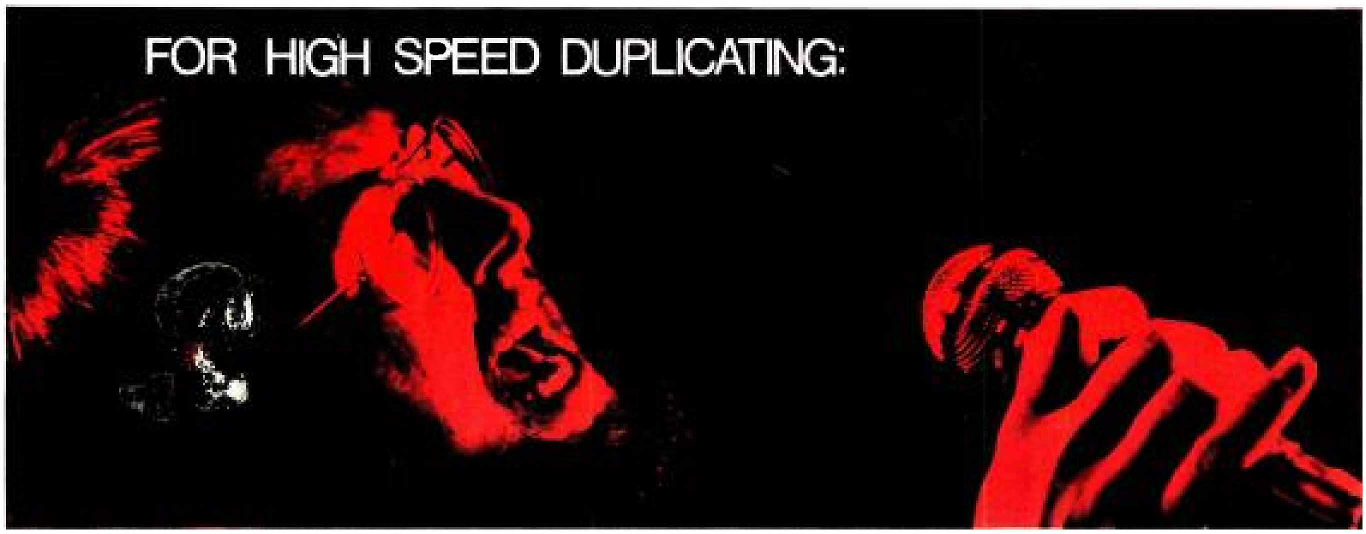

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