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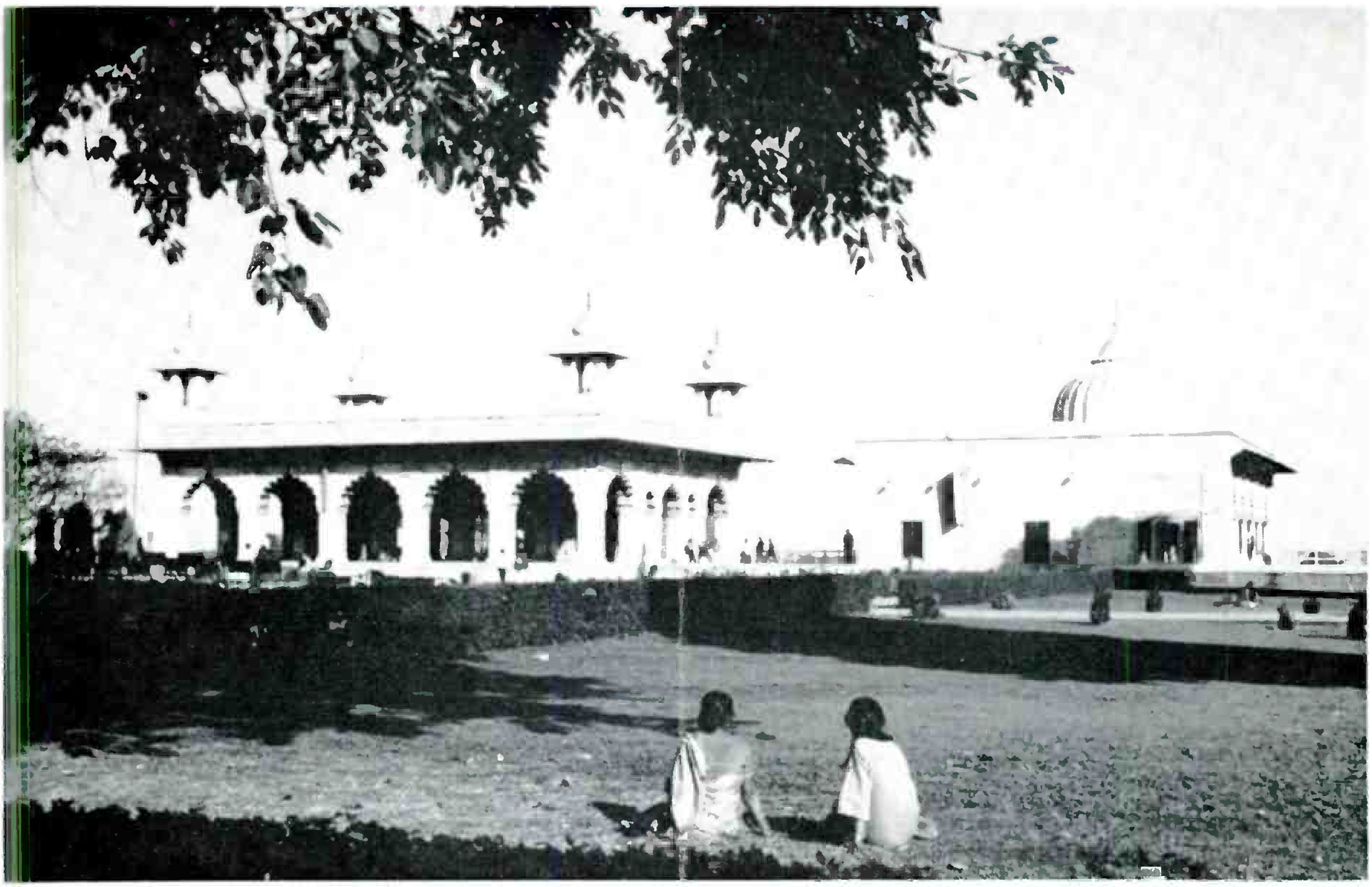
THE SOUND ENGINEERING MAGAZINE
SEPTEMBER 1969 75c

Sound Reinforcement:

Specifying P.A. Amplification

Audio-Visual in a Great Museum

Sound and Light in India



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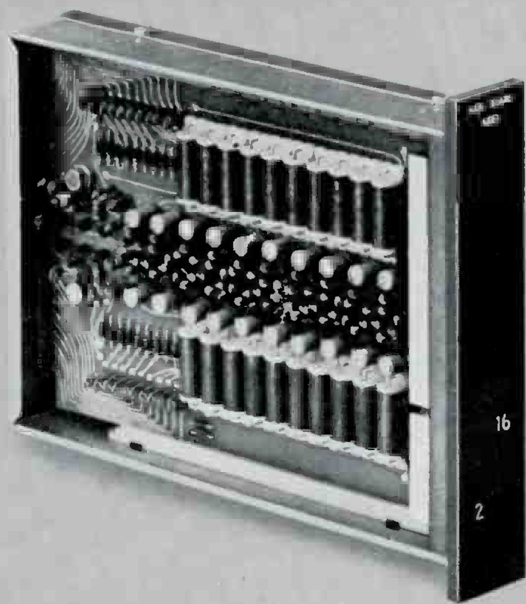

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Coming Next Month

●Next month will feature a complete listing of the papers to be presented at the 37th Audio Engineering Society Convention. In addition, we will offer a guide map to the exhibitions, held this year for the first time at the New York Hilton Hotel.

In addition, Les Brown of WXTR Cumberland, R.I. tells of the trials and tribulations of outgrowing and replacing a broadcast console at his station.

E. T. Canby continues his earlier thesis in the second part of IMPLICATIONS OF THE LOW-NOISE BACKGROUND, an article that is guaranteed to provide considerable food for thought.

And there will be our regular columnists, George Alexandrovich, Norman H. Crowhurst, Arnold Schwartz, and Martin Dickstein. Coming in **db** The Sound Engineering Magazine.

About the Cover

●A view of the Red Fort in India, site of a spectacular new sound and light public exhibition. The installation is described on page 30.

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THE SOUND ENGINEERING MAGAZINE

SEPTEMBER 1969 • Volume 3, Number 9

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Letters

The Editor:
Thanks to Marshall King for his fine article on The Television Radio Mixer. This piece should be required reading for all artists, producers, directors, and anybody else involved with television production. Many of the same problems also apply to recording studios, although to a lesser degree. The main thing is to make production people aware of the problems before the fact instead of during the post mortem.

Let's have more of these fine expose articles from the world of sound production. They help to clear the air between production people and the technical staff.

J. J. Ferree
Chief Engineer
United Recording Corp.
Hollywood, California

The Editor:
As the Nevada Indian exclaimed as he say the smoke cloud rise after the first atom test blast, "I wish *I'd* said that!"—referring to Marshall King's great article in your July issue. I'm sure all TV audio men will go off-scale with their applause!

He has brilliantly spotlighted our frustrations in delivering the best possible audio. Here's hoping all non-technical production people have the opportunity to read this *true life story*!

Bob Jensen
NBC
Burbank, California

The Editor:
I enjoyed reading the editorial in the July issue of db Magazine. Not only are air terminals bad for acoustics, but I might add some large churches are as well.

Where would one get some good and sound ideas on a sound system for churches?

Carl V. Kolata
WTTN AM-FM
Watertown, Wisconsin

This month's articles on sound reinforcement may just have what reader Kolata needs. But we need more articles still on the subject of p.a. and sound reinforcement, so if you have something to say we can be the outlet for it. —*Ed.*

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The Audio Engineer's Handbook

GEORGE ALEXANDROVICH

● Much has been said by many about the selection of proper components in audio systems, and their matching. It seems that this is the right time to attempt a brief summary.

We know about the matching impedances of successive states. We know that we can bridge the source with a load of much higher impedance and still not cause any deterioration of the signal. This holds true for the amplifier circuits designed to perform into an open circuit.

We have learned to be on the alert for the possible troubles which could stem from improper termination of tube-type equipment. The idea here is to match and maintain a constant load. Transformers, aside from the fact that they are heavy, sometimes required that the entire system including individual amplifiers be balanced in order to prevent the pickup of different types of noise caused by the transformers themselves.

Patch bays allowing acess to every part of the system demanded balanced lines, constant impedances and uniform levels. Naturally such strict requirements were placing a tight framework on the design of the faders or gain controls—one of the most essential component parts of the audio chain. In order to provide constant loading to the essentially high-impedance source (tube), the gain control had to be of a constant-impedance type and balanced where required.

Several basic types have been in use for decades, these are: T pads, ladder networks, pi and O faders. L pads and potentiometers have been considered less reliable and, therefore not very useful for professional equipment. It was demanded of the fader that it provides constant loading to the source and the load while the amount of attenuation was varied.

Now let us talk about present state of affairs. Transistors have forced tubes out. Only seldom do we have true 600-ohm circuits, and we don't care if we don't have them. And that is why every time we had a 600-ohm line and put a load across it, the level dropped 6 dB. Is this good?)

Low-impedance sources can supply signal to several loads without a change in level. You can put a 600;600 transformer on the output of the amplifier and call it 600 ohms, output; but is it? Not at all! Connecting the 600-ohm load to the secondary will not produce a 6-dB drop as in tube equipment, but will register only a fraction of the dB reduction of level—and only due to the internal resistance of the transformer. The fact is that the low impedance of the amplifier is reflected into the secondary.

(I hope that the reader realizes that all the talk here centers about transistor amplifiers which have low output impedance output stages with large amounts of negative feedback—the right way to get the most out of transistors in terms of performance including class B circuits and emitter followers.)

What is the advantage of the low source impedance over the "old" 600-ohm type? First you can run long lines with power losses due to stray capacitance and in the source itself. Second you can apply several loads to the source without level change. Third, you get increased damping.

One important aspect of the low-impedance circuit is forgotten by many. When damping of the speaker by the amplifier is discussed it seems that it makes more sense (well the same goes for the stages in the system) when inductive elements are present. Equalizer circuits as well as bridging loads experience a damping effect of the low impedance source.

Let us for a moment review the input impedance of the amplifier Tubes had inherently high-impedance inputs. Except for rare occasions, grid inputs were always fed from a much lower impedance. Matching the high Z of the tube was neither possible nor practical when the question came to transformers. Most of the times a step-up of 10-20 dB was all one would expect from the high-grade coil. Higher step-up ratios would only deteriorate the performance of the transformer. One fact was obvious—the high-impedance grid was fed from the much lower impedance source and this produced the best results.

Transistor amplifiers at the onset of their existence, were crude prototypes of what we have now. Fairly low input impedance (several thousand ohms *versus* megohms of the grid input) was followed by circuits with impedances of hundreds of thousands of ohms or megohms with FET input stages. Noise of the transistor amplifier, although different in nature from the tube, has been tamed to a point where transistors can give tubes a good run for their money. At this point we don't even talk about the size or efficiency of solid state devices.

But no matter how high the input impedance of the amplifier is, low source impedance for the practical setup produces lower noise in the first stage *i.e.* the quieter output. (After all if one wants to measure the noise of the amplifier he shorts the input doesn't he?) Well, what can be more natural than to shoot for the lowest possible source impedance.

Now let us observe the typical audio chain. Mic preamp is followed by the equalizer, then the fader, then the mixing network the booster amp from the mix net sends signal through the

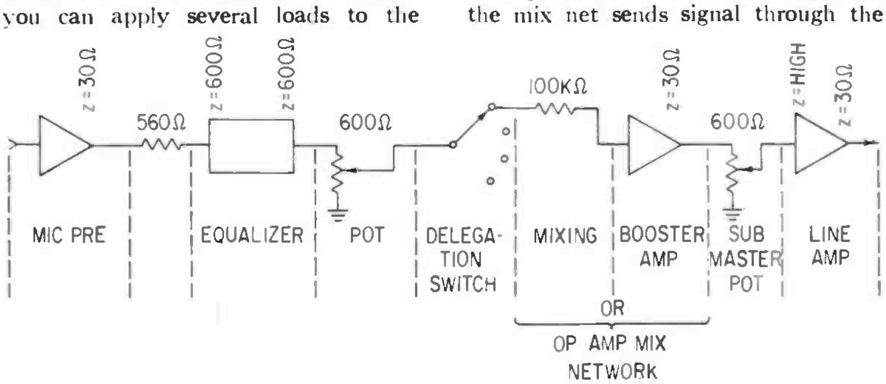
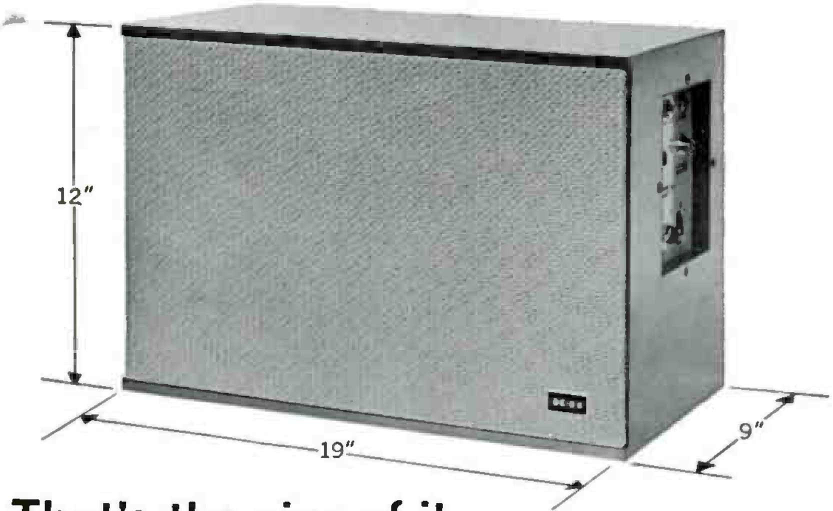


Figure 1. Impedances in the solid-state audio chain.

In my column describing new console equipment displayed at the 1969 AES West Coast Convention, I briefly mentioned solid-state VU indicators. Here, due to the request of many readers, is additional information obtained from Mr. Tom Lippel of Electrodyne, the designer of one such device.

The device is driven by IC's. Nine separate bulbs with a reaction time of 3 milliseconds illuminate light diffusing screens covering the range from =20 to +6 dBm. The release time (decay) is about 200 milliseconds. Accuracy is stated to be within 2 dB with a response of 30 Hz to 20 kHz. Input impedance is balanced 10k. Production is slated to start within the month.



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Batteries, Modulation and the Phantom™

The transistor has emancipated condenser microphones from bulky power supplies... almost! It is true that both voltage and current needed for today's transistor condenser microphones have shrunk considerably; and with it, the size, weight and price of the box on your studio floor.

There are now basically two powering categories: AC power supplies and batteries. I'd like to discard the idea of battery power in fixed professional studio locations. They are simply too unreliable, unpredictable and untrustworthy. That leaves us with AC powered supplies, and there we find three basic systems: A-B Powering in which the DC voltage (usually under 14 V) is applied directly to the two modulation leads; multiplex powering in which the DC voltage (under 12 V) is applied to the modulation center tap; and Phantom™ Powering, applying 48 Volts DC to the modulation center tap.

Now, the details:

1. A-B Powering renders the microphone output circuit poorly balanced, while outlets so equipped cannot be readily used for any other kind of microphone. Aside from that a DC/DC converter (oscillator) must be used to obtain the 50 V or so needed for polarization. High power drain.

2. Multiplex Powering solves the problem of circuit balance, but still requires a power consuming DC/DC converter, draws 5 mA of current through the cable shield (poor practice) and causes problems in isolation between microphone outlets.

3. ONLY NEUMANN offers PHANTOM™ Powering! Again perfect circuit balance; 48 V supply requiring NO DC/DC converter (only one transistor in each microphone); 0.4 mA power drain per unit; high circuit isolation; total compatibility with any other microphone; and central powering for up to 40 microphones from a miniature supply costing only $84.

Why, then, aren't all manufacturers going to Phantom™ powering? Some entered the field before this system was developed and now have a group of customers who don't want to change. Others followed the politically-motivated, half-hearted decisions of standard setting administrative engineers. Only NEUMANN was free to choose because as always NEUMANN is *last* ... but *best.*

Stephen F. Temmer
President
Gotham Audio Corporation

P.S. NEUMANN also makes an A-B powered microphone series at higher cost, if you "standardized" too early.

submaster and then in to the program amplifier.

Let us assume that the equalizer requires constant impedance input of 600 ohms within 10 per cent. Source impedance is 30 ohms. A fixed resistor of 560 ohms in series with the output of the mic preamp would terminate the equalizer input with the Z of 590 ohms or within 2 per cent of the specified impedance. The level drop is 6 dB but output impedance is constant and there is no transformer!

Now to the output of the equalizer: If it requires 600 ohms again (a number of passive equalizers do, for flat response) then we can safely consider a 600-ohm potentiometer-type gain control to follow it. This is the most reliable and simplest attenuator with constant input impedance (providing there is no load on the output). With the new breed of mixing networks built about operational amplifiers, the bridging impedance of the mixing network input acts as an ideal load for the potentiometer (at least 100 times higher than the source impedance of the amplifier, in the worst case). Change of impedance of the potentiometer (as the gain is varied) does not affect the opamp operation, which corrects its own gain with varying load. Even with the standard bridging input, a mixer with a resistance of 10k will result in only 6 per cent impedance change (0.2 dB). If a mixing resistor of 100k is used 0.6 per cent change is all we get. This all means that potentiometer gain control here is the natural solution. How many of you would shy away from high reliability pots on the market for this application?

Now we are at the sub-master gain control. A similar situation, low source impedance with high impedance of the line amplifier. Again a potentiometer can serve us best. We know from experience and the theory of probability that the reliability of a system is inversely proportional to the number of componenets or moving contacts or active elements. In other words, the simpler the device the less prone it is to fail. What is simpler than the pot, and what has better resolution? Whether you attenuate the signal directly or drive the solid-state attenuation system, reliability due to a moving contact remains the same.

It is not the purpose of this writing to degrade the important usefulness and the reliability record of more complex attenuation devices. They have a place of their own in system design, but it was my desire to show in basic terms that strides made in modern technology toward simpler, better, and more reliable circuits have brought about the simplification of requirements. And the simpler the device or the system, the more ingenious it is—providing it works.

The Feedback Loop

ARNOLD SCHWARTZ

● Over the past eight months I have discussed aspects of the technical facilities of some of the large metropolitan radio stations such as WINS in New York City. These stations operate in areas with a coverage as high as ten-million people and more. In contrast, there are many stations operating in relatively small population areas. WMNB-AM/FM, an independent station located in northern Berkshire County, Massachusetts, is in the latter category. It has a population coverage of about 65,000 and is an example of a relatively modest size station with a variety of programming to accommodate diverse community interests.

THE FM SIDE

Don Thurston, WMNB president, showed me around the station. It is housed in a neat, one-story building on Curran Highway located on the outskirts of North Adams. Don explained that the station operates out of three studios; AM, FM, and a third utility studio used for talk shows, interviews, or news. This utility studio can be used to feed either the AM or the FM side. A photograph of the FM studio is shown in FIGURE 1. It consists of a Gates stereo console (solid state), a reel-to-reel tape machine, a tape-cartridge player, and two turntables. Much of the FM programming is automated (FIGURE 2). There are forty-eight sequences. Each sequence can be fed from one of nine inputs selected manually by a nine-position rotary selector switch. The sequencer can be seen just below the VU meters in the left-hand rack. At present there are two reel-to-reel inputs and one cartridge drum which are integral with the automation apparatus, one external cartridge player, and one remote—for a total of five active inputs. The automation can be overridden and manual control assumed for live broadcasting. Changes in program selection for upcoming sequences are easily made. Because of the variety of programming WMNB's format requires something less than full automation. Less complex equipment was thus required so that initial equipment and installation costs were kept below $8,000.

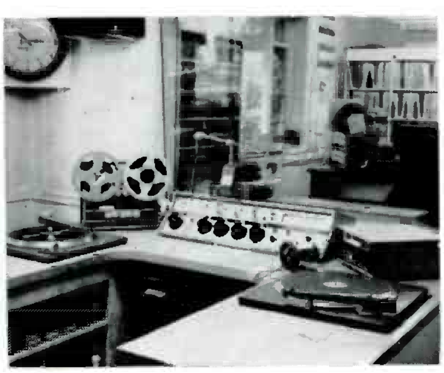

Figure 1. The WNMB-FM studio from master control.

WMNB-FM also transmits background music on the sub carrier (SCA). Because of the favorable location of the transmitting antenna on a mountain top, WMNB-FM has extended coverage. Musical selections for the background music derive from two reel-to-reel tape players which can be seen on the right side of FIGURE 3 (the AM studio). A device called an *Autosperser* is used to vary the sequence of musical selections to avoid monotony.

THE AM FACILITY

The AM studio (FIGURE 3) contains a Gates Yard console (vacuum tube), as does the utility studio, and is in the foreground, but cannot be seen in the photo. Master-control facilities are behind the announcer-operator seat. A turntable, reel-to-reel tape player, and a tape cartridge player are all readily accessible so that a variety of material can be fed to the console. The jack field is also within easy reach of the operator.

ENGINEERING

Don Thurston is intimately concerned with the technical excellence of his station, and is continually improving and updating the equipment. He is also concerned that his technical personnel stay interested and aware of current broadcasting technology. He is

Figure 2. The automation racks in use by WNMB-FM.

Figure 3. All in one room; WNMB-AM master control, remote transmitter and monitor racks, and background music tape decks.

foresighted enough to encourage activities in this direction. It is planned that as soon as the budget allows, transistor equipment, with its low maintenance and higher reliability, will replace the remaining vacuum-tube devices presently in service. Don described an interesting technical innovation that resulted from dissatisfaction with the frequency response of the FM transmission lines feeding the transmitter. Paul Willey, WMNB Chief Engineer, was given the task of devising and installing equalizers to replace existing telephone company equalizers.

The circuit that Paul uses is shown in FIGURE 4, and consists of a parallel resonant circuit in series with a resistor. This network is placed across (in parallel with) the transmission line. A parallel-resonant circuit has a very low impedance at all frequencies except at or

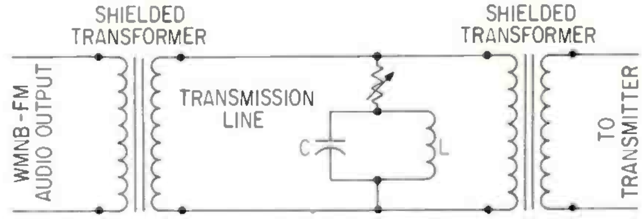

Figure 4. The circuit of the line equalizer used by WNMB as described in the text.

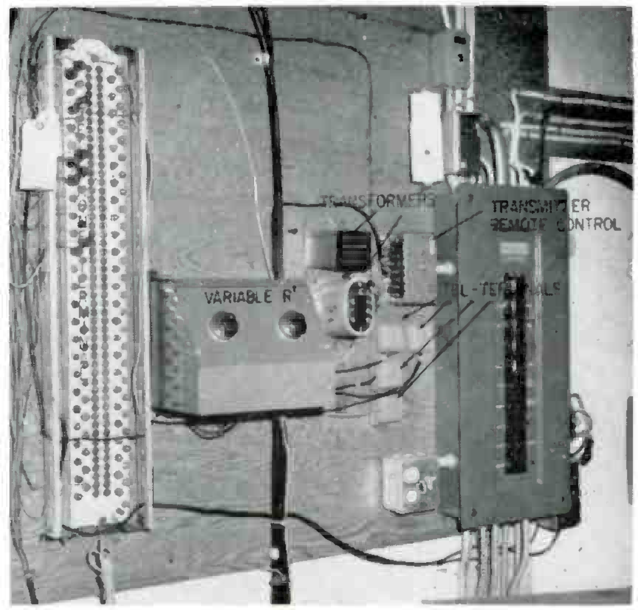

Figure 5. The line equalizer installation in use at WNMB.

near the resonant frequency. The resonant frequency of the equalizer is placed at the upper end of the pass band. At frequencies well below resonance the resistor loads down the line and reduces the output by a predetermined amount. As the resonant region is approached, the impedance of the parallel-resonant circuit increases, thereby effectively removing the load represented by the resistor, and increasing the line output. The shape, amount, and frequency of the boost is determined by the Q of the L-C combination, the value of the resistor, and the resonant frequency. By having available different L-C combinations, and a variable resistor the boost can be adjusted to compensate for various line conditions. When telephone lines are re-routed and line response changes abruptly, WMNB is kept informed, and necessary equalizer adjustments are made at change-over time. The installation of the line equalization circuitry is shown in FIGURE 5. The equalizer is housed in the sloping-front cabinet with the two controls. These controls are variable resistors which are used to trim the response of the network. Comparison of the original response with telephone company equalization, and the final response with telephone company equalization, and the final response with the WMNB equalization are shown in FIGURE 6. A significant improvement is noted above 5,000 Hz. By installing their own equalizer, WMNB was able to improve the line response, maintain more effective control over their signal quality, and effect a savings in line costs.

I was impressed by WMNB's efficient layout, by the well maintained condition of the equipment, and by the orderliness and good management obvious throughout the station.

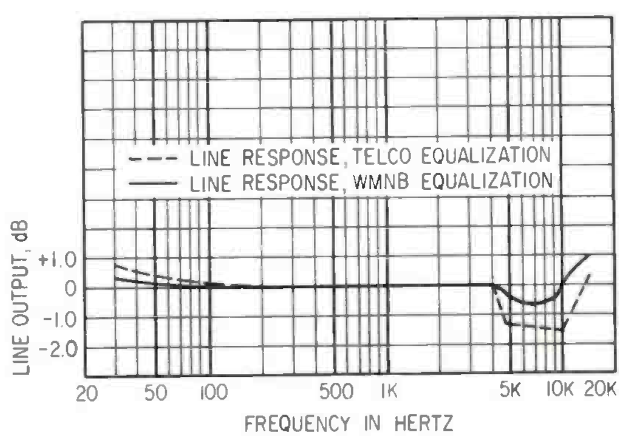

Figure 6. A comparison graph of FM transmission line responses.

Theory and Practice

NORMAN H. CROWHURST

● Back in the early days of audio, specifying an amplifier's gain was somewhat ambiguous. The value measured did not always seem to agree with gain actually obtained when the amplifier was placed in circuit. So the term *insertion gain* was introduced, to signify the gain that putting the amplifier into circuit would provide.

While this change led to a more meaningful specification than had prevailed before, the situation is not completely unambiguous even now. Insertion gain is only applicable under certain "ideal" circuit conditions, not usually met in practice, but the error that happens by using the insertion-gain figure is usually smaller than what could commonly occur with the older method of specification.

To illustrate, let's work through some specific situations. Prior to the introduction of insertion gain as a term, an amplifier intended for raising level but not delivering power, called a voltage amplifier, would be rated by its voltage gain in dB. If the input and output impedances were rated the same, say 500 or 600 ohms, the significance of the rating would not differ greatly from the newer insertion gain. But it would differ, unless two somewhat unusual conditions are met in the amplifier.

To make the example specific, suppose the voltage gain is 40 dB, meaning a ratio of 100:1, so that 10-millivolts input yields an output of 1 volt. The input voltage is measured, or calculated, across the input terminals of the amplifier. The two conditions are: (1) external input source resistance is equal to the amplifier internal input impedance; (2) amplifier internal output impedance is equal to output load impedance. (Figure 1).

In the days when insertion gain was introduced, feedback was quite new. Amplifiers in service for the most part did not employ feedback, and they were of the tube type, using either triode or pentode tube for output stage. With a triode tube, the output source resistance was invariably a fraction of nominal load impedance and with a pentode tube, it was many times load impedance.

So long as the output was loaded with the nominal load value, voltage gain would be the same as insertion gain. What more likely made a difference was the difference at the input end. In those days, voltage amplifiers used a transformer input with a step-up to grid, suitable for working from the nominal input impedance of 500 or 600 ohms.

But the transformer, with the grid across its secondary, did not itself provide a 500- or 600-ohm load. From the viewpoint of the external circuit, the input impedance might be 10 times the nominal value. For a 500- or 600-ohm line to be correctly terminated, a resistance of this value must be connected across it, as well as the amplifier input (Figure 2).

If the line reflected an impedance of 500 or 600 ohms, this meant the amplifier input was now working from a

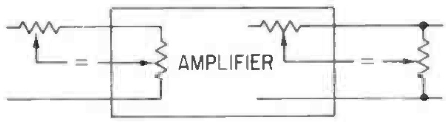

Figure 1. The theoretical conditions required for voltage gain and insertion gain to have the same significance, relative to an amplifier.

The SM60 cannot be stereotyped—is equally at home in the studio or in the field—stand-mounted or hand-held—in uses as diverse as outdoor sporting events and elaborate variety shows. Small wonder that audio engineers have called it one of the most versatile omnidirectional dynamics they've ever encountered, for the SM60 is a unique combination of good looks, strength, performance and economy.

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Lustrous, non-glare metallic finish and tailored-to-the-hand dimensions provide striking on-camera appearance and superior handability. Specially reinforced machined-steel case front is designed to take abuse that would ruin other microphones—you can drop it on its nose without damage to the internal structure! Efficient windscreen and front end are *quickly* and *easily* removable for cleaning.

Best of all, it is priced competitively with conventional "workhorse" microphones. Why not check out an SM60 now? See your Shure Professional Products Distributor, or contact Shure Brothers Inc., 222 Hartrey Ave., Evanston, Ill. 60204—Phone 312 - 328-9000.

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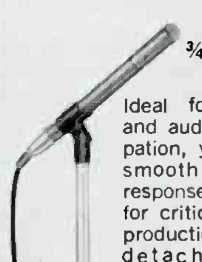

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Self-windscreened and pop-free for news, sports, remotes, and interviews. Also ideal for many studio and control room applications. Comfortably balanced for hand or stand use. Natural response.

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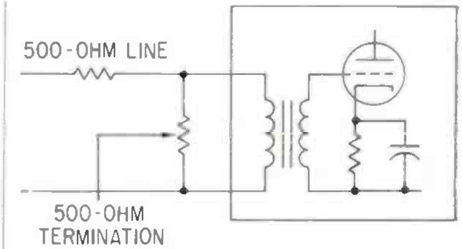

Figure 2. The terminating problem with a typical amplifier of tube vintage (see text).

source of 250 or 300 ohms, made up of the line impedance and its termination in parallel. This could invalidate frequency response (usually resulting in a high-frequency peak, before cut-off) although it did mean the voltage gain was now the same as the insertion gain.

With the advent of feedback amplifiers, their name changed from voltage amplifiers to line amplifiers (because both input and output impedance was designed for line matching) and later on they were transistorized. But the problem of multiplicity of actual impedances remains.

In the case of the tube amplifier input, leaving off the 500- or 600-ohm terminating resistor (Figure 2) would effectively raise the gain by almost 6 dB. The voltage gain was not changed by this, but the insertion gain was. With feedback and transistorization, impedance can be modified in any way desired, but the basic situation remains.

In the tube amplifier, where pentode outputs were used, voltage feedback modified output source resistance so it was usually about one tenth of the nominal load impedance. If the output tube was a triode, the source resistance might be an even smaller fraction of the load value.

For the sake of example, let's assume that the input loading impedance is 10 times the nominal, used as a source impedance, and that the output impedance is one tenth of the nominal output load. Assume also that we are still talking about an amplifier with a gain of 40 dB, but that now we mean insertion gain.

By definition, this means that inserting the amplifier between the source and load impedances, both say 500 ohms, raises the gain by 40 dB (Figure 3). Without the amplifier between, 2-volts input through the source resist-

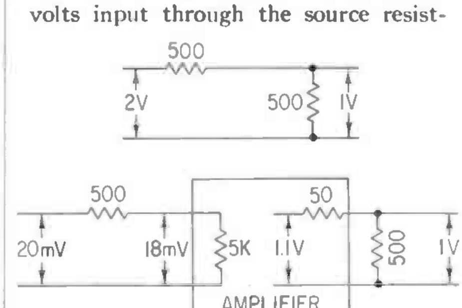

Figure 3. An illustration of insertion gain in a typical line amplifier.

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ance yields a 1-volt output across the load resistance. With the amplifier between, 20-millivolts input must yield the same 1-volt output.

But now, in fact, the 20 millivolts feeds through 500 ohms into an input load of 5,000 ohms. So the amplifier's input terminal voltage will be, not 10 millivolts as it would be for a voltage gain of 40 dB, but about 18 millivolts. Also, if the output impedances matched according to theory, the open-circuit output voltage would be 2 volts. Actually, it is only 1.1 volts.

So, for this amplifier with 40 dB insertion gain, its voltage gain, with output loaded, is 1/.018 = 55.5, corresponding to 35 dB. Unloaded, the output voltage rises to 1.1 volt, representing a gain of about 36 dB.

Back in the days when insertion gain was new, people who had used voltage gain viewed it as cheating. After all, the insertion-gain advocates were using their specification to rate an amplifier that only had 35 or 36 dB gain, as having 40 dB insertion gain. The way they viewed it, this was not "real gain."

The reason for the difference is really that the amplifier does provide a gain, in a form that specification in *voltage gain* fails to recognize. These same people used to call a cathode follower (emitter follower to transistor lovers, now) a *zero gain stage* because the output was at the same voltage level as the input. They called it an impedance-changing stage.

But this also is gain. Providing, say 1 volt of signal, across 50 ohms instead of across 5,000 ohms, represents a current gain of 100:1, although voltage remains the same. So also with our line amplifier. We may actually be using the same input and output impedance, say 500 ohms. But the amplifier doesn't. Its input impedance is 5,000 ohms and its output impedance is 50 ohms.

But using the same external impedance prevents full realization of the available current gain. This can be seen by figuring on using the same amplifier in a theoretically perfect match. This means the input impedance would be 5,000 ohms, and the output 50 ohms.

To match a 5,000-ohm input to a 50-ohm output, without the amplifier

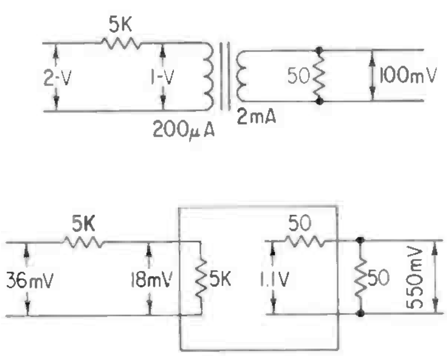


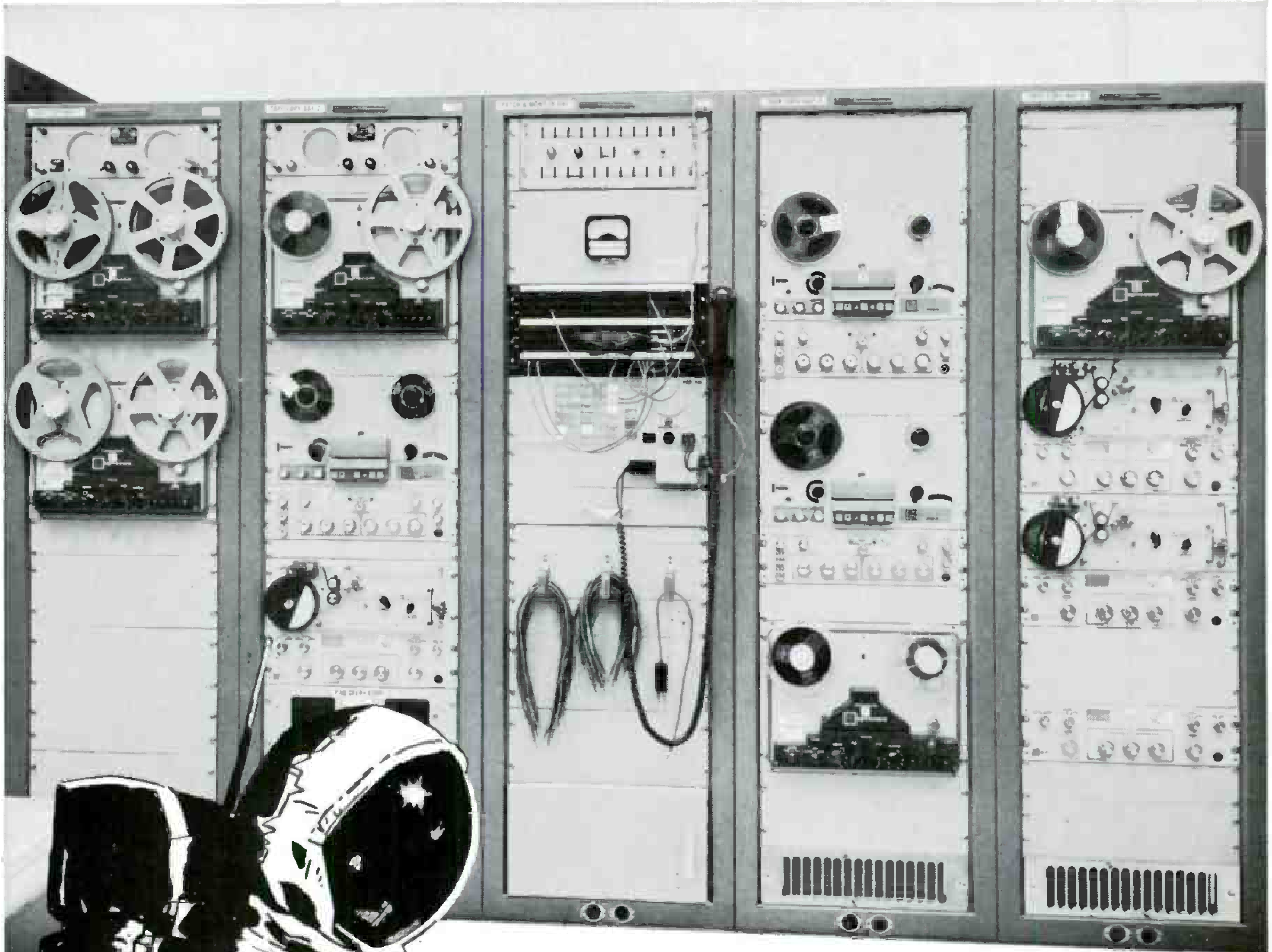
Figure 4. The amplifier of Figure 3 under hypothetically matched conditions.

between, would require a transformer with a turns ratio of 10:1 (Figure 4). A signal of 1 volt, across 5,000 ohms, gives 200 microamps. On the 50-ohm side, this is converted to 100 millivolts at 2 milliamps. To complete the pre-insertion picture, an input of 2 volts will give an output of 100 millivolts.

Now put the amplifier in circuit. For 18 millivolts input, it gives 1.1 volts output, open circuit, or 550 millivolts across 50 ohms. To compare with the pre-insertion picture, 2-volts in for 100-millivolts out has changed to 36-millivolts in for 550-millivolts out. The output is 5.5 times and the input is 0.018 of reference. The over-all gain is 5.5/.p18, or about 300, on a voltage comparison basis, or close to 50 dB.

So the amplifier has an available power gain of close to 50 dB, but it is used in conditions that yield an insertion gain of 40 dB, although our old-time voltage-amplifier merchants, if they haven't yet been convinced otherwise, would rate it at 35 to 36 dB gain.

All that's considering an amplifier intended for use at line impedance, input and output. If input and output impedances differ, the consideration becomes a little more complicated. Also, we've only considered one amplifier, working between theoretically passive impedances. Actually, amplifiers are seldom operated quite that way, except for test purposes. So in our next issue, we'll take up from here.



NASA Manned Spacecraft Center, Houston, Texas

Sound with Images

MARTIN DICKSTEIN

AUDIO-VISUAL EQUIPMENT II (SLIDE PROJECTORS)

● One of the most popular devices in any projection setup is the slide projector. Manufacturers (there are about thirty of them) have added many inovations to permit the user to choose the unit closest to his application.

Some of the reasons for such wide usage are that the user can take his own slides quite easily, thus selecting his subject material to fit his presentation exactly. He can interchange the order of the slides for each showing or he can delete old and introduce new ones at will, he can preview his slides fairly simply without having to set up a projector and thus can set up each presentation individually, and he can pause anywhere in the showing for any desired length of time or proceed at his own desired pace with his live or pre-recorded audio.

Slides are made in three sizes and the projectors are either made to show one, two, or all of these formats. The most usual is 35mm, referred to as 2 x 2-inch double-frame slide. It has an aperture width of 1.34 inches. Less popular, but still listed as a 2 x 2 slide, is the "super" which has an aperture width of 1.5 inches. To achieve the full benefit of the larger opening, a projector must be selected capable of showing this size slide.

The next size, and fairly common in industrial projection systems, is the 2¼ x 2¼-inch slide with an aperture width of 2.1875 inches. Thus, it becomes apparent that the larger the format, the larger the image at the same projection distance from the screen with the same focal length lens. Greater detail can, therefore, be shown.

The largest of the slides in regular use is the 3¼ x 4-inch, or lantern, slide. This format has an aperture width of 3.0 inches. As an indication the difference in image size, the double frame slide will present a picture 50-inches wide at about 31 feet with a 10-inch lens. At the same projection throw with the same size lens, the lantern slide will provide an image of a width greater than 9 feet.

Slide projectors vary in several ways. As a result of the way the slide (up to but not including the lantern one) is fed in front of the aperture and the construction of the housing size and shape, the lamps provided or possible to be used range from 75 watts (for a small unit with a built-in rear-projection screen) to 500 watts quartz iodine, to 750 watts for the larger and more professional models. There is also one model which uses a halogen lamp (24 volts). These units are standard and do not include the ones which are adapted for use with xenon sources. There are manufacturers which specialize in adapting standard models for higher-output light sources for use in large conference rooms or auditoria. In the 3¼ x 4-inch slide projectors, the lamp sources range from 750 watts to 3,000 watts to arc or xenon (1600 watt) in standard models. Of course, almost all models require fan or blower cooling to prevent the units and slides from overheating.

Methods for moving the slide in front of the source range from the horizontal round tray on top of the projector to the vertical tray on top (both dropping the slides into the source-lens line), to the horizontal tray mounted within the projector to the vertical tray mounted almost along side the unit. The latter two move the slides horizontally into projection position. Some of the standard models use straight trays instead of the circular type, and some permit the use of either shaped tray. Another type makes use of the stack method of loading the slides, and there are those which require manual operation to push the slides in line and to remove them.

There also are models which are made for continuous operation in shows, exhibits, or displays which operate either by a rotating drum or disc and holding a limited number of slides, usually 16 for the disc or 48 for the drum as compared with 50, 80 or 100 in the round- or straight-tray type. The advantage of the disc or drum type for its purpose, however, is the ease with which the entire presentation can be changed quickly and easily, the rapid slide change time and the fact that the drum type is made with a 1200-watt source capability (should it be required) for the models showing up to 2 x 2 inches. (Among the units projecting 3¼ x 4-inch slides, one model changes slides in a quarter-second without black-screen between images.) Other models made for display use come with self-contained rear screens and house the projector within the case to make a complete and compact exhibit.

Among the various types of slide projectors, certain features are built into various models and should be considered when the equipment is specified or purchased for any audio-visual system. Some units have self-timers with different timings available for changing the slides automatically. Many include remote-control capability with extension cables available to make the control as remote as desired. Some units include lens-focusing at the remote control unit while others feature automatic focusing with no remote control of this function at all.

The usual remote controls permit the changing of a slide, in either direction, but only one at a time and with each slide showing up on the screen in the event it is desired to move from one position to another several slots away. Where it is required, therefore, that quick call-up of any slide in a tray be available in the operation of the system, there are models manufactured with random-access capability built in. This permits rapid movement from any slot to any other position in the tray without having to manipulate the change device more than once. Changing of slides, taking 3 to 4 seconds average to search and find, can be triggered manually, by radio signal or by computer, depending on the particular model selected.

Lenses normally range in focal length from 3 to 9 inches for the projectors showing 2 x 2-inch slides but others can be had by special order. A zoom lens is also available for some models. In the projectors of lantern slides, the range of focal lengths is usually 6 to 26 inches but 30 inches is available on special order.

Several features which come on only certain models might include a switch to permit use of the lamp at a lower power to extend its life, a preview screen built onto the projector to permit seeing the picture before being shown on the main screen, sequential selection which is a sophisticated extension of the random selection method and slide intermix permitting different size slides

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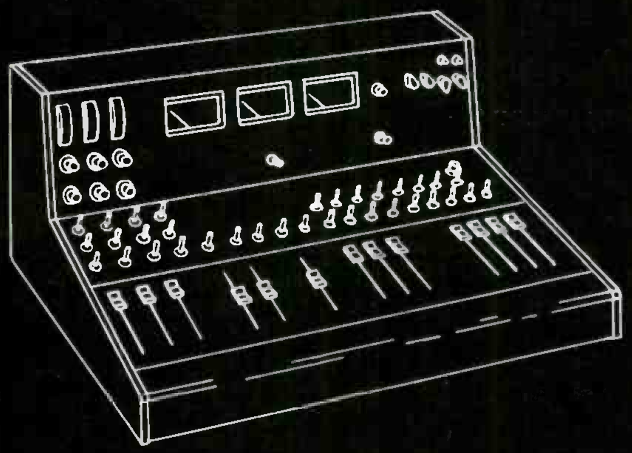

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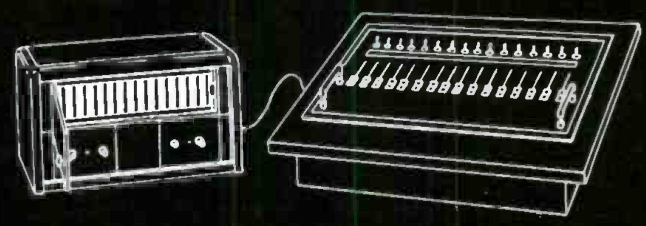

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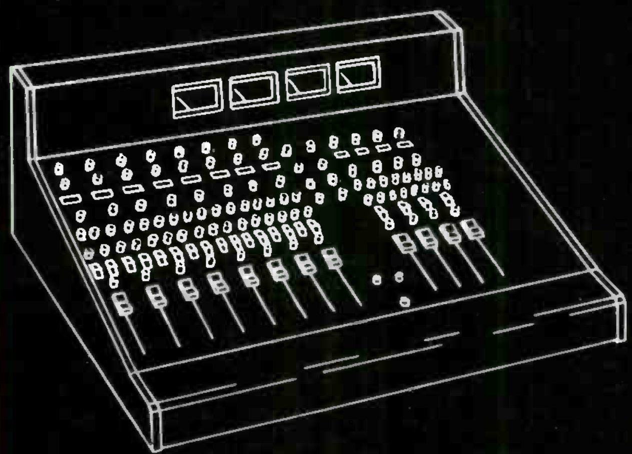

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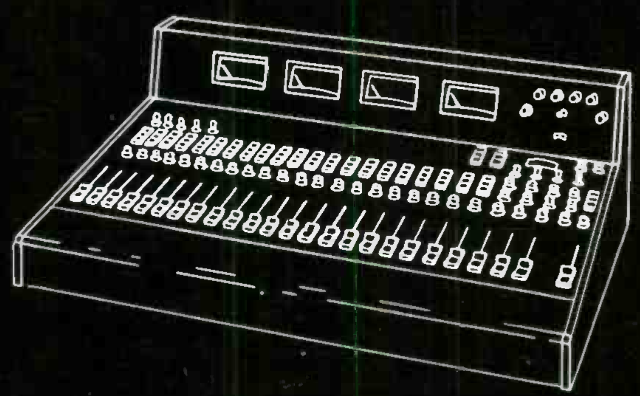

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to be used together in the same presentation. Also, there is now the possibility of projecting a slide on a screen for an instant only (manually) for teaching purposes.

Some slide projectors have provision for showing film strips—a combination of the film and slide. This type of projector will be included in the next series on projectors and accessory equipment that is available for use in audio-visual installations.

However, before we leave the slide projector, note must be taken of the fact that this type of unit has always been the silent type. If sound were to be used in conjunction with slides, a tape recorder was used with sound feeding through a distribution system separate from the slide projector and not even connected to it in any way. Then, it became possible to have sound on one track and a control cue signal on the second track. This latter signal could then trigger the changing of the slides. Complete display units with self-contained rear-projection screens usually house tape recorders also to permit endless loops of tapes to continuously trigger an automatically repeating presentation. If all went well, the show remained in sync throughout its presentation. If not, weak signals failed to change the slides or slides changed when they should not have. However the method, the sound had to come from a separate source such as a tape.

Now, two new slide projectors have been developed which combine sound right on the slide. Syncronization is guaranteed. In one unit, the sound-slide frame combines a 35mm slide with a magnetic sound track which encircles the film. When the slide unit is moved into projection position, the sound starts. When the 35 seconds of audio is completed, the slide remains on the screen but the sound does not repeat unless it is signalled to do by the operator. The operator can change the slide (in either direction) by remote control and the sound associated with the slide being projected will be heard. The tray holds 36 slides, and each can be changed by re-recording the audio or by changing the slide only, or both. Automatic sequencing of the slides is also possible.

The second manufacturer has a projector which holds 40 slides with associated sound track in a cassette unit. The sound track is 60-seconds long, and can be recorded over at any time. In this unit, the sound is "read" by a moving head which rides up to the top of a shaft reading as it goes and automatically returning to its start position when the audio reading is completed, no matter if there is one line of audio or more than one. Here, also the slide and audio can be changed whenever it is desired.

Whether designing an audio-visual system for a customer, or just bidding on a proposal for a complex designed by a consultant, it is necessary to know the equipment available with all the ramifications and all accessories. Many a sound contractor, getting into audio-visual projects for the first time, finds that some of the equipment he took almost for granted was not quite as he expected it to be. Illumination, features, remote-control wiring, lenses, dimensions of the units, distances from the back of the projector to the front, or from the shelf to the center of the lens varied for each projector and could make a difference in the ease with which a system was installed. Having some knowledge of the units available and their capabilities can help when talking to a potential purchaser or when assisting a consulting engineer in the system's design.

The units mentioned and the information given here are admittedly brief, but our intent is to alert the sound/audio-visual contractor to the fact that there is a wide choice of equipment available and to make him research the field to provide the proper equipment to fit the client's needs. This is the way he looks good to the customer in future projects—by knowing his equipment and making sure the buyer knows he can depend on the dealer.

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Specifying P. A. Amplification

M. S. SUMBERG

The correct choice of amplifier for a p.a. or sound reinforcement job is dependent on many factors. Too often, the purchaser tends to either over specify or fail to get enough features to allow future expansion of a system. The author covers the most important factors that must be considered.

THE INEXPERIENCED SOUND INSTALLER will all too often attempt a job with an amplifier that is not correct for the work intended. No doubt the range of available amplifiers is confusing to many, particularly when an attempt is made to evaluate features and functions. An intelligent decision can be reached, however, if all of the important considerations that follow are considered. There is much more to an amplifier than its power output and mic input quantity.

The specification areas will be treated in order.

POWER

Amplifier power is related to the area which needs to be served. TABLE 1 serves as a starting point for this. Beyond the table, trial and error experimentation is needed and/or the use of a noise meter to measure s.p.l. Remember that the average cone-type speaker has an efficiency of 2 per cent and that typical two-way theater-type cone systems will run about 5 per cent. (Re-entrant horn system can run 15 per cent or more efficient.) Thus a little math will show that much less power is required to give the same loudness level with horn speaker systems.

Acoustic conditions must be considered in the power choice. A large auditorium may require 50 watts on an average, but if it has highly absorbtive walls and a full and noisy audience, it may need 25 watts more. Conversely, of course, a highly live hall and a small audience will do nicely with 35 watts or so.

TABLE 2 is a convincing argument against underpowering—an all too common situation. A high-power amplifier costs notably less per watt than equivilant quality low-power amplifiers. So it makes sense to be conservative in specifying power and be certain to get more than is minimally required.

M. S. Sumberg is the director of sales and marketing, sound products and engineering systems for the Bogen Division of Lear Siegler, Inc.

TABLE 1

Locations	Dimensions ft.	Min. Pwr. watts	Recommended amp. pwr. watts
Hotel Room	15 x 12 x 8	0.1	Depends on number of rooms (C)
Classroom	30 x 30 x 10	0.5	Depends on number of rooms (C)
Quiet Office	100 x 50 x 10	3.0	10 (C)
Noisy Office	100 x 50 x 10	6.0	10-15 (C)
Small Church			10-15 (SC)
Large Church			30-60 (SC)
Quiet Factory	100 x 200 x 20		30 (H)
Noisy Factory	100 x 200 x 20		60-100 (H)
Small Theater			30 (SC)
Sports Field Stands	50 x 200		50 (H)

Assumption is made that average noise levels and sound absorbing materials are used. (C) is cone speaker; (SC) is sound column; and (H) is a re-entrant trumpet horn.

Table 1. Location versus audio power requirements.

In addition to protecting you against errors of judgment, you have added some expansion capability. More to the point, a conservatively operating amplifier in use is not working near the toe of the distortion curve (or into it!).

How much extra power is needed? Remember that the ears respond to sound level logarithmically so the margin should be sizable. After all, doubling the power output is only a slight increase in perceived loudness. The cost differences are not great when you are involved with nominally 30-40 watt specifications and want to double them, but I can only urge competent professional installer advice to the inexperienced who find themselves with a job that requires a few hundred watts of power. The cost differences between 250- and 500-watt amplifiers can be considerable.

Don't hesitate to use cut-and-try methods. If you have not under-rated the power required for the job, you can empirically determine the proper locations and sound levels per the speakers (in all but the largest jobs again). Until you have acquired the experience necessary for accurate judgements, you will be wise to over-specify power.

DISTORTION AND FREQUENCY RESPONSE

Let's look at frequency response first. For speech intelligibility of a high order, all that is needed is a bandwidth of 100-6000 Hz. There is no advantage to pay extra for ultra-wide bandwidth available on some models. Even the reinforcement of live music can be done admirably well with a bandwidth no greater than 50-12,000 Hz. So forget your hi-fi orientation that demands ultra-wide bandwidth for everything. For one thing, you probably do not have accessory equipment—mics, speakers, etc.—that will support wide bandwidth; for another, most small speaker line transformers will saturate badly at the low end.

Some installations, of course, demand wide-band sound. In these cases, you must have the over-all budget for good bass and high-frequency speakers and equipment. Then, of course, 20-20,000 Hz response or more is desirable for the amplifier.

TABLE 2

	Amplifier Output Rating	Price	Cost Per Watt
Amplifier 1	30 watts	$113.00	$3.80
Amplifier 2	60 watts	$138.00	$2.30
Amplifier 3	120 watts	$195.00	$1.63

Table 2. The higher the power the lower the cost per watt—assuming, of course, that the quality is otherwise the same.

(I would suggest the use of good line-matching transformers in any case. Poor ones present an inductive near short to the amplifier at bass frequencies, which has been responsible for many output tube or transformer failures in economy amplifiers. Since economy-price amplifiers may well satisfy the needs of an installation in terms of frequency response, it makes sense to use them.)

The relative distortion percentage of an amplifier is directly related to its cost. Figures of 5 per cent at maximum power are commonly found in p.-a. amplifiers, while the better, higher priced ones, will often specify maximum distortion at 2 per cent. (Contrast this against hi-fi amplification which might specify distortion of 0.2 per cent at full power.) Figure 1 shows the relationship of distortion to amplifier power. Note that distortion always goes down as power is reduced in an amplifier. Better amplifiers will reduce distortion sharply and significantly.

Relatively large amounts of distortion are not a disadvantage in a system primarily used for speech. Intelligibility will not be affected. However, music playback or reinforcement systems should not exceed the 5-per cent figure, and preferably should be even lower.

An amplifier capable of 1-per cent distortion or under is suitable for fine reinforcement systems.

OUTPUT VOLTAGE AND IMPEDANCE

The amplifier's maximum rated output power will only be delivered to the loudspeaker if it is correctly matched in impedance. If only a few speakers are to be used, direct connection to the 4-16 ohm taps on the amplifier will suffice, using ohms law to determine parallel or series connection of speaker for proper impedance match.

More involved systems with many loudspeakers, each with individual volume requirements, will need line-matching transformers installed at each speaker. These transformers are normally of the constant-voltage type and are designed to connect to the 25- or 70-volt line of the amplifier. Most p.-a. type amplifiers will have such outputs whereas hi-fi amplifiers invariably do not.

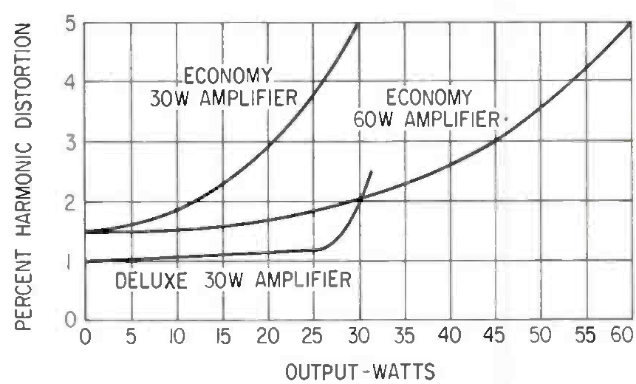

Figure 1. Amplifier distortion curves for some commonly-found p.a. amplifiers.

Amplifier installations are occasionally required to feed out a 600-ohm telephone line to a remote point as when a broadcast feed is required. Transformers used for 600-ohm line aux inputs can simply be used in reverse fashion to deliver a 0 level 600-ohm line from the 25-volt amplifier output.

MIC INPUTS

The purchaser of the system can usually tell you accurately how many microphones he will need (though in not so many words.) A church may require anywhere from two to eight mics, depending on the type of service and the location of active participants that need amplification. On the other hand, a store pitchman only needs one.

Theatrical and concert stage requirements vary widely, but virtually all will require five or more. Nightclubs will want band and vocalist pickup and probably two more mics for announcement and special use.

Packaged amplifiers are sold with one to five mic inputs as a rule, with each input offering individual gain control. Generally, the low-power, low-cost amplifiers come with only one or two mic inputs while amplifiers of 30 watts or more are available with one to five inputs. Of course, one input can be used with more than one mic, if each mic is equipped with momentary press-to-talk switches. Generally, up to five mics per line are practical when used this way. (Only certain installations are suitable for this, of course. If two mics are to be used simultaneously, it will not be possible to mix them if they are on the same line. Then, too, the sensitivity of the mics is reduced along with an increase in the signal-to-noise ratio.)

Aside from this purely quantitative determination, microphone *impedance* must be considered. If the mic cable is not to exceed 50 feet, high-impedance mics will be satisfactory. Beyond 50 feet or so, mic cable's capacitance begins to noticeably attenuate the signal. Low-impedance mics avoid this problem, as well as also avoiding the common high-impedance problem of hum and noise. A low-impedance mic should be used with low-impedance cable and the amplifier input should be also converted to low-impedance use. This last-named conversion is simple with most amplifiers. It usually involves the removal of a shorting plug from a chassis socket with the plug-in installation of an appropriate transformer (supplied by the manufacturer and others). This plug-in arrangement offers you considerable versatility since you may be using both high- and low-impedance mics on different lines. Each mic input can be converted or not as is needed.

OTHER INPUTS

Other than mic inputs, you must consider the need for auxiliary (high-level) inputs and magnetic phono inputs. Aux inputs may be required for piped-music, tuner, tape recorder, or equalized record player. In addition, special tone generators may be required for signalling purposes.

Most p.-a. amplifiers include one or two auxiliary inputs for high-impedance, high-level signals, but only a few will offer the direct ability to handle a magnetic phono cartridge with its need for equalization and amplification. (the same is true of tape-head input capability). Small line transformers can usually be plugged into the aux inputs so that they will accept balanced 600-ohm lines (telephone lines). Some amplifier manufacturers offer plug-in transformer/equalizers that will convert a mic input into an RIAA equalized phono input. In most cases, however, tape-head or magnetic-phono inputs will have to be fed through separate equalizer/preamps and thence into an aux input of your amplifier.

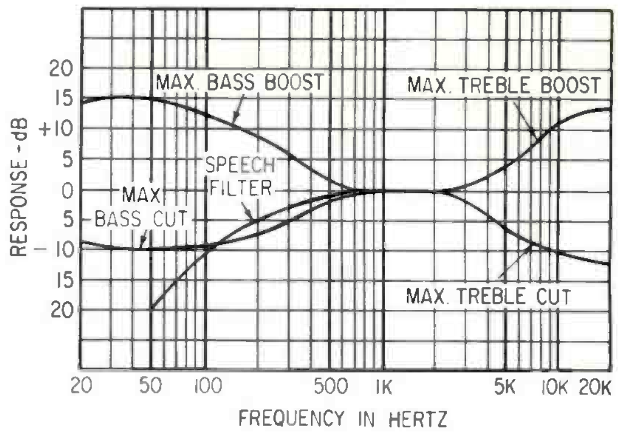

Figure 2. The response characteristics of p.a. amplifier tone controls and a speech filter switch that is found on many.

POWER SOURCE

Most installations are simple enough. The amplifier is being placed in a permanent location and is merely connected to the a.c. But mobility is becoming increasingly important so many amplifiers are now made that can be used from a 12 volt d.c. source. Many amplifiers primarily designed for 12-volt d.c. use, can also be used on 115 volts a.c. A few are designed with automatic source switching for power source fail-safe use.

Other power-source requirements may present themselves to you. Equipment is available to accept most all you are likely to encounter. It is important at the time of purchase that you be certain that the amplifier will properly operate from all the power sources the customer will demand of it.

FILTERS AND TONE CONTROLS

It's rare indeed that a sound installation is done that requires no tonal touch-up afterward. This is the purpose of tone controls and filters. Separate bass and treble control such as is shown in Figure 2 is common on most amplifiers. Bass cut will often be needed to control sound in rooms with excessive reverberation. A sharper bass cut for speech amplification is often of value to improve intelligibility.

Some of the more deluxe amplifiers offer notch filtering that is panel adjustable for the removal of specific problems such as hum, and mic thumps caused by the users. Such filters have the advantage of eliminating the problem without a material shift in the over-all balance effect. A typical filter is shown in Figure 3.

SPECIAL FEATURES

You should be aware of the special equipment features that

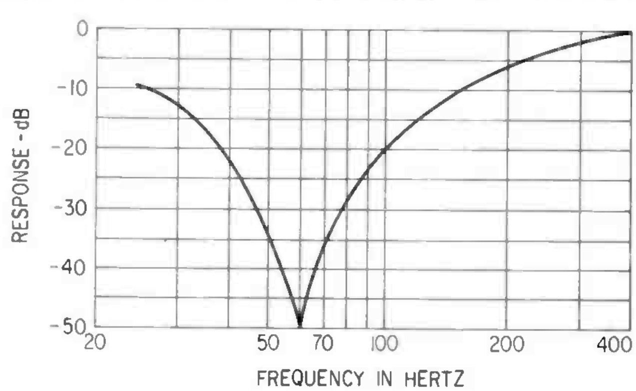

Figure 3. A notch filter such as is found on some amplifiers. In this case, it is adjusted to the 60-Hz position.

Figure 4. This amplifier can be shelf mounted or used portably. It has four mic inputs, two high-level inputs, master control, tone controls, low and high filters, and speaker and meter monitoring.

some amplifier have since one or more will be applicable to special installations.

Systems primarily designed for background music will often want a mic facility that features precedent switching. Amplifiers are available with plug-in devices that will mute the music feed automatically if the mic is switched on. Usually this is accomplished with a remote switch on the mic. When the switch is released, the background music is restored.

Systems with remote loudspeakers will often benefit from amplifiers which include monitor panels that offer either small loudspeakers or vu meters (or both). This permits the operator to check program quality and level from the amplifier.

Many installations require the ability to adjust volume without the amplifier in a remote location. Remote volume systems that will operate from several thousand feet away are available that permit an operator to sit in the rear of an auditorium and control gain for many inputs without the amplifier being present.

Speech p.-a. systems can often benefit from the addition of limiting devices. These prevent one person from being severely loud while another is barely audible. Store-type and other paging systems are particularly benefited from speech limiting.

Figure 5. A complete portable sound package including mic, amplifier, phono top, and speaker—all housed in a carryable case.

PORTABILITY AND INSTALLATION

Where is the amplifier going to be? In the majority of instances, the conventional packaged amplifier in its protective case as shown in Figure 4 is all that is necessary. But more involved installations, particularly with accessory program sources, will benefit from rack installation. Most amplifier manufacturers sell screened decorative rack-panel converters for those amplifiers which do not already come equipped for rack installation. Standard rack width is 19 inches, and they come in a wide variety of heights, with or without backs and door fronts, in different metals and finishes.

Portability is a word that means different things to different people. Some amplifiers are merely carried to their use point, and returned to a storage closet after use. This portability is represented by a handle on the amplifier if necessary. More extensive portability is accomplished with manufacturer-supplied portable cases that will hold the amplifier and (sometimes) speakers and other accessories (Figure 5). Some of the more elaborate cases permit an entire sound system to be transported to sites as needed. The ability of equipment to withstand this, and its ease are considerations to be made at the time of purchase.

Wall-mount kits for amplifiers that are to be permanent in their location, are the solution for simpler installations that must be made more decorative than conventional rack mounting will allow. Such kits are supplied by many manufacturers. They should permit easy removal of the amplifier for service or modification.

ACCESSORIES

Accessories are only important if they are needed—then they become indispensible. Phono tops are among the most common, these are available either for 12-volt d.c. or 115-volt a.c. operation.

Amplifiers often must be placed where unauthorized tampering could occur. Locking plates are made that will secure the amplifier against this and should be specified where necessary.

Of course, there are a wide variety of plug-in transformers and adapters that have already been referred. These permit the conversion of input and output functions to any type of situation that will be encountered. But not all amplifiers have complete plug-in facility, so if your job will require this versatility, be sure to specify it.

SUMMING UP

Manufacturers catalogs are an excellent source for the information you will need to intelligently determine the availability of features you need. From these you will see that manufacturers often offer basic lines of equipment, sometimes distinguished by qualitative differences, more often by differences in versatility and special accommodation.

The cost of an amplifier, particularly one of the large ones, is certainly not insignificant. But when it is compared against the over-all cost of the system, it is not so significant.

A system should be matched. It makes no sense to have superlative amplification with mediocre speakers and microphones. At the same time, truly fine speaker systems and mics will be wasted with a bottom-of-the-line amplifier. It makes good economic sense to balance your system and specify components that will do the proper job required with sufficient safety factors as may be necessary. The guidelines just presented help do that. But, in the long run, there is no substitute for the knowledge you will gain from experience.

No Sound Makes News

JOHN N. BORWICK

Our British correspondent describes some practical uses being put to a giant anechoic chamber recently put into service. It has recorded an orchestra and cured a notorious hall echo

STUDENTS OF GREEK will know that *anechoic* means literally *no sound*. Audio engineers throughout the world have coined the term *anechoic room* for these specially constructed (and very expensive) test rooms which are totally sound insulated. Stand-off walls, deep wedges of sound absorber, floating floors and sound-trap doors—properly designed—can completely shut out extraneous noise. At the same time, any sounds generated within the room are instantly cut off. Since sound energy reaching the room boundaries is wholly absorbed, there is none of the reverberation or overhang that we get in any ordinary enclosure—be it living room, concert hall, or loudspeaker cabinet.

An anechoic room, of course, is mainly used for axial and polar response plotting of microphones, loudspeakers, and other acoustic elements where the random reflections of an ordinary room would interfere with the results. Normally a fairly small anechoic (or dead) room is employed to keep down the problems and expense of constructing something bigger. But the Building Research Station at Watford, near London, is very large indeed—46 by 30 by 32 feet high to the tips of the wedges—and it can be used for really ambitious projects. Here are just two of its latest commissions.

John N. Borwick is a Scott now living near London. His background includes eleven years with the BBC as a program engineer and lecturer in studio operations. He is the author of the BBC's Programme Operations Handbook. His best known credit to American readers is as technical editor of The Gramophone, the distinguished music/high fidelity magazine. In addition, he is currently secretary of the Association of Professional Recording Studios which has close on 150 member studios throughout Britain.

ANECHOIC MUSIC

My first photograph (FIGURE 1) shows the English Chamber Orchestra, conducted by Kenneth Montgomery being recorded right in the BRS anechoic room; chamber music with a new twist. A special platform has had to be built to seat the orchestra which, when joined by the Philip Jones Brass Ensemble, totalled 34 players.

The selected musical works were recorded in stereo by the BBC Transcription Unit with a calibrated coincident pair of microphones. Nothing but the direct radiated sound of the instruments (in natural balance) therefore reached the tape.

Now you may be wondering what is the use of these recordings of orchestral music in completely reflection-free acoustics? Well, the experts have quite a few ideas already.

First, they plan to construct scale models of proposed new auditoria and replay the tapes in them, appropriately scaled up in speed. Probe microphones will be used to record the results at various positions where the audience would be seated. Then, when these new recordings are played back (stepped back down to normal speed) it will be possible to make subjective and objective assessments of the acoustic designs.

Again, the tapes will be used for computer simulation of concert-hall acoustics. The recording is fed in together with varying amounts of such factors as reverberation and reflection. Then subjective evaluation can be made of the resulting playback.

Although this technique has been used already with recordings of quartets, this is the first time such a large orchestra has been possible. Copies of the tape are available on sale to organizations working in the field of architectural acoustics. They should be very useful both in predicting the acoustics of new auditoria and in allowing modifications to

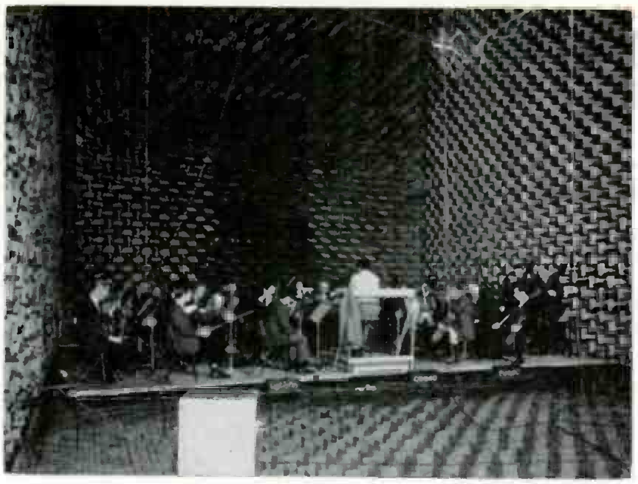

Figure 1. The English Chamber Orchestra makes a no-reflections recording in an anechoic room.

designs to be tested—before the building work itself is put in hand.

CURING A NOTORIOUS ECHO

The second project on which this giant anechoic room has recently been working is the famous echo in London's Royal Albert Hall. This huge concert hall is now 98 years old and is world renowned as a venue for the largest musical performances. It is no less than 3,060,000 cubic feet in volume and has seating for an audience of nearly 6,000—even more people can be packed into the celebrated Promenade Concerts when its stalls area is cleared for standing-room only with a large fountain in the centre.

The enormous, nearly circular building looks very impressive from outside (and inside too) but the numerous concave surfaces produce unwanted concentrations of sound. The worst feature, acoustically speaking, is the circular domed roof rising 140 feet over the auditorium. The focussing effect, and the great distances involved, have meant that certain parts of the arena—notably the back of the stalls and circle—have been plagued by severe echoes. (Concertgoers have not been any happier when told, "Well, you're getting two performances for the price of one!").

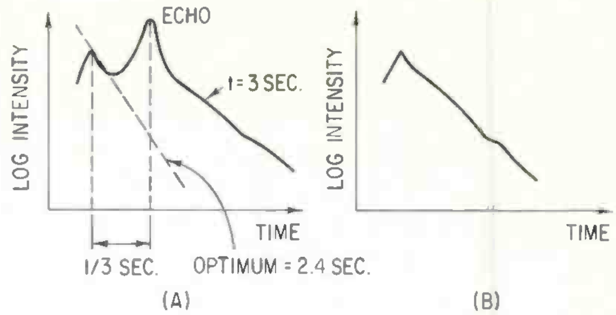

Figure 2. Traces of the reverberation curve before and after treatment.

(Oddly enough, we have just solved the opposite problem in London's Royal Festival Hall. This was deemed to have too *short* a reverberation time and it now has a complex system of microphones/delay/speakers to give synthetic reverberation.)

Earlier attempts at curing the Albert Hall echo have included hanging a huge scalloped screen across the base of the dome and angled reflectors over the orchestra, but these were unsightly and not very effective.

With centenary celebrations only two years off, it was decided to tackle the problem scientifically. Measurements and recordings of all kinds were made in the Hall itself including, for example, the organ playing at octave intervals over its entire frequency range (while an audience waited patiently, and quietly, for the concert to continue). All these tests confirmed the mechanism of the echo reflections from the dome and showed that middle frequency reverberation time was a little excessive at around 3 seconds at 500 Hz (see the oscilloscope trace for this frequency in Figure 2A).

The consultant experts (Acoustical Investigation & Research Organisation Ltd.) decided on an elaborate array of convex bowl diffusers—like flying saucers. They built 109 of these saucers and suspended them about 70 feet above the auditorium floor, spaced to form a kind of false ceiling (see Figure 3).

The diffusers vary in diameter from 6 to 12 feet, having a

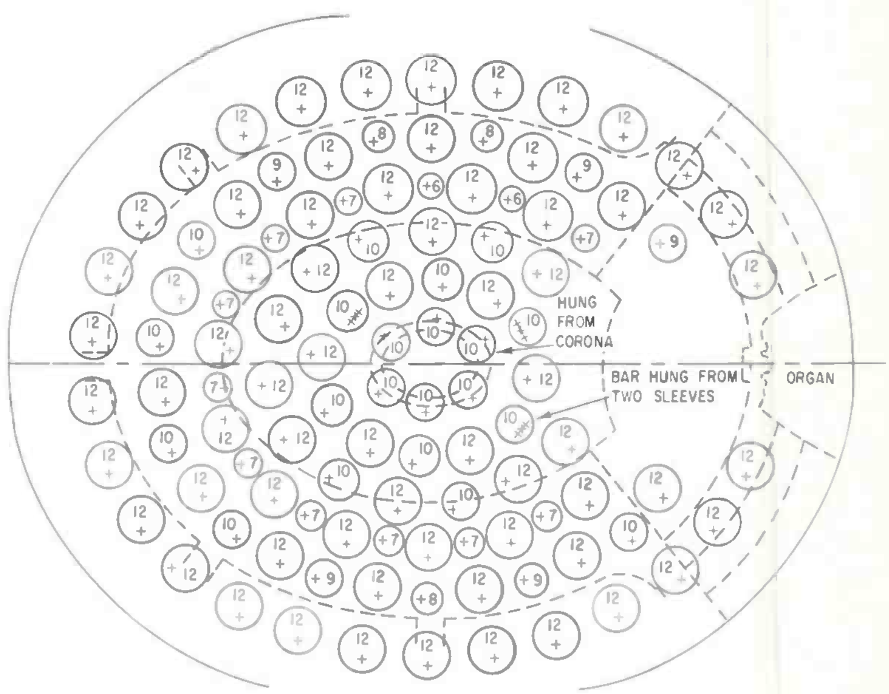

Figure 3. This cloud of saucer-like diffusers hangs 70 feet above the Royal Albert Hall auditorium and cover about 50 per cent of the area. The number in each circle indicates the diameter in feet.

Figure 4. Some of the diffusers undergoing tests in the anechoic room.

radius of curvature of 30 feet. Being made of polyester-resin impregnated glass fiber, they partially reflect sounds downwards. But their convex surfaces help to scatter the sound and, of course, the path length of the reflections is just about half what it would be to the apex of the dome. Laid inside the saucers is a 2-inch layer of glass fiber absorbent with a thin ploythene film on top. The characteristics of this absorbent were calculated to reduce middle frequency reverberation time from 3 to about 2.4 seconds (see Fig. 2B) and the plastic film serves to leave high frequencies unattenuated.

This is where the BRS anechoic room came into the act. As my photograph shows (Figure 4) sample diffusers were suspended in the room and "squeaked" to check that the calculated absorptive and reflective properties were in fact accurate.

I was treated to special demonstrations of the Hall's imperfections with the usual pistol shots and recordings of various instruments. (I already knew plenty about its musical performance, having attended many concerts over the years and worked on live broadcasts there.)

I also attended the special concert which was held to test the effectiveness of the new diffusers. This was given before an invited audience of about 4000, including many engineers and musicians, and was broadcast live so as to get as many people's reactions as possible. The concert included the Berlioz Overture *Le Corsair* and Bruckner's 7th Symphony. For my money, the orchestral definition seemed to have been distinctly improved and I found no one who had been significantly aware of the old echo bogey. So now we have an anechoic Albert Hall (if we change the translation slightly to read *no echo*). And I understand that the recording companies are now becoming interested in the possibility of using this famous old hall for commercial records.

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The Red Fort in Sound and Light

LAKSHMI DEVI

Sound and Light exhibits have become sufficiently popular to have at least one major manufacturer design specific equipment for the purpose. This installation in Delhi uses such a system to enhance the power and beauty of an historical site.

DELHI LIKE ROME IS STEEPED IN HISTORY. On the site where the twin cities of Delhi and New Delhi stand today, several cities have risen and decayed. Their relics are reminders of India's glorious past.

Out of the historic monuments that still exist, the massive Red Fort of Delhi, with its pavilions of marble, has been the silent witness of events, prosperous and disastrous, that have made history over the last three centuries. Emperors have come and have gone, but the Red Fort stands unmoved by the vicissitudes of time and fortune.

The Department of Tourism of the Government of India has set up a program of Sound and Light at the Red Fort. This popular form of spectacle is being used in many parts of the world, to re-enact the history of ancient monuments. The Pyramids of Egypt, Chateaux of the Loire in France, the Tower of London, and Hampton Court in England, are some of the places which have such shows for visitors.

Strains of the melodious plaintive sitar herald the beginning of the program at Red Fort. It is narrated by the *Waquai Navees*, which is the name given by the Mughal Emperors for the recorder of events. He takes the audience back to 1639, when the site was a howling wilderness, with the river Yamuna flowing by its side.

Emperor Shahjahan, the builder of the Taj Mahal, decides to build a new capital at this spot. It takes nine years to build the palace-fort with its high battlements, the royal apartments, the marble baths and a whole city around it for the royal courtiers to live in.

The city is named Shahjahanabad, after the Emperor. There is a nine-day celebration to mark the completion of the work. The Emperor rides in procession, showering newly struck gold coins on his populace to commemorate the completion of the fort in 1648.

Then the narrative is taken up by Francois Bernier, the French traveller, who visited India during Shahjahan's reign. He describes the daily routine of the Mughal Emperor. The day begins with a parade of the royal troops and the animal corps. Later, the Emperor is engaged in the functions of the court.

As dusk falls on the magnificent Fort and the day's busy activities come to an end, the palaces go gay with music and dancing.

The clever interplay of music and lights, enhancing the beauty of the famous marble pavilions, makes one feel transported to this time of Mughal splendour.

Soft lights show up the royal mosque, known as Moti Masjid—"a poem in marble", built by Aurangzeb, the last of the five most famous Mughal rulers of India. The lamps dim and fade away as the narrator describes the sad end of Aurangzeb's fifty years of rule in the ninetieth year of his life.

The story of the Red Fort continues. A succession of weak and worthless rulers follows. One of them is Jahandar Shah, the 'lover'. The mood of the spectacle is gay again and it is remarkable how the mere play of lights and voices dramatises the events effectively, without the aid of actors. Jahandar Shah makes a girl from the streets his queen, and her pumpkin-selling brother governor of a province.

The plunder of the Red Fort is now near at hand. The chronicler describes how the silver ceilings and gem studded walls of *Diwane Khas* (hall of private audience) are peeled off by the invaders. The peacock throne of gold and diamonds is lifted from its platform and all the treasures of the Red Fort are carried away to Persia on thousands of elephants, horses and camels. The drunken Monarch, Mohammed Shah is in a blissful daze.

The fort and its royal inhabitants are subjected to a century of injury and humiliation. The last of the Indian rulers Bahadur Shah, has no kingdom to rule and only his poetic talent for solace. His sad stanzas are still remembered and repeated in the streets of Delhi.

The British storm the Red Fort in 1857 and deport the King and his famous young Queen, Zeenat Mahal, to Rangoon, as punishment for encouraging the mutineers.

The presentation ends with the historic declaration of India's Independence by Jawaharlal Nehru in 1947, and his memorable speech to his countrymen.

The show is over, but the marble pavilions still stand there against the star-lit sky, enchanting the spectators, with their beauty and grandeur.

The Red Fort spectacle has been compiled by a team of distinguished artists and technicians. The direction of the program was in the hands of Chetan Anand, world-famous Indian film director. Emile de Harven was responsible for sound production. Music was specially composed by Ali Akbar Khan.

This article originally appeared in part in **Sound + Image,** *a Holland-printed publication of Philips Industries of Eindhoven. We are indebted to Mr. Robert Smith, editor-in-chief, for his cooperation and assistance in preparing this augmented version.*

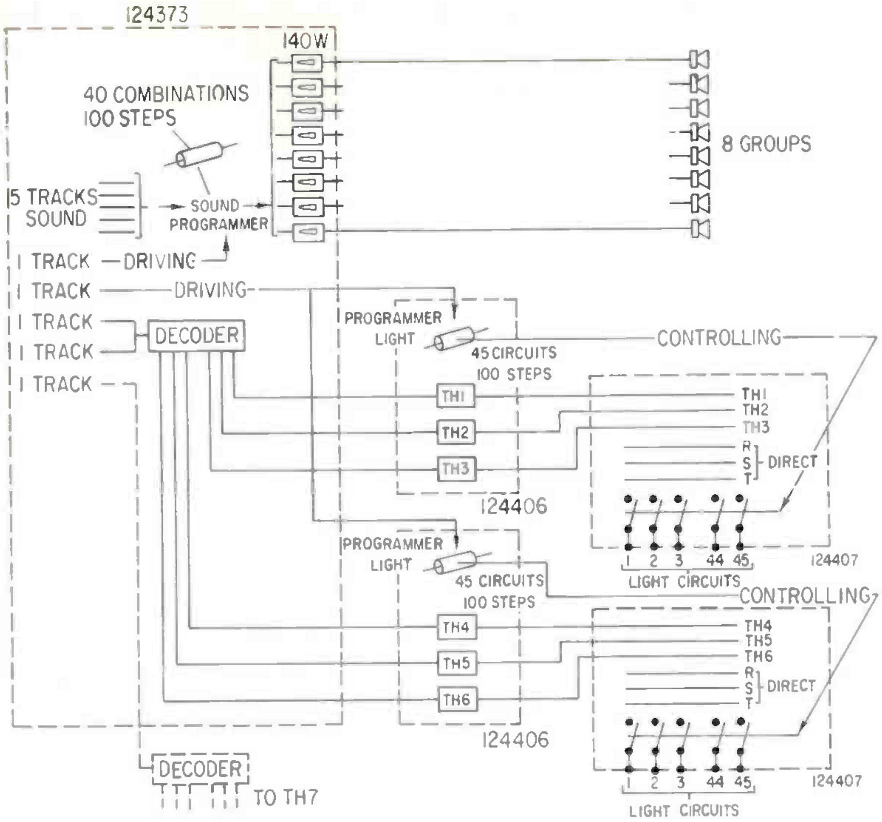

Figure 1. This block diagram illustrates the control equipment for Sound and Light exhibitions supplied by Philips. The TH designations in the enclosures indicated by the model number 12406 are thyristor light controllers. Each of the dashed boxes indicate another sub-system with the Philips model number included.

THE EQUIPMENT

The central controlling element is a ten-track magnetic tape recorder system. 16mm tape is used at a speed of 15 in./sec. The functions of the ten tracks are divided as follows:

Five tracks are used for the sound—mono, stereo, and travelling.

One track is for switching the five sound tracks to eight groups of amplifiers with loudspeakers.

One track switches the light circuits on and off, or connects them to a separate thyristor dimming unit.

Three tracks are used to control the thyristor dimming units (Figure 1), thus enabling dimming of the light circuits connected to them.

The automatic switching of light and/or sound is effected by drum-type programmers such as the unit shown in Figure 2. 24-volt d.c. pulses control the programmer. The programmer may be made to manually rotate one step by pushing the telephone key (SK 1 in Figure 3) into a right-hand position, or not to react on an external pulse by pushing the key into the left-hand position. When SK 2 is pressed the drum turns step-by-step as far as the track with stop peg. The drum can be started again by pushing SK 1 to the right. For changes of program, the drums are readily exchangeable.

The drum will operate on a pulse as short as 0.1 second. There are 102 steps per revolution, with a maximum switching speed of three steps per second. The drum contains 48 micro-switches.

Philips supplied and installed the entire package to the Red Fort display, including all accessory equipment. It has already been viewed by thousands of visitors every evening since its installation. There are now current plans to provide similar installations at other historical sites in India.

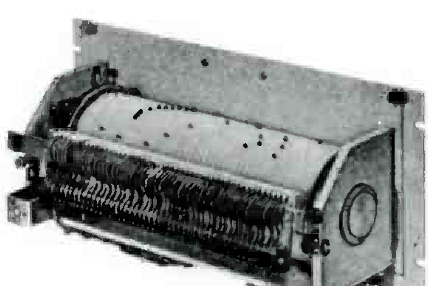

Figure 2. The drum programmer described in the text. Each of the contact pegs may be positioned as needed by individual requirements.

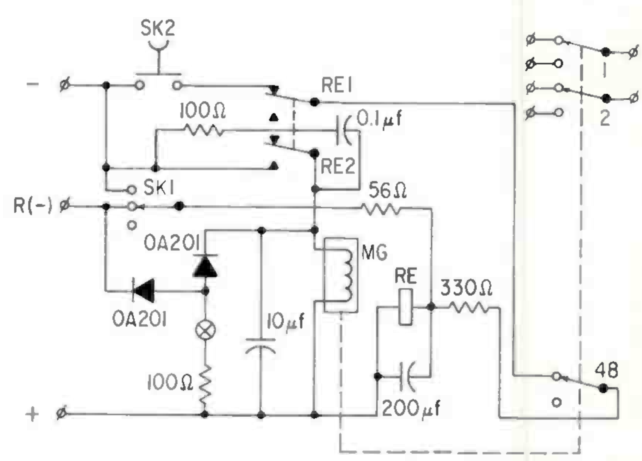

Figure 3. This schematic shows the operation of the drum programmer illustrated in Figure 2. The operation of SK 1 and 2 are described in the text. The extended switch on the right is the contacts of the drum.

Audio-Visual in a Modern Museum

MARTIN DICKSTEIN

The increasing use of audio-visual techniques as educational tools is everywhere in display. One of the more effective and dramatic systems is described herein as the author tours a new display at New York's American Museum of Natural History.

BACK IN 1869, the year the Suez Canal opened and General Grant became the eighteenth President of the United States, the term *natural history* meant the description, study and classification of living and inanimate natural objects. To fulfill this purpose, the Museum of Natural History in New York City was chartered this same year.

At that time, the staff of two men comprised the entire working force of the museum. Today, the staff consists of more than one hundred scientists and close to seven hundred employees and the subjects covered range from animal behavior to radio sounds from space, evolution of man and his role in nature. Natural history today has been expanded to mean a perspective on the entire interrelated natural world in all its complexity.

In keeping with the enlarged scope of the museum's function, exhibits have changed along with the philosophy on methods of display. From small crowded display cases, the exhibits have expanded to carefully built re-creations of the natural environs of the habitat groups being shown. Now, more than a thousand displays with over two hundred habitat groups are on exhibit in fifty-eight exhibition halls. Each animal is presented in a typical true-to-life attitude while people, fish, insects, and microscopic organisms are all shown with all possible realism in their individual dioramas

In 1935, the Museum opened the Hayden Planetarium adjacent to its main building and in 1951 presented its first space travel symposium. In 1953, the Planetarium completed its black-light murals, the only ones of their kinds anywhere, and in 1957 participated in an IGY symposium.

Ten years ago, the decision was made to launch a great new centennial exhibition program using the most advanced scientific knowledge and the most modern display techniques. In the past decade, eleven new halls have opened, a special exhibit on human ecology opened this year, a display on earth history was opened with a filmed recreation of the origin of the earth some four and one half billion years ago, a new display on ocean life and the biology of fishes was finished including a fiber glass and polyurethane model of a 94-foot long blue whale (FIGURE 1) suspended from a single point, creating the impression that there is no support at all, and a model of the Apollo space craft was put on exhibit to bring us up to date.

Films are shown on small rear-projection screens in various exhibits to enhance the displays. Flashing lights are incorporated in several presentations to provide further realism. Among these panoramas of life on this planet, the museum has opened a very large display which makes use of some of the most recent techniques of construction and audio-visual presentation to raise and explore a most provocative question, *Can Man Survive?*.

This exhibit concerns itself with the continued existance of

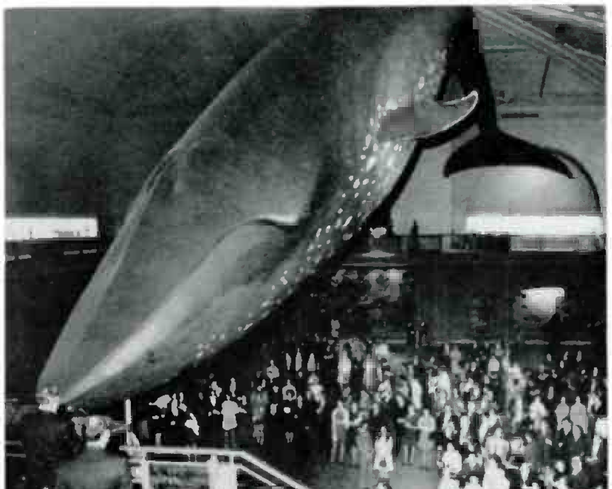

Figure 1. A full-sized replica of a blue whale, the largest animal living on earth. It is suspended from a single point.

Martin Dickstein is a regular columnist in db Magazine, contributing the Sound with Images monthly feature.

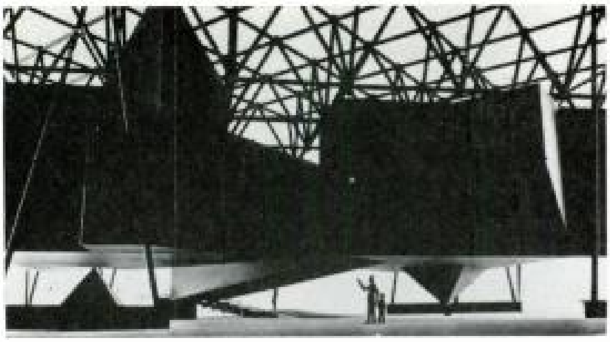

Figure 2. This Takanaka Truss supports the completely suspended exhibit described in the text. (The illustration is actually of a scale model of the truss.)

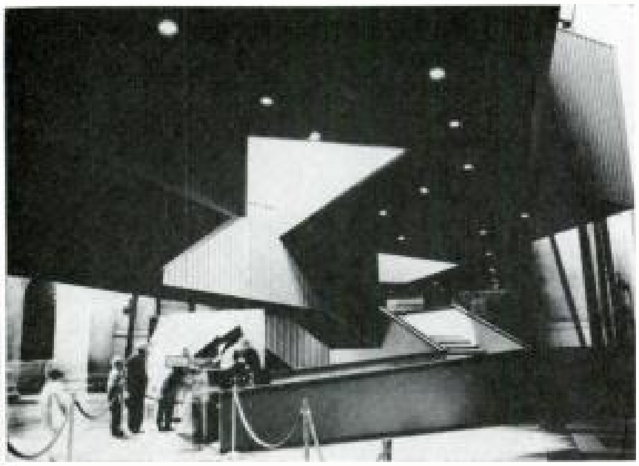

Figure 3. The exhibit entrance showing the steel support beams.

man and shows how heedless exploitation of the environment along with accelerated technology and exploding population have created staggering problems in air and water pollution, as well as urban decay.

Can Man Survive? took two years to complete and cost over a half-million dollars. Because of the size and weight of the display, the entire exhibit is suspended from a Takanaka Truss, a computer-designed open framework (FIGURE 2) supported by steel structure mounted around the floor of the exhibit hall. This is the first use of this concept in this country and has only been applied to a few structures in Japan. The architectural construction of the entire exhibit (FIGURE 3) is in keeping with modern concepts, and provides an area of four thousand square feet through which the visitors (four million are expected during the two years the exhibit will be open) will walk and experience the message being presented.

The ascending ramp of the entrance leads the visitor into a carpeted "conditioning" tunnel. Outside sounds and light are cut off and the viewer is introduced to his new environment of nature by sounds of birds singing, water splashing and soft music. The room itself is fairly dark and has, on one wall, two 10-foot wide screens. 4-minute presentations, running continuously, illustrate the balance and interrelation of all nature, and that for life to continue to exist there must be sufficient food, water, and oxygen. The show opens with a quiet, peaceful dawn and the gentle lap of the ocean on the shore. The sun rises, various landscapes and terrains are shown, different forms of life of the sea are followed by various forms of plant life and then by animal life, including man. Water, from the sea to rain to lakes, is shown to be of importance to all life. Plants are depended on by animals and man, and are dependent in turn on water and air.

A narrator's voice describes the need for oxygen and tells, during a brief segment of the film made by micro-photography, how cells depend on oxygen for life and how the oxygen is carried through the capillaries of a frog's leg.

The two films, synchronized with the four audio tracks, come to a close with the setting of the sun and after a short pause begin again with a new dawn. The projection equipment used in this presentation are 2 JAN 16mm units modified to run on a common motor with a single drive shaft, and containing 900 watt Xenon light sources. Audio originates on Viking tape loop machines and is distributed by AR amplifiers and speakers.

The passageway between this exhibit of untouched nature and the next area is a narrow walkway through which the visitor passes and sees the progress in the physical development of man as well symbols depicting the growth of man's intellect. Numerals, letters and symbols are painted to be sensitive to ultra-violet light. When illuminated in this manner they seem to float in space.

Just before the entrance to the next main area, a 4-foot-diameter hemisphere protrudes from the wall. A continuous loop of film projected into the globe from the rear, tells of the progress of agriculture from the single hand-planted seed to the present technological improvements and equipment. A narrator tape loop, in sync with the film, tells the story.

The equipment used to project this film is standard 16mm with a 1000-watt lamp and 2-inch lens. However, a fish-eye lens is used to project the image onto the sphere. It is interesting that for this segment the entire 1½-minute film has each frame turned upside-down and inverted left-to-right so that the final image is correct for the viewer.

This then leads the visitor into the next main area (FIGURE 4.) Here is seen the growth of technology and the resulting machinery and products. On a screen approximately 8-feet wide a continuous film of technology and its progress is rear-projected showing the strides made in the generation of power, medical science, etc. Much ground is covered quickly as the film runs only approximately four minutes. Here, too, a tape-loop narration describes the film. Electronic music and background sounds of technology are also heard. In keeping with the times, a small 4-inch TV receiver is built into the wall within the exhibit, a bit out of the way and not within the normal range of viewing but adding to the effect of the display.

Moving into the next area (FIGURE 5), the visitor passes a wall made of cubes of various sizes, each projecting a different distance into the path of walk. Each of the blocks is a

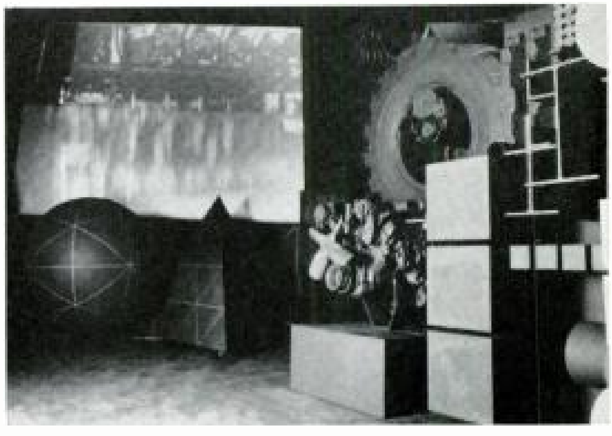

Figure 4. The projection screens of the technology are a A miniature television is built into the wall behind the tire.

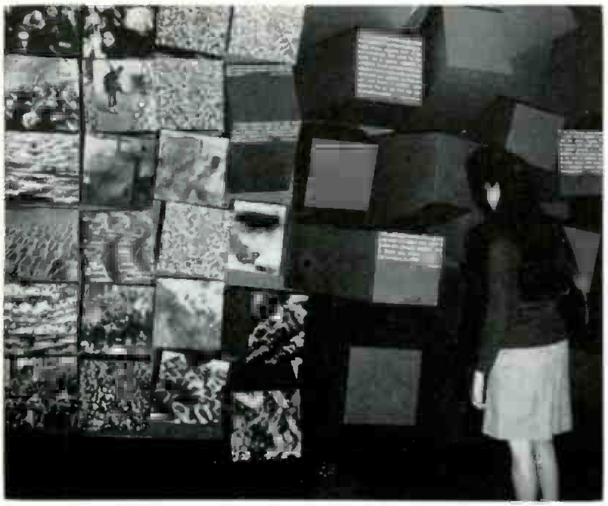

Figure 5. The population/pollution area with the many-cubed wall. Not seen in this photo is a screen with a pollution film as well as a population-increase screen facing the one shown.

mount for a black-and-white photograph and as the viewer continues on his way the number of people in the photos increases from individuals to groups to crowds of people. Photos of the increase of production, products such as cars and tires, and the resultant increase in waste are interspersed. Accompanying sound of peoples' voices and low-frequency noise such as train roars, add to the display.

The projection screen the observer approaches as he walks into the main area shows a continuous film on pollution.

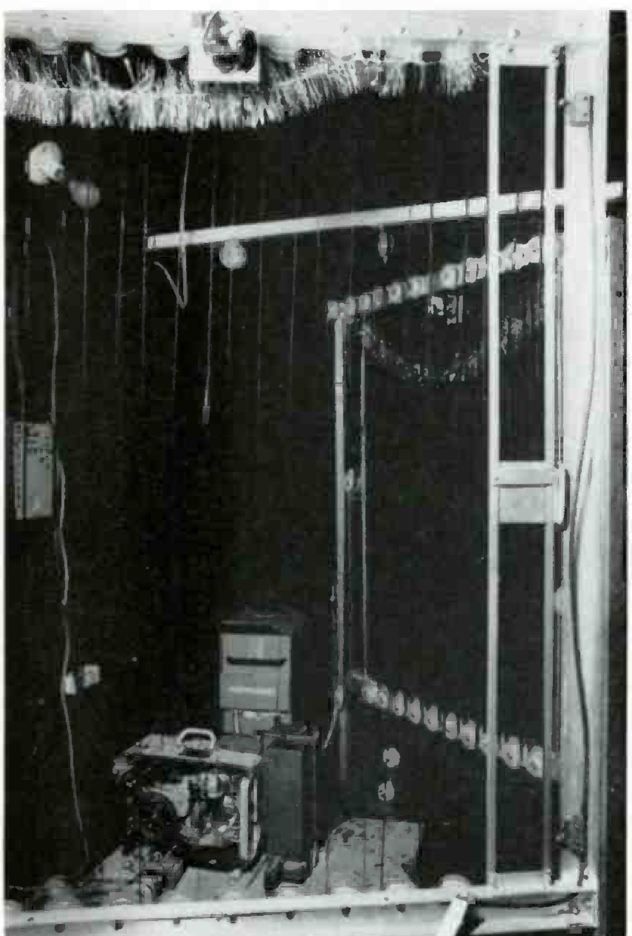

Figure 6. The continuous-loop rack used in the rear-projection displays.

Waste material and garbage is dumped into rivers. Incinerators and power plants dump their waste smoke and gas into the air. People throw their used paper and bottles haphazardly. Voices of people and a narrator tell of carelessness and indifference.

A second screen, around to the right (facing the first one), presents a film on people of various walks of life and their attitudes, including a youth thinking of his future and the old and sickly without one. The sound track for each film is kept soft, enough to permit comfortable hearing from close range, but avoiding overlapping audio due to the proximity of the screens.

Walking into the last display area of the exhibits, the visitor's path is constricted sharply by many protruding pyramids around which the viewer must move. The over-all appearance is now starkly contrasted against the openness of the first area. The peace and quiet have given way to congestion, noise, bright images of projected slides, discordant music, voices of people commenting discouragingly on waste and pollution, and a total sense of foreboding. The pyramids, which are at the level of the passerby, are the projection surfaces on which the many slides are shown. The audience, therefore, must walk through the beams of light making each one a part of the population/pollution explosion and involved in the problems inherent in the waste and decay increasing all around us.

As the public is about to leave the exhibit area, a large revolving sphere (made of steel rods in an open structure 6 feet in diameter) confronts the viewer. Quickly changing slides repeating the theme of the preceding displays are projected onto and through the globe. The images seem to bob in the air as the visitor passes by.

For the projection system in the pyramid area, eight Carousels are syncronized by a punched Mylar tape programmed to operate relays which in turn operate the projectors. A sequence of twenty slides per Carousel is repeated continuously. On the spinning globe, two more carousels are used with 1,000-watt incandescent-light sources. The sequence for each projector consists of only three slides per tray, but these slides are repeated to fill the total capacity and recycle endlessly.

The presentation now at an end, the visitor descends a staircase, As he leaves a narrator's voice follows him with the message that the waste and deterioration are becoming hopeless and that it is up to each one to do his part to prevent total decay.

The entire presentation, produced in a hundred-year young museum using some of the most up-to-date projection techniques to portray a serious and current problem confronting the public, is a most interesting application of lessons possibly learned at such excellent schools as Expo '67. From the novel external support structure, through the display which changes internally even in room size (from the largest at the beginning to the smallest at the end); through the use of twenty channels of sound and synchronized film projectors with continuous loop racks with nylon idler wheels (FIGURE 6); through a multi-track control tape and programmed slide projectors; through carefully located (hidden) speakers to produce the desired effect in keeping with the exhibit; and though the discussion of a most pressing problem of the day; an "old" museum has applied the new to move into the present and to look ahead to the future.

Our thanks to the American Museum of Natural History Department of Public Relations and to Dimensional Communications, Inc., N. J., designers of the exhibit, for their assistance and photographs.

New Products and Services

MICROPHONE

• Live recording work is the purpose of this new microphone. Model 2300 series microphones are omnidirectional dynamics with on/off switches, peak-free 50-15,000 Hz response, and output levels of =56 dB. The case is ≈ inch machined steel with steel grilles with a satin-chrome finish. Twenty foot cables are provided with the mic connector a three-pin type. A windscreen is built in. It may be had with either high-impedance or 150-ohm windings.
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People, Places, Happenings

● Be sure to mark your calendar for the **37th Audio Engineering Society Convention and Exhibition.** The place: The New York Hilton Hotel. Dates for the exhibitions and technical sessions are Monday, October 13th through Thursday, October 16th. This promises to be the most exciting yet, with this move to the giant facilities of the Hilton for the first time. As of press time, over fifty exhibitors had been signed. Next month we will carry complete listings of the papers and our map guides to the exhibits.

● Canadians note that the 19th annual **Convention of the Central Canada Broadcasters' Association — Engineering** will be held at the Skyline Hotel in Ottawa, Canada on the 26th, 27th, and 28th of October. As in past years, it will include a two-day technical seminar on broadcast technical subjects, and engineering luncheon, and two floors of broadcast equipment displays. For further information write to **George Roach, Past Chairman—CCBA Engineering c/o Radio Station CFRA Limited, 150 Isabella Street, Ottawa 1. Ontario, Canada.**

● **S. L. Raia** has been appointed director of advertising and public relations for **Visual Electronics Corporation** according to an announcement of **James B. Tharpe**, president of the firm. Mr. Raia comes to Visual from **CBS Labtoraories** where he held a similar position. Before that he was with **AVCO/Lycoming** as chief of technical communications.

● Four veteran executives at the **Altec Lansing Division of LTV Ling Altec, Inc.**, has been announced by **Alvis A. Ward**, chairman of the board and president of the newly-formed **Ling Altec Group** headquartered in Anaheim, California. **H. S. Morris**, former

vice-president of marketing becomes president of the Altec Lansing Division. "Mo" Morris began his career 41 years ago with **Electrical Research Products, Inc.**, a subsidiary of **Western Electric** and a predecessor to Altec. He worked his way up through the company as a survey engineer, technical inspection superintendent, merchandising manager, and director of marketing. In 1962 he was appointed v.-p. marketing.

W. H. Johnson, former marketing director, succeeds Mr. Morris as division vice-president for marketing. He has

been with Altec since 1858 as midwestern sales manager based in Chicago. He transferred to Altec Lansing in Anaheim in 1959 to become manager of engineering and technical information. In 1960 he was named marketing director.

A. K. Davis celebrates his 40th year with the company having started with Electrical Research Products, Inc. in 1929 as a field installation engineer.

His new title is vice-president manufacturing. Most recently he was general operating manager, a position he has held since 1965.

James J. Noble joined Altec Lansing Corporation at its founding in May,

1941. He first served in the manufacturing department. After service in the Navy during the second world war he returned to Altec as a senior member of the engineering group. In 1955 he was promoted to chief engineer of electronics, and in 1967, was named director of engineering. In this latest upshifting he becomes vice-president engineering.

● **Mirasound Studios, Inc.** at their new location in New York City has announced the signing of **Bob Hughes** and **Bill Radice** to join **Ron Johnson** who has been at Mira sound at its old location and helped introduce 16-track recording to the industry. These three will now work on recently-installed equipment for 24-track recording, as well as servicing the industry with more conventional methods.

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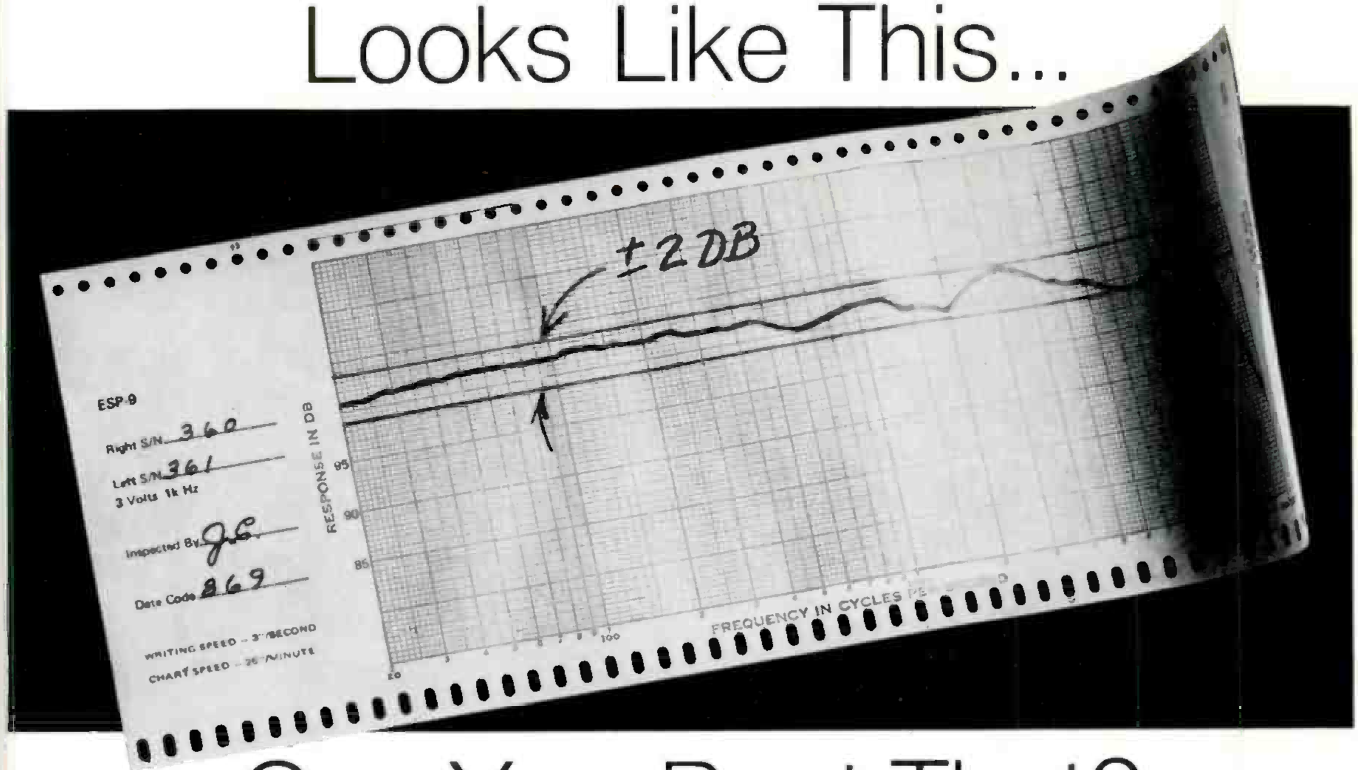

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