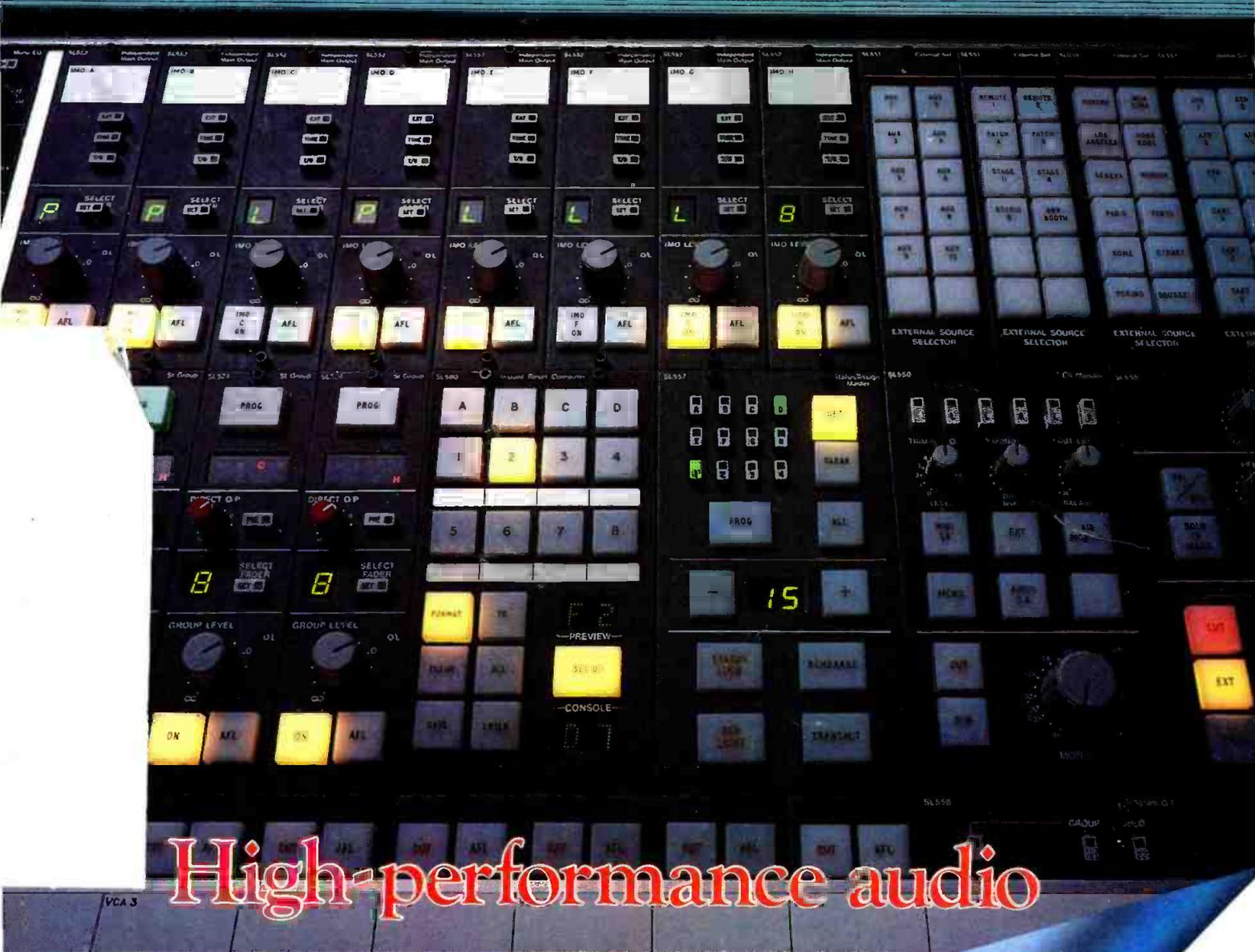


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August 1986/\$3



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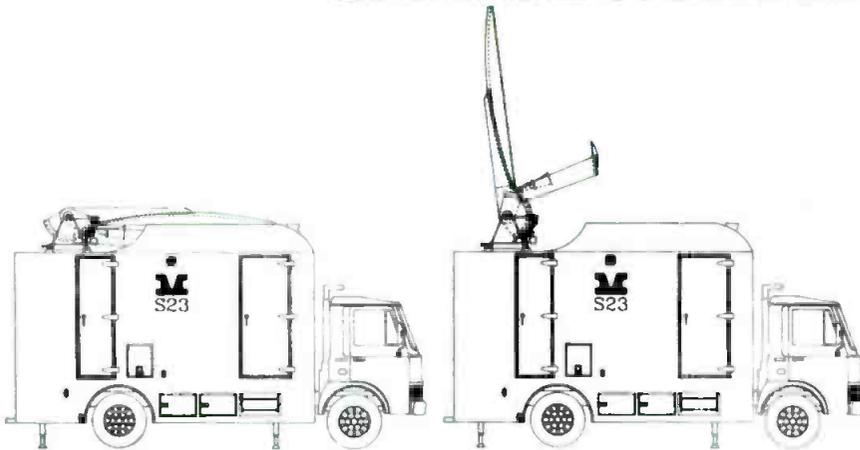


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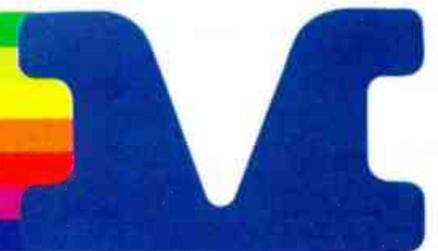
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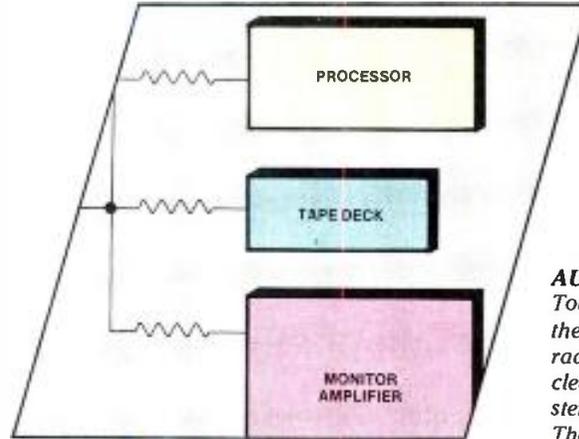
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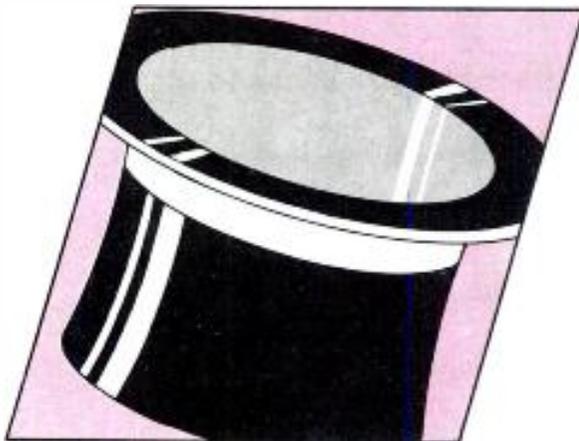
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ON THE COVER

The new generation of broadcast audio consoles must incorporate design features that allow relatively simple basic operations, but provide the capabilities for sophisticated production work. Although the requirements vary from facility to facility, signal dynamics, equalization and distribution are integral elements of premium-quality audio. Shown on our cover is Solid State Logic's SL 5000M system.

BROADCAST engineering

AUDIO SYSTEMS UPDATE:

Today's radio and TV engineers are placing greater demands on their audio systems. As competition continues to increase, radio stations must constantly strive to keep their audio chain clean and bright as possible. Many TV stations are installing stereo audio systems, which bring their own set of problems. The Audio Systems Update examines several important aspects of today's high-performance audio broadcast systems.

22 Limiters, Compressors & Expanders

By Richard C. Cabot, Audio Precision

Today's broadcast facility may use several different types of audio-processing systems. The key to their effective use lies in understanding how they work.

32 Noise Gates and Expanders

By Mike Morgan, U.S. Audio

Often the proper application of a noise gate or expander can solve an audio problem. Formally restricted to recording studio use, noise gates and expanders are now common in many broadcast studios.

38 Distributing Audio Signals

By Scott Hochberg, Logitek Electronics Systems

Audio distribution amplifiers can make signal distribution much easier. This article discusses the types of amplifiers and the considerations necessary for an intelligent purchase.

48 Inside Power Amplifiers

By Cal Perkins, Fender Musical Instruments

The studio speaker amplifier is often forgotten. If it works, leave it alone. However, the high-quality sound needed by stations demands high-quality monitor systems, which begin at the amplifier.

106 Perceptions of Audio Perception

By Terry Pennington, Rane Corporation

Are we dealing with facts—or our perception of facts? When it comes to evaluating audio components, can we really be objective?

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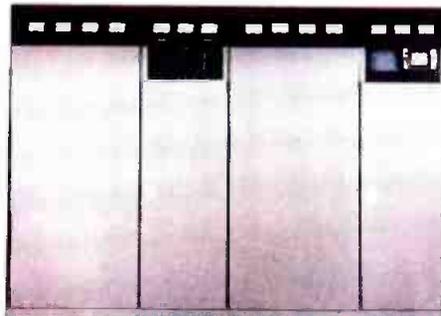
Naturally when it came to choosing the transmitter for his next station in Omaha, Nebraska, there was only one choice: Comark's "S" Series 240kW rig.

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First national SBE convention shaping up

The first national SBE convention is shaping up to be the technical event of the year. According to the society, more than 80 exhibitors were registered as of June 1. The SBE expects about 225 exhibit booths to be filled by the convention's opening.

Convention registration materials are being mailed to engineers this month. The attendance is expected to approach 2,500, according to one SBE source. In order to make the convention as affordable as possible, special discount hotel rates and air fares are available. Engineers making reservations on TWA through Apex Travel Service in St. Louis will receive a 40% reduction in TWA coach fares. To qualify for the discount, reservations must be made through Apex Travel. In Missouri call 800-392-1473. Outside Missouri, call 800-325-4933. Mention the special SBE profile number 99-10405 when you call.

The convention, Oct. 14 to 16, marks the first time SBE has hosted a national event. One reason for the interest lies in the lack of sufficient hands-on technical sessions at other national conventions.

To support this need, a broadcast engineering conference is being held in conjunction with the equipment exhibition. The conference, hosted by **Broadcast Engineering**, is being coordinated by John Battison.

Some of the technical sessions include stereo TV measurement techniques, tuning and adjusting TV antennas with a spectrum analyzer, fine-tuning FM final stages, the care and feeding of folded monopole antennas and the new FCC/FAA tower marking and lighting rules. An additional important session on non-ionizing radiation also is scheduled. See convention schedule on page 144.

Registration for the equipment exhibition is free. The fee for the 3-day technical seminar is \$25. The Wednesday luncheon is an additional \$10. Tom Keller, senior vice president, NAB, will be the luncheon speaker. For more information, contact Sam Caputa at KEZK-FM, 314-725-2184.

128th SMPTE to be biggest ever

Projections for the 128th SMPTE technical conference and equipment exhibit indicate that the exhibit and atten-

dance records established at the 1985 conference could be short-lived.

The conference and exhibit will be held Oct. 24 to 29 at the Jacob K. Javits Convention Center in New York.

SMPTE has reserved one of three major exposition levels in the convention center for the equipment exhibit, technical sessions and engineering meetings. About 275 to 300 companies will occupy 775 to 800 booths in the equipment exhibit.

By comparison, 253 companies occupied 750 booths at the 127th SMPTE, held last October in the Los Angeles Convention Center. A total of 15,618 registered for the event.

For further information contact SMPTE at 595 W. Hartsdale Ave., White Plains, NY 10607.

SMPTE opens new headquarters

A reception was held on June 12 to celebrate the official opening of SMPTE's new headquarters in White Plains, NY.

The new 3-story building contains 14,000 square feet of office space. Except for a small area rented to a non-SMPTE-

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BROADCAST engineering

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Rediscovering audio

There was a time not so long ago, when as far as most TV operations were concerned, you couldn't give audio away. You remember. Audio was only the stuff that accompanied the picture. The advent of stereo television, thankfully, has changed all that. Yes, broadcasting—an industry that loves discovering new things—has rediscovered audio.

Think back 10 years ago. Your on-air audio mixing desk was an audio-follow-video switcher that, shall we say, lacked a certain amount of finesse. Your production board was a modified radio console with outboard mixers and machine controls. Not very sophisticated stuff. True, it got the job done, but not without some sonic compromises.

The implementation of stereo broadcasting in the United States was not the sole cause of television rediscovering audio, but it has certainly been the focal point. Stations that once treated audio as little more than a poor step-cousin to the video are spending the money and time necessary to upgrade their facilities to produce first-class audio to match their first-class video.

Competition in the broadcast industry has been blamed by a variety of people for a variety of sins. But one thing that we can be thankful for is the facility improvement that competition in the marketplace makes possible. You couldn't justify an expenditure of \$100,000 for audio system renovation unless it would give your station a competitive advantage in the market, or at least allow it to remain on par with the other stations in town.

TV audio system performance, from the console input to the transmitter, used to be relatively unimpressive compared to FM radio. Years ago, if a group of radio engineers got together they would always like to talk about TV audio. The topic was guaranteed to generate a few laughs. But the attention given to TV audio equipment and system improvements has changed all that. Most radio engineers would die for the audio equipment now installed in some TV stations and production houses.

To many TV engineers, stereo audio is a new technology. It is something that they are not accustomed to or comfortable with. The learning process is just beginning at many stations. Engineering managers and TV audio equipment manufacturers have told us that a critical need currently exists for experienced, trained audio technicians at video facilities. Many stations have drawn from the staffs of nearby FM stations or recording studios for technical advice. If you are feeling bewildered at the prospect of rewiring your plant for stereo, don't worry. You're not alone.

This issue of **Broadcast Engineering** focuses on audio. We hope that the editorial package will help in the educational process for both radio and TV engineers. There was a time when articles relating to audio were greeted with a lack of enthusiasm by TV readers, but not anymore. The aural portion of the TV signal is too important to be left to the uninformed. It holds too much potential to be treated as an afterthought.

The broadcast industry is in a constant state of change and television is in the center of the storm. Think about the dire predictions that we heard for over-the-air television a few years ago. Some of the more widely touted predictions were that:

- cable penetration would destroy small-market television;
- pay TV channels would seriously erode conventional network advertising revenue;
- direct-broadcast satellites would eventually take over most feature program distribution;
- high-definition television would become the medium of choice for major film releases; and
- home VCRs would make a significant cut in over-the-air viewership.

So far, at least, none of these predictions of doom have come to pass. It is certainly true that inroads into over-the-air television's traditional hammerlock on home viewing have been made, but nothing like the projections of a few years ago had warned. The reason is simple. Competition has kept the TV industry on its toes.

People watch and listen to both programming *and* technology. In our business you can't separate one from the other. It was the competition from premium pay TV services and feature film VCR releases that made stereo television attractive in the first place. Let's face it, nobody spends money unless they have to for competitive reasons. Over-the-air television has seen the challenge of quality audio and has risen to the occasion. Further improvements will surely follow. Yes, television has rediscovered audio. And not a minute too soon.

!:-:-))))))



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U.S. and Mexico to relax AM daytime restrictions

By Harry C. Martin

Daytime AM stations on Mexican clear channels soon will be allowed to provide full-time service. An agreement between the United States and Mexico, yet to be signed by the Mexican government, will relax past restrictions and allow daytimers to begin post-sunset operations.

In late spring the commission began mailing show-cause letters to each affected AM daytimer stating that, absent objection, its license will be modified to specify nighttime operation with specified power allotments. Upon ratification of the U.S./Mexican agreement the commission will release public notices giving affected AM daytimers the go-ahead for full-time operations.

In response to new international agreements regarding AM foreign clear channels (the United States has reached an agreement with Canada and an agreement with the Bahamas is being negotiated), new AM technical rules have been adopted that implement metric groundwave curves to replace the curves that had been based on English units. The new metric groundwave curves will go into effect Jan. 1, 1987. However, applications filed before that date will be processed under the rules in effect at the time of their filing.

AM applicant preferences reconsidered

The FCC is reconsidering its decision to eliminate preferences for minority and non-commercial applicants for AM facilities to be made available on the Canadian, Mexican and Bahamian clear channels.

A federal court overturned a commission decision that departed from the minority preference policy for applications for the foreign clears. The court found that the commission failed to observe proper procedure and failed to consider all relevant factors. The commission must reconsider whether preferences will be awarded to eligible minority and non-commercial applicants for the newly available facilities.

The minority preferences previously available to applicants for U.S. Class I-A clear channels were deleted from the rules last fall. That ruling also is subject to a pending reconsideration petition.



TV stereo rules clarified

The commission has clarified its rules protecting the Broadcast Television Systems Committee (BTSC) stereophonic pilot tone.

TV receivers designed to decode the BTSC pilot tone may not be activated by other subcarrier stereo or communications services. Thus, stations using alternative subcarrier transmission methods, and monophonic stations, must be careful to suppress any signals at the BTSC pilot tone frequency.

By the same ruling, TV stations, at their discretion, may leave the stereophonic pilot tone on during mono programming.

Proposed LPTV changes

The commission has proposed to change its filing window procedures for LPTV and TV translator applications. It also proposes a procedure whereby displaced LPTVs and TV translators may move to new channels.

The flow of incoming applications will be limited by placing a cap on the number of applications that may be filed by any one applicant during any particular window. A limit of five or fewer applications per party was suggested by the FCC. To enforce the cap procedure, applicants would be required to list the names, addresses, occupations and ownership interests of parties to the application.

The FCC hopes this will prevent applicants from filing under different business names. The commission also seeks comments as to whether filing windows should be restricted to state or regionally defined geographic areas.

The agency also proposes that an LPTV or TV translator station displaced by land mobile radio service or by a full-service TV station be allowed to modify its permit or license to specify operation on a new channel. The displaced LPTV or TV translator would have to show that operation on the new channel would not interfere with other licensed operations and would not be mutually exclusive with another LPTV or TV translator application.

Minimal commission role in home-dish scrambling

In a recent speech to the House Communications Subcommittee, Mark Fowler, FCC chairman, criticized pending legislation that would require greater FCC regulation in satellite signal scrambling. Fowler stated that the commission should, however, authorize more TV translator and LPTV stations to meet service needs in rural areas. He also expressed the commission's willingness to get involved in the passage of legislation to directly and severely punish persons who intentionally interfere with satellite communications.

Presently, regulation of TV receive-only (TVRO) dishes is limited to the pre-emption of local zoning ordinances directed toward TVRO antennas. However, pending legislation would push the commission further into the regulatory mode by requiring it to establish a uniform scrambling format or set rates for TVRO programming. Legislation requiring monitoring of the price and availability of scrambled programming also has been proposed.

As to implementing a uniform scrambling standard, Fowler stated that the programming industry's widespread use of VideoCipher II negates the need for any FCC involvement in that area. He said involvement in program rates and practices also is unnecessary because the marketplace, rather than the FCC, is best qualified to decide what pay TV services should cost the consumer.

Cable restrictions proposed

In June, the FCC issued a notice of proposed rulemaking looking toward prohibiting any single MSO from owning or operating systems serving more than 25% of U.S. cable subscribers.

The controversy over the concentration of cable ownership was triggered when a Montana cable operator petitioned in February for rulemaking. The petition, plus congressional concern over increasing concentration in the cable industry, was prompted by the Supreme Court's invalidation of the must-carry rules and by the acquisition of Group W Cable by ATC and TCI. Through that acquisition, ATC and TCI will control 25% to 40% of the country's subscribers, and, as the Montana operator pointed out, TCI will command an 88% share of subscribers in Montana. [:-?-)]]]

Martin is a partner with the legal firm of Reddy, Begley & Martin, Washington, DC.

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MUSE system first to be demonstrated for HDTV

By E. B. Crutchfield

Last month, the basic concepts of HDTV in relation to broadcasting were reviewed. As a general term, HDTV means a system that has more lines per picture, a wider aspect ratio and finer detail than conventional NTSC pictures. The most highly developed system, and the only one currently being sold, has 125 lines, an aspect ratio of 3:5.3, a bandwidth of 30MHz, 2:1 interlace and a 60Hz field rate.

This system has been proposed as a world standard for producing programs for release on videotape or film. As videotape, the signal would be converted to NTSC, PAL or SECAM. When the system was developed, it was planned to produce pictures at least as good as 35mm film produces. The results have been quite good.

On the program

Whether this system will be accepted as a formal standard is still in question. The equipment is on the market, and two production facilities are in operation. What has emerged as important for broadcasters is that:

- some form of HDTV is likely to appear on the consumer market in the next few years via videodisc, tape or DBS;
- reactions of those who have seen HDTV suggest that it could become extremely popular; and
- whatever system (or systems) become the standard, it is unlikely that NTSC, with its 4.2MHz bandwidth, can be improved to where it can successfully compete with HDTV.

The question is, will high-definition television, delivered by media with wider or unregulated bandwidths, have the same effect on broadcast television that high-definition radio (FM) did on AM radio? Rather than wait for an answer until it's too late, NAB and MST have initiated the ATTB demonstration to assess and inform the industry of the prospects for broadcast delivery of HDTV.

The first system to be demonstrated will be MUSE (multiple sub-Nyquist sampling encoding), developed by NHK, Japan's broadcasting network, for transmission via satellite with frequency modulation. ATTB plans to use vestigial sideband AM (VSBAM) to save bandwidth. Because the MUSE bandwidth

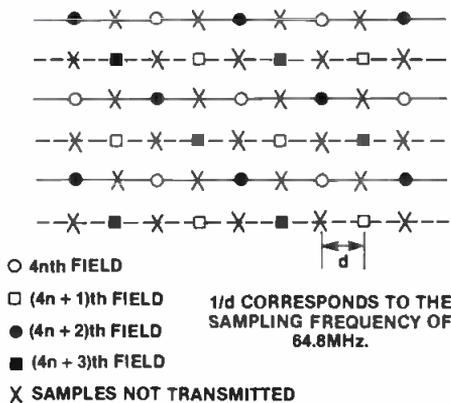
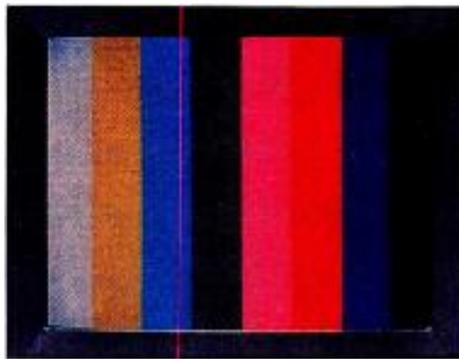


Figure 1. MUSE picture-sampling pattern. The cycle of sampling is completed every four fields.

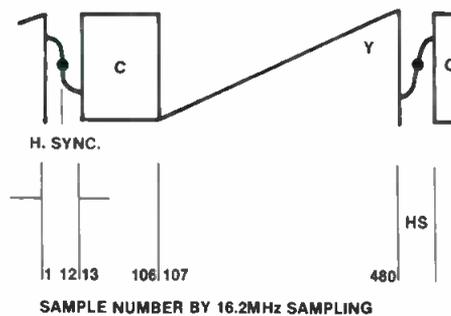


Figure 2. MUSE waveform at the horizontal rate. Color information (C) is time-compressed and transmitted separately from luminance information (Y). Synchronization is determined from the zero crossing of the sync signal. Note: Up to four channels of audio are transmitted digitally during vertical blanking.

video is only 8.1MHz, the VSBAM signal should occupy less than 10MHz. Up to four audio channels can be digitally encoded and transmitted with video in the bandwidth.

Some details

How do you get 30MHz of video into an 8.1MHz sack? How MUSE works is not widely understood, partly because of its sophistication and partly because development and refinement are still pending.

A 4-field sampling pattern is shown in Figure 1. The basic sampling period is 15.4ns. Because there are 1,125 lines and 30 frames per second, the result is 1,920

samples per line, only one-fourth of which are transmitted for any given line. Because the samples are transmitted as an analog signal, required bandwidth is reduced to about 8MHz. Stationary portions of a picture are reproduced using data from all four fields of a cycle, so that a high-definition picture results.

For rapid motion, a blur would result in images constructed from data taken from four sequential fields. To deal with this problem, MUSE has motion-detecting circuits that use only single field information. The resolution is considerably less (about one-fourth) during motion, but this is not particularly noticeable because the eye's sensitivity to detail decreases with motion. The picture detail is softened but the viewer does not notice it.

The system also considers situations in which there is uniform motion of a portion of the image, such as when the camera pans a scene. Because all elements of an image or section of an image are moving together, it is possible to detect the rate of motion and shift all the data from, for example, the first field by a calculated amount to align it properly with data from the second field. Then, both first and second field data are shifted to align with the third field and so on. In this way, a high-definition picture can be reproduced.

The equipment to make this complicated procedure work requires a good deal of high-speed processing circuits and copious memory. The results, however, are impressive.

Beyond broadcast

Whether MUSE will become part of a successful consumer product line will depend upon, among other things, how good manufacturers are at reducing the size and the power requirements of its circuitry. Considering what has happened with digital watches, computers and portable CD players, this is not likely to be an obstacle. At least one manufacturer has developed a prototype videocassette recorder for home use that takes advantage of the required frame store memory to solve some of the problems of helical tape technology as well as processing MUSE.

How well MUSE will perform in the terrestrial broadcast environment remains to be seen. The prospect of broadcasting wide-screen pictures with apparent resolution equal to a 30MHz bandwidth makes it well worth trying. (:-:)))))

Crutchfield is project director for the Advanced TV Terrestrial Broadcast Project, a joint project of NAB and the Association of Maximum Service Telecasters.



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Learning the basics of AM radio

By John Battison, P.E.

Although many **Broadcast Engineering** readers are experienced and knowledgeable engineers, there are increasing numbers of inexperienced engineers who have recently entered into broadcasting. Many of these men and women are coming into the business armed with a technical education or even 4-year college degrees. Others are entering broadcasting with little technical knowledge but a wealth of excitement and enthusiasm, the way some of you probably did.

Now that the FCC requires no proof of technical expertise, the door is open to almost anyone who wants to become a broadcast engineer. For those just starting in the field, technical training is often difficult or expensive to obtain.

During the next few months, this column will relate some of the basics of broadcasting. For new engineers, this information should be enlightening, and for the old-timers, the review might even refresh your memories.

FCC rules

Despite the relaxation by the FCC, the basic broadcast rules still emanate from the commission. Although broadcasters may have a great deal more freedom than before, the FCC still requires that stations comply with a number of technical, as well as administrative, rules.

Every broadcast engineer should have a copy of the FCC rules. The copy should contain both Parts 73 and 74. It's critical that the copy be as up-to-date as possible. With the rules constantly changing, waiting six months or more for a revised copy is just asking for trouble.

There are two ways to obtain a current set of rules. You can purchase a set of the *Code of Federal Regulations (CFR)* from the Government Printing Office. The two volumes, 47 CFR Parts 0-19 and 47 CFR 70-79 cost about \$30. The printing office accepts credit cards. If your station belongs to NAB, you can update the rules with attachments from the NAB's *Engineering Report*.

The second way to obtain a set of rules is to contact the Rules Service Company, Bethesda, MD. The loose-leaf set is up-



dated quarterly. A 1-year subscription costs less than \$100.

Station classes

The FCC rules define various classes of AM radio stations. The basic classes are: clear, regional and local. Current practice uses the CCIR designations as Class A, B and C, respectively. You will not need to know much more about this subject unless your station decides to expand its coverage area.

Coverage

Coverage is an area fraught with complications for the newcomer. In general, the 0.5mV/m contour is defined as the daytime service area. In addition, the commission requires that cities with populations of more than 2,500 have to receive a minimum of 2mV/m to be included in the station's service area population count. The FCC also requires that 5mV/m be placed over the city of license to qualify. This important point will be discussed later.

Day and night coverage is calculated in different ways. In the case of local stations, the rules provide a simple way to compute the estimated service area. The process is straightforward and basically consists of adding the signals from co-channel stations within various distance radii. For the other classes of stations, you have to consider the root-sum-square (rss) value of various co-channel signals.

It is not unusual for a station to have a daytime (0.5mV/m) service contour extending out to 50 or 60 miles. At night, however, that same station's signal may extend to only five or six miles with a 20mV/m contour. This is often the case for Class IV or local stations. A good example of this situation is WOSU-AM. The station is located in Columbus, OH, and operates at 820kHz.

The daytime contour is approximately 50 miles. At night, the 6-tower directional array and reduced power limit the coverage to approximately 13mV/m, which barely covers Columbus.

One problem with the different signal strengths and coverages centers on sta-

tion coverage maps. Although the sales staff may want the contour lines to extend to the most remote regions in your area, that practice may not be wise. The commission expects broadcasters to use accurate coverage maps when promoting the station. Although a little smoothing can be done on the contour drawings, don't get carried away. In fact, if you are ever in a situation in which you are asked to provide data on your station, insist on using the actual 0.5mV/m daytime contour.

Modulation

Probably one of the most talked about, and perhaps least understood, areas of broadcasting is modulation. Modern transmitters are capable of perhaps 200% of positive modulation. However, the FCC limits positive modulation to a maximum of 125%. Negative modulation must not exceed 100%. Failure to properly control a station's negative modulation can result in carrier cutoff and heavy distortion.

To properly measure the station's modulation, a modulation monitor is used. Many of these devices measure modulation with a meter and a peak reading lamp (usually an LED). To the newcomer, these two displays may cause some confusion.

The meter is accurate only if steady-state tones are being used. During normal programming, the modulation meter (unless it's an LED display) can only indicate *relative* modulation. You can use the peak lamps to accurately set the modulation level. The peak lamps can be triggered quickly, much quicker than the meter, and therefore better represent the station's actual modulation.

For stations engaged in stereo broadcasting, the need to accurately measure modulation is paramount. In these cases, the manufacturer of the stereo exciter may specify the methods and equipment to be used.

Next month, we'll look at a common element in AM broadcast stations—antenna tuning units (ATU). Although most stations have some form of ATU, few engineers really understand the important role they play. In September, we'll focus on how you can calculate the values of emergency ATU replacement parts, even if you don't know their original values. |:-:->))))

Battison, BE's consultant on antennas and radiation, owns a radio engineering consulting company in Columbus, OH.



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Midsummer potpourri

By Elmer Smalling III

Many new corporate satellite services using both video and data are appearing around the country, with thousands of earth stations being planned. One major corporation has predicted an additional 3,000 to 5,000 dishes will be added to its network within the next couple of years. This widening customer base for satellite equipment manufacturers will cause improvements and advances in technology. Broadcasters may expect to benefit from the industry growth as well.

In April, the FCC issued an order allowing blanket licensing of very small aperture terminal (VSAT) networks. VSAT systems use antennas with diameters less than five meters. This order will help smooth the way for the thousands of new terminals planned for evergrowing communications needs. Unintentional Ku-band interference between operators, especially those using steerable antennas, will need to be addressed soon. A good start in this direction would be an inter-industry monitor group.

VDF—by satellite

NAVSTAR, a navigation satellite network capable of vehicular direction finding (VDF), is scheduled to be completed in 1988. When it is finished, a total of 18 satellites will be in use by railways, airlines, trucking companies and automobile manufacturers. VHF, UHF and microwave frequencies will be involved in this service. Applications of the system for satellite news gathering can be expected.

Small antennas atop vehicles receive positioning data on a constant basis, as

Smalling, BE's consultant on cable/satellite systems, is president of Jenel Systems and Design, Dallas.



well as feeding information back to the system. Accuracy specified for the network will allow locations to be determined within 150 feet, while speeds can be determined within 1mph increments. This determination is accomplished by comparing timing data from a number of NAVSTAR satellites.

Sun outage season

The fall sun outage period is approaching. Loss of satellite-to-earth signals results when the sun is directly in line with the boresight of the antenna and completely overpowers the satellite signal. The smaller the antenna, the longer the problem exists, because of the decreased directional characteristics of small antennas. Common sun outages may last from less than a minute to more than 30 minutes. Varying degrees of interference range from complete loss of picture at the peak sun angle to light noise at fringe angles.

During the time of year when the sun crosses over the boresight of your antenna, you will experience an outage each day for about a week. There is no cure for some sun outage, no matter how large the antenna or sophisticated the equipment. Plan to cover that time with programming from a different satellite or videotape.

If you lease satellite time, your lessor

should be able to supply outage times for your location. If you subscribe to network programming, you may check with the network's engineering department for the information.

There are several very large FORTRAN V programs (for large computer systems) involving spherical mathematics and matrix mechanics that can accurately predict the sun outage for any satellite and earth station location. Simpler outage calculation programs, using terrestrial location and satellite identification inputs for personal computers, are less plentiful. As we hear of them, we will try to run tests and present the information and program availability in future columns.

On private TVROs

In mid-June, Dallas hosted a consumer satellite exposition. Two years ago, there were hour-long lines to get tickets, more than a hundred dishes in the parking lot and hundreds of exhibits that covered the full spectrum of satellite communications. This year, there were no lines, few antenna systems in the lot and few exhibitors. In fact, nearly half of the available exhibit space was empty.

It is sad if the lackluster turnout was indicative of a withering of the consumer satellite business. The consumer sector of the industry has been responsible for equipment cost reductions and many design features that have been incorporated into today's commercial satellite communications equipment. It was not that long ago that a satellite TVRO, capable of receiving just one transponder, cost \$50,000. Today, a system capable of receiving all transponders of all CONUS (continental United States) satellites, both C- and Ku-band, costs less than one-tenth that original figure. What effect special service scrambling will have on the TVRO industry has yet to be determined.

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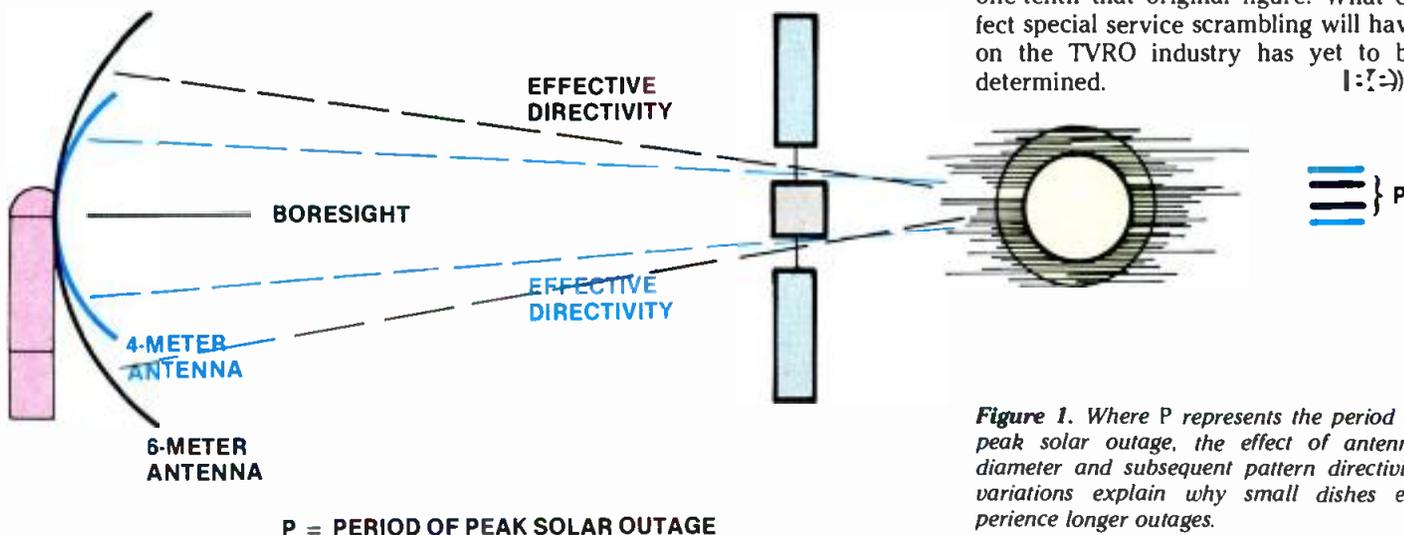


Figure 1. Where P represents the period of peak solar outage, the effect of antenna diameter and subsequent pattern directivity variations explain why small dishes experience longer outages.

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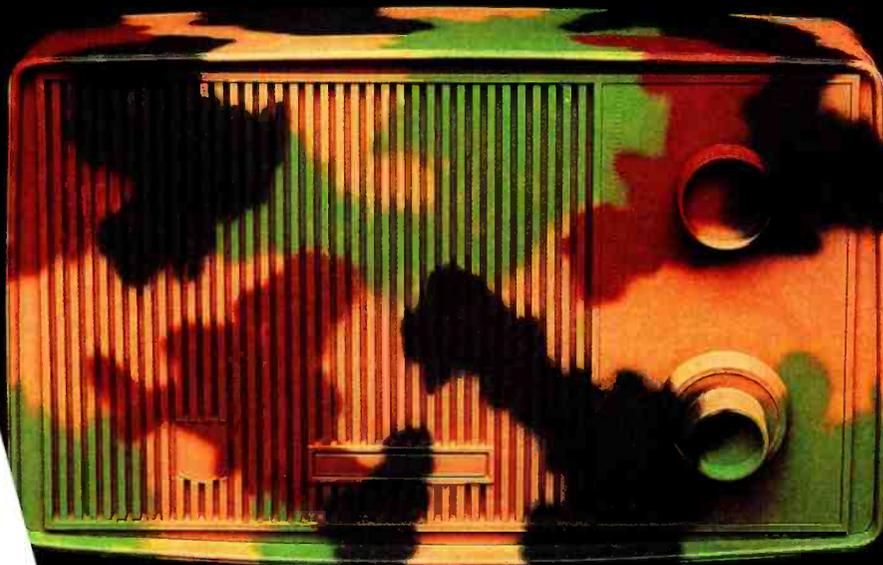
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Synchronous AM in FM systems

By Jerry Whitaker, editor

High-quality reception of stereo FM and stereo TV broadcasts requires attention to many aspects of transmission system design and maintenance. One area often overlooked by the user is synchronous (or incidental) amplitude modulation of the carrier by program material. Synchronous AM is generated as tuned circuits with finite bandwidth are swept by the frequency of modulation. Synchronous AM is generated as tuned circuits with finite bandwidth are swept by the frequency of modulation. As the bandwidth of an FM transmission system is reduced, synchronous AM increases for a given carrier deviation (modulation).

Bandwidth and its effects

Figure 1 illustrates the mechanism that results in the generation of a synchronous AM component on the FM signal. The transmitter passband shown assumes that the output cavity is the sole bandwidth-limiting stage in the transmitter. This may or may not be true in reality, depending on the design of the unit and attention to detail during tune-up.

The curve shown in Figure 1 is not degraded by narrowband stages prior to the final cavity that could distort the smooth skirts of the passband. If one or

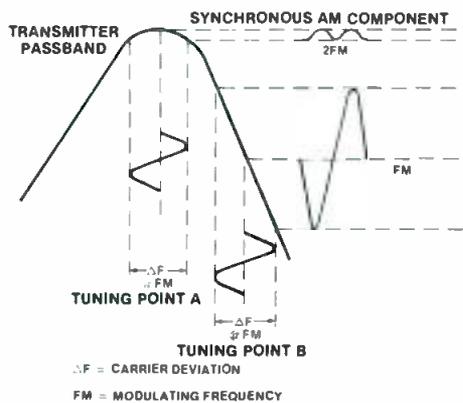


Figure 1. The generation of synchronous AM in a bandwidth-limited FM system. Note that minimum synchronous AM occurs when the system is operating in the center of its passband.

more stages prior to the PA were mistuned relative to the output cavity, distortion on one or both sides of the curve would be present.

For the purposes of our discussion, however, we will assume a perfectly tuned transmitter, and a transmitter design that provides sufficiently wide bandwidth to pass normal modulating signals. Examine tuning point A of Figure 1, which illustrates carrier deviation off-frequency from the true passband center

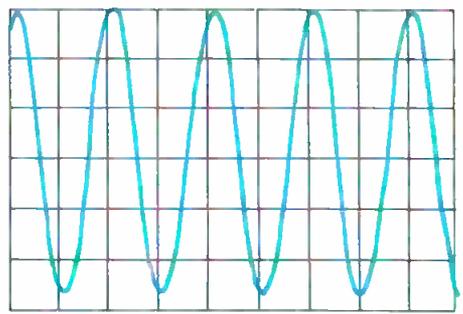
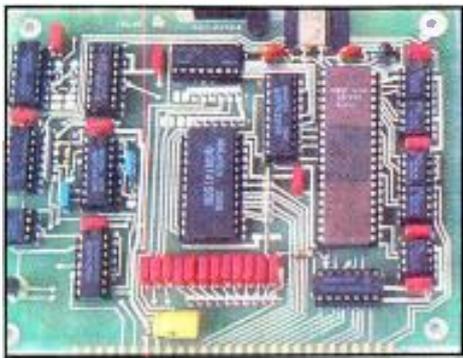


Figure 2. The demodulated synchronous AM signal produced when the transmitter passband is adjusted so that the modulating signal falls on the skirt of the passband curve. Note that the AM signal is near sinusoidal.

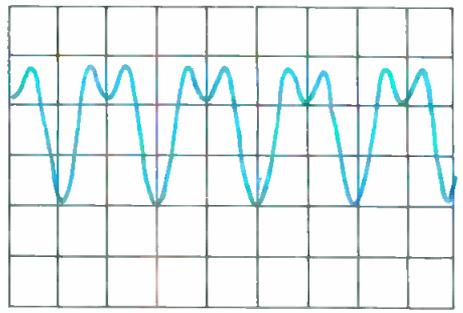


Figure 3. The demodulated synchronous AM signal of the system shown in Figure 2 as the peak of deviation begins passing through the passband center. Note the smaller amplitude of the AM signal and the presence of the second harmonic.

by a significant amount. In actuality, the passband of the transmitter would be off-frequency from carrier deviation. In any event, the result is the same. A large AM component is generated on the FM signal because of the varying output of the PA at different modulating frequencies.

In actual operation, the transmitter passband would never be as far removed from the carrier center frequency as shown on Figure 1.

The same effect shown in the curve of tuning point A can be simulated (if you are so inclined) in a properly operating transmitter by detuning the input to the PA stage and then applying program modulation. You will find that RF power output varies by a measurable amount with modulation.

Correct transmitter tuning relative to the carrier is shown at tuning point B of Figure 1. The carrier deviation is centered within the transmitter passband. Notice that the synchronous AM component is reduced significantly.

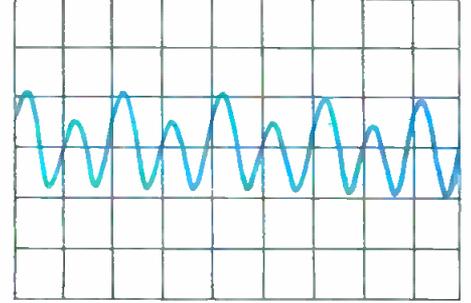


Figure 4. The demodulated synchronous AM signal as the transmitter passband begins aligning with the center of deviation. Note that the synchronous AM signal continues to decrease in amplitude and the second harmonic content of the waveform continues to increase.

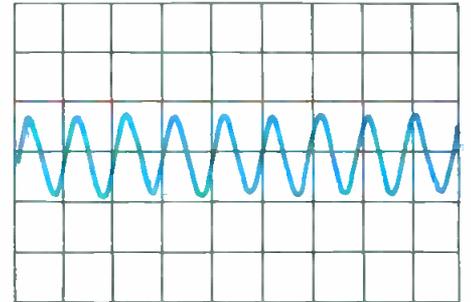


Figure 5. The demodulated synchronous AM signal with the transmitter passband properly aligned with the center of deviation. Note that only the second harmonic of the modulating signal is present.

Notice also that the synchronous AM component has doubled in frequency to twice the modulating frequency.

By understanding the mechanics of synchronous AM, adjustment for optimum performance of an FM system can be accomplished. Figures 2 through 5 show actual measured oscilloscope traces of the demodulated synchronous AM component on an FM signal. As the passband is tuned to the center of carrier deviation, the results predicted in Figure 1 can be observed.

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Tuning for minimum synchronous AM

By Jerry Whitaker, editor

The importance of minimizing synchronous AM components in an FM radio or TV aural transmission system is discussed in this month's "Circuits" column. Here, we will examine how to tune for minimum synchronous AM in a typical transmitter.

Trade-offs

Tuning an FM transmitter for best performance often involves a trade-off of PA stage efficiency for minimum synchronous AM. The passband shown in Figure 1 illustrates a poorly adjusted transmission system. Assuming that the passband of the transmitter is correctly centered at the carrier frequency, a synchronous AM component will be generated during modulation because of the frequency-dependence of the RF output caused by the narrow bandwidth of the system. (See this month's "Circuits" column for additional details.)

The passband shown in Figure 2, on the other hand, provides a much flatter response to modulating frequencies, resulting in less synchronous AM for a given carrier deviation.

A number of elements can affect the bandwidth of a broadcast transmitter. Because of the high input capacitance of a grid-driven final power amplifier, grid tuning is usually the limiting factor for the entire transmitter. Output tuning obviously has a significant effect on performance, but once the cavity is adjusted for good efficiency, the grid circuit usually becomes the critical element.

Aside from PA grid tuning, the second most significant adjustment in terms of minimum synchronous AM is generally PA loading. Loading of a resonant power amplifier cavity beyond the point of peak power output usually broadens the passband of the cavity, reducing the synchronous AM components. Be aware, however, that tuning for each type of transmitter is unique. Consult the manufacturer for recommendations.

Tuning for minimum AM

Before proceeding to tune a transmitter for minimum synchronous AM, confirm that the load is sufficiently broad to permit wideband modulation. Most modern antennas will provide a VSWR of below 1.1:1 over a frequency range of $\pm 300\text{kHz}$. The 1.5:1 VSWR bandwidth should be at least $\pm 500\text{kHz}$.

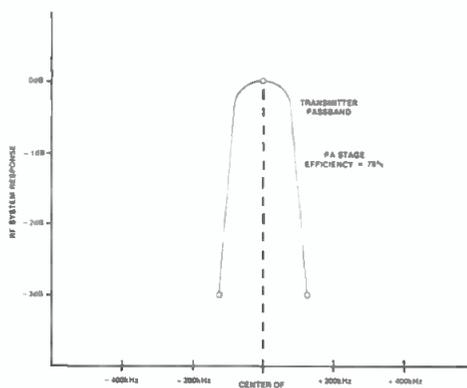
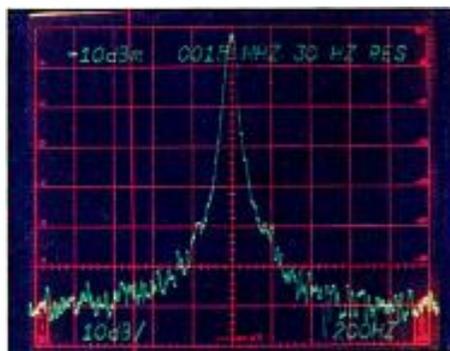


Figure 1. The passband of a transmitter misadjusted to result in narrowband response (-3dB points $\pm 100\text{kHz}$).

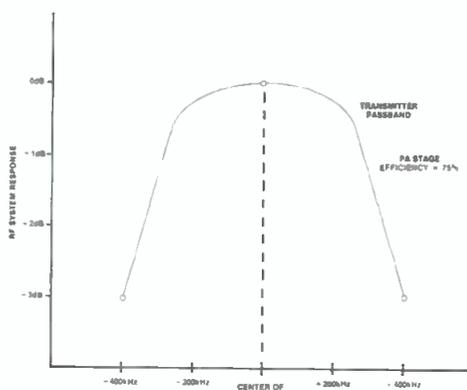


Figure 2. A properly adjusted transmitter passband (-3dB points $\pm 400\text{kHz}$).

Configure the transmission system for normal operation and tune the transmitter for normal output power and efficiency, according to the manufacturer's instruction manual. Confirm that the meter readings for all RF stages agree closely with those specified on the manufacturer's test data sheet.

Connect a wideband envelope detector to a sample port in the RF output line. Use a line tap rather than a tank sample in order to clearly see the effects of the load on the system. The input impedance of the envelope detector must provide a nearly perfect match to achieve low VSWR on the sampling line. Any VSWR on the sampling line will produce synchronous AM at the detector because of voltage peaks caused by movement of

the standing wave along the line with modulation. Not all modulation monitor AM detectors provide a sufficiently good match to allow accurate measurements of low-level synchronous AM. Instead, use a precision envelope detector with at least a 30dB return loss to the sampling line for adjustments. Connect the detector to a high-quality oscilloscope.

Modulate the transmitter 100% with a 400Hz tone (system in monophonic mode). Fine-tune the transmitter for minimum AM as displayed on the scope. Refer to Figures 2 through 5 of this month's "Circuits" column to guide you into the best tuning positions for the transmitter.

Remember that optimum passband tuning is reached when the detected synchronous AM component doubles in frequency to 800Hz and when the waveform is a clean sinusoid.

The transmitter passband is now centered on the carrier frequency with symmetrical skirts. Next, adjust the PA grid and cavity tuning controls to broaden the transmitter bandwidth and reduce the 800Hz synchronous AM component. Adjust the IPA stage as necessary. Be certain to maintain a clean 800Hz sinusoidal signal on the scope.

Observe the operating parameters of each RF stage to ensure that all are within specified limits. Calculate PA stage efficiency and compare it with the typical values listed in the manufacturer's instruction manual.

Avoid broadening the bandwidth of the transmitter by heavily driving the PA into saturation. This procedure will usually flatten the response of the tube input, but the resulting phase response abnormalities can seriously affect higher-order FM sideband components.

Finally, shut the system down and switch the transmitter to a dummy load. Repeat the synchronous AM measurement. Do not change any tuning adjustments. The synchronous AM measurement on the antenna and on the dummy load should be virtually identical in a properly operating system.

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Management for engineers

Can we talk?

By Randall L. Wagner

At a recent National Association of Broadcasters engineering management seminar, the group was asked to give examples of communication problems. "I had been out of town for three days on business," one attendee reported. "When I arrived home, late in the evening, I had a note from my secretary. She informed me that while I was gone, the company had restructured the station and I now had a new boss."

This incident is a good example of how to *not* communicate with your staff. Although it may seem to be an extreme example of poor communication, events like it occur every day. Employees like to know what is going on within the organization. If management fails to keep employees fully informed, then the employee grapevine shifts into high gear. Some managers incorrectly believe that they shouldn't inform their employees about bad news. This approach, however, fails to recognize that when faced with an informational vacuum, employees are likely to fill it with rumors.

Many employees report that the grapevine provides most of the information they receive about the company's operation, but most indicate that an immediate supervisor is the preferred source. Employees prefer to get their information directly and personally from their superiors. Although many employees participate in the grapevine, they do not want it or the company bulletin board to be their principle source for company information.

Four suggestions

If you're a manager or supervisor, you can improve communications in your company by following these suggestions:

- *Look for ways to be near your employees.*

Managers at Hewlett-Packard often leave their offices and wander around among the employees. The company calls this *management by walking around* (MBWA), and believes it is essential for good communication.

Interaction can take place both in work and non-work environments. Managers should strive to talk with employees at coffee breaks, at the employees' work stations, when walking to or from work,



or even in the local shopping mall. Rather than trying to avoid their people, effective managers seek ways to be among them.

If you aren't the type of manager who easily communicates with the staff, it may be difficult to change. In addition, you can expect your employees to be a little suspicious at first. After all, you will be showing them a new side of you. Give them a little time. They will open up when they see you can be trusted.

- *Hold regular meetings.*

You probably don't want to attend more meetings than you already do. However, effective managers actually have more meetings than do ineffective ones. Companies need to train their people on how to conduct good meetings. Managers should conduct regular meetings to talk about group objectives, upcoming changes and ways of improving work.

- *Keep middle managers informed.*

Too often, first-line managers and employees do not know what is happening within a company because upper management does not inform middle management. Or, sometimes top management will pass on information to the lower-level managers with a warning to keep the information confidential.

It's best to follow an open door approach. If employees want to know about something, tell them. If you don't, they may make up their own answers or draw wrong conclusions. Either way, the result will be misinformation.

- *Take responsibility for keeping your staff informed.*

Some companies make communication a part of each manager's responsibility. At Xerox, managers and supervisors are expected to sit down with their groups and discuss objectives. Supervisors are also responsible for making certain that all employees know the standards for success on their jobs. During merit reviews, middle managers appraise how well the supervisors accomplish these communications responsibilities.

Keys to success

According to a survey of civilian executives in the Department of the Navy,

the three most important requirements for success in management positions are:

- ability to communicate verbally,
- ability to communicate in writing, and
- ability to listen carefully.

There is little doubt that effective organizational communications can improve productivity, morale and the stability of the work force. According to my research and experience, supervisors and managers can significantly improve communication by following five guidelines:

- Communicate the overall mission and objectives.
- Communicate individual job responsibilities.
- Communicate performance feedback.
- Communicate upcoming changes.
- Communicate in person.

Person to person

The last guideline from the list is the most important. Employees like to receive communication face to face, from a person—not from some memorandum. Ineffective communicators tend to avoid mingling with their subordinates. Instead, they communicate through official policy, memos and other non-personal means. These methods do little to encourage 2-way communication between people.

Finally, during personal contact, effective communicators tend to be open and direct. They do not hold back information. Rather, they share it naturally and easily. Employees are not afraid to ask them questions about sensitive issues. Supervisors should encourage communication about job problems and other employee concerns.

Maybe improving employee communications sounds to you like a lot of extra work and effort. You're right—it is. That's the catch. Most managers say they believe in more and better employee communication, but that they don't have the time to carry it out.

Broadcast engineering managers must attend to a myriad of duties and responsibilities. Often, there are not enough hours in the day. It probably seems that you simply don't have the time to really communicate with your employees. Frankly, however, you don't have the time to *not* communicate with your employees.

Wagner is vice president of the Center for Management Institutes, Lafayette, IN.

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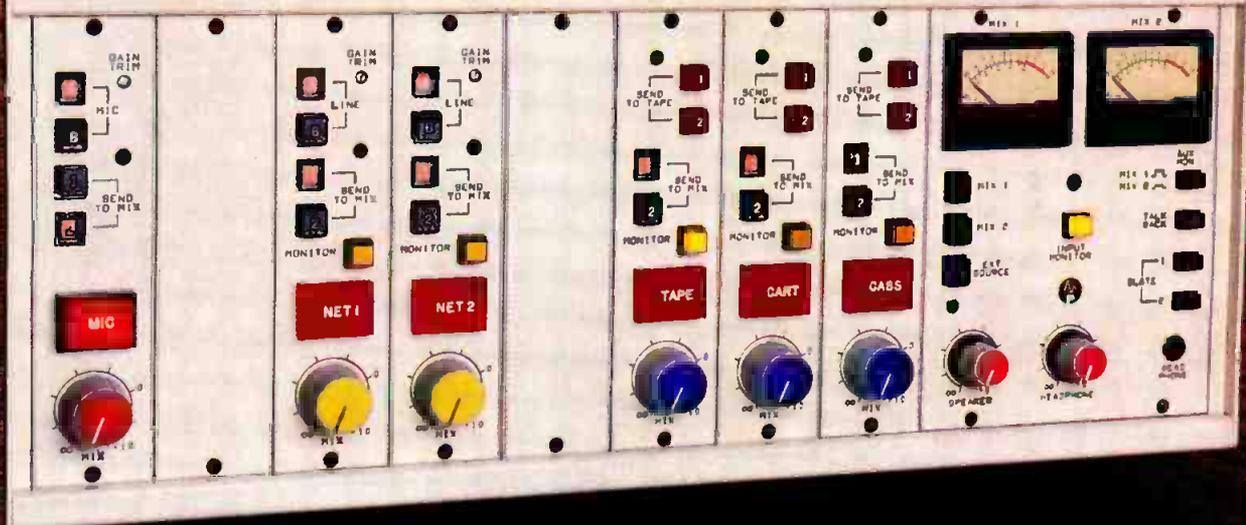


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Limiters, compressors & expanders

By Richard C. Cabot, Ph.D., P.E.

Limiters, compressors and expanders can solve many of today's audio-processing problems—if you understand how they work.

From the earliest days of recorded sound, people have been trying to cram more signal into the recording and broadcast media. Because the dynamic range of the human voice or common musical instruments is much greater than that of conventional discs or tape, devices were developed to *compress* the dynamic range of signals, making the loud sounds softer and the soft sounds louder. Unfortunately, some audio processors actually create problems when dealing with the dynamic range of the human voice. These problems include amplifier overload, pickup of room noise and excessive sibilance in speech.

Gain changing

Dynamic range-changing devices provide an output signal, which *supposedly*

differs from the original signal only in level. The unit's gain changes with the signal level. The shape of the waveform theoretically remains the same, but its size (voltage) is made larger or smaller as necessary.

System gain is an important characteristic for these types of devices. Therefore, their *steady-state* operation can be described by plotting input level vs. output level on a graph. On a log-log scale (decibel output vs. decibel input), a graph similar to that shown in Figure 1 would result.

This type of graph is commonly referred to as a *transfer curve*. For a conventional amplifier, the graph is a straight line at a 45° angle. The gain of the amplifier determines where the line is positioned on the graph, but the slope is always the same.

Compressors

When someone uses a microphone, any motion causes the signal levels to fluctuate. Sometimes the fluctuation is due to unavoidable movement, as with a stage production, and sometimes it is due simply to the normal range of gestures and other movements a speaker makes.

The solution to this problem usually is found in the audio-processing chain.

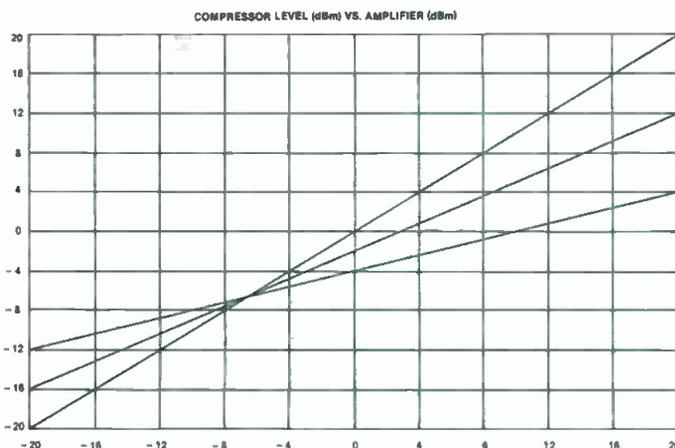
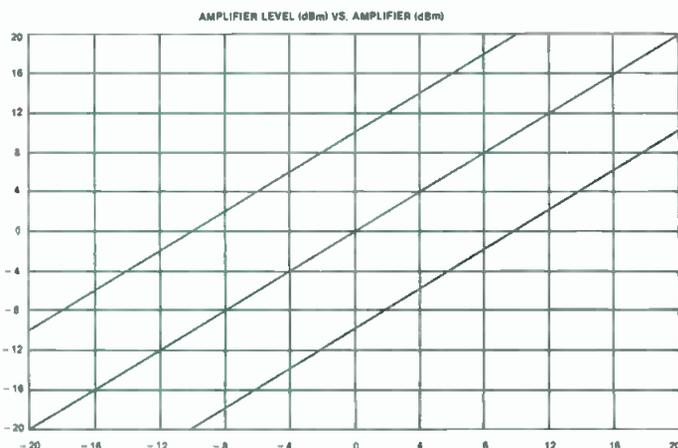
Broadcasters often use compressors to make the air signal sound louder. Many believe that, in the battle for listeners, the loudest signal will capture a larger audience. This theory has led to a proliferation of compressors optimized for broadcast use.

These devices can be quite complex. Some compressors provide multiband operation. In this configuration, the compressor divides the frequency spectrum into several bands and processes each one separately. Although this approach produces a subjectively louder sound, the result is a frequency response that is a function of level.

Some broadcast audio processors are composed of both a compressor and a limiter. The compressor is used to reduce the signal's dynamic range; the limiter prevents overmodulation. Limiters intended for AM use sometimes treat the positive and negative signal peaks differently. The processors can allow slight overmodulation of the carrier in the *Figure 2*. Typical compression graph showing how the output level decreases or increases dependent upon the input level.

Cabot is vice president and principal engineer for Audio Precision, Beaverton, OR.

Figure 1. A basic transfer curve, showing output in decibels referred to 1mW vs. input in decibels referred to 1mW (log plot). A conventional amplifier produces a line at a 45° angle, with gain determining the actual position on the graph.



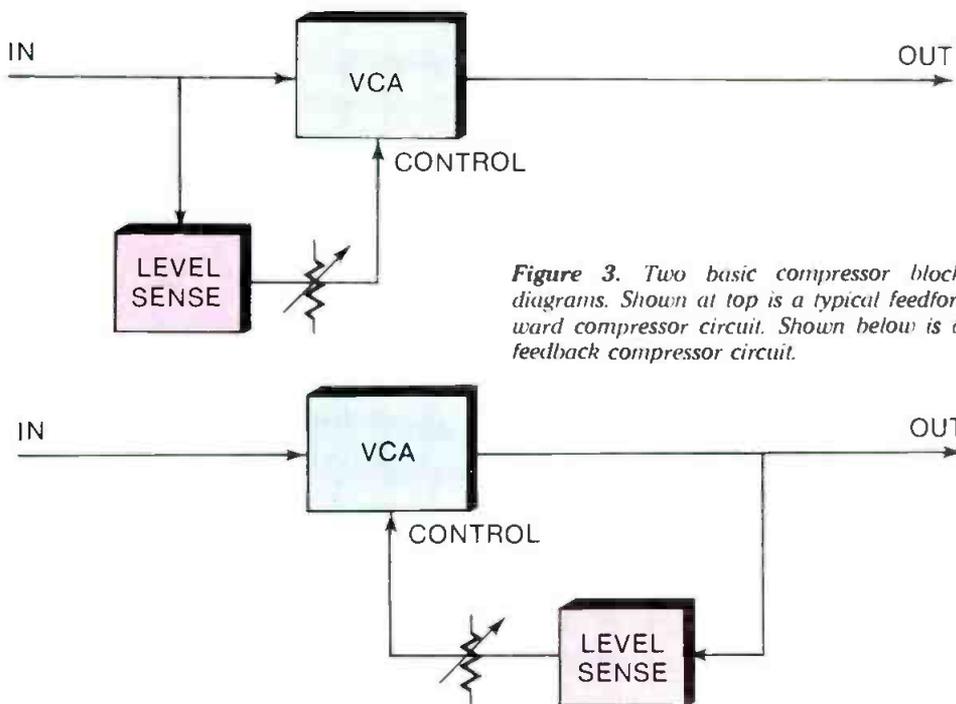


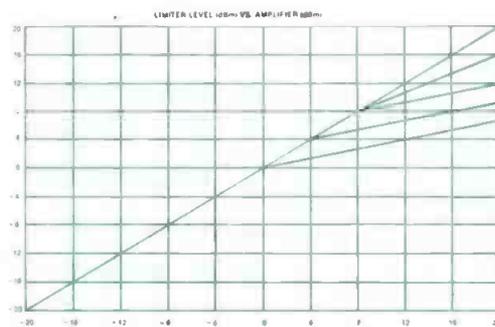
Figure 3. Two basic compressor block diagrams. Shown at top is a typical feedforward compressor circuit. Shown below is a feedback compressor circuit.

Compressors come in two types: *feed-back* and *feedforward*. The classic block diagrams are shown in Figure 3.

The feedback-type compressor is the older and more common of the two. In it, the output signal level is sensed and fed back to the gain control element, which precedes it. As the input level is increased, the output level tries to increase. This is sensed by the level sensor circuit, in an effort to reduce the amplitude. Changing the gain after the level sensor changes the slope of the compression characteristic. These circuits are easy to build and are self-correcting for errors in the gain element or level sensor. However, the circuits guarantee that the output will overshoot its final value when the input level is suddenly increased.

Continued on page 26

Figure 4. Transfer curve for a typical limiter showing the gain reduction in the output signal above the threshold or turnover point.

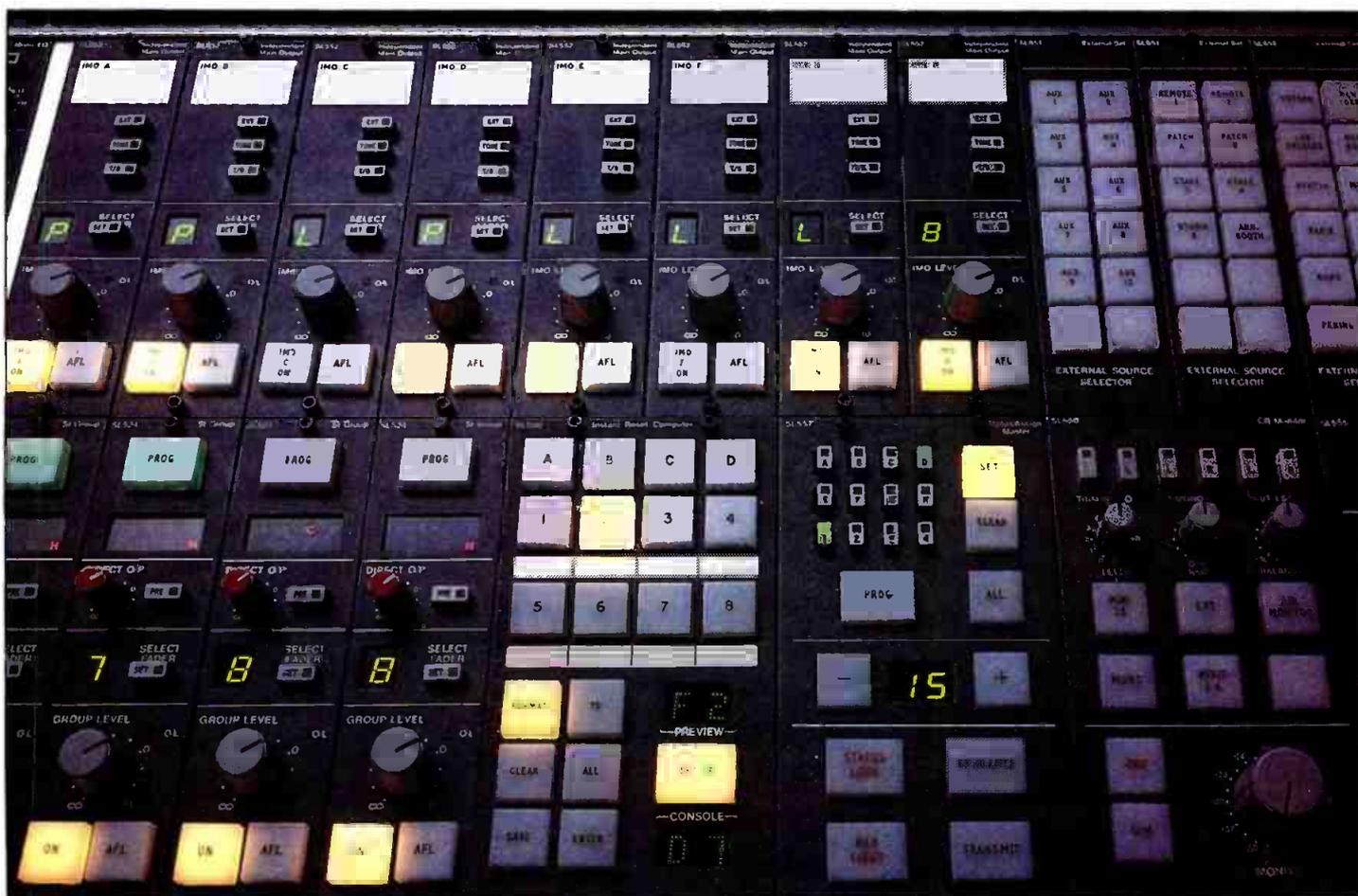


positive direction and not in the negative direction. This process keeps the modulated signal linear, eliminating the distortion that would occur if the carrier were allowed to disappear (excessive negative modulation).

A compressor is a device that will increase the level of soft sounds and decrease the level of loud sounds in a somewhat predictable manner. An example of this is graphed in Figure 2.

As the input signal amplitude in-

creases, the output signal amplitude increases by a smaller amount. When the input signal amplitude decreases, the output signal amplitude decreases by a smaller amount. There is always a point at which the input level equals the output level, called the *unity gain point*. The slope of the curve is called the *compression ratio*. A compressor whose output level increases by 1dB for every 3dB of input level increase is said to have a 3:1 compression ratio.



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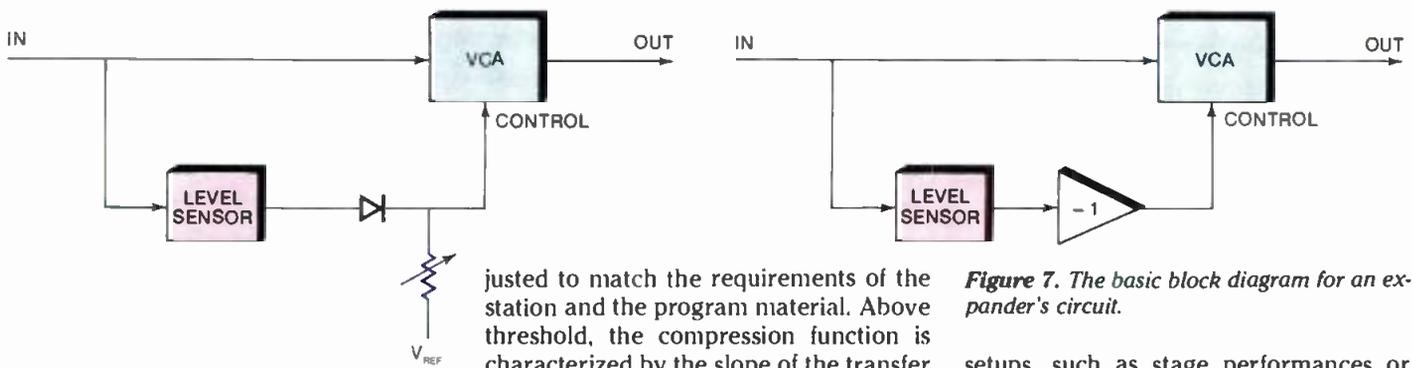


Figure 5. The basic limiter block diagram. A typical compressor may be essentially converted to a limiter, by the addition of the diode shown, in transistor-based circuits.

Continued from page 23

Feedforward designs sense the input level and generate the necessary control voltage for the gain element to make the output level change as desired. This avoids the overshoot problem, but places more stringent requirements on the accuracy of the level-sensing and control circuitry.

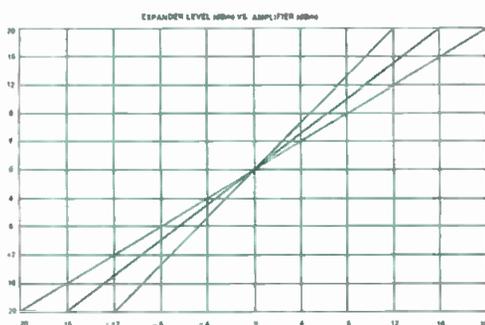
The graphs shown in Figures 1, 2, 4, 6 and 8 are all straight lines on linear decibel scales. This characteristic is obtained with level sensors that output a voltage proportional to the decibel signal level. Voltage-controlled amplifiers (VCAs) also exhibit similar characteristics by which the gain in decibels is proportional to the voltage on the control input.

Limiters

Sometimes the broadcast engineer is faced with a signal that is fairly constant in level, but occasionally increases suddenly, causing the system to clip or to distort. Examples of the sudden increases might be firearm sounds or cymbal crashes. To correct such signal fluctuation requires a limiter, a device that operates as a standard amplifier for signals below some input level, but becomes a compressor for signals above this level.

A transfer curve for a typical limiter is shown in Figure 4. The level at which the limiter changes from unity gain to compression is called the *threshold level*, or the *turnover point*. This point is usually variable, allowing the threshold to be ad-

Figure 6. Typical transfer function for an expander circuit. The graph shows the basic function of making loud sounds louder and soft sounds softer.



justed to match the requirements of the station and the program material. Above threshold, the compression function is characterized by the slope of the transfer curve, as is the case with a conventional compressor.

The *knee* in the transfer curve may be sharp, as shown in Figure 4, or it may be rounded. Some limiter manufacturers claim that the side effects from a rounded knee characteristic are less audible. However, this is a matter for your ears to decide.

A compressor can be converted into a limiter by the addition of a diode before the gain control element, as shown in Figure 5. The dc voltage from the threshold pot is applied to the output side of the diode. This forces the signal level to exceed the threshold before compression can occur.

As with compressors, limiters can be designed as either feedback or feedforward. The feedforward-type limiter requires predictable characteristics in the level sensor and voltage-controlled element. This is not difficult to do with transistor-based circuits. The feedback-type limiter does not require closely controlled elements if the exact compression slope is not a major concern.

Limiting thresholds are set by the diode bias voltage or its equivalent components. The limiting function may be performed with an FET or a light-dependent resistor/LED combination. This opens the way for inexpensive limiters to be built into some power amplifiers and mixing consoles. Today, many small portable mixers provide highly effective built-in limiters.

Expanders

Expanders are the functional inverse of compressors: they make soft signals softer and loud signals louder. The technique of making loud louder and soft softer is graphed in Figure 6. The slope of the lines is *always* greater than the 45° slope of an amplifier.

If an expander has an increase of 3dB in output level for a 1dB increase in input level, it is said to have an expansion ratio of 3:1. This will exactly cancel the dynamic range compression of a 3:1 compressor. The block diagram of an expander is shown in Figure 7. The only change from a compressor is the addition of an inversion stage to make the gain increase with increasing signal level.

Noise gates

Broadcasts and recordings must sometimes rely on multiple-microphone

Figure 7. The basic block diagram for an expander's circuit.

setups, such as stage performances or panel discussions. Unfortunately, when there is no sound from the desired source, each microphone continues to pick up ambient noise. What is needed is a way to turn down the microphone's gain when the signal level drops below some desired value. The device that does this is called a *noise gate*.

Noise gates are to expanders what limiters are to compressors. Above the threshold level, a noise gate operates as a normal amplifier. Below the threshold, the gain decreases with decreasing signal level, making soft sounds much softer. This effectively gates out or removes the noise, but does not affect the desired signal. This noise gate characteristic is graphed in Figure 8 and is similar to a limiter's transfer curve that has been flipped diagonally.

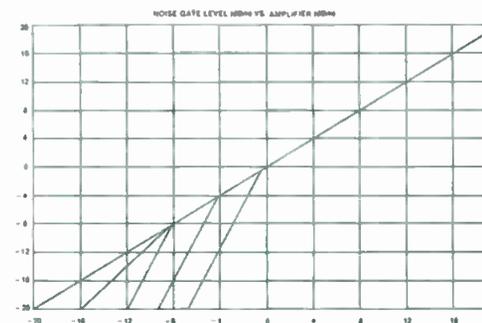


Figure 8. The transfer function for a typical noise gate circuit. The curve resembles the transfer curve of a typical limiter flipped diagonally from that shown in Figure 4.

As with a limiter, there are two important parameters: the threshold level and the expansion ratio. If the threshold level is adjusted, the unit can discriminate between desired signal and unwanted background noise. If there is insufficient level difference between them, there will be erratic changes in gain as the noise gate switches in and out of expansion. The noise gate block diagram (see Figure 9) looks like a cross between an expander and a limiter. The inverter is used, as in an expander, to make the gain increase with increasing signal level. However, the diode now stops the level sensor's output from exceeding the desired threshold. When this occurs, the gain is clamped. Below threshold the unit functions as a conventional expander.

Time effects

So far, this article has considered only

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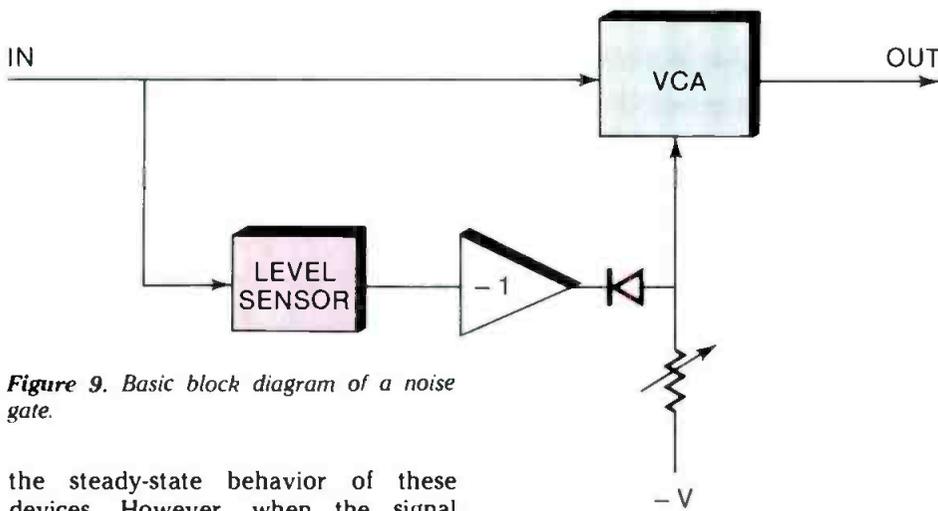


Figure 9. Basic block diagram of a noise gate.

the steady-state behavior of these devices. However, when the signal amplitude changes with time, such signal processing is not so easy. Audio signals are, by their nature, ac waveforms that go positive and negative many times per second. However, the signal amplitude must be controlled without affecting the waveshape of these ac signals. For example, if the signal amplitude is adjusted too quickly, the waveshape will be changed, causing audible distortion. If it is adjusted too slowly, a compressor or limiter will not be able to control the peaks.

Figure 10 illustrates a typical limiter's time response. A tone burst changing 20dB in amplitude is applied to the input. When the signal amplitude increases, the limiter takes some time to respond,

resulting in overshoot at the output. As the limiter adjusts to the new gain required, the output amplitude decays to the desired value. When the signal amplitude drops, the output level also drops by the same amount. As the limiter readjusts to the new signal level, the output gradually increases.

Many audible problems are related to the time required to adjust the gain. These are the pumping and breathing sounds sometimes heard as the medium-level background sound is modulated in amplitude by large-level sounds. If a limiter is designed to be slow responding to completely avoid these problems, it

will not be able to prevent peak amplitudes from exceeding the desired level. With any design, there is a trade-off between audible side effects and incomplete processing.

Compressor and limiter features

There are many features available on compressors and limiters that may be important for a particular application. Most professional compressors provide a visual indication of the gain or gain reduction taking place. Many units allow

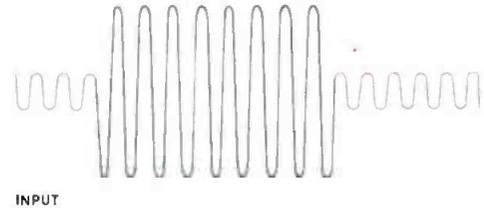
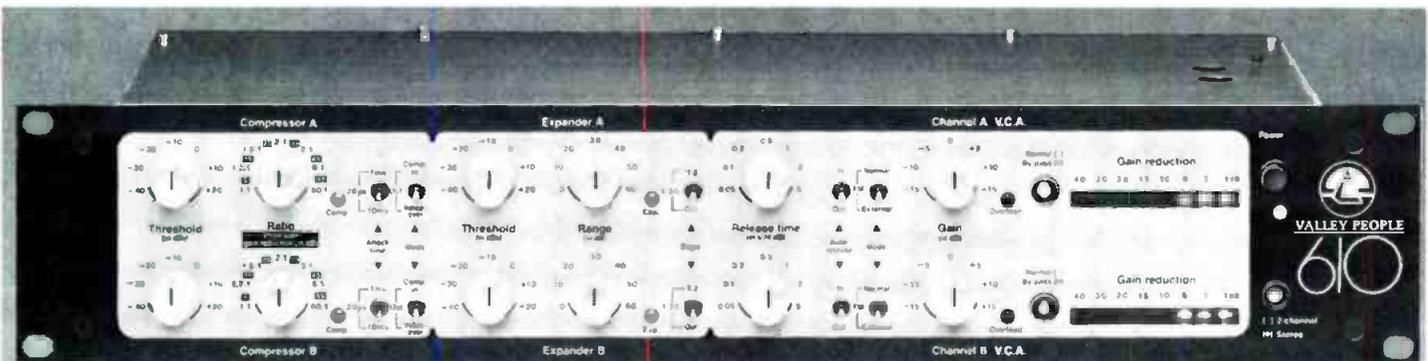
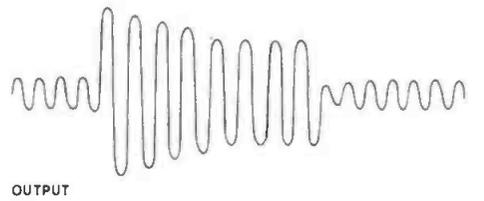


Figure 10. Representative waveforms showing probable tone-burst response for a compression circuit. The waveforms illustrate the time response of such a compressor.



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switching this display to also monitor the input or output signal levels. This visual indicator can be helpful when adjusting drive levels in a system.

Some compressors and limiters allow the control voltages in the level-sense path to be tied to other similar units for use in multichannel systems. If separate units are used on the two channels of a stereo sound mix or broadcast, tying together these points will prevent the image from shifting between the two channels because of unequal channel compression.

A few units allow the level-sense circuitry to be patched for special effects. The *sense* input is usually inserted into an EQ path for removing rumble or other noise that would disrupt the level-sensing action. An unusual, but useful, application for this feature would be to use a microphone picking up background noise to control the level of the main microphone channel. With a unit set for a 2:1 expansion, the desired signal (announcer) would remain at a fixed level above the noise (crowd).

Compressors can sometimes be used as remote-controlled attenuators. Inputs for remote gain-control setting can be handy in special situations. For instance, a simple variable dc voltage could control the speaker or headset volume in a studio. This design eliminates the problems associated with routing audio through

remote volume controls.

Performance specifications

The standard distortion and signal-to-noise performance specifications are difficult to apply to dynamic range modifying devices. Because the gain changes with input signal level as well as the selected ratios and threshold voltages, these performance measures also change. The noise generally becomes worse at high values of gain (low signal levels for expanders and high signals for compressors). Distortion will sometimes peak at intermediate values of gain and sometimes at the extremes of gain, depending on the type of gain control element used. Be wary of units that are specified at only one gain or at a 1:1 compression ratio. It is best to have a family of distortion curves for different gain settings.

Specifications such as frequency response, common mode rejection and maximum input level should be comparable to other types of signal-processing devices. The precautions taken with unbalanced systems apply especially to compressors, which can increase system hum by many tens of decibels when they have no input signal. Using such a device at different places in the system places differing constraints on residual noise and headroom. Carefully study the system's gain structure before

specifying any particular device.

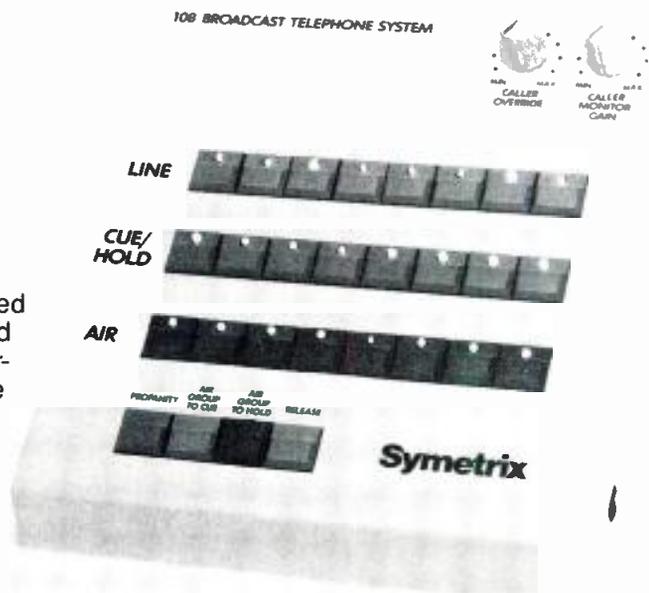
It is difficult to quantify the specifications unique to limiters and compressors in a way that allows meaningful comparison of the audible performance of different units. Attack time and release time are only two aspects of the dynamic behavior. The limiter's distortion performance during the attack portion of its response will significantly alter the perceived distortion for actual program material. Many compressors and limiters have marginal headroom and hard clip on large inputs until the level sensor responds and reduces the gain. Other devices are designed with more headroom, or a *soft clip* circuit, which greatly reduces the level of high-order distortion products during overdrive.

Some compressors and limiters suffer from leakage of the control signal into the output signal path. This results in low-frequency energy at the output during large swings in signal level. This problem often occurs in 2-tone difference frequency intermodulation measurements if the tones are spaced closely enough in frequency.

Compressors and limiters, more than any other signal-processing devices, should pass a *listening test* before you make a purchase. Until more is understood about the necessary performance criteria, paper specifications are not completely reliable. [:-:~))]]

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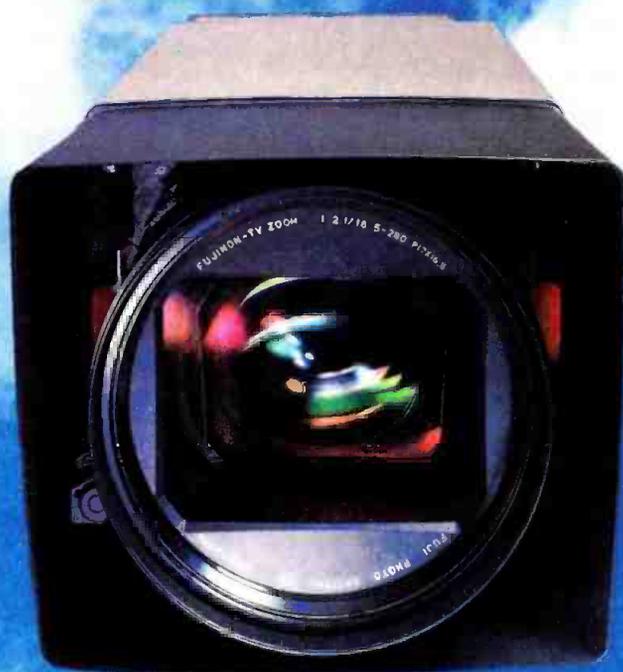
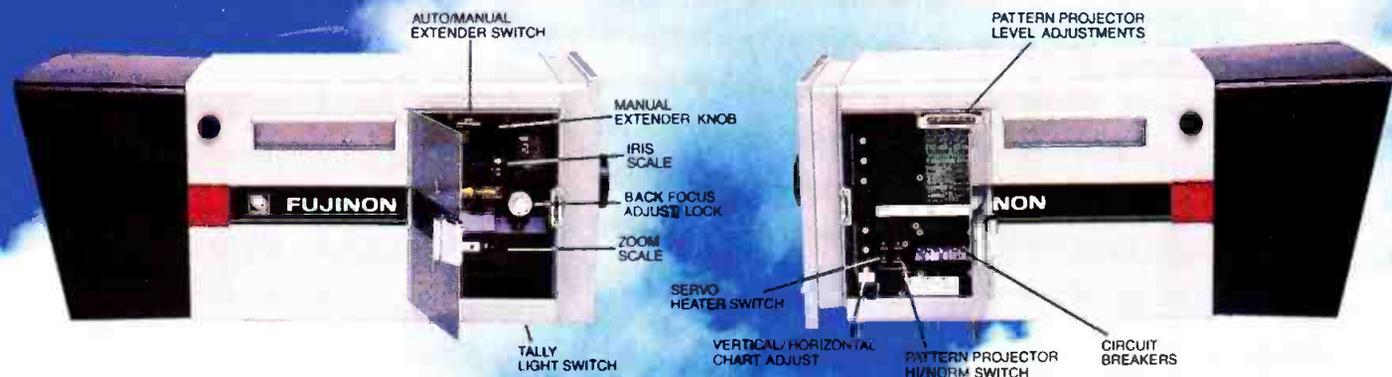


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Noise gates and expanders

By Mike Morgan

Noise gates can eliminate unwanted noises that adversely affect the quality of your recordings.

As radio and TV stations become more sophisticated with respect to audio processing, a whole new range of tools becomes available. To many radio and TV engineers, these devices are relatively new and may be unfamiliar. Two of the more common recording studio devices that are now seeing broadcast applications are the noise gate and expander. Properly used, they offer a wide range of production effects and solutions to processing problems.

Noise gates

A noise gate can be adjusted to discriminate between desired audio signals and unwanted audio and noise such as ground hum, background room noise and leakage from other audio sources. When properly adjusted, noise gates will pass signals you want to hear and reduce the volume of or eliminate undesired signals.

During the attack or *turn-on* period, the noise gate cannot remove background noise because it is reacting to the overall level. This means that the noise gate may be only marginally effective for musical programs in which unwanted noise may be heard.

A common problem with noise gates is modulation of the noise floor. This typically occurs with musical programs because most instruments have relatively long sustain and decay times. The problem may be partially overcome through the use of long *release times*. A noise gate's release time is defined as the rate at which the device falls to maximum attenuation after the signal that caused the device to attack or turn on is removed. The major disadvantage of using a gate with a long release time is that a large portion of the extraneous sound and noise, which the gate is employed to eliminate, passes through unaffected.

The most effective method of reducing unwanted noise from signals that exhibit long sustain and decay times is *expansion*. Expansion is so named because the processor used is configured to expand the signals' dynamic range.

There is a vast difference between expanding a processed signal's dynamic range and eliminating noise. No existing

noise-reduction system can discriminate between signal and noise, passing only the signal while eliminating noise in real time. The effective use of a noise gate or an expander is contingent upon the existence of an acceptably high S/N ratio between the nominal system operating level and its quiescent noise level.

Using expanders or gates provides a method of extending the dynamic range of the processed program, resulting in a noticeable reduction in *perceived* noise levels. However, no device will totally eliminate noise.

Proper adjustments

The proper use of gates and expanders requires that the engineer understand the functions and correct adjustment of the controls commonly found on these devices.

- The *threshold* adjustment determines the point below which the device begins to attenuate the signal. If, for example, the threshold is adjusted to 0dB, a signal appearing at the input at 0dB (0.775Vrms) or higher will be passed through the device unattenuated, while those signals below 0dB will be attenuated. (See Figure 1.)

- A *range* control, sometimes called depth control, is provided on most gates and expanders. This adjustment presets the maximum amount of processor attenuation (reference threshold). Therefore, if the range control is set at 40dB, unwanted noise will be reduced by no more than a nominal 40dB below the threshold setting. (See Figure 2.)

- The *release* adjustment affects the rate at which the gate or expander will fall from unity gain to the maximum attenuation determined by the range control. A release control setting of 0.2s, for example, may indicate that the rate of attenuation is occurring at 0.2s per 20dB of attenuation. Therefore, if the range control is preset at 40dB, the device will release from threshold to maximum attenuation in 0.4s (40dB/20dB x 0.2s) in the absence of a signal at the input above threshold level.

- A *ratio* control (or slope control) is found on many expanders. This adjustment determines the amount of attenuation the device will produce for each decibel of decrease in input signal level below the threshold.

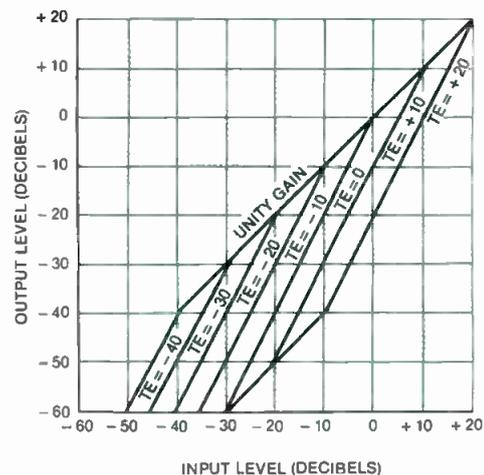


Figure 1. The effect of the threshold control as a transfer function. The slope is set to 1:2 (TE = threshold of expansion).

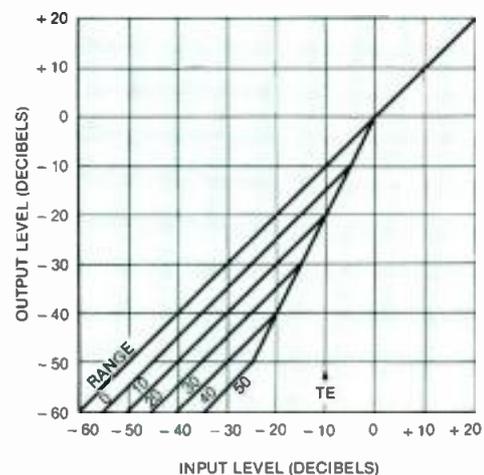


Figure 2. The effect of the range control on the transfer function is shown above. The slope is set to 1:2.

The ratio, or slope, is expressed as the change in input level in decibels below threshold to the change in output level in decibels. Thus, a slope of 1:10 indicates that for each 1dB drop in input level below the threshold, the output level will decrease 10dB. (See Figure 3.)

- An *attack* or *attack time* adjustment affects the rate at which the gate or expander will turn on, or switch from maximum attenuation (range) to unity gain. In general, gates attack quickly (in 1ms or less) while expanders may attack more slowly. Attack time is directly related to the integration time of the rec-

Continued on page 36

Morgan is a technical consultant to U.S. Audio, Nashville, TN.



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David Peters, Assistant Engineer KGLT Radio Station, Bozeman, Montana.

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August 1986 *Broadcast Engineering* 33

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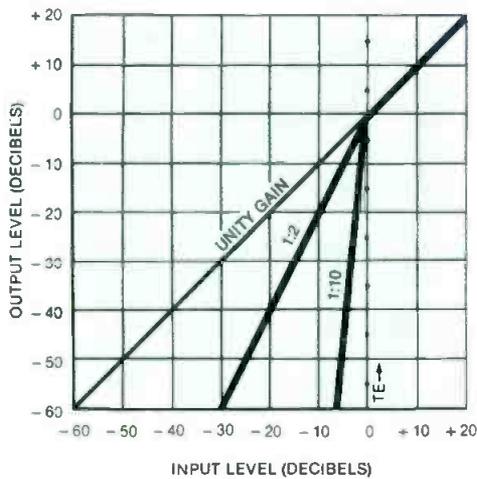


Figure 3. The effect of the slope control on the transfer function. The threshold of expansion (TE) is set at 0dB. Both 1:2 and 1:10 slopes are shown.

Continued from page 32

tifier circuitry used to convert the audio input to a dc control voltage. It is this control signal that is applied to the device's gain control element.

In general, fast attack times tend to create pops or clicks in the output signal when turning the device on to unity gain. Conversely, the slower attack times or longer integration times may not allow the device to react to fast transient information, such as a handclap, but cause no audible popping or clicking during turn-on.

Most gates and expanders feature a mode of operation known as *keying*. In this operational configuration, the unit's control circuitry responds to an external audio signal not necessarily related to the input signal. In this manner, the input signal appears at the output only when the external signal, or key signal, is present at the key input at a level above threshold. The controls can be adjusted to make the input signal track the dynamics of the key signal, causing an expander to function as an envelope follower.

Common uses for gates

The term *gate* may also be applied to an expander operating at an exaggerated slope, 1:10 or greater, with fast attack characteristics.

The most common use of the gate is as a voice-activated switch, or VOX. In this application, the gate is inserted in the signal path between a microphone pre-amplifier output at line level and the following stage. The controls are then adjusted so that the presence of a speaker's voice turns the gate on. This application helps attenuate or eliminate room noise, crowd noise, air-conditioning rumble and feedback in the absence of the speaker's voice.

Gates are often found in conference PA and teleconferencing installations. They are particularly useful in multiple-

microphone panel or press conference situations. In these instances, the microphones should be off, or at least attenuated, unless the speaker is talking. A multichannel gate system can be used to automatically switch on the appropriate microphone. This process greatly increases the audio quality from panel discussions and news conferences by reducing background noise.

Expanders

Although the noise gate has its place, it does not have the flexibility of the expander, which is unsurpassed for general noise reduction in real time applications.

Sometimes, landlines or satellite signals have been overprocessed. In these cases, it is possible to add back some dynamic range with an expander. The expander can also be used to reduce ambient noise from tape hiss and hum. The expander is especially useful in 1:1 cassette duplication. In this use, the expander reduces apparent noise by attenuating tape hiss during fades.

For studio and remote recording, noise gates and expanders offer the recording engineer and broadcaster another helpful tool. Properly used, these devices can solve a number of production problems. With the growing use of these tools in broadcast applications, the industry can look forward to increasingly cleaner, better audio processing. (:-:-:-:-:-)

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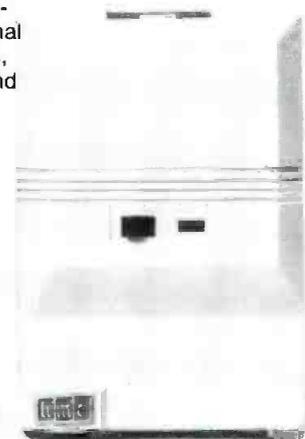
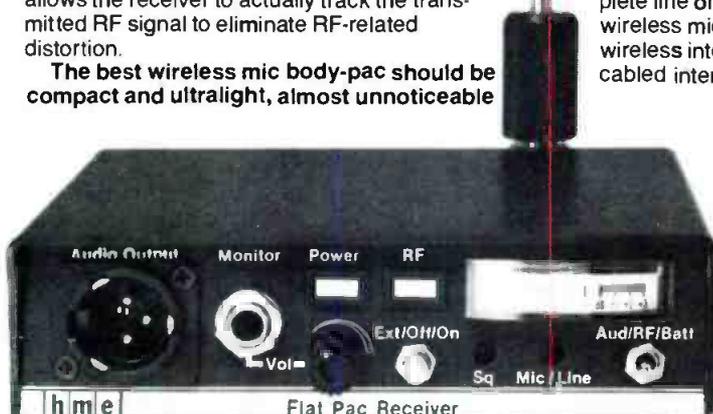
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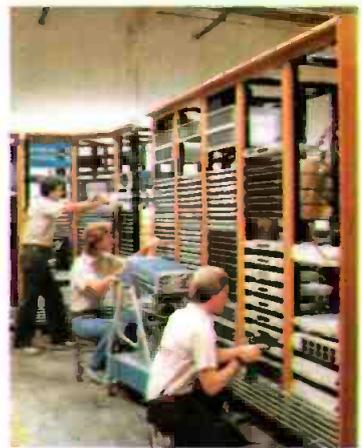
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August 1986 *Broadcast Engineering* 37

Distributing audio signals

By Scott Hochberg

The proper use of distribution amplifiers can improve the performance of almost any broadcast facility.

The program director/on-site engineer was having a problem. Even though the meter on the board was indicating proper levels, no audio was being sent to the transmitter.

The station's console was directly connected to the transmitter, as would be expected. However, in addition to feeding the transmitter, the console's output was bridged by four different tape machines. (See Figure 1.) Although this interconnection scheme had worked for several years, the failure of only one component was now causing a major problem for the station. In this case, one of the tape machine's input circuits had failed, placing a short across the console's output.

This episode exemplifies the fact that in this day of microprocessors and compact discs, there are still some engineers who consider an audio distribution amplifier (DA) to be a frill.

Passive splitters

In general, a DA should be used wherever any output needs to feed more than one downstream device. Years ago,

Hochberg is president of Logitek Electronic Systems, Houston.

Figure 1. Feeding several inputs from one source allows a failure in one device to take down a whole system.

the DA was often viewed as just one more piece of equipment that was as likely to fail as any of the downstream devices. Some engineers thought it didn't make sense to use DAs when resistor build-outs (such as that shown in Figure 2) would work just as well.

Today, however, most DAs are quiet and reliable. Their internal workings have been greatly simplified by integrated op-amps. In fact, the noise added by virtually any DA is far less than the noise floor lost by resistively isolating 600Ω devices. Although you can feed multiple high-impedance outputs without serious noise problems, you are inviting trouble, because this type of interconnection scheme leaves you with no isolation between devices. And, as described previously, if one single load fails, the whole system may fail.

Types of DAs

DAs are available in two basic configurations: stand-alone and modular. Stand-alone DAs are great if you have only a small number of sources to distribute. They are often mounted in 1-rack-high panels. The output connectors are usually terminal strips, making them easy to install.

Modular DAs have much higher density and are better suited to multisource distribution. Generally, if you have more than five channels to distribute, and they

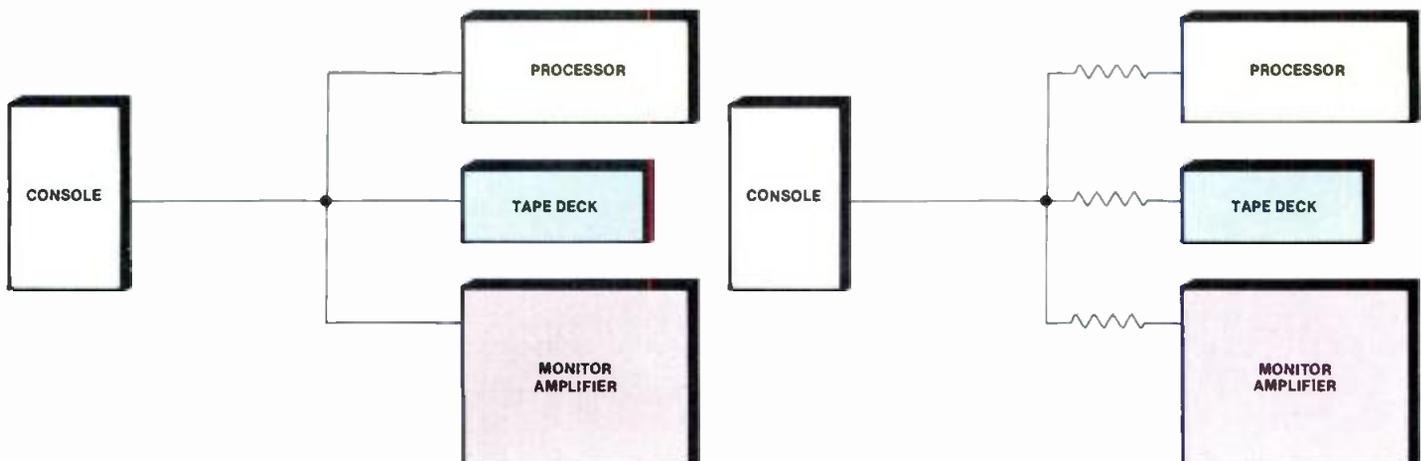
all can be fed conveniently from the same physical location, choose the modular type. You will usually save both space and money with a modular system, especially if you have a great many sources to distribute. Also, you often gain the extra advantage of being able to add other types of audio modules to the same mainframe.

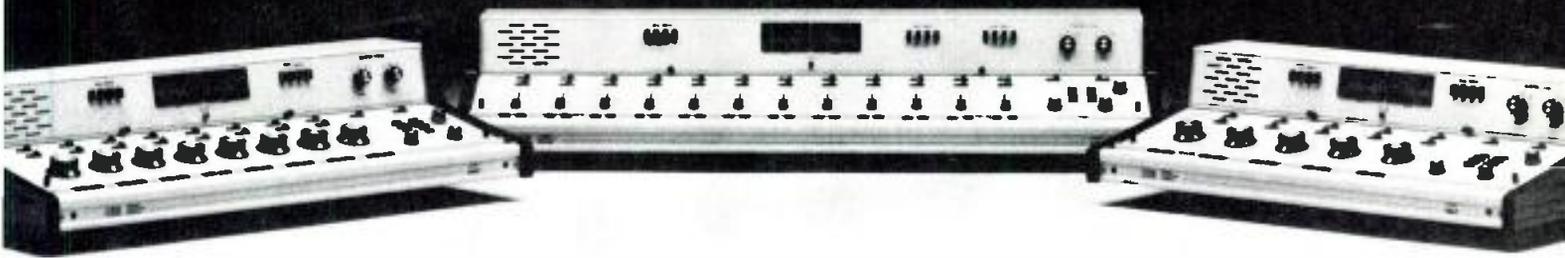
Some manufacturers offer *miniframe* systems. These systems allow you either to buy a single DA or to mount several DAs in a 1-rack housing. These systems are becoming increasingly popular in video applications. They typically are offered in a 3-to-a-rack-unit system, which matches the width of many video monitors. This design makes a convenient and versatile package for both studio and remote van applications.

Inputs/outputs

Although most DAs today have *active-balanced* inputs and outputs, there are still a few manufacturers offering transformer isolation. Many engineers think they need transformer isolation on their equipment. This belief is especially common in larger plants, such as TV stations. However, transformers are seldom necessary for most applications. The in-

Figure 2. Passive isolation helps prevent failures from propagating through the system. Unfortunately, the signal loss through the resistors decreases the system's S/N.





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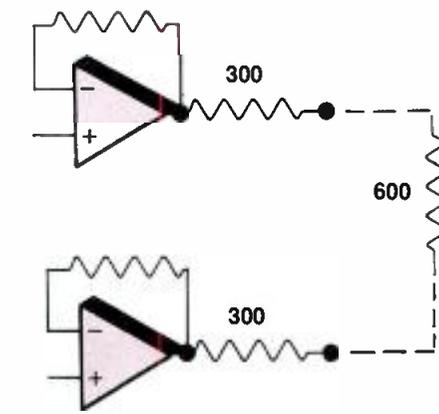
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house equipment is usually within a reasonable distance so transformer isolation really isn't necessary. However, telephone lines or multibuilding installations, where the interconnecting lines are long, may benefit from transformer coupling.

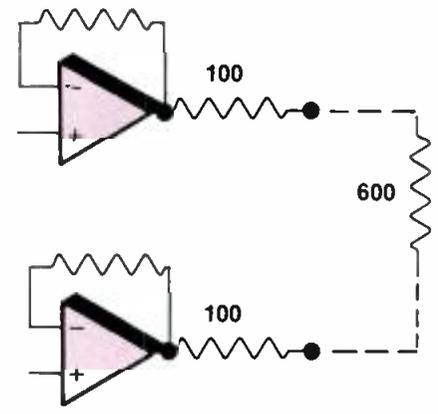
High-quality audio transformers are expensive. This is one reason DAs that use them tend to cost more. In many instances, it may be preferable to use DAs with active-balanced outputs and then add external transformers in those places where you really need them.

Usually, DAs have balanced outputs. However, there is one application that is perfect for a DA with unbalanced outputs. Large videotape duplication systems often use non-broadcast VTRs. Here, the closed nature of the system lends itself to unbalanced operation. There are several multi-output, unbalanced DAs designed for such applications. If you use these types of DAs, be extremely careful in wiring the system. The noise problems that can occur with unbalanced wiring are obvious.

DAs are available with either fixed or adjustable output levels. If all of the devices you are feeding require roughly the same input level, then a fixed output DA may be adequate. If, on the other hand, the expected levels vary, it might be worth it to pay the extra cost for individual output adjustments. Of course,



With 300Ω series output resistors, 50% of the amplifier's output will appear across the load. This will typically provide +22dBm in a unit with 18V bipolar supply rails.



With 100Ω series output resistors, 50% more voltage (3.5dB) will appear across the load. Although the maximum output level increases, dynamic range remains the same, because the noise floor rises by the same 3.5dB.

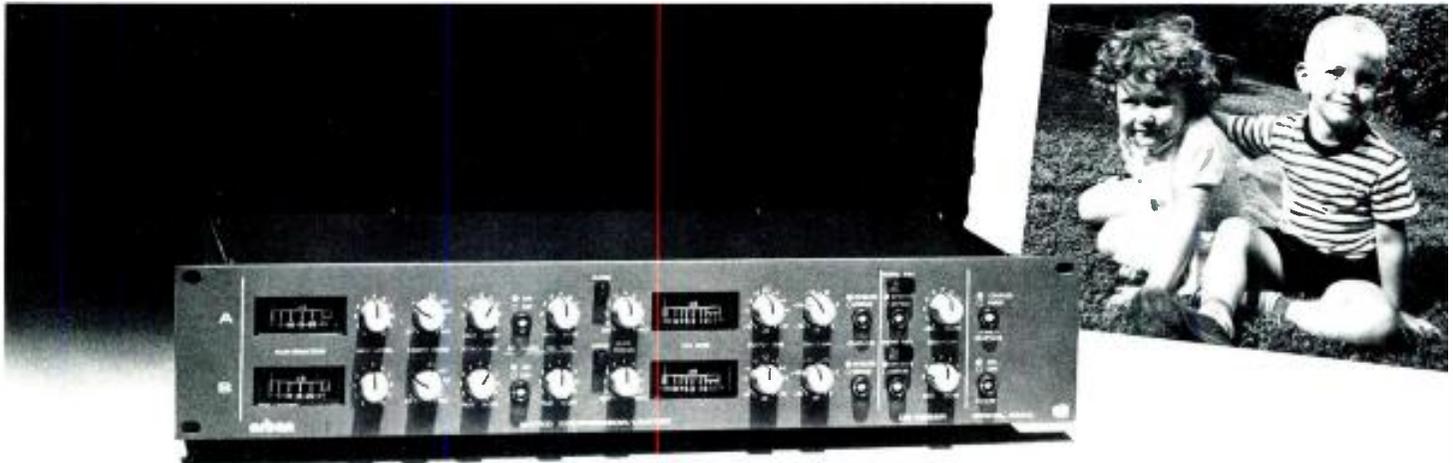
Figure 3. An active-balanced output circuit acts like a voltage source driving a series-source resistance.

the quality of the adjustment pots can make a big difference in your long-term satisfaction with the product. It's of little help to have adjustable output levels if the controls are hard to adjust accurately or are likely to fail.

Specifications

After you have made the basic

mechanical decisions, what about quality measures? Because DAs are relatively simple devices, most models have excellent specifications for standard audio performance measures: THD, S/N and frequency response. Be sure you read all the fine print before you make your decision. There are a number of ways to measure a device's performance. You



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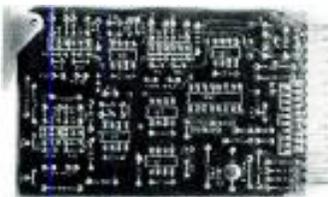
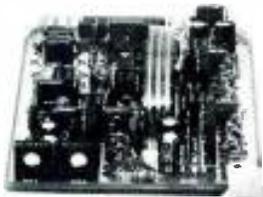
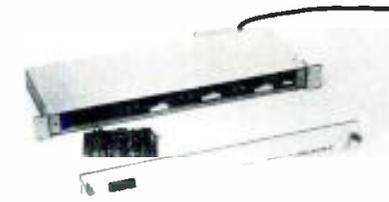
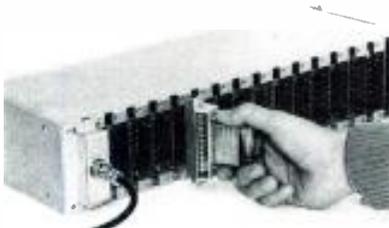
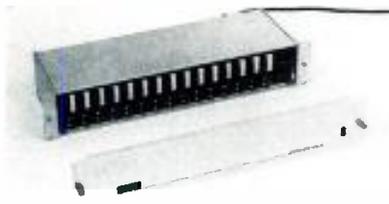


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need to understand how the equipment's specifications were developed in order to make meaningful comparisons.

One specification that is becoming increasingly difficult to use for comparison is maximum output level. An active-balanced output stage acts like a voltage source driving a series source resistance. (See Figure 3.) This means that the maximum output level depends on the *ratio* between that source resistance and the load resistance. You can increase the output level by either increasing the load resistance or by reducing the source resistance.

Consider a couple of ways to specify maximum output level. If you specify the maximum output level into a load greater than 600Ω , then the equipment's maximum output level will be higher than if specified at 600Ω . You could also lower the DA's source impedance below 600Ω , which would provide more output voltage across the load. The latter method would provide a higher maximum output level, but at the cost of an

equivalently higher noise floor.

In other words, by changing the ratio of the output source resistance to the output load resistance, you can change the top and bottom levels of the dynamic range, but you will always change the top and bottom levels equally. Because you are not actually getting better performance, it's questionable whether the extra level really does any good. After all, your maximum output level needs only to be a bit higher than the maximum input level of the devices that are being fed.

There is one advantage to a lower source impedance. With long cable runs, the output source impedance combines with the cable capacitance to form a low-pass filter. This filter results in high-frequency rolloff. A 300Ω source resistance in each output leg can become a significant problem if the cable runs are several hundred feet long. If your cable runs are typically this long, you need to minimize your source impedances on all audio equipment.

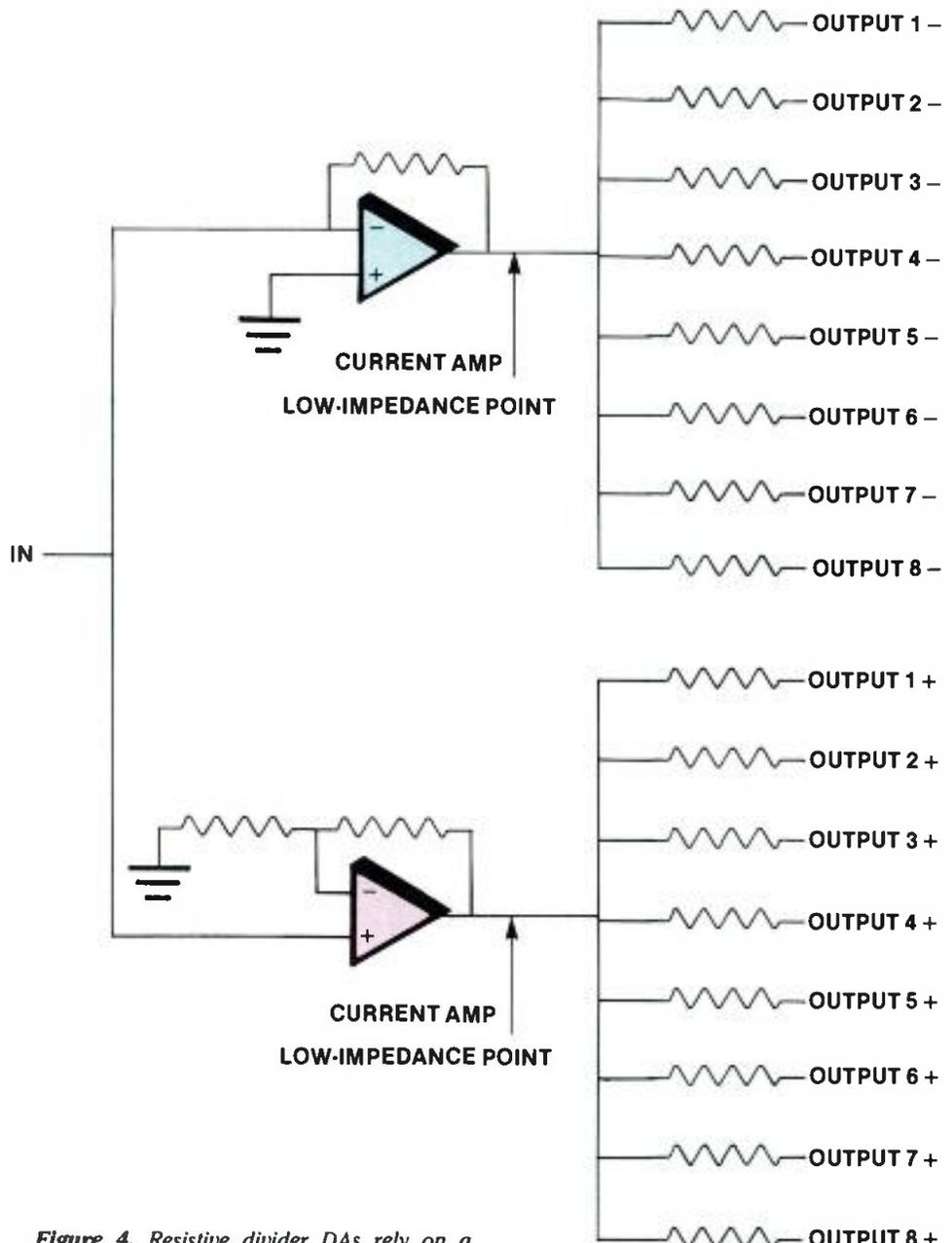


Figure 4. Resistive divider DAs rely on a single high-current driver to feed all the outputs for each polarity.

Continued on page 46

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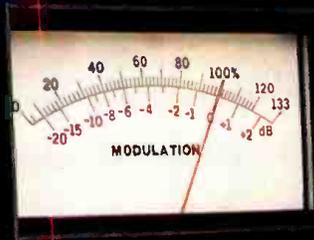
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0.02 1.47 30.2

0.00 2.00 -1.0



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0.00 2.00 -1.0

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LEFT METER

12 CAL	31 TOTAL MOD	32 STEREO
33 LEFT CH	34 (L-R)	MAIN

TOTAL MOD STEREO MAIN

1 0 0 1 0 0 1 0 0

100% = 2.79 kHz 100% = 2.55 kHz 100% = 2.29 kHz

RIGHT METER

12 CAL	31 TOTAL MOD	32 MAIN
43 RIGHT CH	34 RS LEVEL	35 PHASE CAL

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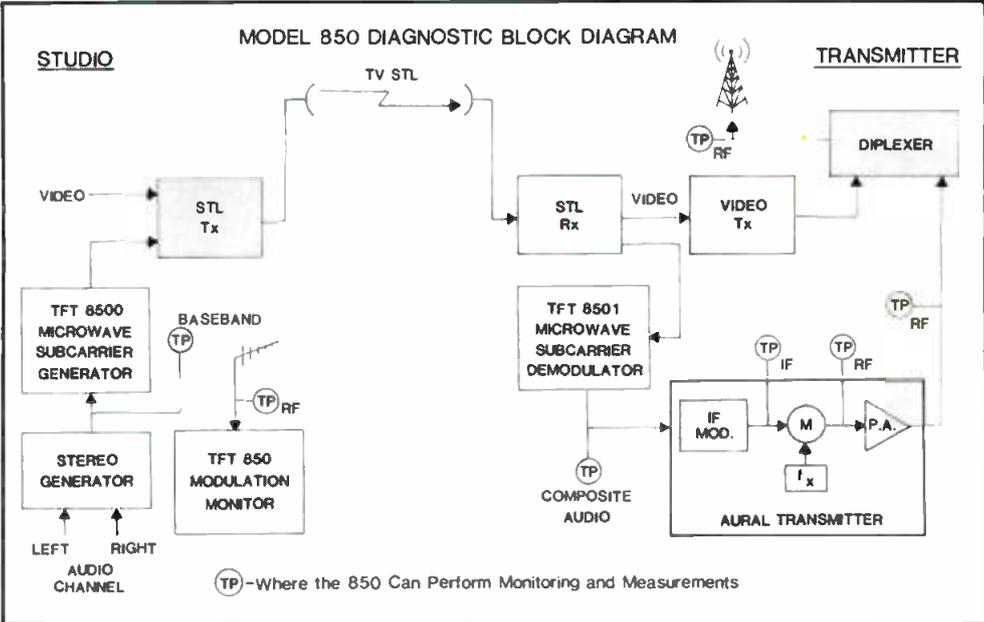
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Continued from page 42

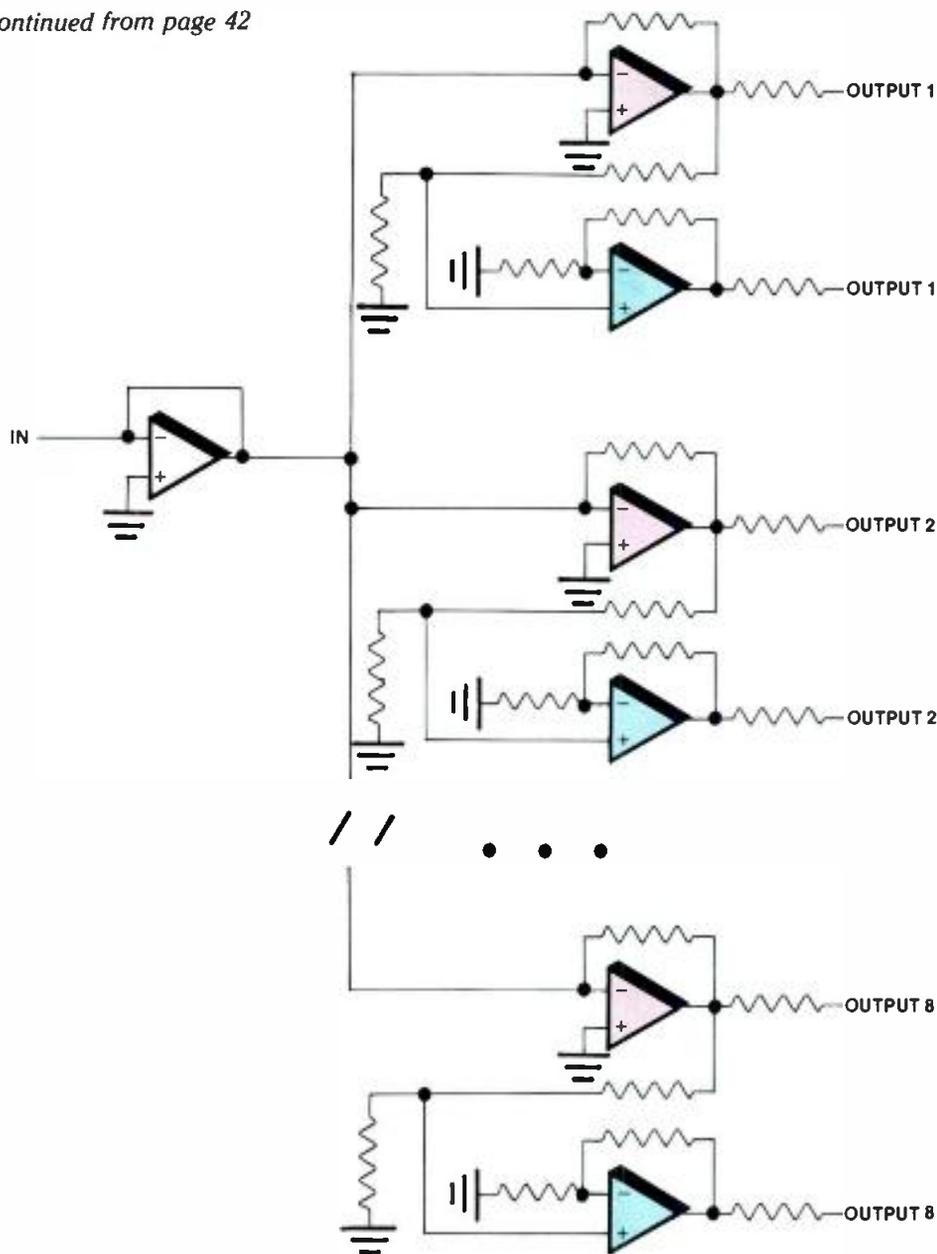


Figure 5. DAs with individual driver outputs have more amplifier circuits than resistive divider types. However, each circuit is simpler and failure of one output driver will not cause the entire system to fail.

The key to obtaining the best product for your application is a thorough understanding of the specifications. If you understand how the manufacturer developed them, you can intelligently compare the specifications of one device to another's.

Output drivers

Internally, there are two basic ways DAs are constructed. Some DAs have a single output amplifier, which drives all outputs through a resistive divider (see Figure 4). Others have an individual amplifier to drive each output, as shown in Figure 5. Because today's integrated circuit amplifiers are so inexpensive, there is not a significant cost advantage to one method over the other.

Some engineers like the redundancy provided by having an amplifier for each output. This design prevents a single component failure from crashing the en-

tire system. Other engineers would argue that with individual amplifiers, failure of one output while the other outputs continue leads to confusion in troubleshooting and operations.

The trade-off between a string of simple circuits in the first case and a single, more complicated circuit in the second case is probably an even call. The main variable might be the quality of the individual design, rather than the particular type of circuit used.

The need for DAs in virtually every broadcast application is so evident that some manufacturers include DAs as a standard feature in audio consoles. Because most consoles must feed more than one device, this is a useful feature. Even if you don't have one of these built-in DAs, the variety of DAs on today's market ensures that you can find a unit that will meet your needs—at a reasonable price. [:-?;-:))]]

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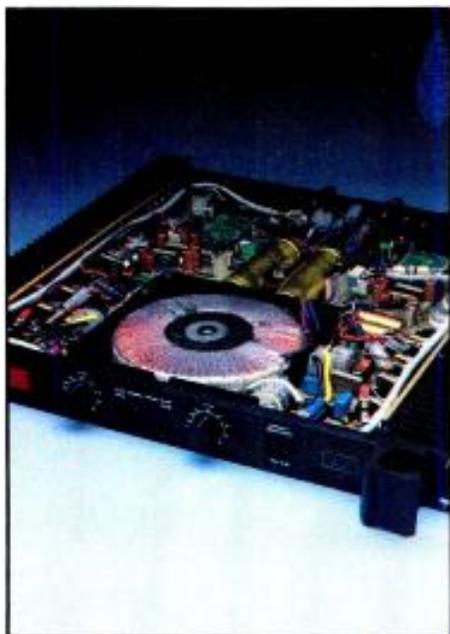
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Inside power amplifiers

By Cal Perkins

With today's high-tech audio requirements, both performance and reliability are important in a speaker power amplifier.



power capability. On the other hand, an amplifier with far more power than the speaker is capable of handling also is a bad buy.

Too often, power amplifiers are purchased on the basis of brand loyalty or familiarity. They are less often selected according to a carefully thought-out plan. Before you make that critical purchase, learn all you can about power amplifiers to make a better decision.

Performance

Cute circuit tricks and beyond-the-state-of-the-art data sheet specifications are of little value if the amplifier will not perform adequately in the job for which it was intended. Products with similar specifications can exhibit surprising, *real world* performance differences. In most cases, if you notice audible differences between two amplifiers with similar

Costs

To today's manufacturers, the power amplifier's major cost areas include the package, the power supply, the output devices and the heat exchanger system (heat sink). The actual type of circuit that is used has only a minimal effect on the amplifier's total cost.

Power supplies

Before a power amplifier can provide power to a load, it must first get its power from somewhere. In all ac-operated amplifiers, the power supply converts the 50Hz to 60Hz 120V source into direct current with a value somewhere between $\pm 20\text{Vdc}$ to $\pm 125\text{Vdc}$. The most widely used power-supply design is a conventional capacitor input filter full-wave bridge with a transformer having a center-tapped secondary, as shown in Figure 1.

In days gone by, broadcast engineers seldom thought about the speaker power amplifiers used in their studios. If sound was coming from the speakers, they figured the amplifier must be working properly.

Today, increasing demands are being placed on broadcast monitoring systems. Radio and TV stations now use high-quality analog and digital sound sources. These audio sources provide audio quality never before available.

It's becoming more common to find engineers on station staffs who really understand audio and realize the value of proper monitoring facilities. These engineers recognize the importance of being able to *hear* the sound without having to wonder if the speaker power amplifier is overloading or adding distortion to the speaker's sound.

Unfortunately, when it comes to speaker power amplifiers, stations sometimes end up purchasing amplifiers that are inadequate for the particular application. A common mistake is to purchase an amplifier with insufficient

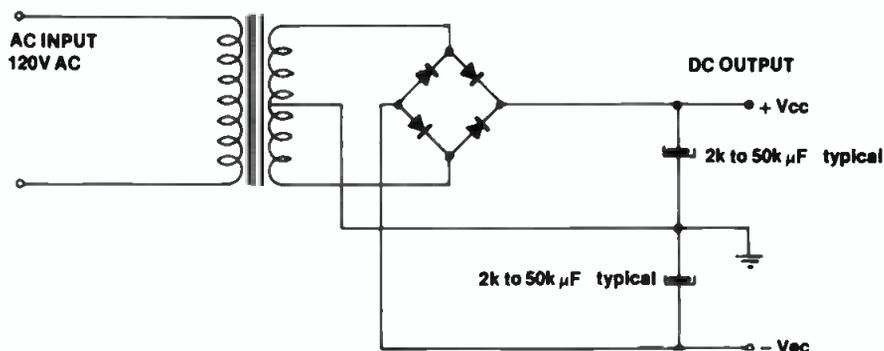


Figure 1. Conventional capacitor input filter full-wave bridge.

specs, this can be attributed directly to abnormal performance of one (or both) of the products.

Because commercial usage may sometimes stress the amplifier beyond its designed linear operating region, performance outside of the typical operating conditions can be more important than data sheet specifications. Low- and high-frequency overload characteristics, intermodulation distortion products generated when in the non-linear region, high-frequency stability, and the capability to handle real world reactive loads are some viable criteria by which to evaluate an amplifier.

Although relatively unsophisticated when compared to today's switching technology, the conventional power supply has several redeeming qualities. First, it uses only four parts. Second, it does not produce a large amount of RFI or power-line noise. And third, the supply does not require shielding or heat sinking, as does a switching-type supply.

The disadvantage, however, is that 50Hz to 60Hz power transformers are large and heavy. A transformer used for a dual 250W amplifier can weigh from 20 to 30 pounds. Let's see what can happen with a conventional power supply.

Continued on page 52

Perkins is manager of pro audio product engineering research and development for Fender Musical Instruments, Portland, OR.

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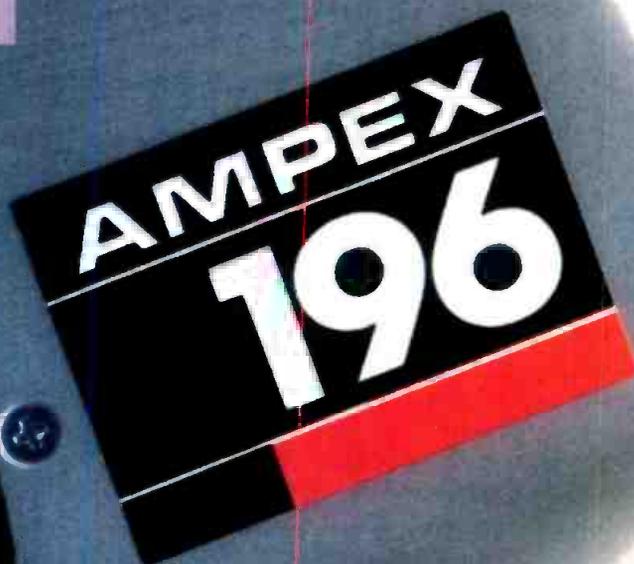
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Continued from page 48

Figure 2 shows the ac line current superimposed on the 120Vac line voltage. (Note: The diodes conduct only near the peak of the ac waveform and the 120Vac sine wave is somewhat *flat-topped*.) Line voltage is distorted because the peak capacitor charging current seen on the transformer's primary causes a voltage drop in the building wiring. Because the filter capacitors charge to the peak voltage, it is important that the primary ac wiring be sized not for the rms current draw, but for the peak current draw. For this reason, touring

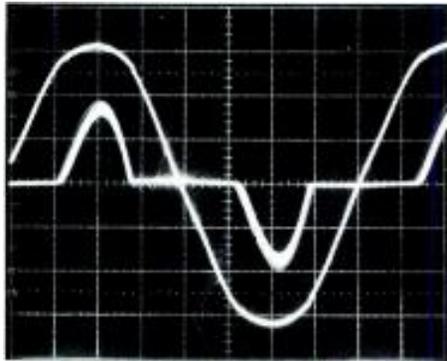


Figure 2. Composite exposure showing the input voltage and current into a 750W amplifier delivering 289W of pink noise into a 4Ω load. Line voltage is 50V/div. The rms line voltage is 114Vac. Current is 17.39A peak/div. The rms line current is 13.04A and peak line current is 31.3A.

groups and large sound installations often use 00 (double 0) and/or 0000 (4-0) gauge wire in their power distribution systems when the total rms current draw would indicate that No. 4 gauge wire would be sufficient.

Because the peak power-line current is at least twice the average current for a conventional supply, the building wire gauge service to any *group* of large power amplifiers should be at least three wire gauges smaller in number (No. 10 to No. 7) than the minimum required by electrical code. Having a good, well-regulated ac service will make an audible difference.

Remember that a power amplifier's output power is proportional to the square of the voltage, and a 10% loss in peak line voltage is reflected back as a 19% loss in power. Typical power losses can run as high as 20% to 35% if the ac line voltage is not *stiff* enough.

The power supply's regulation is primarily determined by the dc resistance of the power transformer. Once the filter capacitors reach a limiting value, any further increase in capacitor size does not significantly affect the long-term dc regulation.

Stored energy

Because the energy storage capability of the supply is directly proportional to the capacitance and the square of the

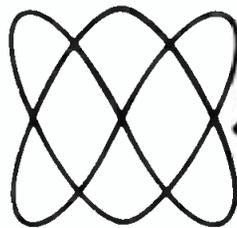
voltage, a 40% increase in voltage will double the energy. However, large capacitors are not necessarily better. The larger the capacitor, the more inductive it becomes, and the high-frequency impedance of the power supply could be raised by blindly using too large a filter capacitor. A better approach is to bypass the large electrolytic with a smaller film and foil (not metalized film) capacitor to ensure that the high-frequency impedance will remain low.

Phase-controlled backslope

The *phase-controlled backslope* power supply (as shown in Figure 3) has been rediscovered by the audio industry. The phase-controlled supply was originally used for preregulation in large dedicated power control systems. Basically, the phase-controlled supply consists of an SCR (silicon-controlled rectifier) that turns on (and off) the ac line voltage to the power transformer primary as a function of phase angle.

Because the maximum amount of time that a diode can conduct current is 1/120 of a second (8.33ms), why not leave the power transformer off and gate it on only when the power supply diodes are conducting and charging the filter capacitors? Taking that thought a bit further, why not wait until after the peak voltage to begin conducting, and then conduct on the backslope of the ac

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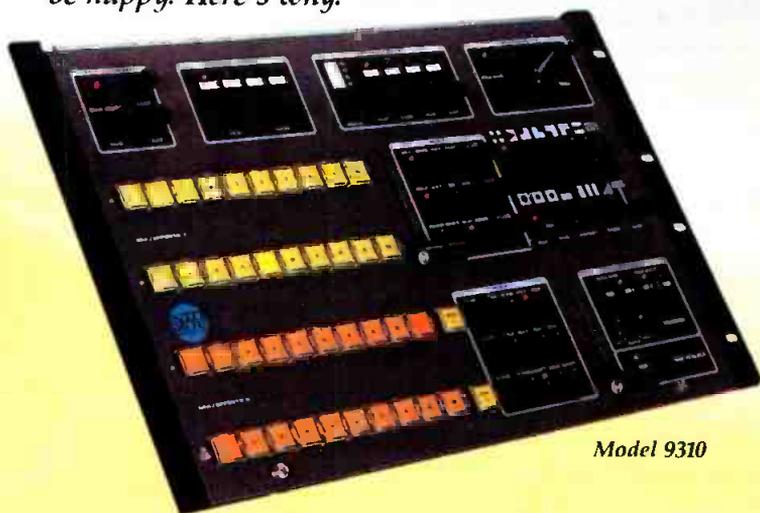
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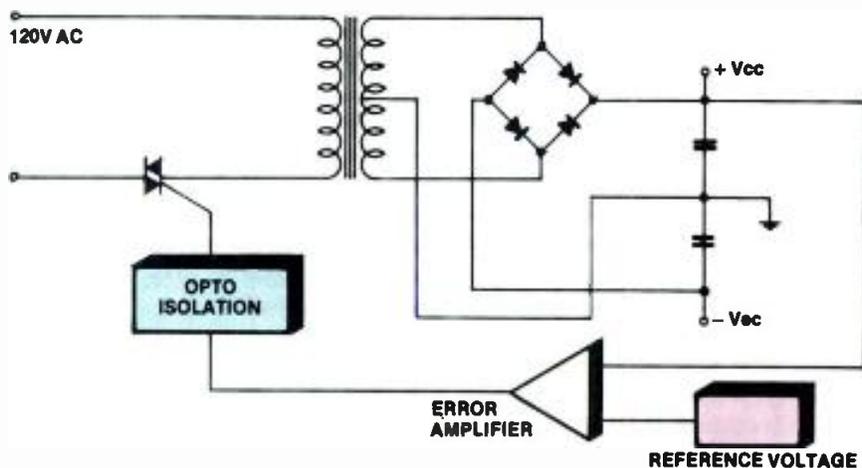


Figure 3. Phase-controlled power supply with primary regulation.

waveform? Because the transformer is off more than it is on, the number of primary turns can be reduced and the core size also can be reduced.

Unfortunately, the narrow conduction angles caused by the SCR switching necessitate that the peak line current be quite high because the total energy is a *voltage-current-time* product. Because the peak current is quite high, so is the rms current. High rms current means high transformer temperatures because the power dissipated by the transformer is I^2R . In comparison to conventional supplies, well-designed backslope supplies draw only about 10% more line current when compared to the 200% or more of line current consumed by some designs.

Perhaps the most deleterious effects from a phase-controlled supply are the perturbances it creates on the ac line. (See Figure 4.) Because of the low dc resistance of the power transformer, large *chunks* are effectively taken out of the line every time the SCR switches on. When the SCR turns on, the power transformer appears as an effective short across the power line. Under typical operation, more than 20V peak can be chopped out of an ac power source with a 0.24 Ω impedance (75 feet of No. 10-3 wire connected to a 400A service, including connectors). A quick calculation shows that the peak current is 83A.

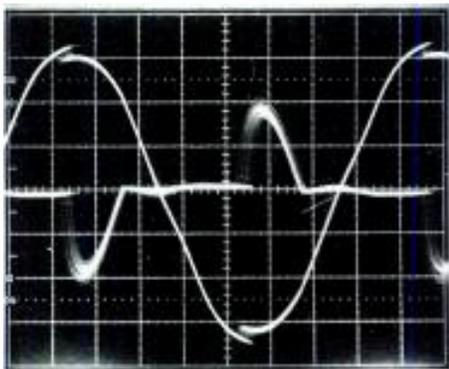


Figure 4. Scope photo of effect on ac power line caused by a phase-controlled power supply. The rms line current is 13.9A. Peak line current is 38.2A. The amplifier is delivering 30Vrms of pink noise (225W) into 4 Ω . (Note: current waveform is inverted.)

Phase-controlled power supplies can provide excellent regulation and do offer protection against excessively high input voltages. With this regulation, the amplifier can be designed to maintain its output power specifications to line voltages as low as 108Vac. Conversely, a power amplifier with a conventional supply will lose 19% of its output power if operated at 108V.

At least one new amplifier has appeared on the market using SCR control on the secondary of the power transformer, which mitigates many of the problems with primary phase control. Perhaps the biggest design benefit from using the phase-controlled concept is the convenient control port for the amplifier's protection mechanisms.

High-frequency switching

High-frequency switching power supplies have, so far, found limited application. Component cost, reliability, power dissipation requirements (a 2,000W supply that is 95% efficient still needs to dissipate 100W of heat), and electrical noise problems have slowed widespread acceptance. As with phase-controlled power supplies, power-line perturbances are difficult to eliminate. And, in some cases, the power-line problems can seriously degrade a system's performance. An amplifier that is small and lightweight is of little use if its power supply causes other equipment to hum and buzz.

The load

The ideal load for almost any power amplifier is a *resistive* load. A resistive load has the following properties:

- all the power delivered to the load is dissipated in heat;
- the load's resistance does not change with frequency; and
- the load's resistance does not change appreciably with level.

When driven from an amplifier, the *maximum load voltage* occurs when the voltage across the output transistor is at the *minimum* value and load current is at *maximum*. The amplifier's output stage then sees minimum voltage at maximum current.

Inductors and capacitors are altogether different. In the ideal state, neither an inductor nor a capacitor will dissipate power. Real world capacitors suffer from imperfect dielectrics and, therefore, possess some equivalent series resistance (ESR).

In an ideal capacitor, the current in the capacitor is proportional to a constant (capacitance (C)) times the rate of change of voltage with respect to time. Ideal capacitors exhibit the following characteristics:

- When energized from a discharged state with a step function (a switched battery), the current is at maximum while the voltage is initially zero. As the capacitor charges, the current exponentially decays while the voltage exponentially increases to its maximum value.
- When energized from a sinusoidal source, the voltage across the capacitor lags the current through the capacitor by 90°.
- Energy is stored in the capacitor's dielectric.
- Capacitors do not dissipate power.
- It is not possible to instantaneously change the voltage across a capacitor.

Inductors are the dual of capacitors. The voltage across an inductor is proportional to the constant (inductance (L)) times the rate of change of current with respect to time. Ideal inductors exhibit the following characteristics:

- When energized with a step function (a switched battery), the voltage is at maximum while the current is at zero. As the inductor builds up its magnetic field, the current through the inductor exponentially increases and the voltage across it exponentially decreases.
- When energized from a sinusoidal source, the voltage across the inductor leads the current through the inductor by 90°.
- Energy is stored in the inductor's magnetic field.
- Inductors do not dissipate power.
- It is not possible to instantaneously change the current through an inductor.

Inductive or capacitive loads (reactive loads) are the nemesis of many power amplifiers. Many amplifiers will oscillate or even blow up with the capacitive loads. An inductive load may trigger the amplifier's protective circuits that will act in consort with the output stage and power supply and force the load further into an unsafe operating condition.

The fundamental property of inductance states that it is not possible to instantaneously change the current in an inductor. Yet many of the protection circuits implemented in commercial designs try to do just that. As a result, the load resonates with the power-supply capacitors while the output stage is helpless to control the situation when the protection circuit is activated.

Figure 5 illustrates the voltage/current relationship of a resistive load and a pure

Continued on page 58

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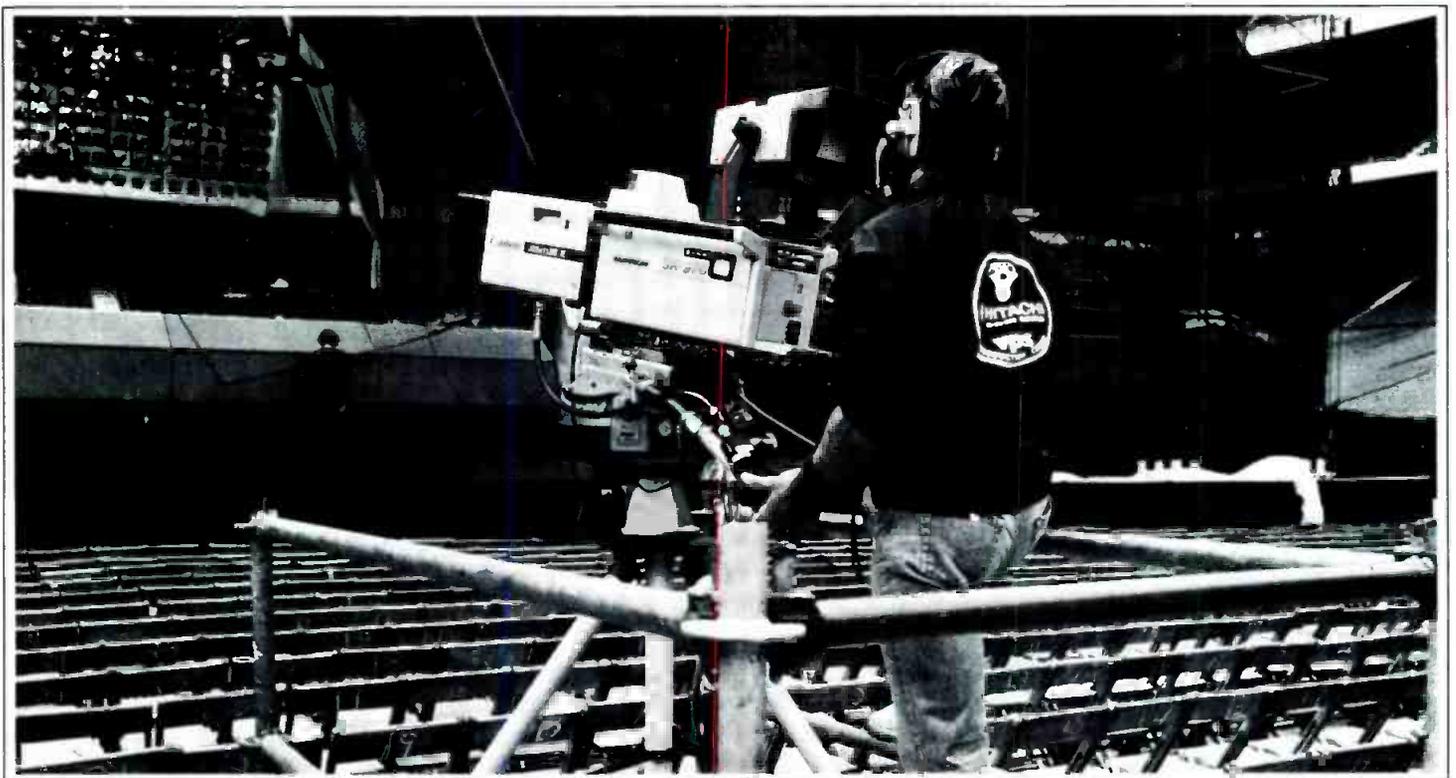
The largest producer of live concert videos in the U.S., VPS requires lightweight, low-maintenance broadcast cameras it can put on the road for long stretches.

Azimzadeh considers the SK-970 the only studio camera with 2/3-inch mobility and EFP handling. So it can meet the demands of often makeshift stadium facilities, while delivering the broadcast images that are needed for larger-screen multiple projection.

Since each of the four SK-970s and two SK-97s in the

travelling package has complete self-contained auto setup, a separate box isn't needed. And any potential problems are confined to one head.

Although VPS earmarks two SK-97s and SK-970s for studio use, the ability to use both wherever they are needed is a welcome economy. Still, the greatest asset of the SK-97 and SK-970 is rockbottom reliability. To Azimzadeh, concerts are just like live TV—no one can afford any slip-ups, or an equipment failure.



"Since each SK-97 and SK-970 has its own on-board computer, I can set everything up at the same time automatically."

Terry McIntyre, Remote Supervisor
F&F Productions, Inc.
St. Petersburg, FL

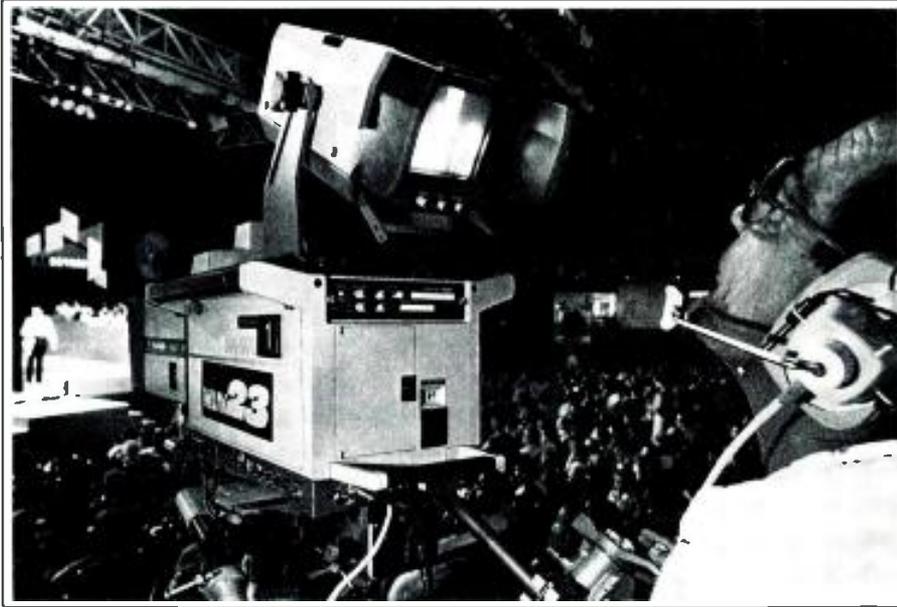
As a mobile production facility covering sports and large outdoor events for local and network TV, F&F needs broadcast quality on location.

They also need fast, independent setup. So they keep three handheld SK-97s and four compact studio SK-970s

permanently stowed on one of their trucks. And with complete computerized auto setup on-board each camera, the crew can set all of them up at the same time from parameters stored in memory without having to worry about drift or last minute adjustments.

The SK-97 and SK-970 also perform superbly under low-light conditions. As a result, notes Chief Engineer Dennis Lusk, both can use very large lenses. And with real-time registration compensation automatically correcting for any changes throughout the travel of zoom lenses, the cameras are ideal for the demands of sports coverage. Resolution and colorimetry are also unsurpassed, according to Bill McKechnie, another Remote Supervisor. In fact, the SK-97 is often run by F&F as a "hard" camera, in place of the SK-970. Location recording is done on two Hitachi HR-230 1-inch VTRs.

Most important, however, is the almost complete interchangeability of both cameras. Not only are they easy to work with, but they are also easy to link up. And so similar electronically, a single set of spares can cover any potential emergency.



"The SK-97 is a real mini-cam that can be completely integrated into a total studiowide auto setup system"

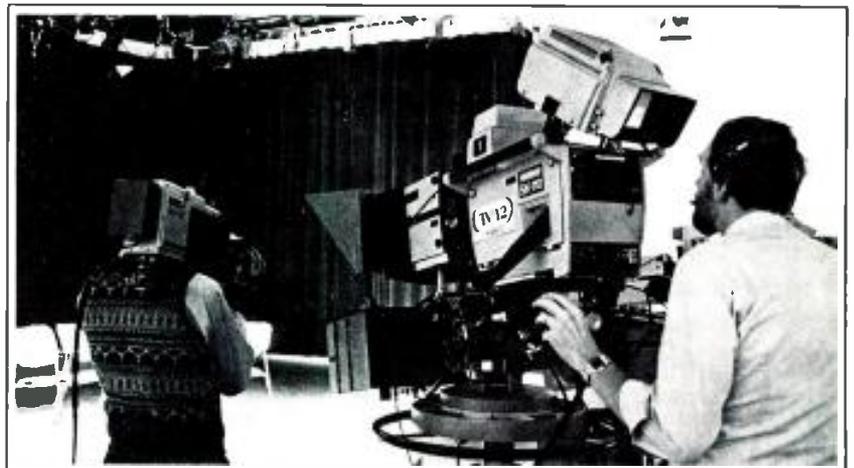
Bill Weber
Vice President for Engineering
WHYY Television
Philadelphia, PA

WHYY has extensive production facilities at Independence Mall and more studios on the drawing board. To plan for this rapid growth, WHYY sought a family of broadcast cameras that was as flexibly integrated as it was advanced.

While evaluating computerized camera systems, Bill Weber and his staff found that the Hitachi SK-110 studio unit and the portable SK-97— with the same basic complete auto setup—were so perfectly matched in colorimetry and resolution that pedestal and handheld work could be combined without a hitch. And because the SK-97's auto setup is also completely self-contained, both cameras are as electronically independent as they are geared toward common console control.

Staffers like Senior Video Engineer Bob Miller consider the SK-97's auto setup easy-to-use, as well as accurate and reliable. And the on-board lens and scene files give operators instant-filter and color correction at each camera head, in addition to the console. So the staff looks upon the Hitachi SK-97 as a studio camera that they can shoulder.

As facilities grow, WHYY's Weber knows that he will have the flexibility to configure and reconfigure SK-110s, SK-970s, and SK-97s to meet production requirements of most any complexity without encountering technical snags. In fact,



with Hitachi cameras at other sister stations in the Eastern Educational Network, joint productions can even be assured of a common look.

For a demonstration of the SK-97 and SK-970 in your studio, contact Hitachi Denshi America Ltd., Broadcast and Professional Division, 175 Crossways Park West, Woodbury, NY 11797; (516) 921-7200, or (800) 645-7510. Canada: Hitachi Denshi Ltd. (Canada), 65 Melford Drive, Scarborough, Ontario M1B 2G6; (416) 299-5900.

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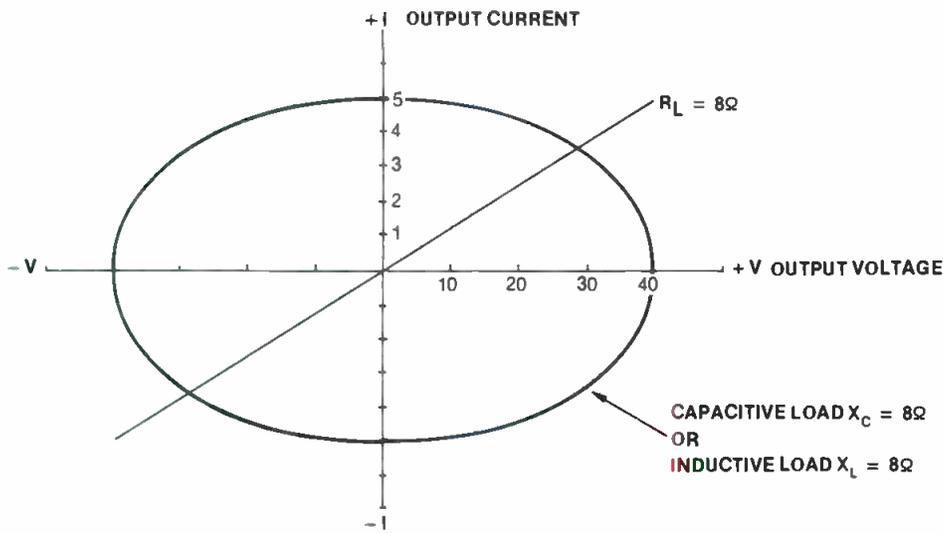


Figure 5. Load line for a resistive and pure reactive load.

Continued from page 54
reactive load.

Loudspeakers present the power amplifier with a load that is a hybrid of R, L and C. A loudspeaker's minimum impedance is determined by the dc resistance of the speaker's voice coil, and this determines the *maximum peak current* into the speaker. Although there are amplifiers on the market that can synthesize negative output resistance, which theoretically cancels the real dc resistance of the loudspeaker's voice coil, the voice coil resistance is present and still dissipates power. The amplifier's negative output impedance cannot compensate for the lost dissipation, but it can correct drive aberrations. Figure 6 shows a typical speaker impedance curve.

The impedance curve of a typical loudspeaker mounted in a vented box (see Figure 7) shows that the loudspeaker and box combination form two closely coupled resonant circuits. Fortunately, the minimum impedance is limited by the dc resistance of the speaker's voice coil, and when going through resonance, the overall impedance increases. Nonetheless, the real speaker's load is far more difficult to drive than a pure resistive load. Loudspeakers store mechanical energy as well as electrical energy, and when pushed to the limits, the load becomes non-linear. Actual measurements show that a loudspeaker load angle (phase shift between voltage and current) can vary by as much as 60°.

Mathematical analysis shows that, for a

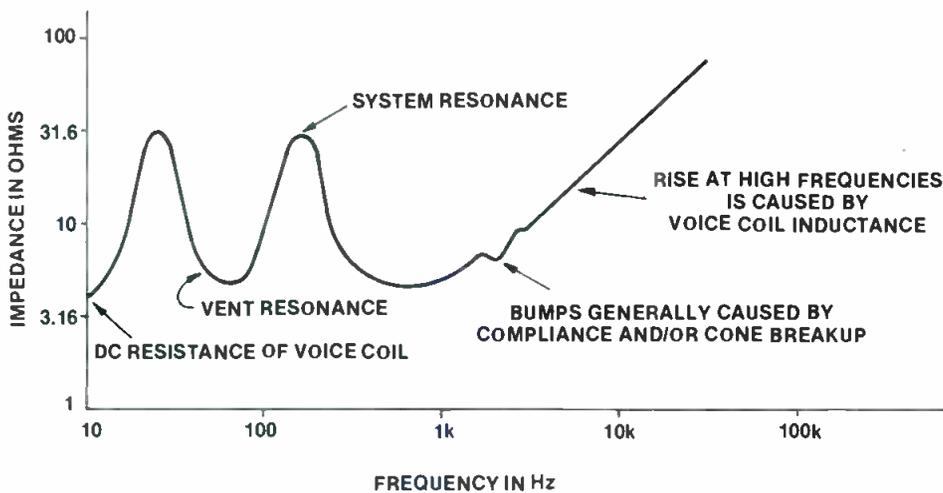


Figure 6. Typical impedance curve for a speaker mounted in a vented enclosure.

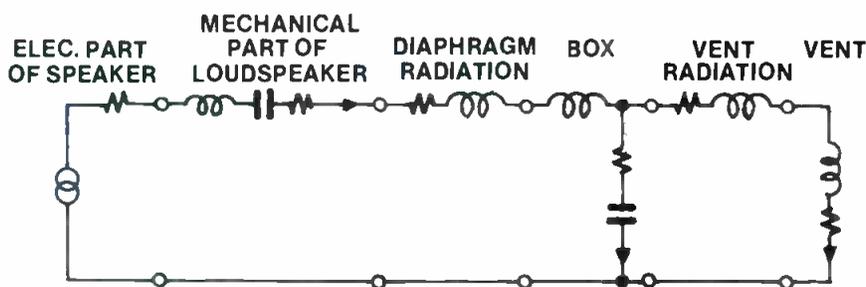


Figure 7. Equivalent electromechanical acoustical circuit for a loudspeaker in a vented box.

load of 60°, the current flowing in both the amplifier and the load is at one-half the peak value when the amplifier's output voltage is at zero. When the output is at 0V, then there is one-half the total supply voltage across the output transistors. The amplifier's output transistors see combinations of $\frac{1}{2}I_{pk}$ and E_{pk} or $\frac{1}{2}E_{pk}$ and I_{pk} simultaneously.

Designing the output stage to handle a 60° reactive load without the encroachment of protection circuits is at least a minimum requirement for proper amplifier design. Because speakers seldom meet their nominal spec sheet impedance specifications, it is best to consider the speaker's dc resistance as the minimum value.

Prudent design would call for an amplifier design centered on a nominal 4Ω rating for unabated protection circuit operation. This does not imply that the power supply needs to supply steady-state 4Ω operational power. Nor does it imply that the heat sink be designed for 4Ω operation under worst-case reactive dissipation conditions.

If we assume that the power supply is well regulated, an interesting fact surfaces. If the output stage is designed to handle a 60° load at one impedance—say, 4Ω—then the output stage will automatically handle a 90° reactive load at an impedance twice as high, such as 8Ω. However, this does not imply that the long-term dissipation of the amplifier needs to handle the excessive heat generated by a 90° load. An 8Ω 90° load will generate about 56% more heat than does the worst-case 4Ω dissipation condition into a resistive load. In any event, the power amplifier's protection circuits should not encroach upon the loudspeaker load line.

The output stage

Once the load requirements have been quantified, a study of how the output stage functions is in order. Let's first investigate the simple resistive load condition. Figure 8 shows a simplified

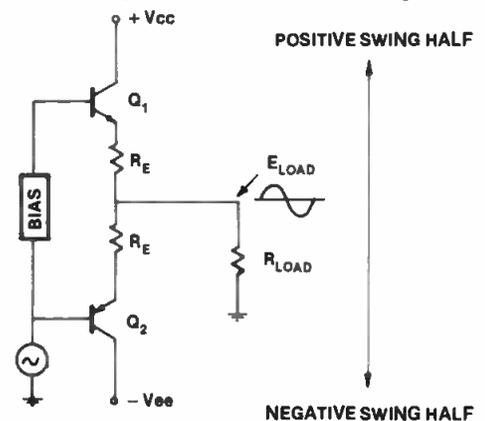


Figure 8. Simplified bipolar complementary output stage.

2-transistor complementary output stage driving a resistive load. Figure 9 shows the load voltage superimposed on the steady-state power-supply voltage.

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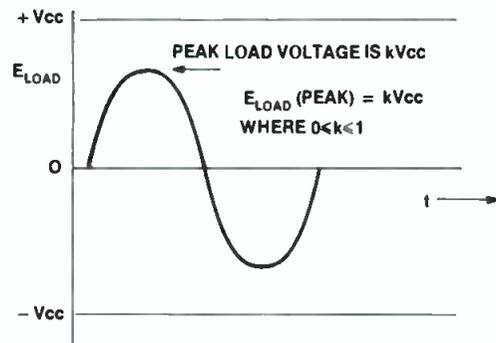


Figure 9. Load voltage and power-supply relationships.

It can be shown mathematically that class B efficiency is not a linear function of output power. In a class B amplifier, maximum dissipation occurs at 40.5% of full output power. Figure 10 shows the relationship of the output current, the load voltage, the voltage across the transistors and the power pulses that have a frequency double that of the output voltage frequency.

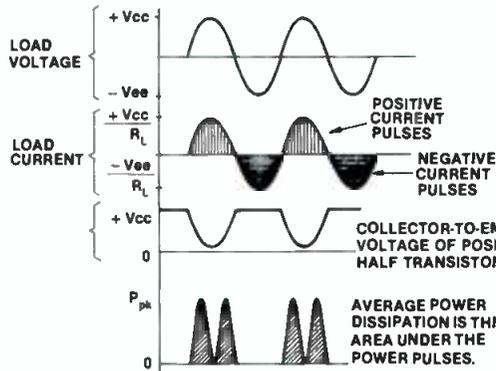


Figure 10. Time relationship of output stage current, voltage and dissipation.

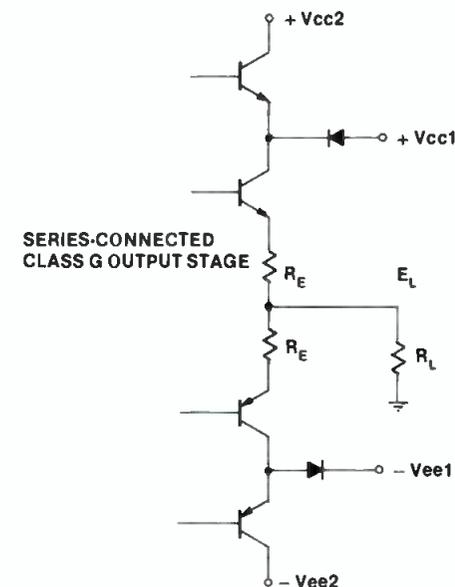
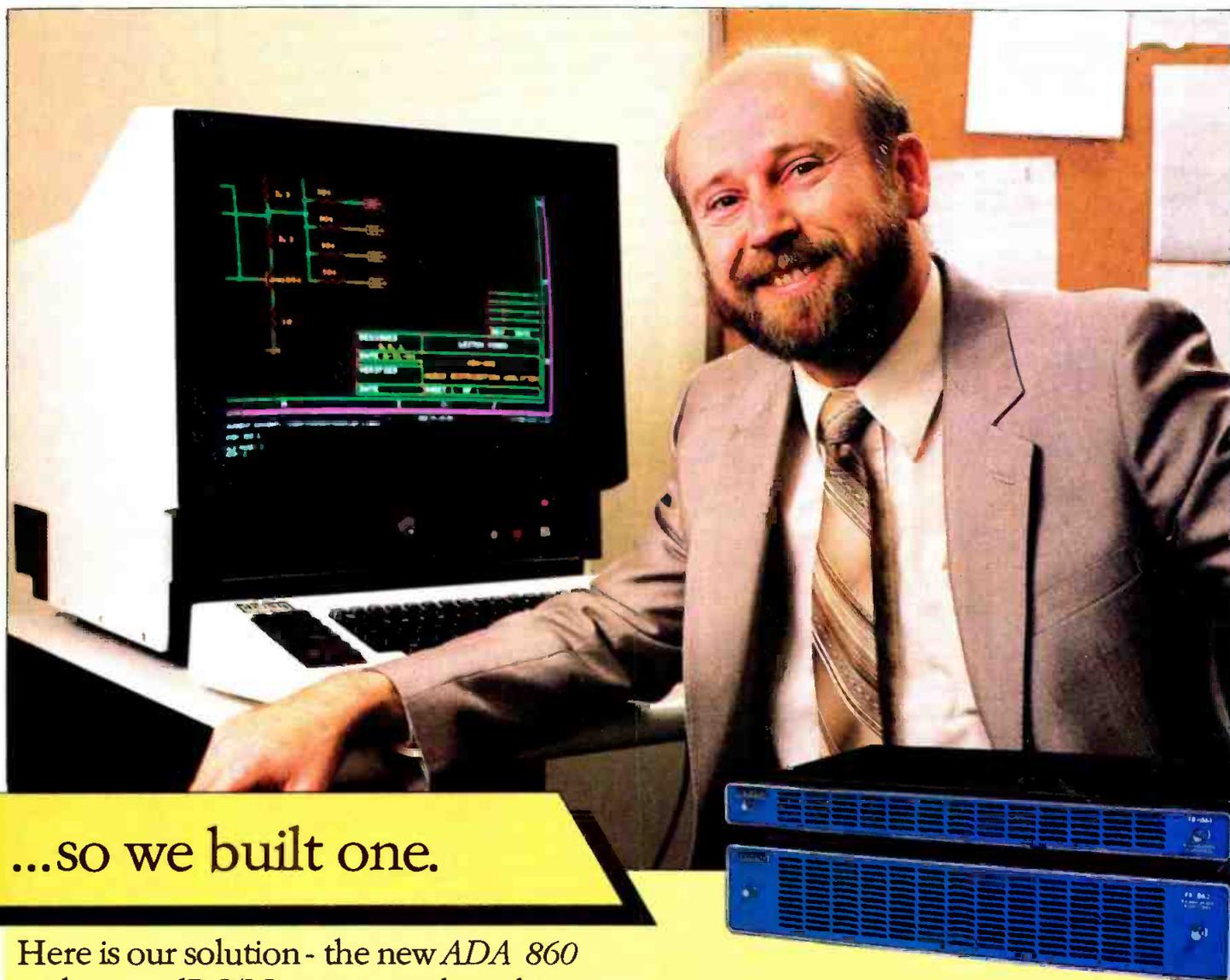


Figure 11. Typical class G circuit design.

Two classes of amplifiers have been developed to reduce the output stage dissipation. The class G amplifier (see Figure 11) makes use of a series-connected output stage with diode switching to two different power-supply levels. The second type of amplifier, class H (shown in Figure 12), simply uses

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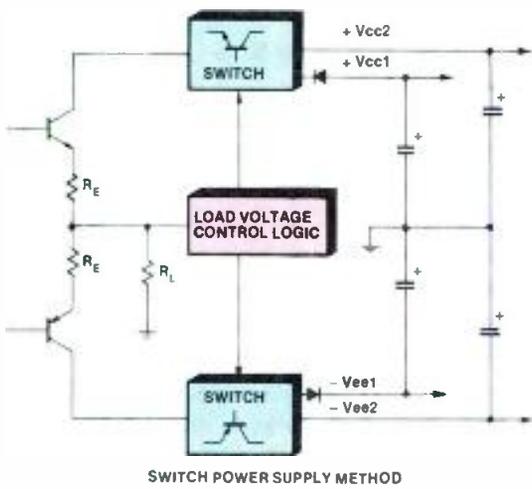


Figure 12. Typical class H circuit design.

switched power supplies and a more conventional output stage approach.

These designs realize an approximate 4:1 reduction in maximum worst-case dissipation and a reduction in power transformer size. At full power, the two classes can be a few percentage points more efficient than class B. However, actual circuit implementation may limit the full power dissipation to a value close to the class B type because of the added saturation losses of the additional series transistors. (See Figure 13.)

Now that you know how the output stage behaves with resistive loads, let's investigate the more general case of

reactive loads. Because the voltage/current relationships are displaced in time (that is, a phase shift) the relationships change somewhat from the resistive case. The worst-case dissipation occurs for a 90° reactive load case and can result in a 214% increase in output stage dissipation. Here, the worst-case dissipation increases from 40.5% output power to 127.32% output power (Figure 14).

Safe operating area (SOA)

Power transistor SOA is the single most important parameter in solid-state amplifier output stage design. Fortunately, advances in diffusion technology,

masking and device geometry have enhanced today's power-control technology.

A bipolar transistor exhibits two regions of operation. The first region is known as the dissipation region. Here the voltage-current product remains unchanged over any combination of voltage (V) and current (I). Gradually, as the collector-to-emitter voltages increase, the electric field through the base region causes hot spots to form, and the carriers actually punch a hole by melting the silicon. The result: a dead (shorted) transistor. If Murphy's Law comes into play, the dead device will blow all the

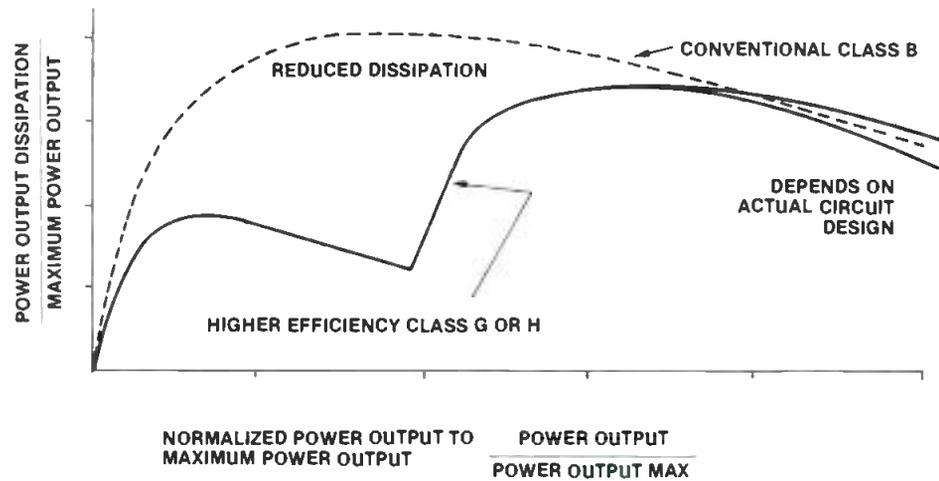
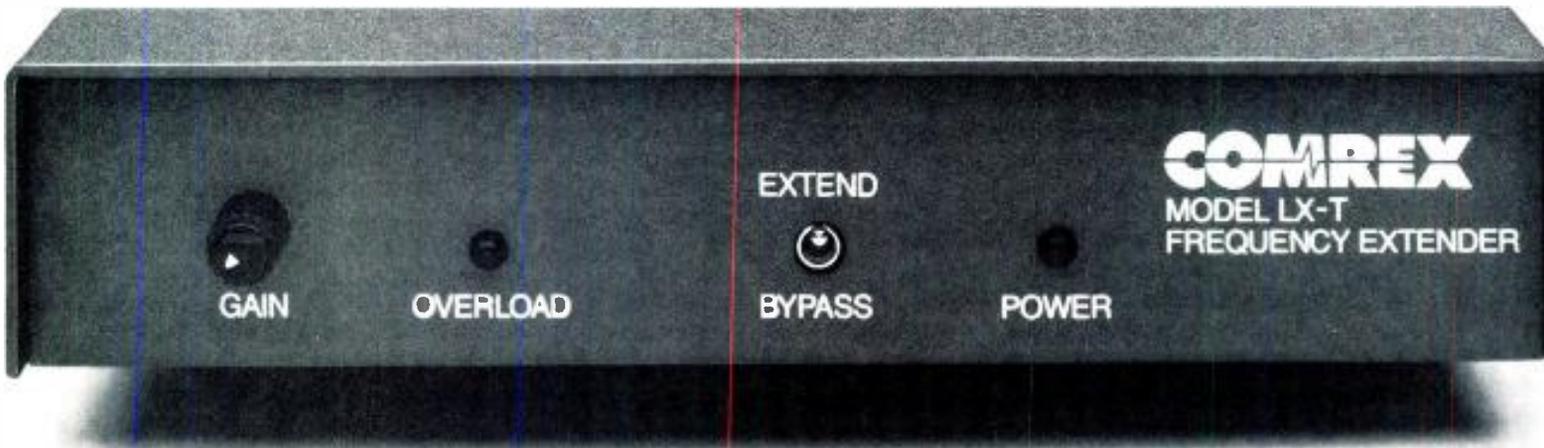


Figure 13. Class B dissipation as a function of power output (classes G and H also shown).



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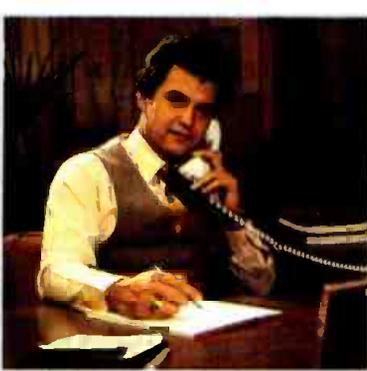
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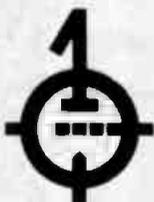


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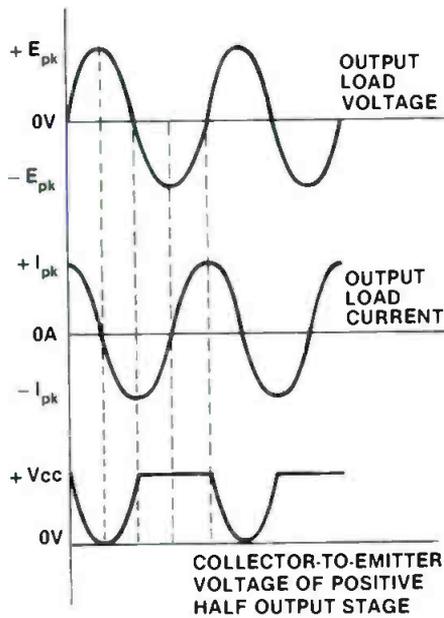


Figure 14. Voltage-current relationships for a 90° capacitive load. Note that the absolute worst-case dissipation occurs when the full power-supply voltage and the maximum output current occur simultaneously.

others in the amplifier, cause the amplifier's protection relay to arc-over and burn the contacts closed, then roast the speaker.

The second region is known as the secondary breakdown ($I_{s/b}$) region. Here the power transistor dissipation varies in a non-linear inverse relationship with the

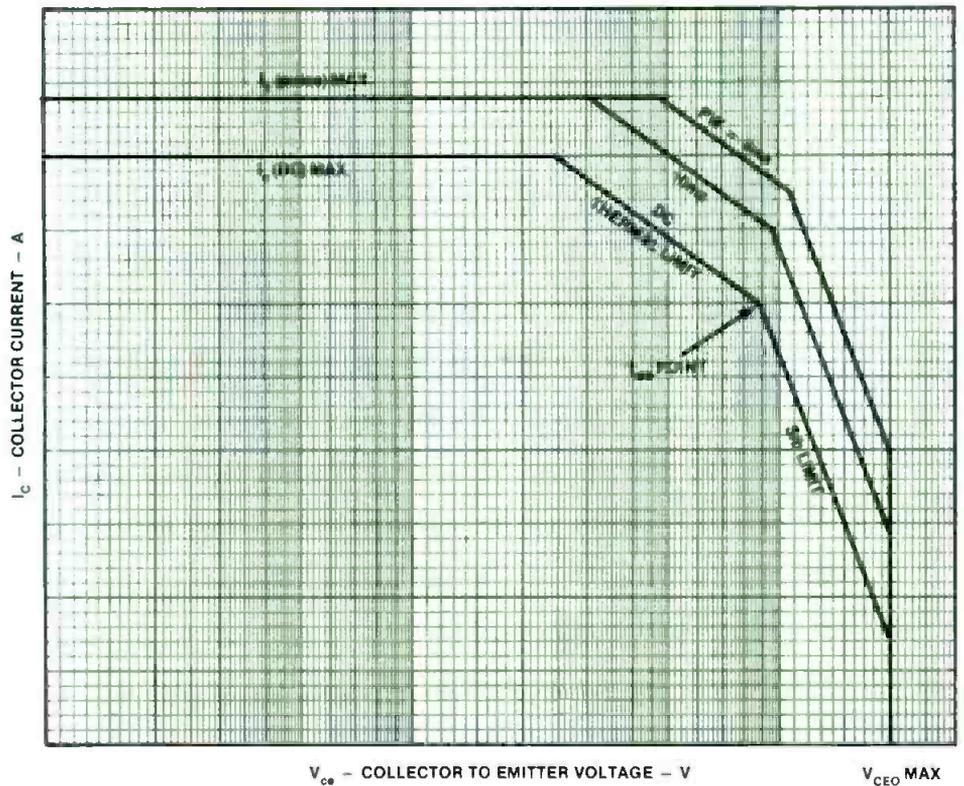


Figure 15. Manufacturer's data sheet of SOA.

applied collector-to-emitter voltages when the transistor is forward-biased. The $I_{s/b}$ point on the power transistor's SOA chart is the inflection point at which the secondary breakdown phenomenon

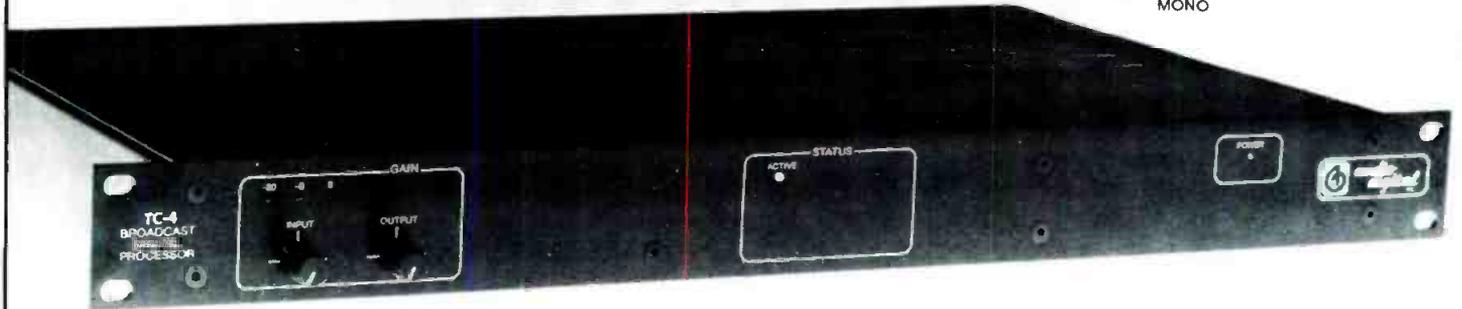
occurs. Figure 15 shows a power transistor's SOA.

To get the manufacturer's information into some type of useful format, a family of curves at various operating temperatures needs to be developed and plotted on a linear graph. This replotting



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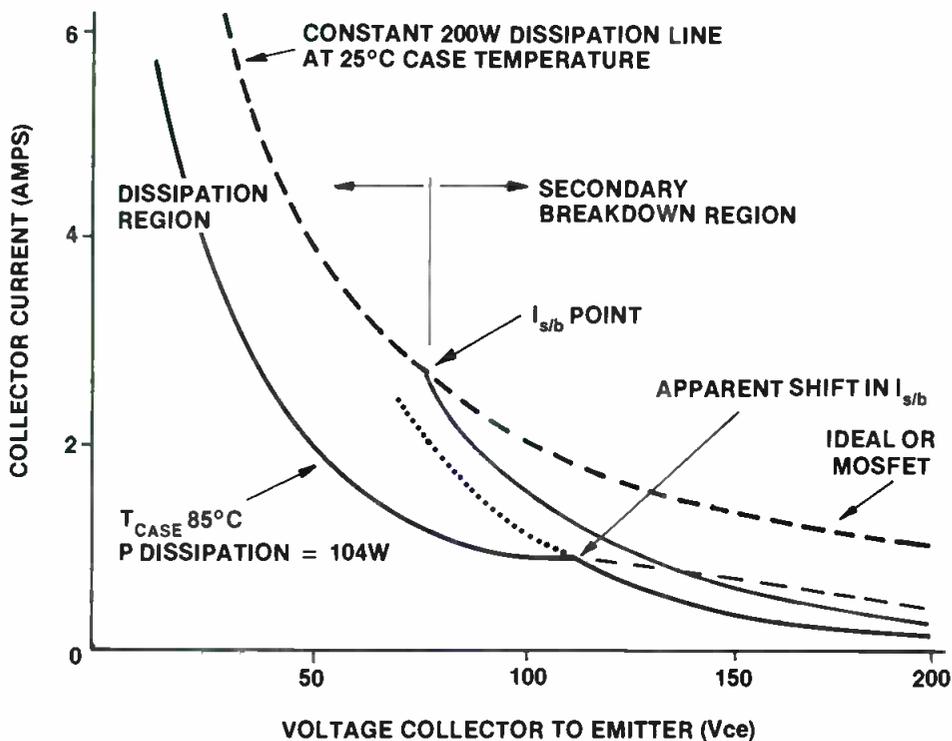


Figure 16. Temperature derating of silicon power transistors plotted on a linear scale.

gives a clear picture of what the data sheet indicates as compared to what happens in actual operation. It also clearly shows that the $I_{s/b}$ point moves up in voltage with increasing temperature. Figure 16 shows the temperature derating phenomena.

When these analytical tools are applied and the commercial designs are evaluated, two facts become evident. Products that are not as reliable as hoped for stand out, and there are a few products that should fail but do not. This can be traced to the conservative ratings of

some semiconductor companies.

With improvements in today's fabrication processes, output device SOA is primarily a function of the size of silicon inside the package. Package type, of course, determines the ultimate dissipation because of thermal saturation with a temperature rise. A good TO-3 or a 2-screw-mounted plastic package will dissipate approximately 350W to 375W if properly mounted. Figure 17 demonstrates the relationships between case size and power dissipation.

Circuit design

There are probably almost as many circuit topologies for power amplification design as there are companies producing them. The most popular types of output stage designs fall into one or more of the

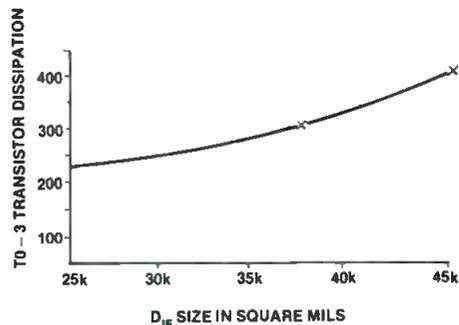


Figure 17. Relationship between case (die) size and transistor dissipation.

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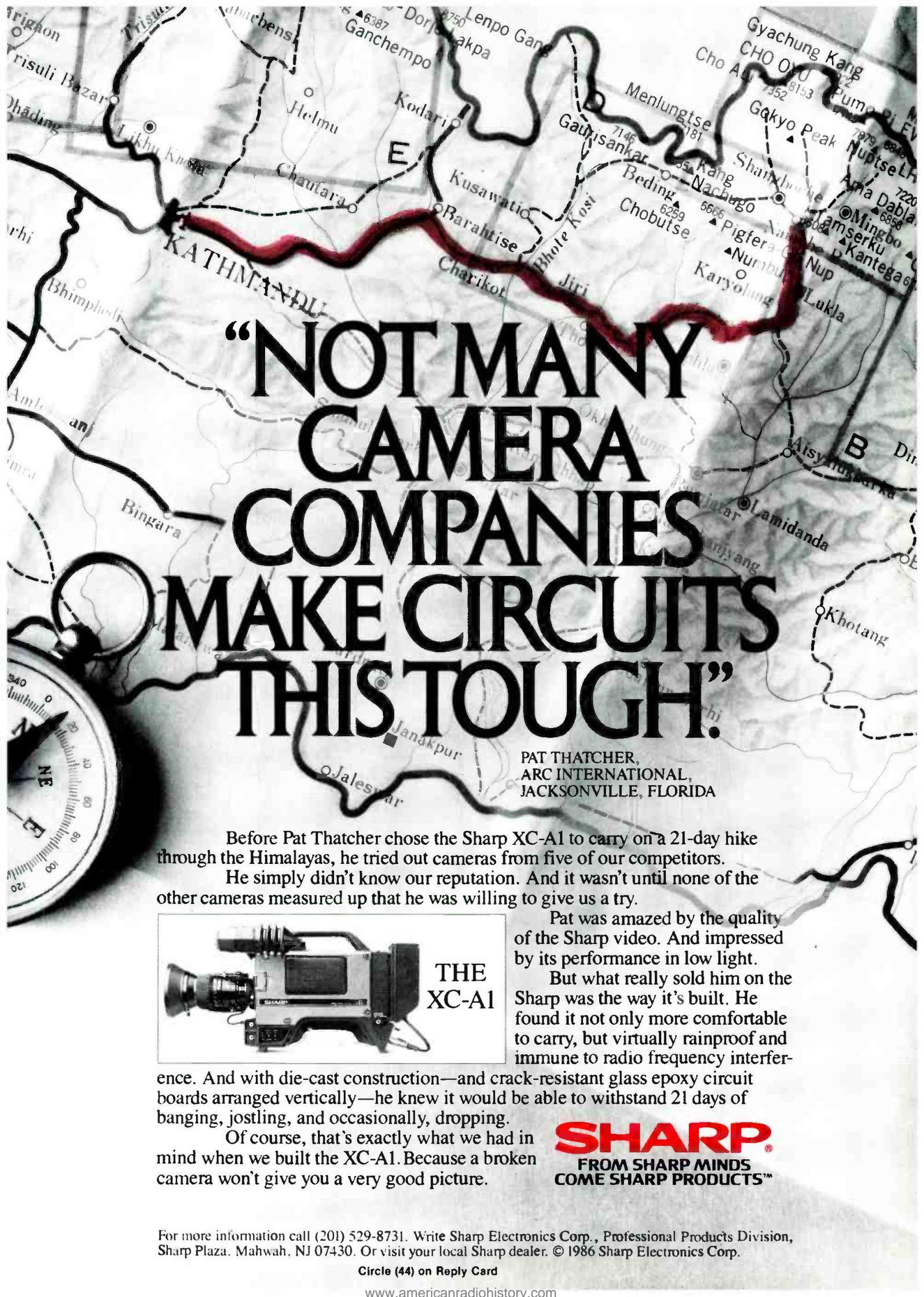
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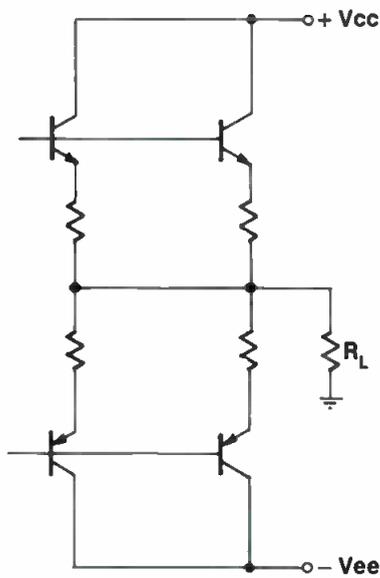


Figure 18. Power-supply ground-referenced conventional, parallel-connected and unity gain output stage.

following categories:

- unity voltage follower output stages, such as full complementary/symmetrical or quasi-complementary designs;
- output stages with voltage gain that perform the requisite small-to-large signal level shifting;
- conventional design chassis ground-referenced power-supply output stages;
- floating bridge output stages with no chassis ground reference; and
- grounded bridge output stages with a chassis ground reference (this approach necessitates floating power supplies).

With each of the five categories, the circuit can be implemented with series-connected output devices, parallel-connected output devices, or any combination of series/parallel configurations. Usually the more esoteric approaches are used in order to design around some inherent component limitation, either real or self-imposed. (See Figures 18 through 23.)

In some specialized cases, the conventional approach simply will not work. A high-voltage amplifier is a good case in point because the breakdown voltage limitations of most devices necessitate some type of series-connected output stage. To meet the power dissipation requirements as predicted by the load, the output stage may also need a series/parallel configuration.

Most power amplifiers today consist of three basic stages of amplification. The *input stage* is usually a differential amplifier. The *intermediate stage* level shifts and amplifies the input stage signal. Unless the input stage has a current mirror and is well buffered, the preponderance of the amplifier's gain is provided by the intermediate stage if the topology is a totally discrete design. Designs with IC front ends have voltage

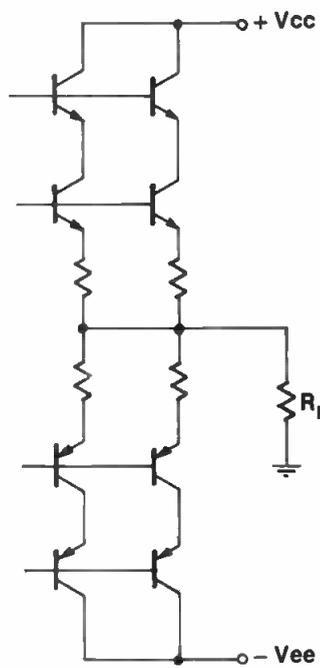


Figure 19. Power-supply ground-referenced series-/parallel-connected output stage with unity gain.

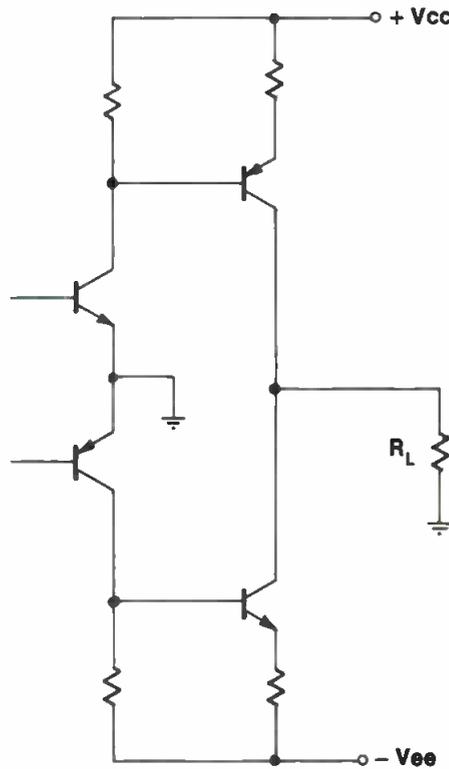


Figure 20. Power-supply ground-referenced output stage with gain.

gains of 10,000 or more. Usually the intermediate stage has a gain from 50 to 5,000. Last is the *output stage*, which may or may not have gain. Output stages with gain are generally limited to a value of less than 20 (26dB).

Input stage

Today, almost all input stages are bipolar or FET differential amplifiers. This is true whether the circuit design uses all discrete devices or has an IC front end. The popular 5532 IC has an NPN bipolar FET input stage, while the

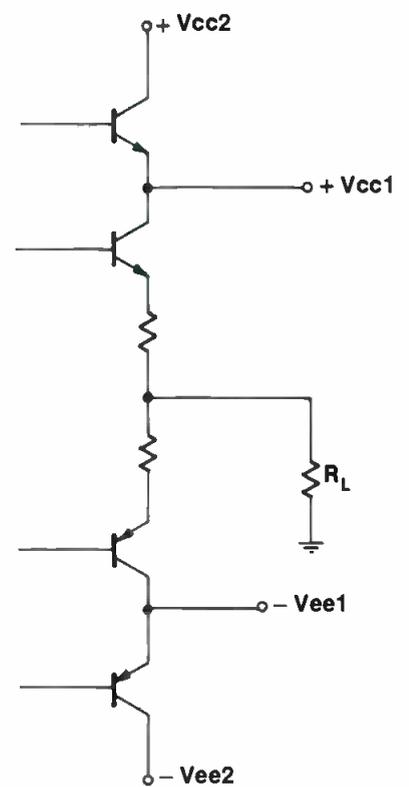


Figure 21. Power-supply ground-referenced with high-efficiency class G output stage with unity gain.

T1072 uses an FET input stage. Many times discrete designs use cascode-connected bipolar or FET differential amplifiers. A cascode-connected (see Figure 24) input stage is superior in performance to the standard differential amplifier (shown in Figure 25) in some areas. The cascode-connected input stage:

- provides better high-frequency response;
- raises the high-frequency input impedance because the cascode connection eliminates the input transistor Miller effect caused by the collector-to-base capacitance (C_{ob}); and
- gives superior power-supply rejection.

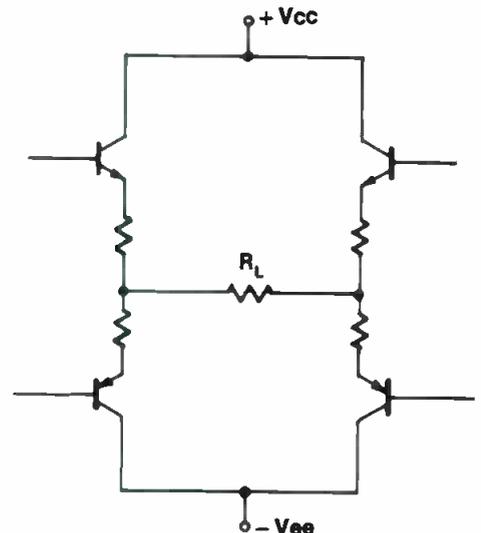


Figure 22. Floating bridge output stage with unity gain.

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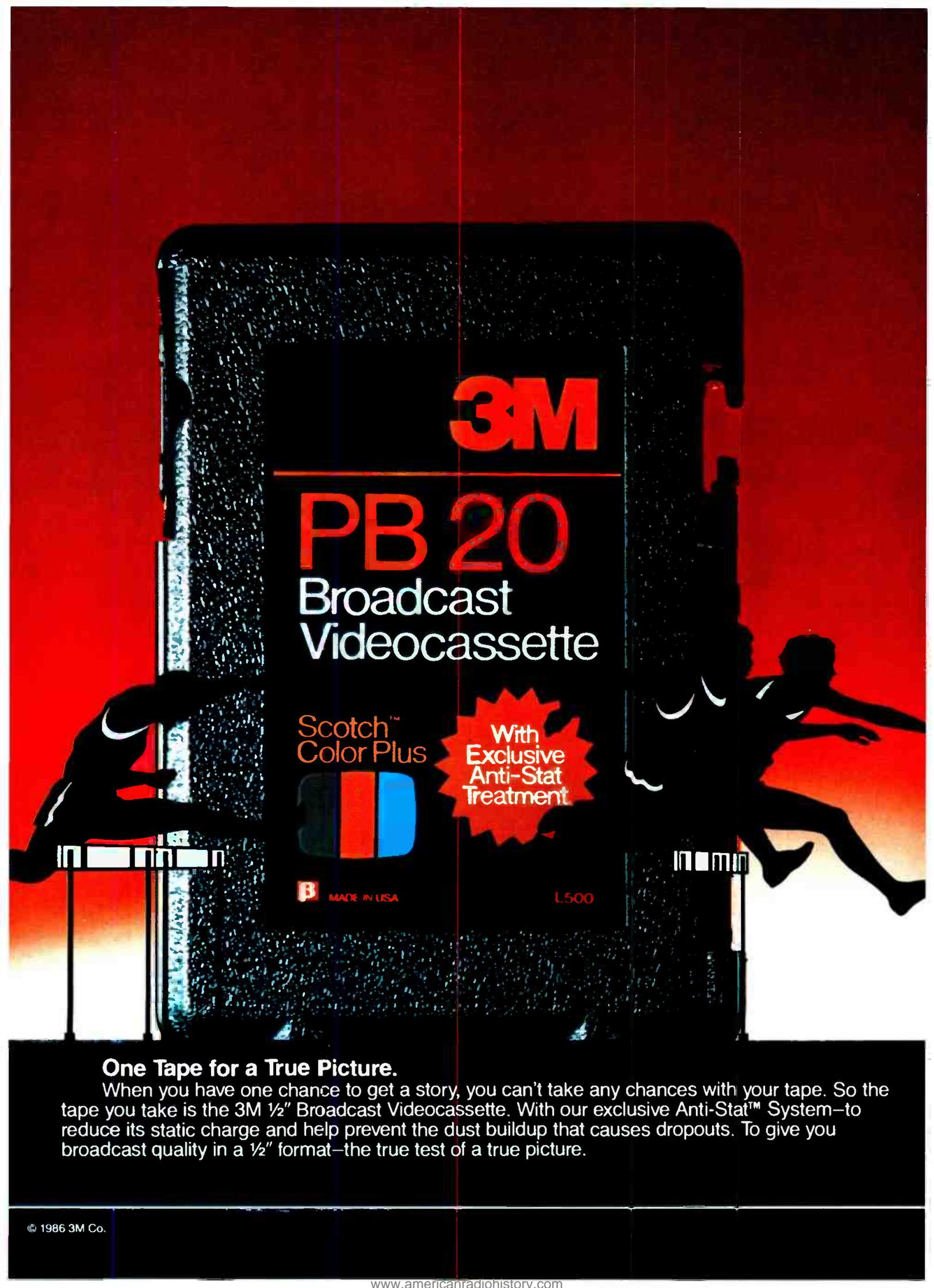
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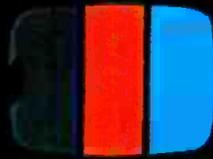
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Continued from page 68

tion rates for the amplifier because the first stage output impedance is determined only by the collector load resistance. Looking down into the collector of the cascode transistor, you would find that the output impedance can easily approach 100MΩ.

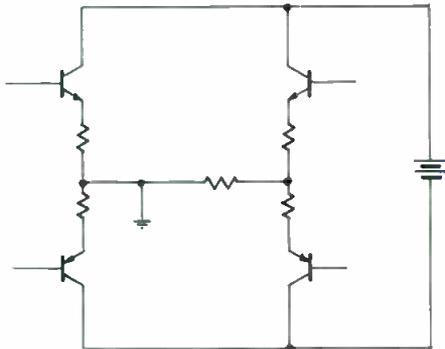


Figure 23. Floating power supply, ground-referenced bridge with unity gain.

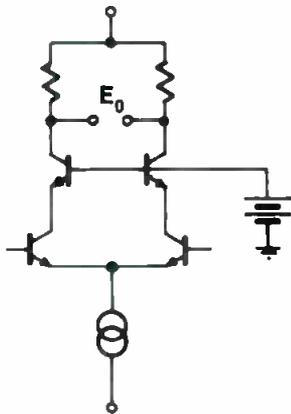


Figure 24. Cascode bipolar differential amplifier.

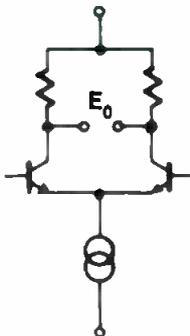


Figure 25. Standard bipolar differential amplifier.

Because of the high output impedance, cascode-connected input differential amplifiers are excellent voltage-to-current converters.

If the circuit topology takes advantage of the differential input stage, the power amplifier's power-supply rejection ratio can easily exceed 120dB. With more than 120dB of power-supply rejection ratio, the power-supply impedance and filter capacitor size become less of an issue when it comes to crosstalk and bass punch.

Some circuit designs have a poor power-supply rejection ratio, so adding a large amount of filter capacity can make an audible difference. The added capacitance reduces the power-supply impedance, reducing the power-supply-generated noise, which can leak into the amplifier's output circuits. This type of problem is especially evident in stereo operation.

Intermediate stage

The intermediate stage circuits, used to drive the output stage, can be classified as symmetrical or asymmetrical. In a symmetrical scheme, both the positive and negative signal swings are driven equally. This ensures that the interelement capacitances of the output stage and frequency compensation networks do not unbalance the signal, causing second harmonic distortion. When the output stage has equal drive, the large-signal frequency response of the positive and negative halves should also be equal. For this reason, the amplifier should exhibit a symmetrical slew rate. Surprisingly, however, amplifiers with symmetrical slew rates are among the minority.

An asymmetrical drive scheme is one in which the positive and negative half pull-up and pull-down are not equal. Active current source loads and bootstrapped resistive collector loads, unless carefully designed, will not deliver the same low-distortion performance as a symmetrical drive scheme. This is especially true at high frequencies. There are some 0.002% THD amplifiers on the market using asymmetrical drive. However, the amplifiers achieve the low distortion with more negative feedback than would be used with a symmetrical drive approach.

Slew symmetry, high-frequency stability and overload recovery are the performance characteristics that are the most visible artifacts of an asymmetrical drive scheme. These factors are especially noticeable when the amplifier is driven into its non-linear region.

When an amplifier is driven into clipping, the small signal analysis flies out the window and the other phenomena control the amplifier's performance. The differences between asymmetrical and symmetrical drive become especially apparent during overdrive conditions. In light of this, it is not valid to evaluate circuit performance solely on linear steady-state conditions. Figures 26 through 29 show four basic approaches often used for the intermediate stage design.

Output stage

Whether symmetrical or asymmetrical in design, the output stage voltage and current drive use discrete devices. These devices provide voltage amplification and the necessary level shifting to provide the full load signal swing needed with unity gain output stages such as emitter follower (bipolar) or source

follower (MOSFET) circuits.

In many designs, most of the total amplifier distortion is not produced by the output stage, but by the drive stage. A well-designed drive stage will measure less than 0.05% THD with no feedback applied. Depending on the beta linearity, transconductance and circuit design, it is possible to get the output stage distortion down to the 0.05% level. Again, this 0.05% THD value is obtained before the feedback loop is closed around the amplifier.

Maintenance

To ensure long, healthy, high-power amplifier life, you will need to perform some periodic maintenance. If the units are fan-cooled, filters will need to be cleaned. After several thousand hours of

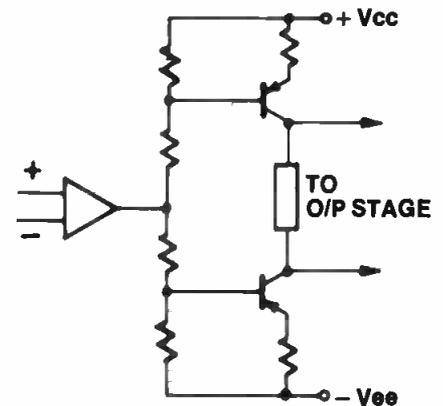


Figure 26. IC front end with discrete level shift, symmetrical drive.

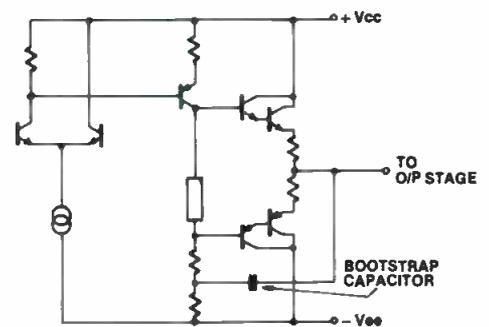


Figure 27. Asymmetrical discrete design using a bootstrapped collector load on intermediate (voltage gain) stage.

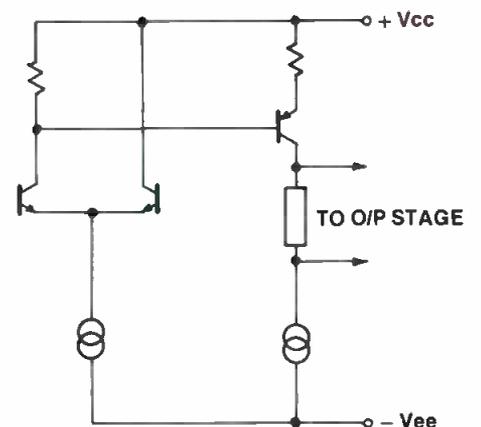
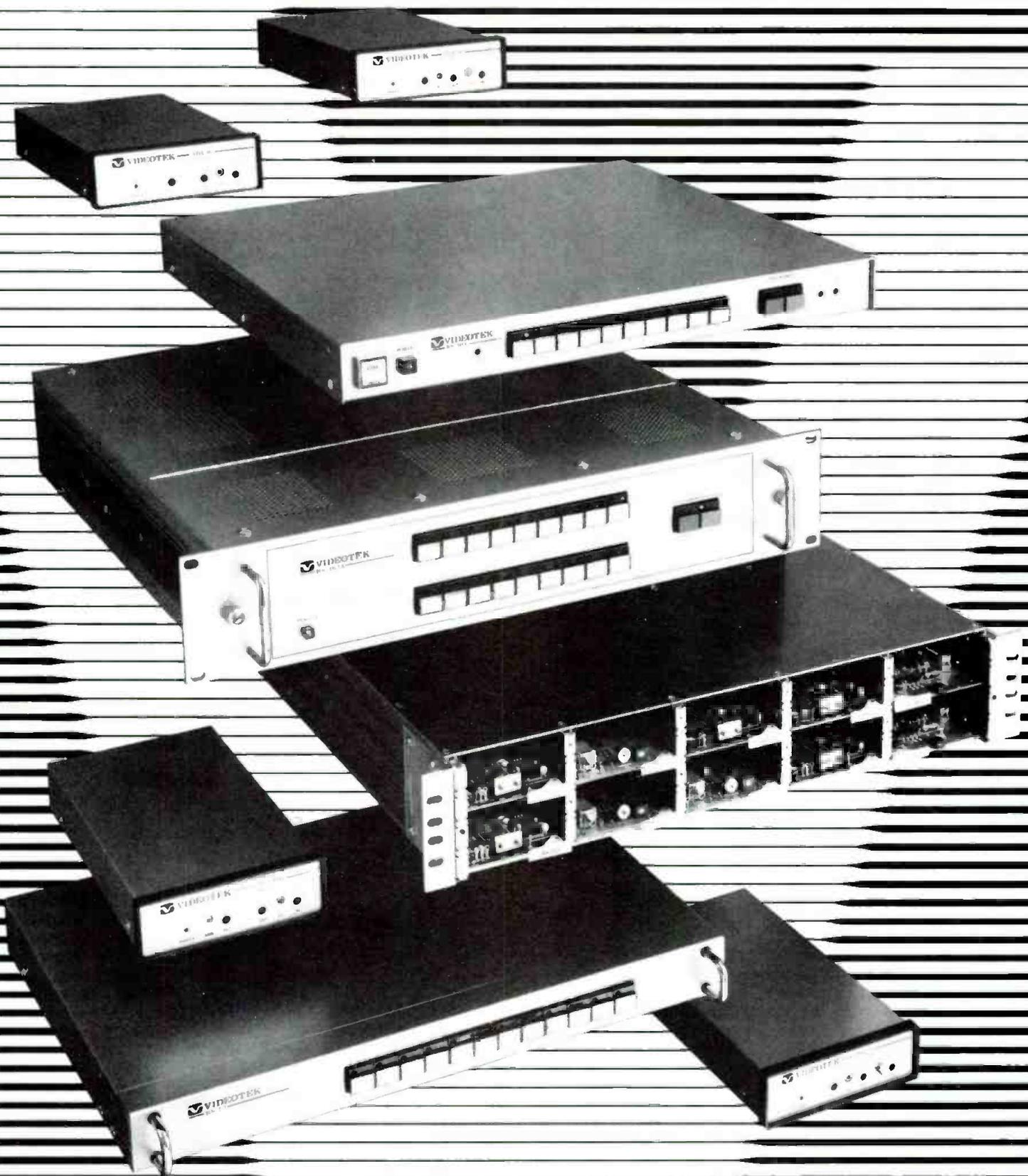


Figure 28. Asymmetrical discrete design using a current source for second stage load.



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operation, the fans will have to be replaced because the bearings will fail.

More insidious, however, are failures that occur after several years of operation. Experience with many hundreds of amplifiers indicates that the dominant cause of failure is a dramatic increase in thermal resistance between the output transistor and its heat sink. In the typical situation, there are two mechanisms causing the output transistors to fail after a period of time.

The first, and most obvious, is the gradual loosening of the mounting screws. These screws clamp the output transistor to the heat sink. The heat sink's continuous expansion and contraction during thermal cycles causes many fasteners to loosen.

The second cause of amplifier failure is the eventual evaporation of the silicon oil used in the zinc oxide/silicon grease

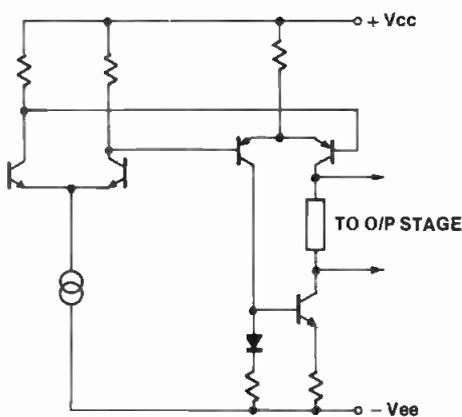


Figure 29. Symmetrical discrete design also known as Wilson current mirror.

thermal joint compound. After repeated thermal cycles, the silicon oil is squeezed

out of the compound and evaporates. This results in a poor thermal joint and, possibly, a loose transistor. This poor thermal contact will cause the transistor to run much hotter, even to the point of destruction.

The solution to these two types of problems is simple. Simply check the mounting screws and joint compound every two or three years. Tighten the screws and replace the joint compound as needed and you may avoid catastrophic amplifier failure.

As you can see, there are a number of important elements involved in the design of a power amplifier. Although you may not want to investigate the internal design for each amplifier you purchase, being aware of what elements comprise a good speaker power amplifier can help you choose the best unit for your particular application.

MOSFET technology

By Harry Klaus

Some amplifiers use an output transistor called a MOSFET (metal oxide silicon field effect transistor). MOSFET indicates a fundamental difference from bipolar in the operation of the devices.

Field effect transistors operate by modulating electron flow from the source to drain. This is accomplished by making thousands of small paths through which the electrons must migrate. Each path has a gate conductor positioned close to, but insulated by, a metal oxide layer. Electron flow through each path is controlled by the electrostatic field from the gate electrode, which leads to the name field effect. Because the gate is insulated, and needs no current to drive it, it takes only voltage.

Klaus is director of engineering for the David Haffner Company, Pensauken, NJ.

The field effect transistor responds rapidly to changes in gate voltage, as compared to the time necessary to turn on a bipolar device. This is also true when the drive is removed. There is no such thing as stored charge in an FET.

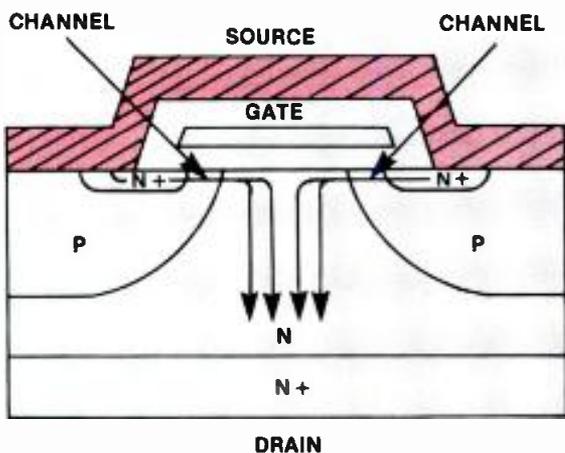
Input parameters

The bipolar transistor is a current-driven device. A current must be applied between the base and emitter terminals to produce a larger current flow in the collector. The MOSFET is fundamentally different. A voltage applied between its gate and source terminals will produce a current flow in the drain.

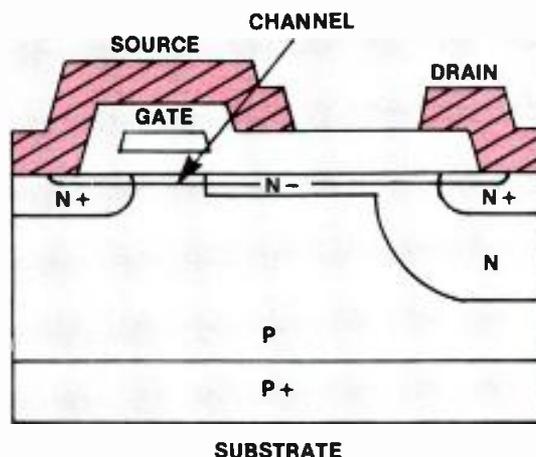
Only a small amount of current flows in the MOSFET gate for a specified level of drain current. Therefore, the rated input impedance of the MOSFET is much higher than for a bipolar device. However, the

MOSFET has an input capacitance that must be charged and discharged if the drain current is to be changed. To further complicate matters, during the transition from the turned-off state to the turned-on state, the effective input capacitance changes noticeably.

The base-to-emitter voltage required to turn on a bipolar device is about 0.7V. However, depending on the type of MOSFET used, it may require from 1V to more than 10V between the gate and source to turn on this device. When using the common-source output configuration, the driver stages can use either the same voltage as the output stage or a higher voltage from a separate supply. Using the same supply voltage as the output stage lowers the efficiency, resulting in more heat dissipation. However, building a separate higher voltage supply for the driver stage increases the circuitry cost



Cross-sectional structure of a vertical-type MOSFET.



Cross-sectional structure of a lateral-type MOSFET.

Continued on page 78

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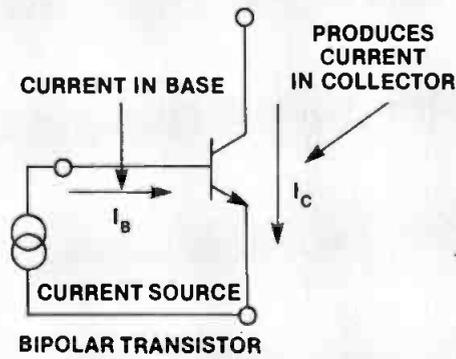
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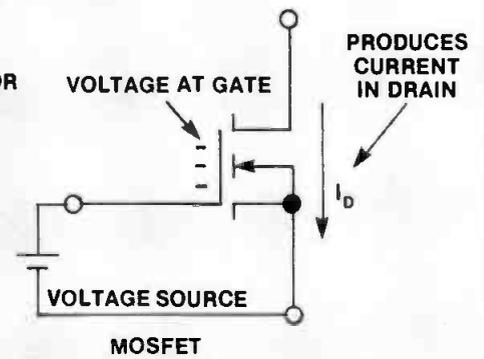
Continued from page 74

and complexity. The common-source arrangement for the output stage eliminates the efficiency disadvantage, but at the cost of circuit complexity.

Because MOSFETs have a high power bandwidth figure, they have a greater tendency to oscillate. Care must be taken in the interface between the drive circuitry and the MOSFET's gates. Of the two basic types of MOSFETs, the vertical type seems to be more prone to self-destruction than the lateral type, if allowed to oscillate. The gate-to-source voltage must be limited or the device will be destroyed.



Block diagram of a bipolar output device, which is current-driven.



Block diagram of a MOSFET output device, which is voltage-driven.

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Output parameters

The bipolar device is more efficient, because the voltage drop across the device is less as saturation is approached. The MOSFET, however, has an area of constant resistance that eliminates the need for the emitter resistor, which accounts for losses in bipolar circuits. Also, the MOSFET has an area of constant current, an advantage in power-supply rejection.

Another MOSFET advantage is that it does not display the secondary breakdown phenomenon that can (and often does) destroy a bipolar device. This reduces the need for complex protection circuitry that can also be sonically degrading. Protection must be provided, however, to assure that the MOSFET gate-to-source voltage limit is not exceeded.

Thermal considerations

The MOSFET's positive temperature coefficient characteristic makes it easy to connect devices in parallel. In parallel wiring, the current through a MOSFET decreases as temperatures increase. If one device is handling more than its share of current, its temperature will rise, reducing its current level to match other MOSFETs within the grouping. This characteristic prevents thermal runaway.

You might expect thermal tracking of the output device to be unnecessary. However, MOSFETs have a negative temperature coefficient when operated below a certain current level. At low drain currents for a given gate-to-source bias voltage, an increase in temperature causes more current to flow. At higher currents, above the point where the curves cross, the opposite is true. This transition point varies from about 100mA in the Hitachi lateral type to more than 10A in some vertical types.

The thermal tracking circuitry for MOSFETs can be eliminated if the device quiescent current is above this transition point. The compensating feature means that fewer devices of a given wattage may be required for similar output levels.

The typical MOSFET wattage rating is lower than for a bipolar device with a similar case type. Typical values run

Continued on page 81

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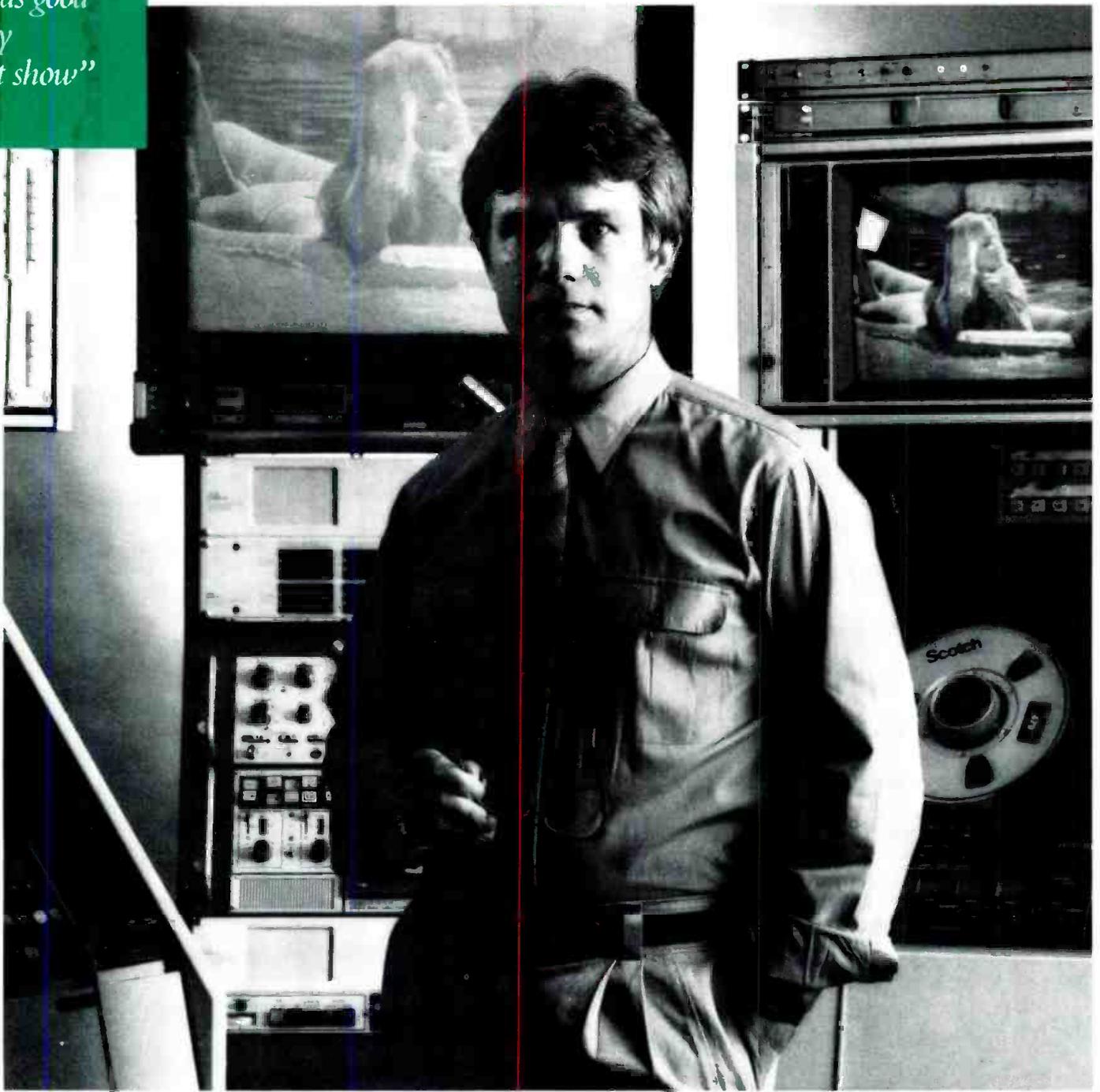
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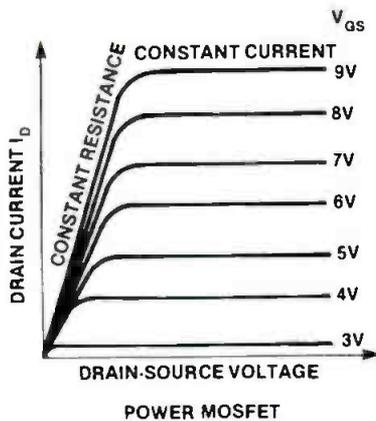
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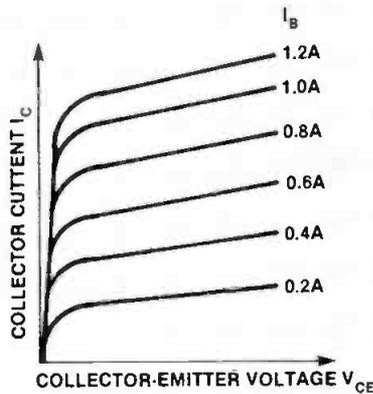
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POWER MOSFET



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Comparison of the idealized output characteristics of bipolar devices and power MOSFETs.

Continued from page 78

from approximately 100W to 150W for MOSFETs and 200W to 250W for bipolars with a TO-3 type case. The lack of secondary breakdown problems generally associated with the MOSFET allows greater use of its potential.

Because of the MOSFET's high-frequency power bandwidth and its corresponding tendency to oscillate at high frequencies, special attention should be given to bypassing the power-supply rails. The bypassing should be located as close as possible to the output devices. Ground returns should be as short as possible. Each channel should have its own grounds returned to a central point at the power supply.

At high frequencies, bipolar devices tend to draw more current. This is because it takes time to clear the minority carriers out of the base region. With push/pull circuitry, both the positive and negative devices are turned on at the same time. Conversely, current drawn by MOSFETs is the same at any frequency because they can be turned off much faster. With no increase in current at high frequencies, the power-supply requirements are the same for low frequencies, and there is generally no major increase in heat dissipation.

Editor's note: This article is meant only as a summary of the MOSFET and bipolar technologies. For more information, contact power amplifier or MOSFET device manufacturers.

Glossary

MOSFET

Metal oxide silicon field effect transistor. A device in which the current flow between the source and drain terminals is controlled by an electric field, caused by application of a voltage to the gate terminal.

Bipolar

A 3-terminal p-n junction device in which the current flow between the emitter and collector terminals is controlled by a current applied between the emitter and base terminals.

Common source

A hookup configuration in which the source terminal is connected to a fixed reference point and the output signal is taken from the drain terminal.

Power bandwidth

The frequency extremes at which the amplifier output is 3dB less than its rated output at 1kHz for a constant input level.

Vertical/lateral FET

A presentation of the direction of current flow as seen in a cutaway view of the device.

Saturation

A level of current flow producing the minimum voltage drop across the device.

Temperature coefficient

A rating of the change in current flow when the device temperature changes and all other parameters are held constant.

Thermal runaway

A regenerative process whereby an increase in device temperature causes an increase in current flow which, in turn, produces a greater temperature increase.

Quiescent current

The idling current flowing in a push/pull circuit used to prevent simultaneous turn-off of both devices.

Secondary breakdown

A catastrophic failure mode in bipolar devices which occurs when the maximum voltage is exceeded, damaging a portion of the device. This is followed by a regenerative process that rapidly increases current, quickly destroying the device.

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Guidelines on camera maintenance

By K. Jayaraman
and Bernd Poth

The same problems occur in all types of cameras, whether manual setup or computer-aligned. The symptoms can lead you to the solutions.

The technical quality of a TV program begins with video signals generated by the camera. Any deviation from proper operation results in compromises of the final product quality. Any TV production facility, then, must have cameras that operate at the peak of their capability at all times.

Troubleshooting cameras is difficult if you do not know the basic principles of their operation. Even if you have a thorough knowledge of how cameras operate, the process can still present problems. The sheer number of different manufacturers' models adds to the complexity of rapid troubleshooting and repair. Computer-controlled camera chains with diagnostics can take much of the mystery out of troubleshooting a system failure. However, not every facility has that advantage.

Just as there are similarities among the many different models, there are similar problems that may develop. Following is a general troubleshooting guide that can

be applied to any camera, whether ENG or studio, manual or automatic. In each case, a type of failure is listed. It is followed by several possible causes (in italics) and their possible solutions. By using this guide, along with the diagrams in your camera operation manual, you should be able to more easily locate the source of problems.

•No picture output.

No power:

Check on/off power switch position. If the camera is battery-operated, check the battery condition and connections.

Fuse defective:

Check fuse. Replace burned fuse(s) only with proper replacements.

Camera in standby mode:

Switch from standby to operate.

Obstruction in optical path:

Is the lens cap still in place? Check the

position of any filter wheels. Avoid pointing the camera at bright lights while determining the problem.

Video output cable not connected:

Check video cable and all connections. Repair any questionable connectors.

Monitor defective:

Check the monitor or use a different one.

Beam failure:

Check beam supply and sweep circuits. Most cameras have an automatic shut-down circuit to protect the camera tubes in the event of sweep failure. If sweeps are absent, the beam is disabled.

•Color-bar signal works; no through-the-lens video.

The problem may be in the camera head or may be lack of power to the head. If the unit is an ENG/EFP camera, the pickup pre-amps may have failed:

Check for video signals into the color

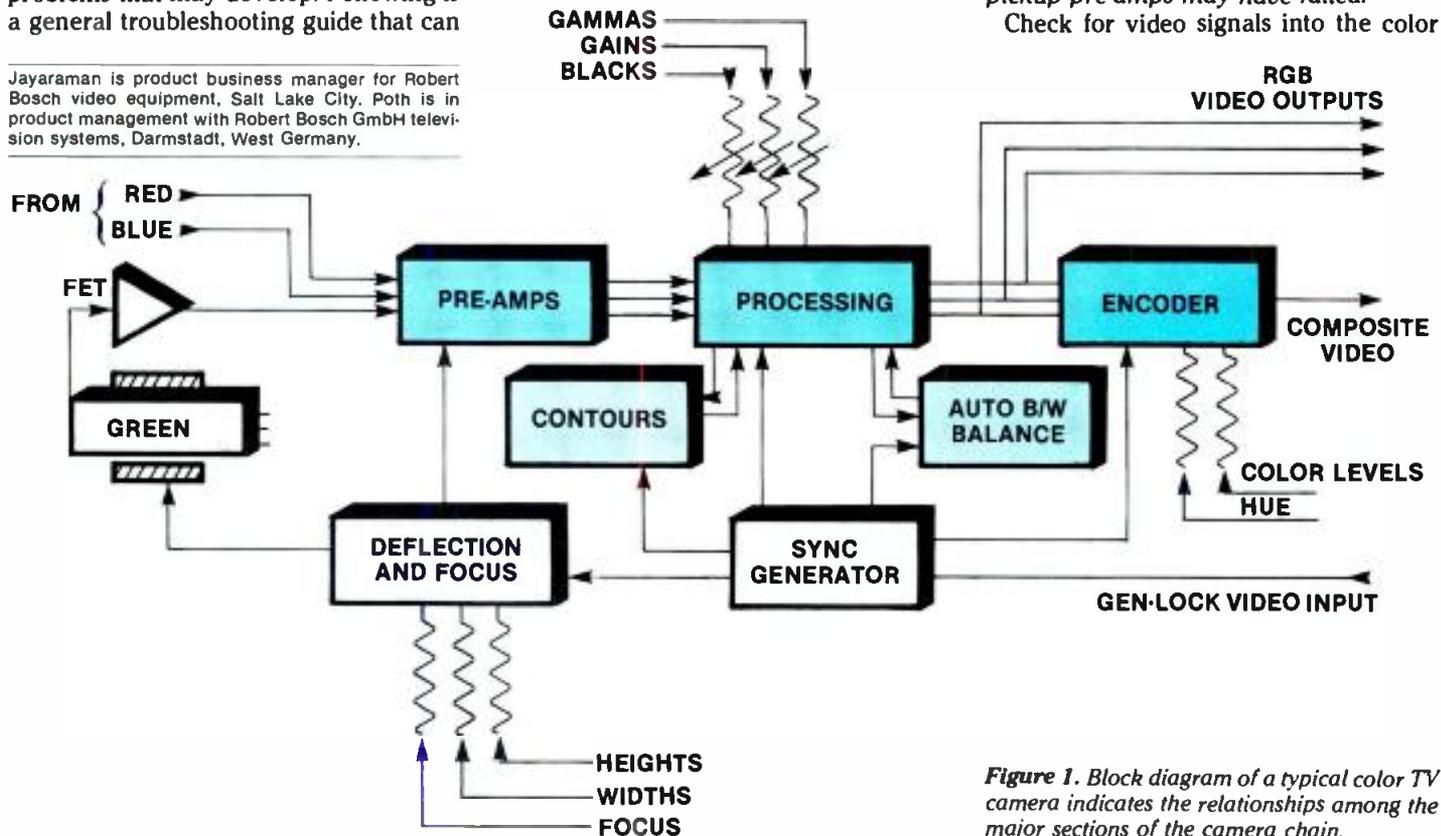
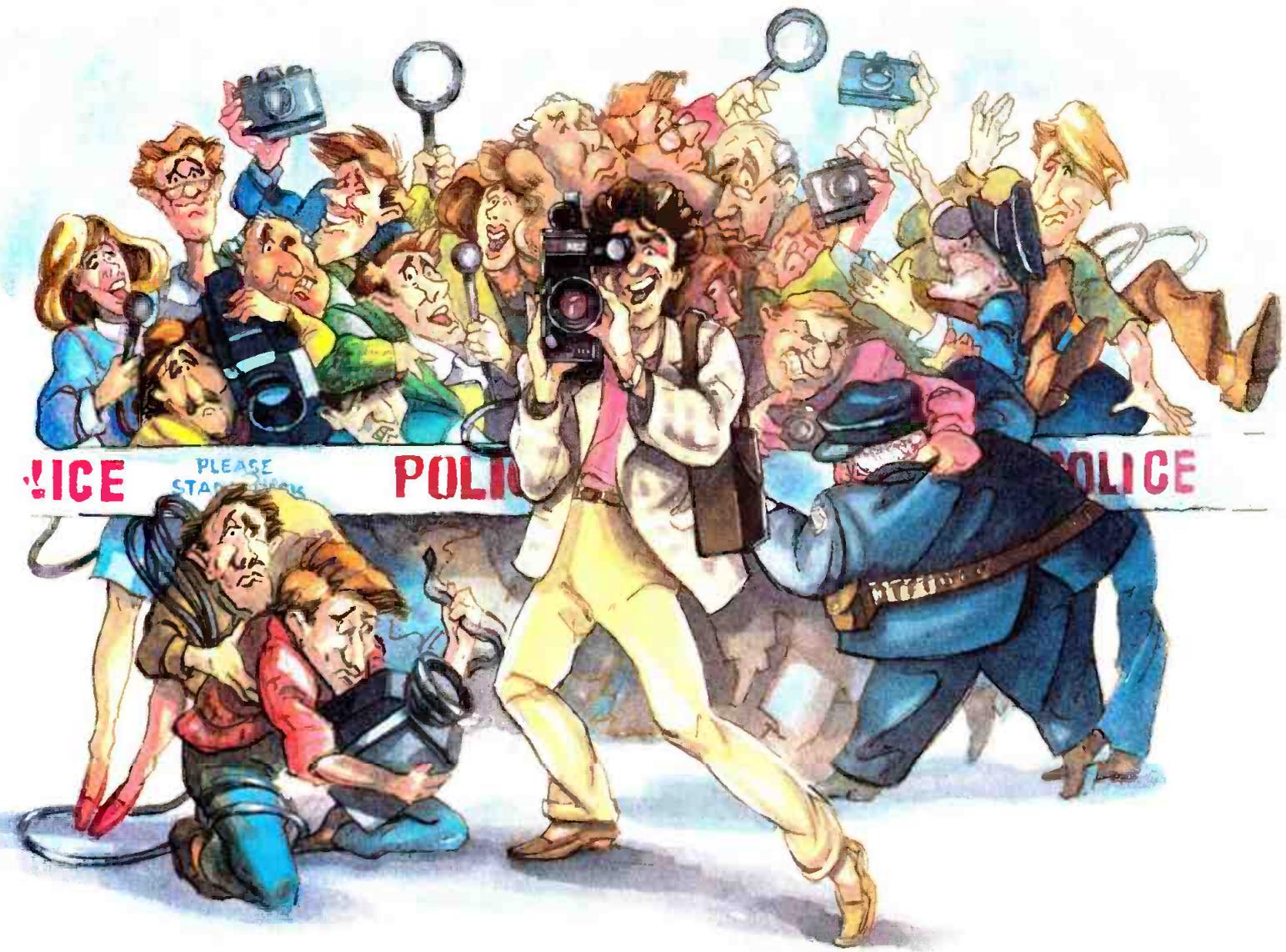


Figure 1. Block diagram of a typical color TV camera indicates the relationships among the major sections of the camera chain.



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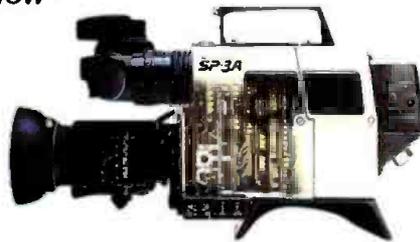
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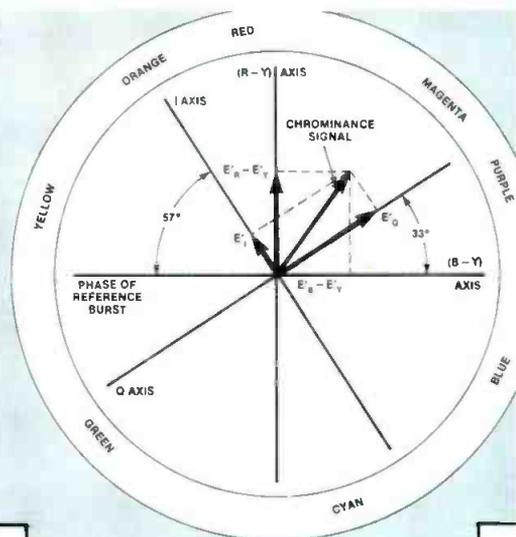
Color equations

Do not make indiscriminate adjustments. Remember that in typical 3-pickup cameras the luminance signal is derived primarily from the green channel. When color is turned off, pictures on the monitor will be affected more by changes to green circuits, than to red and blue. They do not operate completely independent of one another. The reason for this interac-

tion results from the formulation of luminance and chrominance signals from the RGB components, as shown by the following equations.

$$E_M = E_Y' + [E_Q' \sin(\omega t + 33^\circ) + E_I' \cos(\omega t + 33^\circ)]$$

where



The phase relationships in an NTSC chrominance signal can be viewed according to I/Q or R-Y/B-Y axes.

$$E_I' = -0.27(E_B' - E_Y') + 0.74(E_R' - E_Y')$$

$$E_Q' = 0.41(E_B' - E_Y') + 0.48(E_R' - E_Y')$$

and

$$E_Y' = 0.30E_R' + 0.59E_G' + 0.11E_B'$$

The color difference signals, according to NTSC, are E_I' and E_Q' , as indicated in the diagram as the resolution of the chrominance signal onto the I and Q axes. I and Q are said to be in quadrature because of the relationship of the sine and cosine functions in the first formula.

The secondary color difference signals, finding greater popularity through component products, E_{R-Y} and E_{B-Y} may be seen as the resolution onto the R-Y and B-Y axes. R-Y and B-Y are also common in encoder and decoder designs because fewer and less expensive components are required to achieve the R-Y/B-Y decoding axes.

The differences between R-Y/B-Y and I/Q are in terms of the angle referred to the phase of reference burst and the difference axes. In addition, while R-Y and B-Y are of equal bandwidths, Q is bandwidth limited compared to I. The I axis (the orange to cyan) is more critical to response of the human eye in creating color detail in the decoded picture than Q axis (the magenta to green). For that reason Q can be limited more than I with acceptable results.

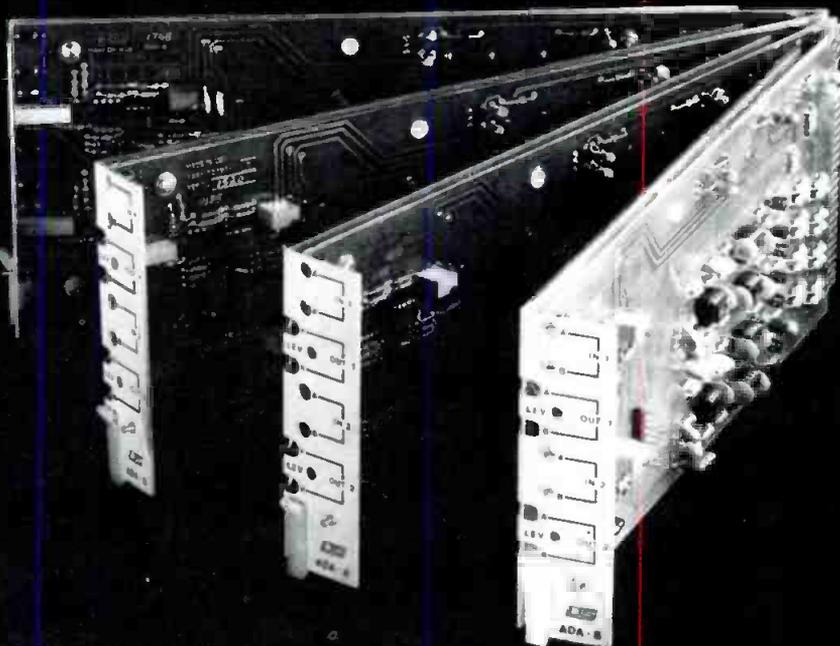
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encoder. If there are no inputs to the encoder, begin with the pre-amps and trace the path to the encoder.

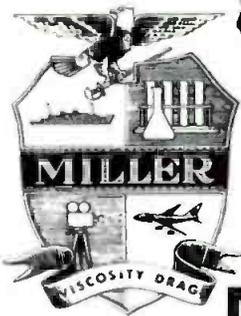
•Unnatural colors in pictures. Whites have color tints.

Encoder is improperly adjusted. Subcarrier appears in white areas on waveform monitor:

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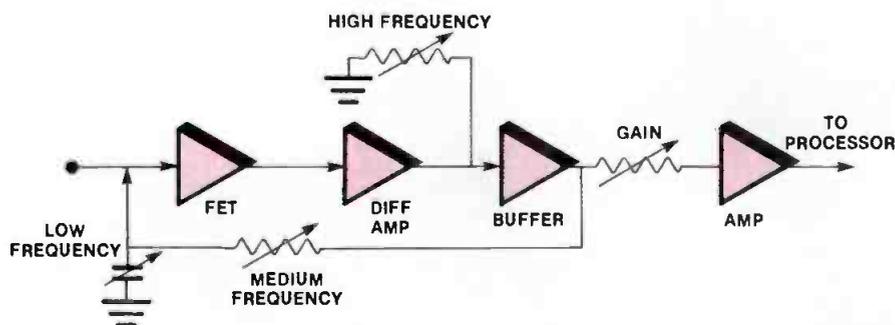
Pre-amps

Signals produced from camera pickup devices are measured in microvolts. In order to avoid interference to such small signals, the signal levels are increased by pre-amplifiers, which are usually located as close as possible to the output connections of the tubes.

Because video signals include frequency components ranging from dc to at least 5MHz, wideband circuits must be employed for the amplification. Such circuits require compensation

components to control the wide frequency span. Improper settings of peaking capacitors and resistors can result in oscillations in pre-amp circuits that cause interference in the color channel.

Avoid pre-amp adjustments unless camera tubes have been changed. Then, make such adjustments only if necessary. They are critical to quality pictures and should be made only after studying a circuit diagram to learn how each affects the overall signal.



Camera pre-amplifiers use high-gain wideband circuits with compensation capacitors to aid in gain control.

Switch the camera to color bars and adjust the encoder for the correct bar presentation. If there are still problems, make certain that RGB signals are present at the input to the encoder.

- Output signal amplitude too high or low.

Input to monitoring equipment not terminated or double terminated:

Check signal path from the camera to the monitoring equipment. If the signal loops through several monitoring units, check for correct terminations. A single 75Ω termination should appear only at the input of the final unit in the chain.

Lens servos not operating correctly:

Check the operation of automatic circuits, in particular the iris.

- Output video level too low.

Insufficient light or improper beam settings:

Increase the iris opening or illumination on the scene. Check for proper beam alignment.

- Black bars rolling upward through the picture.

Power-supply regulation causing hum in video and/or sync:

Check all power supplies in the camera, sync and monitoring equipment for correct dc voltages and for dc purity. Check the condition of any high-farad capacitors used between dc buses and ground throughout the circuitry. Repair all supplies that show lack of regulation as hum on the dc waveform. Also check all coaxial video and sync connections for failures or intermittent grounding conditions.

- Output video is noisy.

Gain switch set too high:

Check position of the gain switch. Additional gain should be used only if available light is insufficient to achieve a proper output signal level. The use of unnecessary gain increases the presence of inherent circuit noise.

Beam alignment is improper:

Check the beam adjustment according to the camera operation manual.

Pre-amp or pickup tube in one of the channels is defective:

Monitor output of the individual channels to isolate a bad pre-amp. If the pre-amp seems to be working, replace the tube.

AGC circuitry is defective:

Check AGC circuits.

- Output video bar signal has no color.

Individual RGB channels are not equal; color balance is wrong; or incorrect filter position is in use:

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white surface. Check the position of all filter wheels. Manually adjust the channels and color temperature to achieve the proper white.

•Output video shows improper coloring in black, gray and white areas.

Red, blue or green channel is missing from final signal:

Monitor the output with test signals, then use the standard gray scale chart to see if all three color channels are present.

•Output video has improper color in

dark/black areas.

Black level or shading is incorrect:
Adjust the black levels and shadings.

•Despite alignment of black and white levels for the three channels, output video shows improper color.

The gamma of one or more channels may be incorrect:

Adjust the gamma alignment of the three channels with a gray scale test chart. Begin by setting the middle step of the crossed-stairstep pattern at 54 to 56 IRE units for the green channel.

Then match the red and blue channels to the green. The ascending and descending diagonal stepped lines should be straight. Incorrect gamma causes a bowing of the diagonals.

Flare compensation is incorrectly set:
Adjust flare compensation controls according to the instruction manual.

•Picture is out of focus although the lens is adjusted for best focus.

Tube back focus setting is incorrect:
Check the back focus. Green should be set first. Red and blue should be adjusted to match green.

Electrical focus is incorrect:
Check electrical focus circuits and adjustments. Follow the instruction manual to set green focus and subsequently red and blue.

Dirty optical path:
Check front and rear lens elements and prism/optical block for dirt. Clean the surfaces with approved material, according to the lens and camera manuals.

Contour/detail signals inactivated:
Switch contour/detail or enhancement circuits on. If focus does not improve, check those circuits for failure.

•Picture is out of focus over the zoom range.

Back focus of the lens/tube path is not correct:

Check the back focus of the tubes. Always use the green channel as a reference and adjust the red and blue channels to match. Make certain that the camera lens is specified to match the back focus capability of the camera in question.

•Edges of the picture produced by the camera have color fringing.

Camera registration is incorrectly set:
Check red, green and blue registration. Match red and blue to green channel.

•In output video, black levels are below zero, while brighter points in the output show streaking and lag.

Bias light is defective:
Check the bias lamp for operation. Adjust bias circuits for correct values.

Beam optimization is incorrect:
Follow the instruction manual for adjustment of beam-optimizing circuits.

•Output video is pumping.

Auto iris oscillates:
Check the manual iris by disabling the auto iris system. If the signal is not stable, repair or adjust the auto iris system. If the iris system appears to be operating correctly, check the clamping circuits in the video chain.

| :? :)))

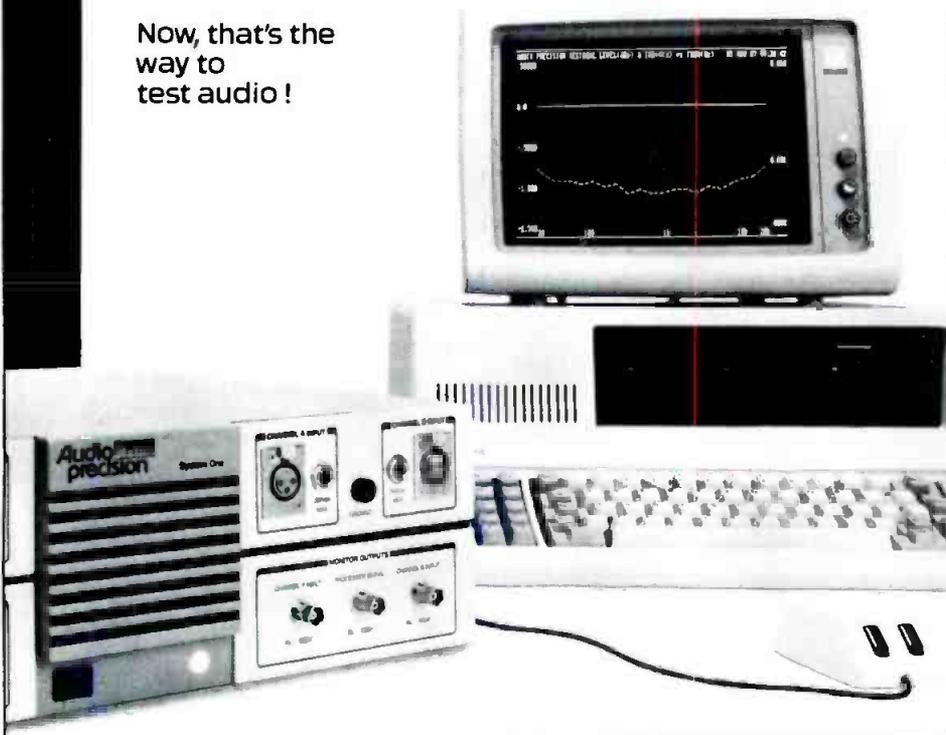
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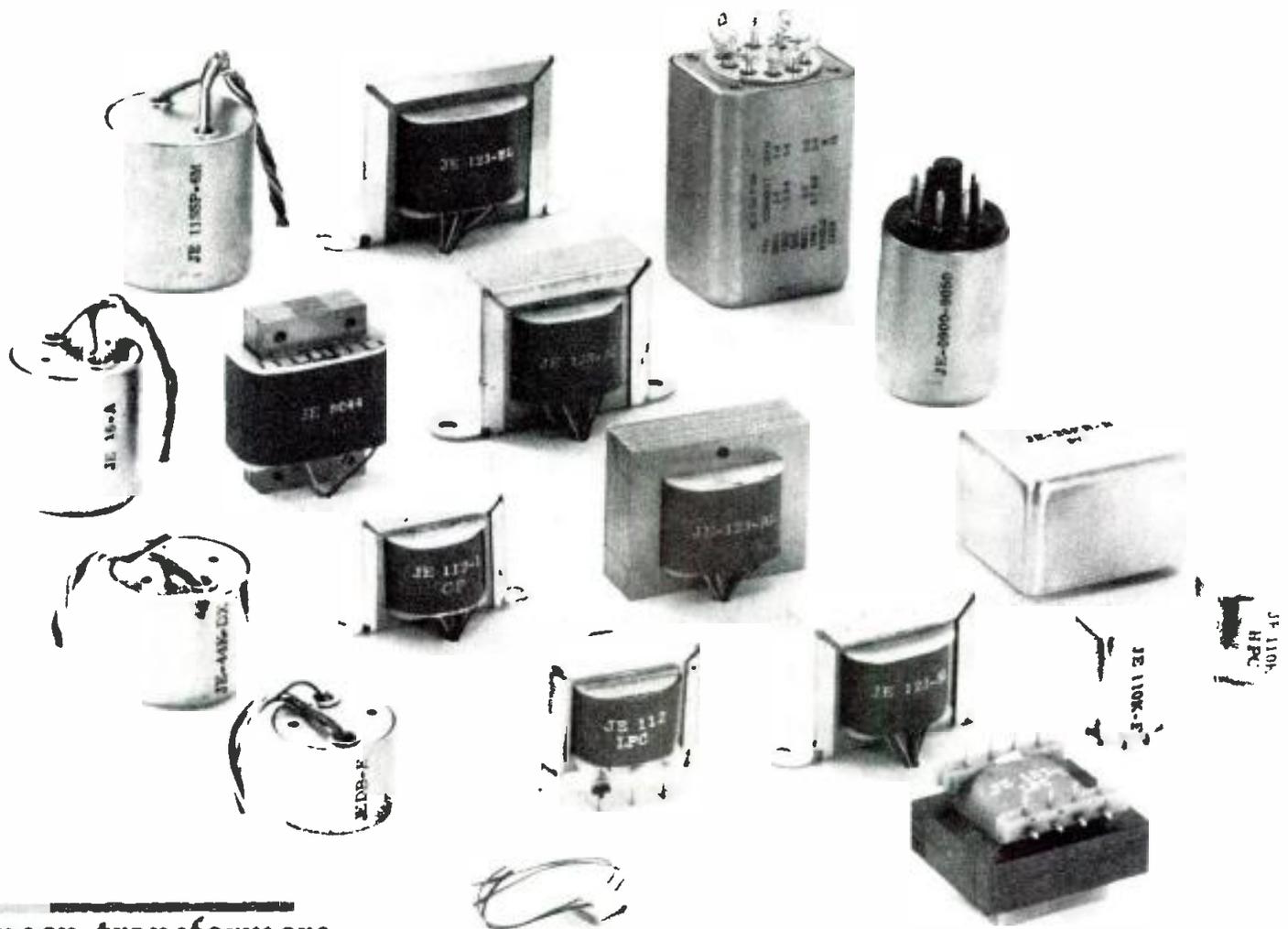
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TV camera optics

By Carl Bentz, TV technical editor

To shed light on TV camera optics, we must focus on laws of physics.

Light seems complex because it appears to exist in two different forms simultaneously. To explain camera tube or CRT operation, for example, the photon theory of energy packets with momentum might be more straightforward. To study optical systems—lenses, mirrors and prisms—the wave nature of light is more appropriate.

Millimicrons and terahertz

Wavelengths and frequencies ($\lambda = c/f$) determine the color of light ($c \cong 3 \times 10^8$ m/s, the velocity of light). The visible light spectrum ranges, in wavelengths, from $400\text{m}\mu$ to about $700\text{m}\mu$ ($\text{m}\mu = \text{millimicron}$). Those longer than red (more than $700\text{m}\mu$) are *infrared*, while waves shorter than violet (less than $400\text{m}\mu$) fall in the *ultraviolet* range. White light is a composite of all of the wavelengths between these two limits.

The frequencies of a light source do not usually change. The range spans from 1THz (1 terahertz = 10^{12} Hz) for infrared to almost 10^6 THz for ultraviolet. The speed of light does vary with the medium through which the light passes. Yet, only if there are certain motions of the source or of a mirror surface in the path of the light, do we see any apparent change in frequency in accordance with Doppler theory.

When light strikes

When light waves strike the boundary between two media, two different events may occur. (See Figure 1 and related article, "Reflections," page 102.) The light may be *reflected* from the surface (boundary), or it may pass into the new medium.

Reflection usually brings to mind mirrors, within which an image seems to appear. Reflection also occurs with rough surfaces. Light becomes *diffused*, because as the light rays take different directions, they are no longer parallel with one another. Instead of an apparent image, the reflecting surface is seen.

When light strikes a junction between two media, at least some of the light will be reflected. In fact, beyond a certain critical angle of incidence, all light is

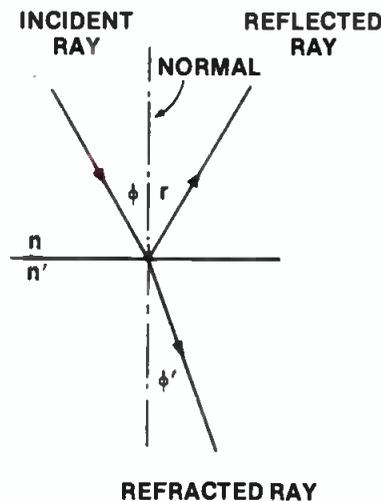


Figure 1. The smooth surface reflects light by keeping the rays relatively parallel to one another, while the rough surface scatters or diffuses the rays. Only the reflecting surface itself is visible.

reflected. To reduce reflection and increase efficiency, coatings may be applied to a lens. Calcium or magnesium fluorides as coatings reduce reflection to 1% to 2% of the incident light. (It is curious that hydrofluoric acid, from which these chemical salts are formed, etches some types of glass.)

When non-reflected light passes through the media junction, the new medium dictates what happens. If the material is *transparent* (a clear glass), light passes through, the rays remaining relatively parallel. The object that was the source of the light waves is visible through the glass.

Translucent material, a variation on transparency, causes partial scattering or non-uniform bending of light waves as they move. If an object is viewed

through translucent material, its basic shape may be visible, but detail is lost because information that forms the image has been rearranged.

Opaque material absorbs and/or reflects light from numerous irregular internal surfaces. The light cannot pass directly through or escape, and nothing emerges on the opposite side.

The media

Optical systems for TV cameras consist of combinations of lenses and prisms. The optical system concentrates light from a scene, separates it into red, green and blue components, and focuses the three color images on the light-sensitive faceplates of the pickup devices. The shapes, placements and specific glasses in optical elements of the camera all play a role in making this possible.

As light passes through a medium, a characteristic *index of refraction* can be determined for that material. The index is a ratio between the speeds of light in free space and in the material. Unless a specific wavelength is stated, the index is determined from the primary wavelength ($589\text{m}\mu$) of a yellow sodium flame.

The index for air at standard conditions (20°C and 760mm Hg) is often stated as *unity* (1) for simplicity, but that is far from true. Violet ($436\text{m}\mu$) and red ($656\text{m}\mu$) lights produce indices of 1.0002957 and 1.0002914, respectively. The difference, although appearing small, is sufficient that astronomers must make corrections in star position calculations. Their job is more complex because the refractive index of air varies with the depth and density of the atmosphere.

The red-to-violet variance in the index for a medium (the *dispersion*) explains how an equilateral prism breaks white

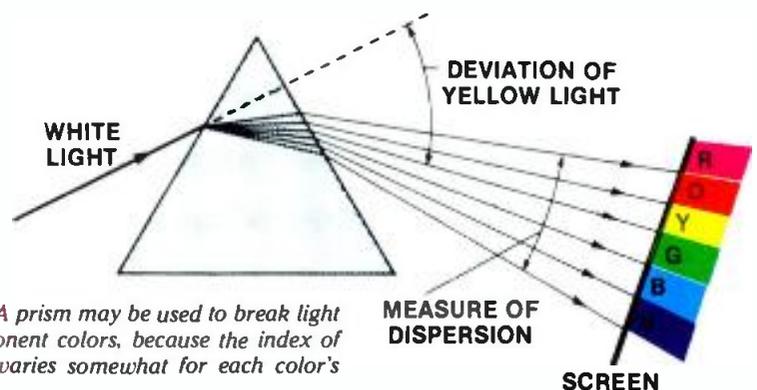


Figure 2. A prism may be used to break light into component colors, because the index of refraction varies somewhat for each color's frequency.

Acknowledgments: Assistance in the preparation of this article was provided by Angenieux, Canon, Fujinon, Schneider and Tamron. Some graphics adapted from Television Engineering Handbook (edited by Blair Benson). McGraw Hill, 1985.



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light into a rainbow spectrum. Each wavelength is affected linearly. For less energetic light of longer wavelengths, less bending occurs. (See Figure 2.)

As light passes from one medium to another, the rays are bent or refracted. The amount of bending depends upon the refractive index of the media and the angle at which light falls upon the junction between them. (See Figure 3.) The thickness of the second medium (for example, a lens) through which the light passes will also determine the overall change in direction.

Components

A complex TV zoom lens must pass the wide bandwidth of visible white light, bending it as necessary to form an image on the pickup devices. Ideally, all elements in the lens will provide frequency-independent refraction of the light. Any deviation (dispersion) causes *chromatic aberration*. In TV optics, a result is an undesirable separation of colors, which appears as fringes around objects. (See Figure 4.)

The greater the bending power of the lens (that is, the greater the surface curvature), the greater the effect dispersion will have on the image formed by the lens. This fact creates a problem in the manufacture of high-magnification lenses.

A simple convex lens (see Figure 5) has

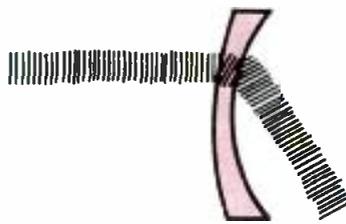


Figure 3. The amount of bending as the light ray enters the lens is determined by the index of refraction of the air and glass. As the ray passes back into air, it is bent again.

two focal lengths. One (F) is the distance from the lens to the image for which an object exists at infinity (as in a camera). F' is the distance from the lens to the object for an image at infinity (as in a projector). If both faces of the lens have the same curvature, then the two distances are equal ($F = F' = f$), and the lens may

Figure 4. Different refractive indices can result in various colors focusing at different points.

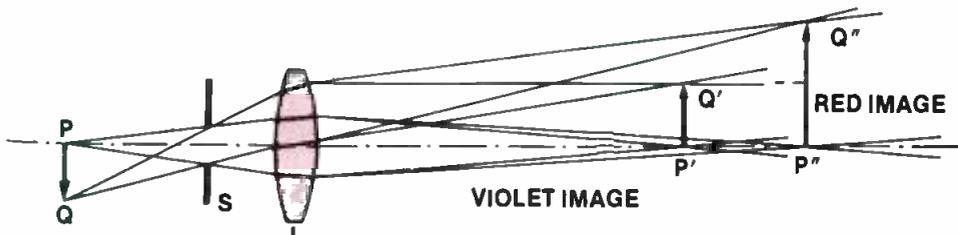


Figure 5. Theoretically, a simple double convex lens has two focal points. In the TV camera, the fixed focal point for an infinite object distance is most important. Between the lens and point F' an erect, magnified image occurs.

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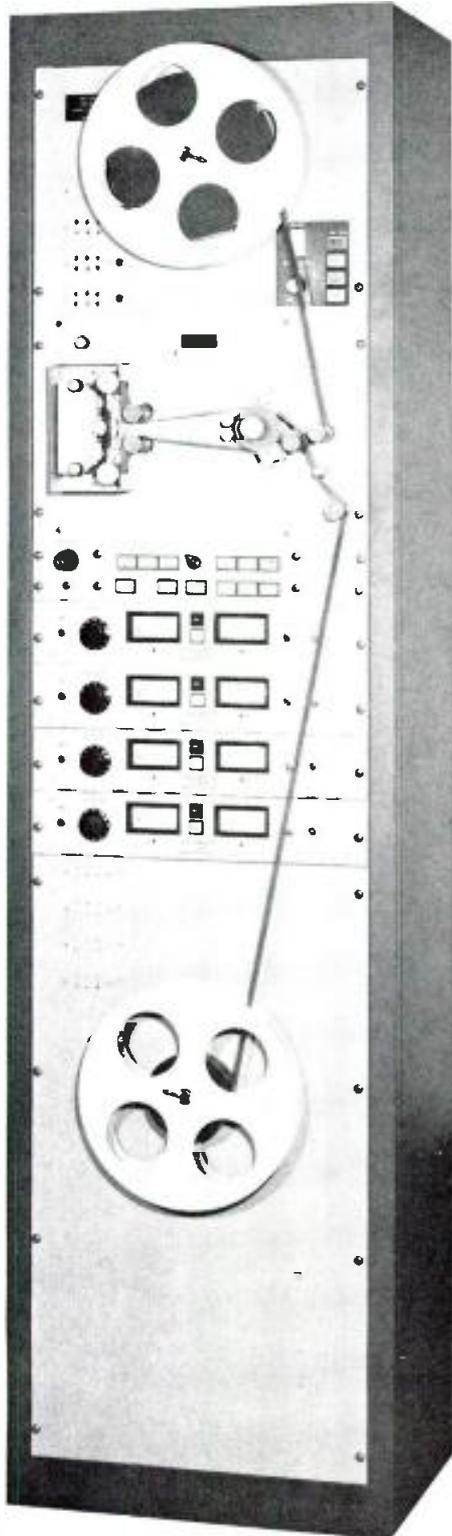
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be oriented either direction.

If the entire diameter of a lens disk is used to form an image, light refracted near the edges may not converge at the same focal point as light passing through the center. A resulting distortion is a variance of magnification with distance from the center axis of the lens. (See Figure 6.) The image appears sharp, with pincushion or barrel distortion showing in lines removed from its center.

Convex lenses cause light rays to converge or meet at a focal point; concave lenses cause the rays to spread or diverge. Combinations of convex and concave shapes with each other and with flat or plane surfaces may be used to correct optical distortions. (See the related article, "Lens Types," on page 105.)

Apertures and f/stops

One method to reduce lens distortion is through the *aperture* control of an *iris*. The circular iris blocks rays passing through areas near the lens edge. Removing the errant rays reduces the effective diameter and aperture of the lens. The image is not as bright because there is less light being gathered into it.

Optical systems are rated by *relative aperture*. Commonly known as the *f/stop* number, the rating is derived from the focal length (FL) and effective diameter (D) of the clear lens area, or $f/ = FL/D$. An *f/4* lens has a focal length that is four times the effective diameter. If the effective diameter is increased by a factor of two, the aperture becomes *f/2.8*; reducing the diameter by half pro-

vides a relative aperture of *f/5.6*.

The smaller the numeric value of the *f/stop*, the *faster* the lens is rated. Fast lenses with large effective diameters allow more light to pass. Consequently, faster shutter speeds (or shorter exposure times) can be used in film cameras. Less light is needed to televise a picture. As the numeric value increases, exposure time increases.

Another rating uses transmission, or *T/stops*. In this method, the value relates the amount of light that passes through the lens and strikes the film surface. Cinematographers claim *T/stops* to be more accurate for their work than *f/stops*.

Fields in focus

The aperture of a given focal length lens controls the *depth of field*. With larger apertures, the distance from the camera into the objective view that is sharply focused is limited to a few feet in front of and behind the primary object in the scene. The range of image sharpness increases as the aperture decreases.

If the aperture is reduced to a pinhole, the depth of field is effectively infinite. The light level is insufficient to be practical, however. Early photography with the *camera obscura* used small apertures instead of lenses and required exposure times from minutes to hours.

The focal length of the lens also affects

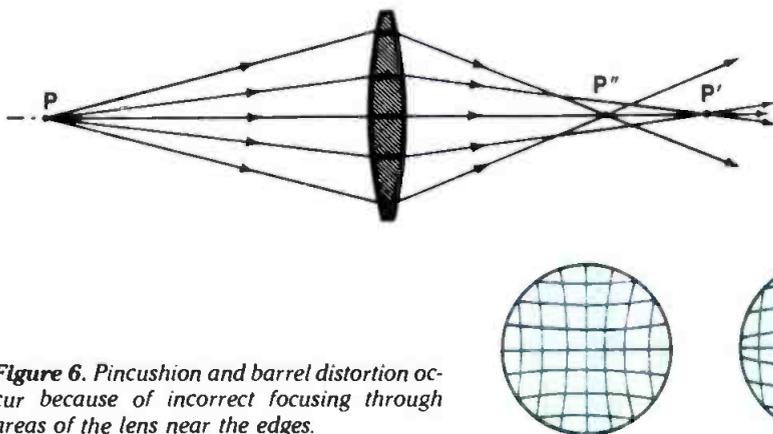


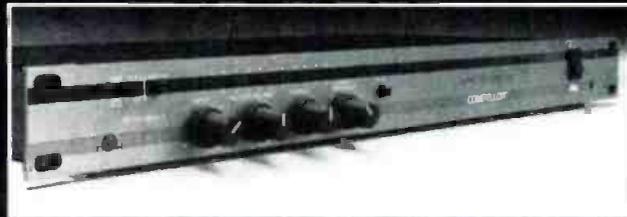
Figure 6. Pincushion and barrel distortion occur because of incorrect focusing through areas of the lens near the edges.

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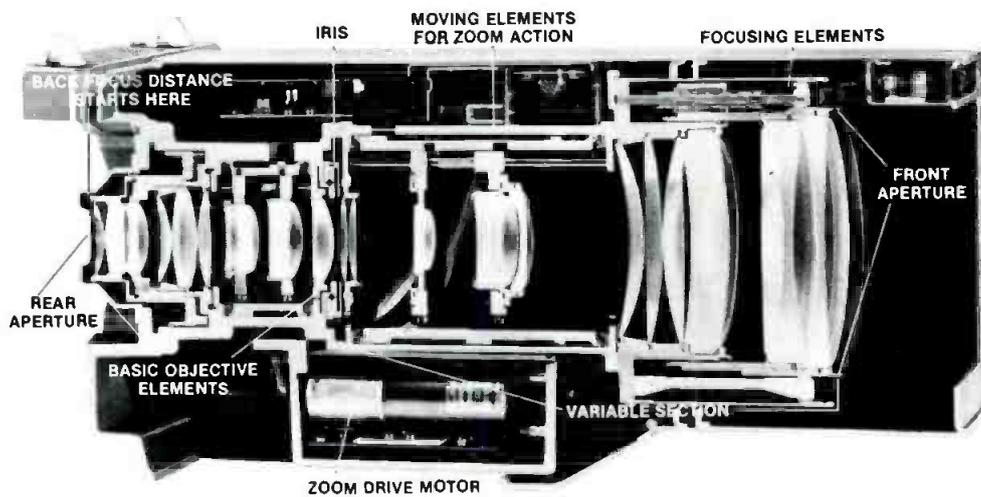


Figure 7. The cross-sectional view of a Schneider 30X 1.5-inch zoom lens system shows the relative placement of 31 individual pieces of glass, some cemented together for better light transmission characteristics.

the depth of field and the relative perspective of the viewed image. For longer focal lengths, depth of field decreases, and the perceived distance between objects—the key to visual perspective—seems to decrease.

An Immovable lens

A simple magnifying glass is moved to provide the best image. With cameras, however, the lens is fixed and images must always be in focus at the specific point behind the lens. For photography, the image must focus on the film plane.

In a TV camera, the image must fall on the pickup tube.

The distance from the most extreme point of the back element of the lens to the faceplate of the green tube or CCD is called the *back focus distance*, and it varies from camera to camera. As a result, optical systems are designed for specific camera models. Some amount of adjustment is normally possible, although it is generally a minimal amount. The red and blue distances should be equal to the green, but sometimes those two tubes must be

physically moved to achieve correct back focus.

Another factor of the lens that should be matched to the camera is the *clear aperture of the rear lens*. If the aperture is too small, only a small portion of the faceplate is illuminated. If the rear aperture is too large, part of the image spills beyond the beam-swept area of the faceplate.

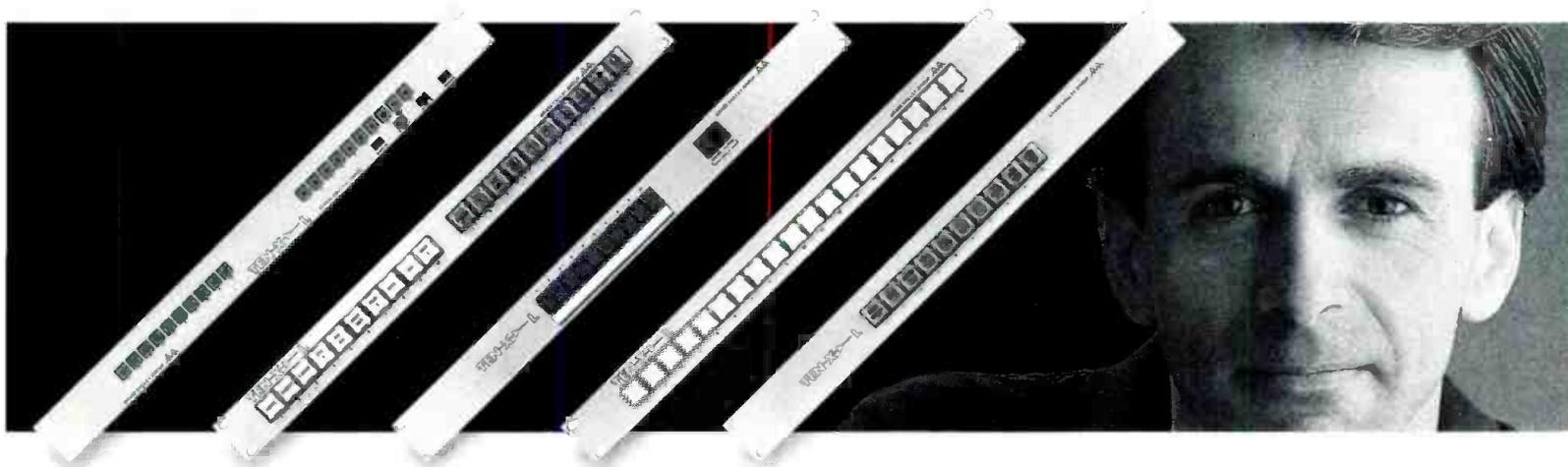
Introducing zoom

Prior to *zoom* optics, a set of fixed focal length lenses were mounted on a turret at the front of the TV camera. When the director wanted a closer view, the operator turned the turret to position a longer lens. The concept presented problems for ENG cameras, because turret assemblies with several lenses were heavy. For convenience, if nothing else, the zoom lens was developed.

To achieve a variable focal length, at least three groups of elements are needed. (See Figure 7.) The front *stationary objective* group can be adjusted over a limited distance with the focus ring. Next is a *movable zoom* group. Finally, a rear *stationary prime* or *relay* group determines final image size as light passes into the camera head. The rear group also fixes the back focal length.

Simple lenses could be used to create a zoom optical system, but each group normally consists of more than one element.

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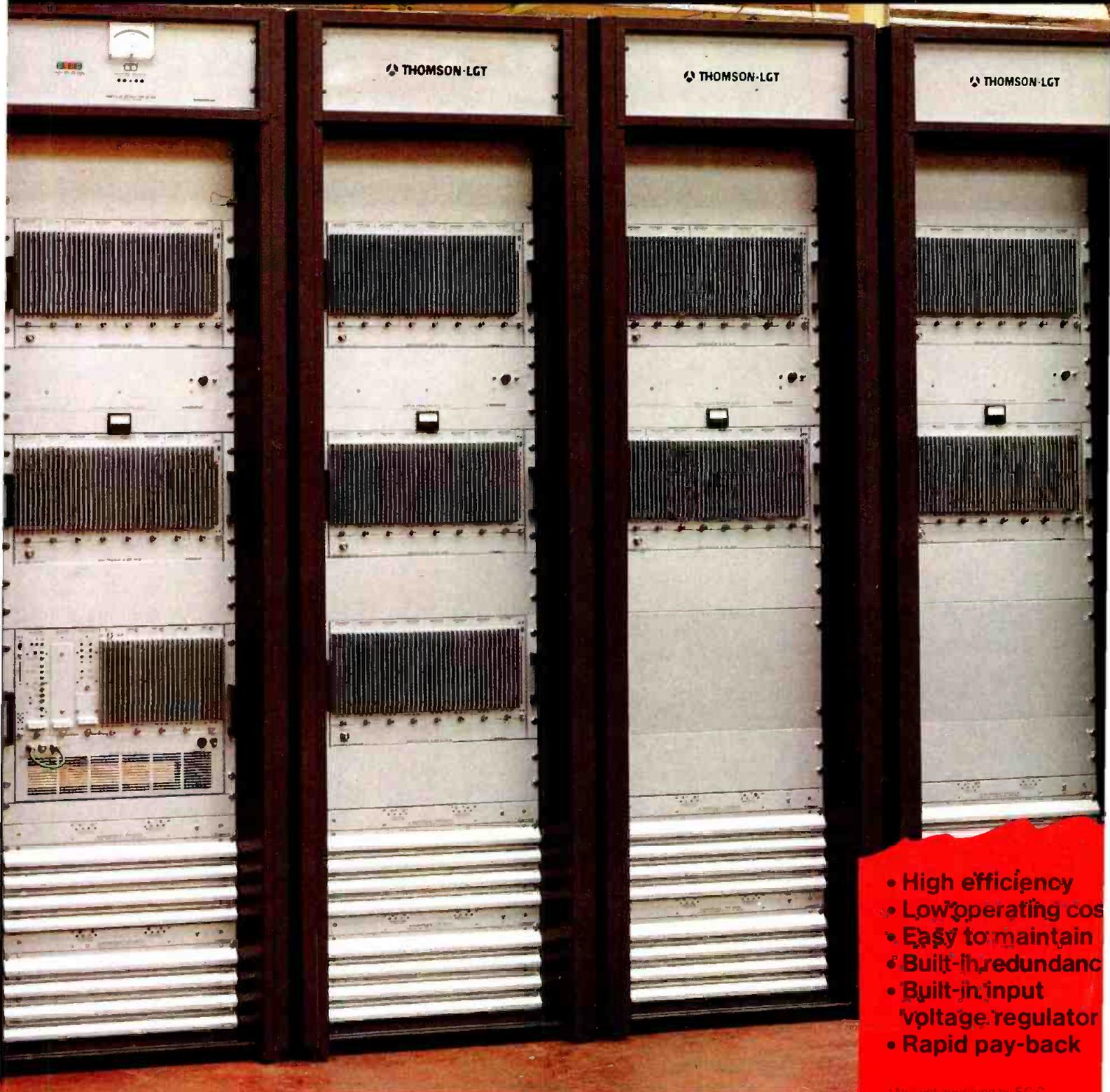
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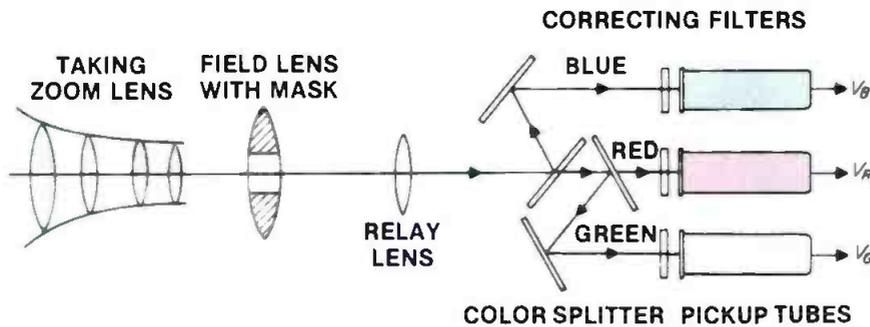


Figure 8. Dichroic mirrors may be used to separate a full color image into red, green and blue images for the pickup tubes.

As a simple example, a convex lens is effectively split to form two plano-convex types at the front and rear of the system. A divergent corrective lens used with

each reduces optical aberrations.

The elements of the groups are cemented together for stability. Materials used for optical cements are critical,

because their refractive indices have an effect on the overall refraction.

Between the front and rear groups, a zoom or magnifying group also contains corrective elements. When positioned correctly, the zoom group sees the image produced by the objective group and creates a new image from it. The rear relay group picks up the image from the zoom group and relays it to the beam splitter and pickup devices.

The focal length of a zoom system may be further altered with a range extender. Bringing a 2X range extender into operation between the zoom and relay group doubles the image size and the focal lengths at both ends of the zoom range. Unfortunately, the laws of physics require the aperture to be halved.

In a well-designed zoom lens, a scene that is in focus at the closest (longest focal length) setting remains in focus as the lens is adjusted to its widest angle setting (shortest focal length). However, lens systems with a special macro portion of the zoom range for extremely close work often require adjustment of the focus.

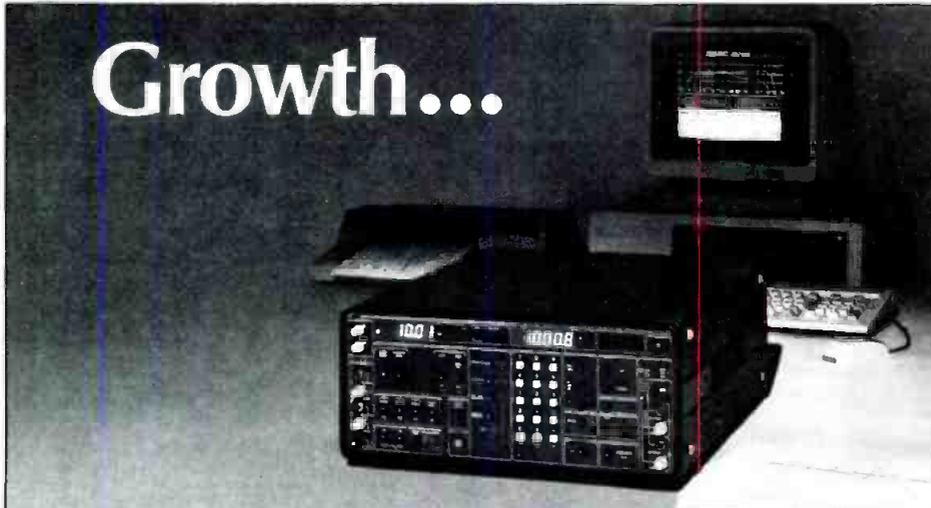
Beam splitting

Although the lens portion of the optical chain is designed to reduce separation of light into colors, the final section must efficiently split the beam into red, green and blue. Most early color cameras used front-surface dichroic mirrors to perform the separation. Dichroics involve thin layers of material that can discriminate between colors of light, allowing one to pass through, while causing another to be reflected.

As with all other elements in the optical path, the index of refraction of dichroic coatings is the secret to their effects. The thickness of the dichroic layers is only a fraction of the wavelength of the color to be affected. With layers plated onto the front surface of a mirror, green and red are transmitted, while blue is reflected. (See Figure 8.) A second dichroic passes red and reflects green. In each case, trim filters precisely define the wavelength of light that reaches the camera tube.

Dichroic mirrors are effective in color separation and allow all three tubes (or, in early camera designs, four tubes) to be in parallel. Today, more efficient splitters use prisms, although the tubes can no longer lie in a convenient side-by-side configuration. Careful selection of indices of refraction, placement and shapes causes one or more prisms to split the light into red, green and blue components, again, with trim filters to achieve high color accuracy.

Although the shape of the camera may be determined somewhat by the optical block, prism optics are more stable and smaller in overall dimensions than their mirror counterparts. (See Figure 9.) The size is reduced even more if CCD devices are cemented directly to surfaces of the



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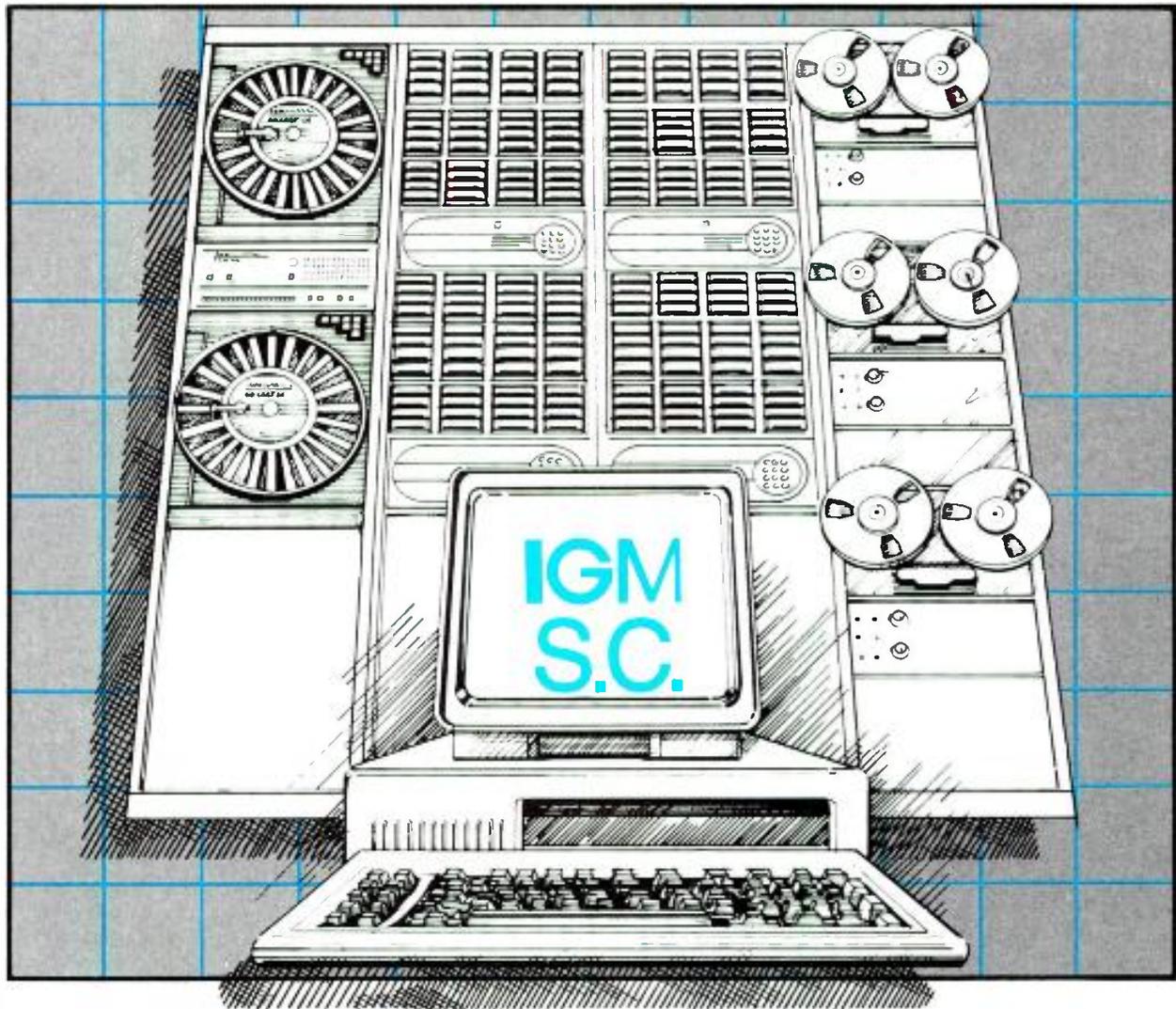


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prisms. An added benefit from CCDs is freedom from registration errors.

The right lens for the job

Selecting a TV lens involves several factors. The lens must match the camera. Some literature refers to the optical format by tube diameters. More accurately, however, the format indicates the diagonal of the scanned area on the camera tube faceplate. A ½-inch tube generally provides a diagonal measurement of 11mm.

Only one-fourth of the image produced by a 1-inch lens would fall on the faceplate of a ½-inch tube. A ¾-inch lens would leave a portion of the 1-inch tube unexposed. The relay group at the rear of the lens matches the required size. Some cameras, designed to use more than one size of camera tube at the same time, must have elements in the optical block to achieve the correct format for each tube.

The back focal length of the lens must match the camera design. Some adjustment is normally available on lenses, but the amount of adjustment is to compensate manufacturing tolerances. For best results in specifying a lens, mention the camera model on which it will be used.

Choosing the appropriate lens speed for a camera requires more attention than picking the fastest lens system that also meets other required parameters. The f/stop for TV lenses refers to the largest relative aperture, which occurs at the wide-angle zoom position. As the zoom group moves toward the longer focal lengths, aperture remains constant until a knee in the transmission characteristic is reached. From that point on, the aperture may change rapidly as the end of the zoom is approached.

Selection of aperture must also involve

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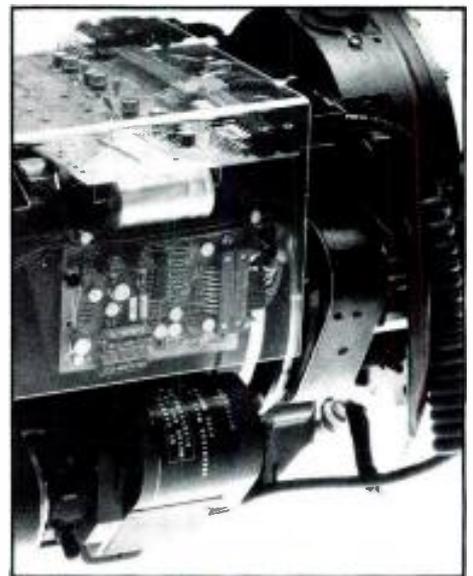
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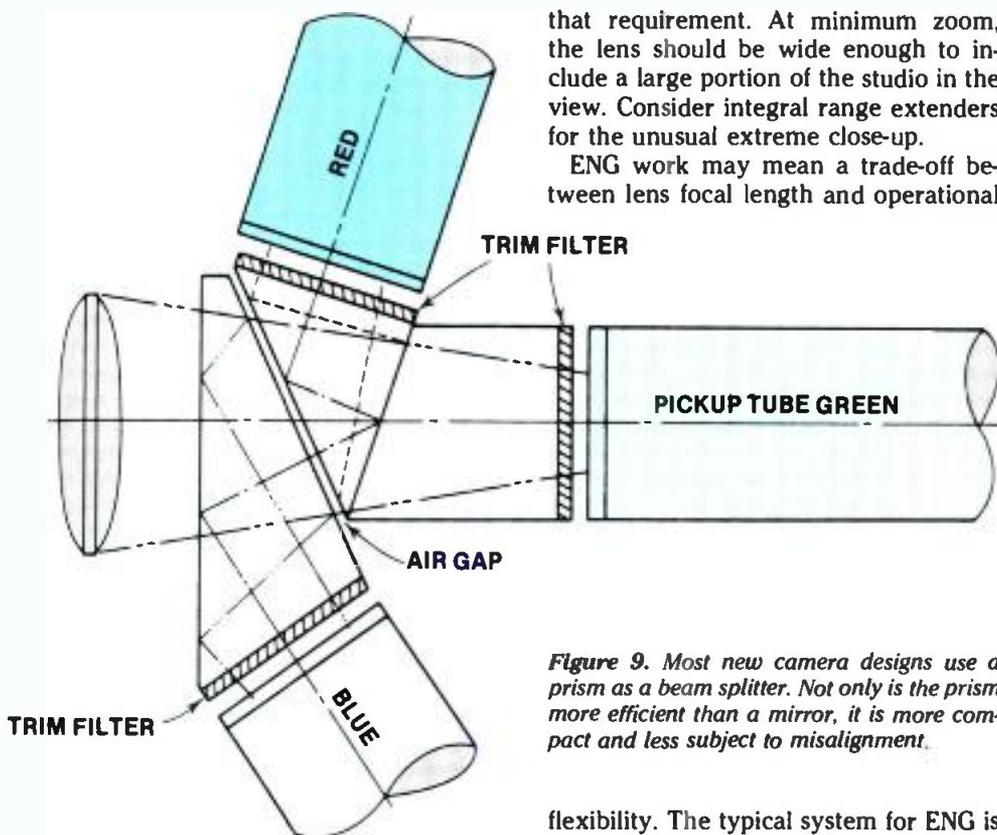
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that requirement. At minimum zoom, the lens should be wide enough to include a large portion of the studio in the view. Consider integral range extenders for the unusual extreme close-up.

ENG work may mean a trade-off between lens focal length and operational

Figure 9. Most new camera designs use a prism as a beam splitter. Not only is the prism more efficient than a mirror, it is more compact and less subject to misalignment.

the f /stop equivalent presented by the optical block in the camera. If the camera specifications call for an $f/2.8$ lens, using an $f/1.2$ lens is more than expensive overkill. Excess light passing through the lens can result in undesirable reflections in the optical system. As a general rule, pick a lens aperture that is equal to or smaller than the internal portion of the optical system.

The lens you select will probably include an automatic servo iris that is controlled from signal level-sensing circuits in the camera. Servo control of zoom is also likely and may include a feedback circuit for cameras with lens setup memories. Some systems include servo focus features as well, but many keep focus as a manual control function.

Focal lengths and zoom ratios must be tailored to the application. Cameras for sports and OB events typically use longer zoom lenses. A zoom ratio of 40X or 44X allows a fixed camera in the press box to provide good close-up views of players on the field. At their shortest range, they also produce reasonably wide-angle views of the sports facility.

A 44X lens on an ENG camera at the playing field level would be less practical. The shorter distance from camera to subject rules out the long lens. The portability advantage of ENG cameras is also lost, because zoom ratios more than 14X normally require a tripod for satisfactory use. The weight alone of a long lens is excessive for portable camera operation.

In the studio, a longer lens is occasionally useful for quick access to extreme close-ups of small objects. As studio dimensions are usually limited, a zoom ratio of 14X to 18X will suffice for

flexibility. The typical system for ENG is in the 14X zoom range. Movement of the camera operator is magnified by the lens. As a result, even integral extenders often remain unused, unless some stabilization is available. For a relatively stationary camera, a tripod and pedestal-type mount might be considered. ENG, however, is not static and the tripod may be an encumbrance. In its place, a gyro-stabilized lens system can significantly reduce camera shake. Gyro-based units can be effective for any production work in which the camera physically moves.

Lens systems for outdoor use need some type of weatherization. Because dust and moisture are prime enemies of the lens, special attention to water proofing and prevention of dust ingress will pay off. Conversely, lenses specified strictly for the studio do not require the added protective design.

Maintenance

In most cases, the greatest maintenance requirement of the lens system is cleaning the outside housing and the glass surfaces. The front element, which is exposed to the elements, may collect dust or become splattered with water. Dust should be removed with a light touch from a soft lintless cloth. An even better cleaner is a small can of compressed air. Whenever possible, avoid touching the glass surface of the lens.

Carefully remove smears on the glass with a detergent solution. Avoid exotic cleaning solutions. For unusual situations, contact your lens manufacturer. Once the lens is clean, consider installing a clear glass cover over the front element. The cover ensures protection for the lens at a minimal cost.

The rear lens surface and any optical elements inside the camera also must be

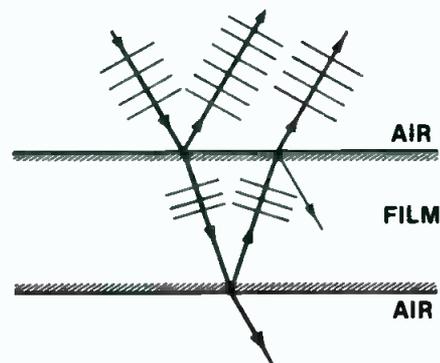
Reflections

Mirrors reflect light by bending light rays back into the immediate medium. If the surface is planar, a sharp image appears at any distance. The light waves are bent, but remain relatively parallel to one another. If the surface is curved, the waves reflect in various directions. Depending upon the type and smoothness of the curve, the image may be enlarged or reduced in size and may be inverted.

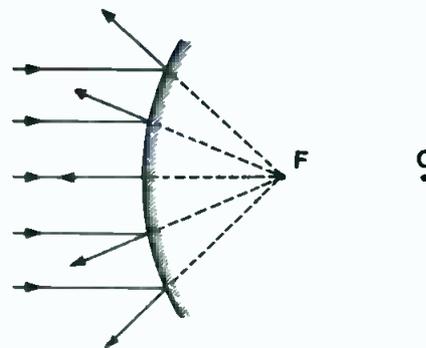
The angle at which light strikes the surface is the angle of incidence, while the angle of light leaving the surface is the angle of reflection. The two angles, measured from a normal line that meets the surface perpendicularly, are equal. This law is never broken, even if the surface is not smooth.

Plane glass mirrors may reflect from the front surface (first point contacted by the light) as well as from a rear silver-plated surface. Except for possi-

The angle of incidence is equal to the angle of reflectance, both measured from the normal, a line meeting the reflecting surface at an angle of 90° .



A front-surface mirror is preferred over a rear-surface plated mirror in high-quality optics, because only one reflecting surface exists, avoiding secondary reflections.



kept free of dust, because particles on those surfaces may appear *in focus*. Again, a soft cloth or brush and the can of air are preferred methods of cleaning.

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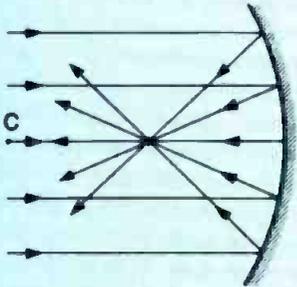
ble effects work, the double image resulting from a rear surface mirror would be undesirable. Therefore, mirrors in camera optical systems may be metallic or glass with a polished plated layer on the front surface.

A concave mirror, as found in reflecting telescopes, causes light rays to converge at a focal point in front of the mirror. Images seen between the focal point and the mirror surface are enlarged and upright; images viewed beyond the focal point are inverted.

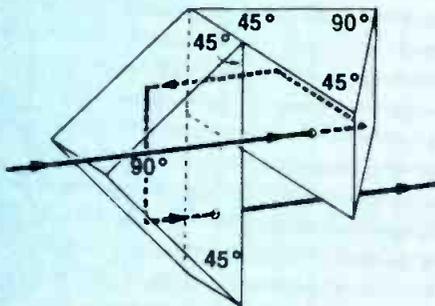
The convex mirror creates a virtual image behind the surface. The image is always erect and is smaller than created with a plane mirror. Convex rearview mirrors on automobiles allow a wider-angle view than plane-types provide.

Another highly efficient reflector is the prism. Although rarely used in TV optics, the double Porro prism with 45°-45°-90° angles allows realignment of light for easier viewing in high-quality binoculars.

A concave mirror causes light waves to be reflected and converged at a focal point in front of the mirror.



A convex mirror causes light to be reflected divergently toward its source, while a virtual image appears behind the mirror.



If the system includes front-surface mirrors, never rub the surface to remove dirt or smears. Use soft brushes or air.

The movable elements of a zoom lens



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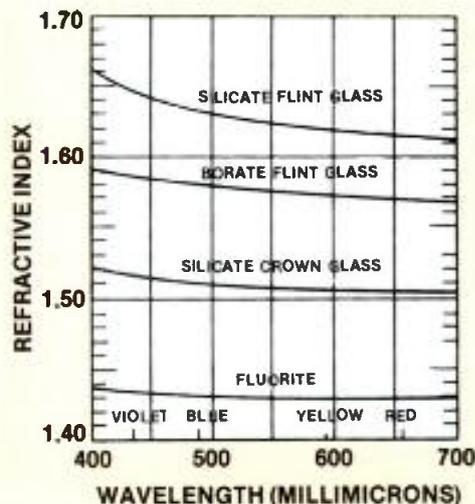
Optical materials

Not all optical materials, including the glass, are the same. Technically, any substance that can be fused (or melted) and subsequently cooled below its fusion point (a supercooled liquid) without crystallization falls into the category of glass. In other words, glass is not technically a solid.

Most common glasses consist of minerals with silicon, boron and/or phosphorous oxides. Different types are manufactured to meet various applications. The base mixture and additives control the dimensional stability and dispersion.

Ordinary window glass contains silicon (sand or quartz) with high percentages of soda and lime. A high quartz and/or fluoride content is desirable for astronomical lenses for better transmission of ultraviolet light. The thermal insensitivity of Pyrex results from the base mixture of boron and silicon.

For optical systems, crown glass is a



A comparison of refractive indices for different glasses at different wavelengths.

hard sodium-silicate mixture with a low refractive index, while flint glass is a soft lead-oxide material with a high index. The ideal glass for TV lenses has a low dispersion coefficient (minimal

variation in refractive index over the visible spectrum). Crown glass best meets this requirement. Some prisms require the higher index of flint glass. Corrective elements within the lens system could use crown glass or thinner elements of flint glass.

Non-mineral glasslike methyl methacrylate polymer, the basic material of Lucite and Perspex glass replacements, closely resembles crown glass in many ways. Polystyrene substitute for flint glass. These organic replacements are not generally capable of duplicating all of the optical and mechanical parameters of their inorganic counterparts at present.

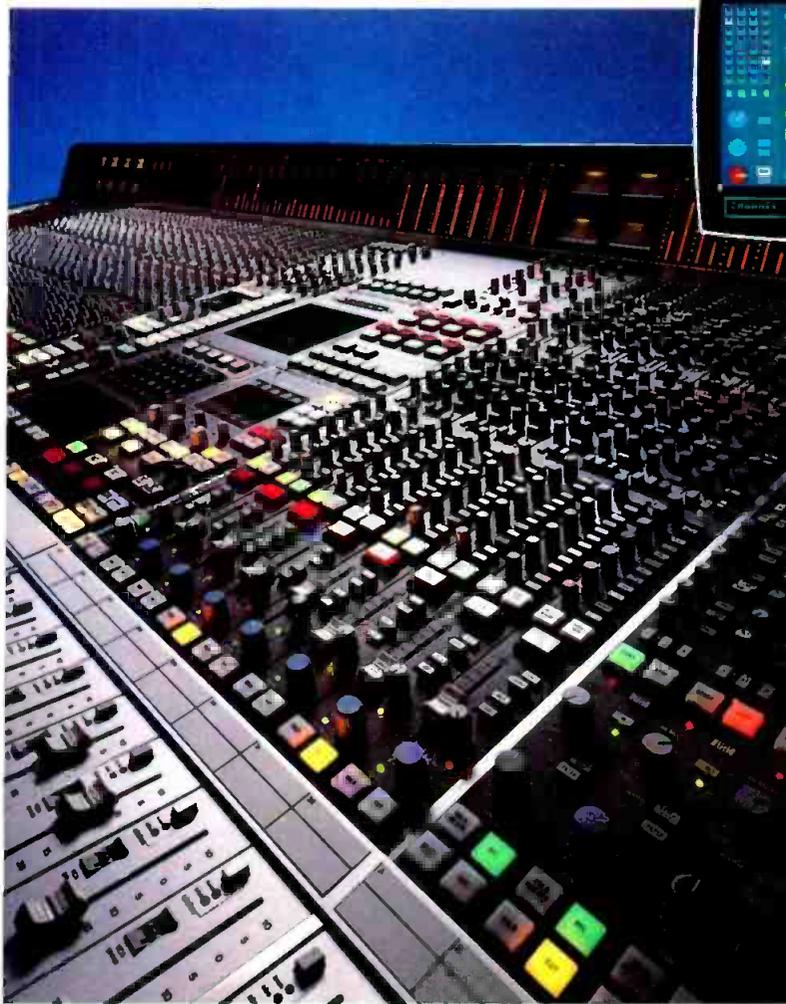
Appearing to be like glass, diamonds consist primarily of carbon. They are generally more valuable, with greater dispersion to provide greater brilliance. Rutile, a synthetic diamondlike material of titanium dioxide, has a dispersion of eight times that of diamond. In these minerals, various impurities in the base materials impart overall colorings, including yellow and blue, which may reduce the value of the gem.

are usually enclosed in a partially sealed environment. In theory, dirt should not get into that environment. If it does, consider sending the lens to the manufacturer for servicing. Glassware elements

in zoom lens systems are best considered non-user-serviceable parts, and are best left to qualified optical specialists.

If you have found it necessary to remove the lens housing, you may wish

to check the operating manual in regard to lubrication of moving parts. The environment in which a lens is used may require a different lubricant than the manufacturer originally used. If that is



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the case, use only the manufacturer-specified oils or greases, sparingly.

Lens systems for ENG have few internal adjustments. Studio lenses, however, do have additional maintenance needs. Many have electronic circuitry for servo control features. Before making adjustments or repairs, study the manual to thoroughly understand the circuit.

Adjustments may be needed for integral pattern projectors found in some systems. Access to these adjustments has been simplified by designs with housings that can be removed without unmounting the lens from the camera. In others, access doors make available only the areas for adjustment, and keep the other areas protected.

The TV camera optical system, more than any other assembly of the camera chain, requires a thorough understanding by the maintenance technician. Unwarranted disassembly can result in greater problems than existed in the first place. If there is any question on the best approach to a problem, contact the manufacturer for advice.

TV camera optical systems are among the most sophisticated devices in the station. As in any maintenance project, do not try to fix something that is not broken. Because of critical alignments involved with the optics, focus on the real problems, then proceed with care.

Lens types

There are six primary lens types, based upon shape. Most common is the double convex lens, which has the greatest light-converging power. Parallel light rays passing through the element are forced to converge at a point that is related to the focal length of the lens.

If one side of the lens is flat, the element is plano-convex. For the same convex curvature, this lens has only half the converging power of the double convex type.

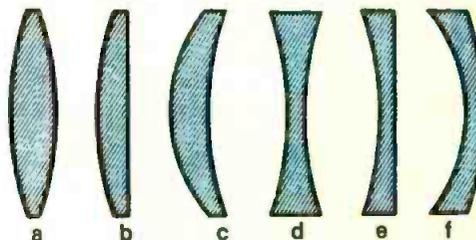
Also considered a converging lens is one type of meniscus lens. Although the back side is concavely shaped, the radius of curvature is less than the front surface. As a result, light rays are converged, but the focal distance is greater than either the double or

plano-convex unit. The meniscus is the weakest lens type.

Diverging lens elements are commonly associated with the concave shape. As with convex, the double concave element has the greatest diverging power. Such lenses do form an image, but the virtual image appears to be on the same side of the lens as the object.

The plano-concave lens has only half the diverging capability, but otherwise retains the characteristics of the double lens. Such elements provide optical corrections in the lens system.

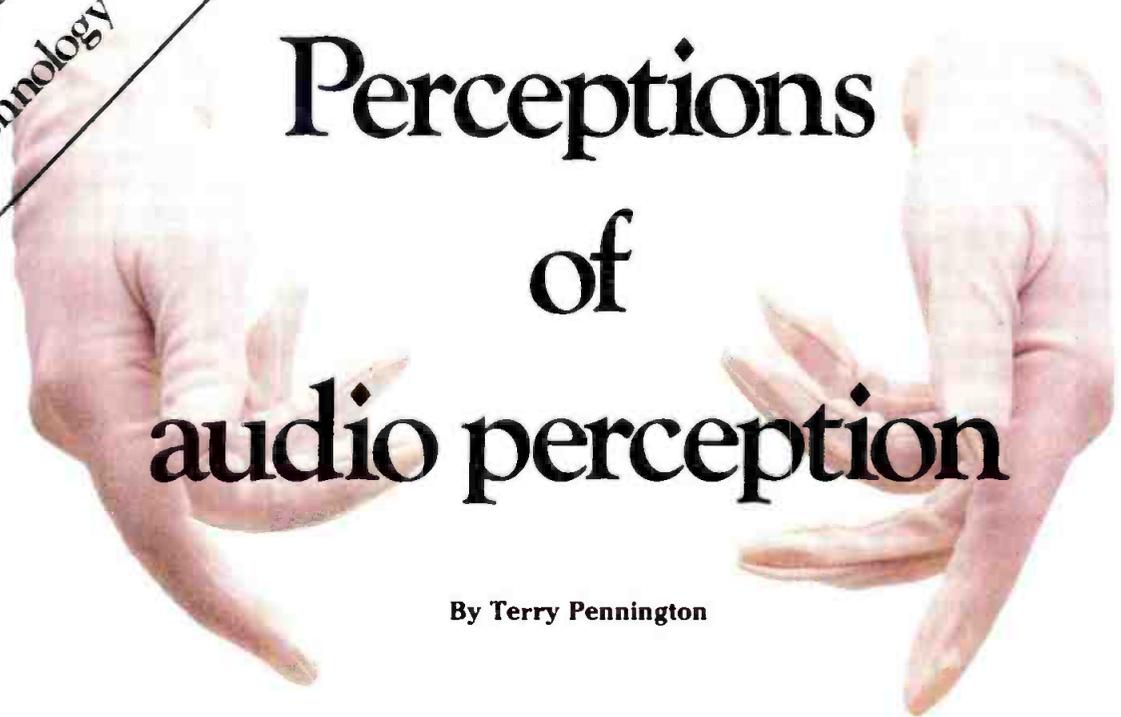
A concave meniscus lens also exists. Again, the back side of the lens is curved, this time with a convex shape. The convex curvature is less than that of the concave side. Parallel rays passed through the lens do not converge.



Six primary lens types are used in TV optics: (a) double convex; (b) plano-convex; (c) convex meniscus; (d) double concave; (e) plano-concave; and (f) concave meniscus.

Viewpoint on technology

Perceptions of audio perception



By Terry Pennington

Facts don't matter—perception does. In the race to keep up with technology, don't lose sight of reality.



Subjective evaluation of audio components continues to be one of the most hotly contested issues facing audio pro-

Pennington is director of technical marketing and development at Rane Corporation, Mountlake Terrace, WA.

fessionals, despite the attempts of many engineers and authors to shed objective light on the issue. It is critical that anyone involved in the selection and evaluation of audio broadcast products for radio, TV and post-production facilities be aware that what we believe

we hear is more a function of what goes on inside of our heads than what occurs on the outside. It is also imperative that equipment manufacturers realize that subjective evaluation does not take precedence over science and plain common sense.

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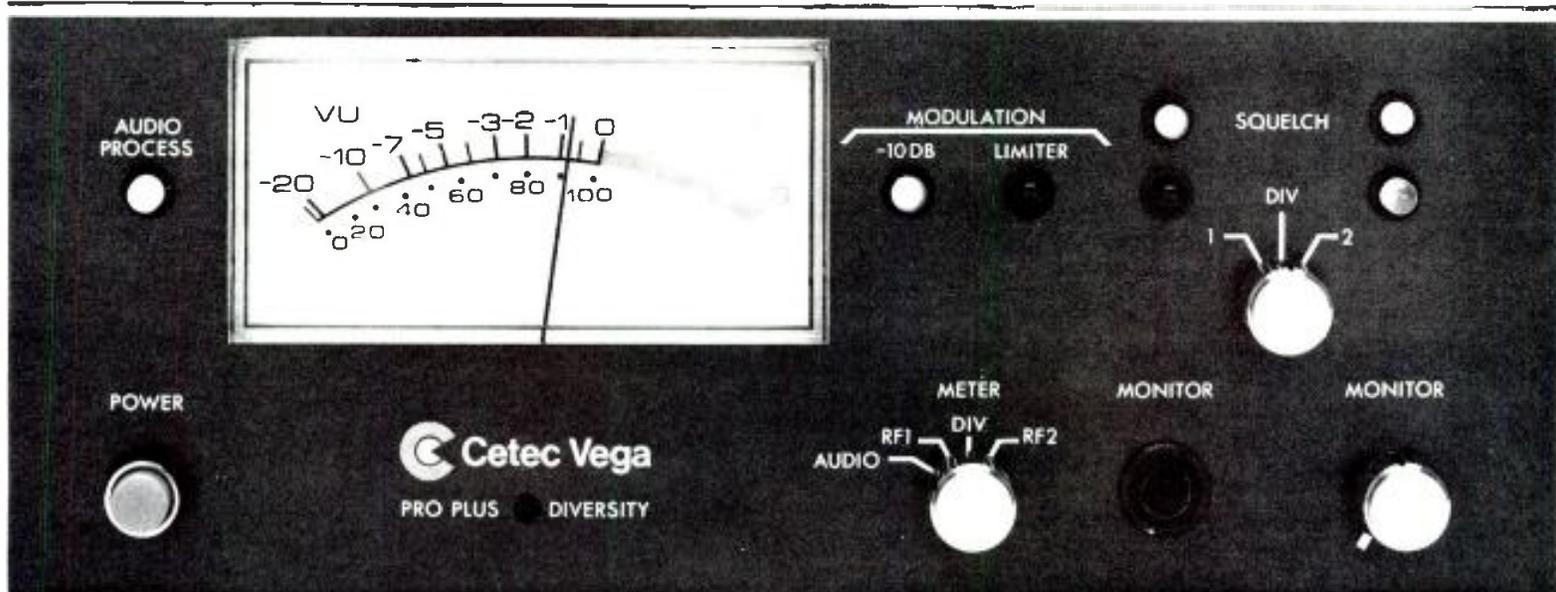
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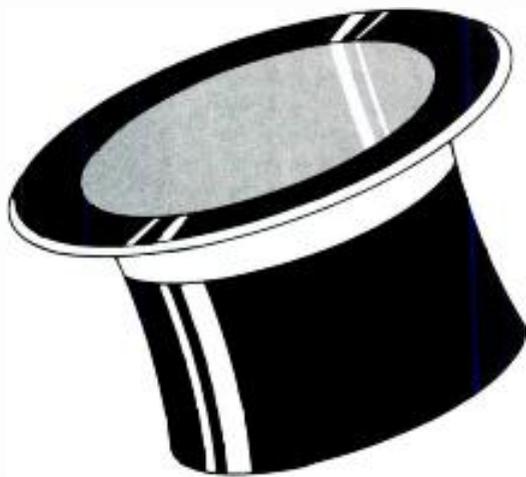
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Science is a waste of time if one tries to use it to change faith.

Perception vs. facts

It is not the facts that matter, it is the perception that matters. There is no quantity of facts large enough, or proof strong enough to overcome preconceptions. Science is a waste of time if one tries to use it to change faith. It simply does not work.

A designer of audio equipment is sometimes asked to include in a product electrical performance features that, based on logical scientific thinking, have little value in terms of the application of the equipment. Features such as incredibly high slew rates, little or no overall negative feedback or *trendy* components often do little to improve the performance of the equipment in the *real* world. Including such features in an otherwise quality design is not wise if concrete, scientific proof of their value is not readily available.

Mark Twain said it best when he observed, "There's a great deal of human nature in people." Human nature is the dictator that mandates what we expect to hear, see, feel, taste or smell. If you touch something that *looks* hot it will feel warmer than it really is, especially if it is at a neutral temperature. If the temperature is moderate, our expectations will outweigh reality. By the same token, physical form and adjacent color drastically change the perception of a specific color. This perception is not caused by a lack of resolution of the sense of sight, but rather, by a lack of objectivity in the brain.

Most humans possess the ability to discriminate between red and yellow, blue and green. Yet, they cannot readily distinguish one musical pitch from another without a close reference. If most of us were to hear a performance of any well-known work in the key of C at this moment, and in the key of A a short time later, we would not be aware of the change in pitch.

Volatile memory

How does this relate to audio perception? It is really quite simple. If 50 people could somehow manage to sit in the same seat at a live performance, and receive the same precise audio information, all 50 would develop a different perception.

If they listened to a reproduction of the same performance at a later time, made with microphones of the same pattern and frequency response as their ears, and a 100% perfect storage medium, all 50 would have differing opinions about the fidelity of the reproduction. Even if the reproduction were less than perfect, some would think it was more accurate than others. It simply is not possible for the human mechanism to remember exactly how the original performance actually sounded.

Another audio equivalent would be to take a trip to Boston's Symphony Hall to hear a live performance of the Pops, and then listen to a recording of the performance later in your own living room. The object of the reproduction, of course, would be exact duplication. The microphones, however, were not in your seat at the performance. Strike one. The microphone's frequency response is different than that of your ears. Strike two. The microphone's pickup pattern is different than your ears. Strike three. Then, sum into this equation the characteristics of the recording console, equalization, the recording medium, the playback medium, speakers and the acoustics of the room and you see the problem.

Good senses, poor interpretation

Human perception relies on multiple elements: the senses, expectation and faith, to name a few. It has been shown, time and time again, that what you *expect* to occur most likely *will* occur.

The senses give our brains a transducerlike input, allowing us direct con-

What you expect to occur most likely will occur.

What do you think?

This article expresses the views of the author. It correctly points out the need to carefully evaluate new equipment specifications in light of practical applications in the real world of radio and TV broadcasting. What are your views on this topic? Write us at:

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tact with our surroundings. These inputs are altered by the enormous computational resources of our brains to suit individual expectations of reality. It is these modifications of our sense inputs, specifically as they relate to audio, that cause the uproar that pervades our field.

The religion to which we subscribe in professional audio will directly change what we perceive we hear when auditioning a component or system. Those who belong to the *Church of Tubes* will perceive the demonstration of a new solid-state device quite differently than a member of the *House of Silicon*. What one believes to be true usually will be.

Subjective evaluation

As audio technology progressed to the level that mandated critical evaluation of audio performance by the ear, a myriad of dilemmas began to surface. These stemmed from the occurrence of two seemingly identical devices that sounded quite different from each other. On the test bench, no measurable differences could be found. The rational scientist would conclude from this situation that the wrong operational characteristics were being measured. After all, when this phenomenon was first noted, the only easily measured parameters were frequency response, harmonic distortion and phase shift. Because the frequency response and phase deviations of a component are directly related, the evaluation could be limited to two parameters.

The questions, however, would not answer themselves. How could two similar pieces of equipment sound so totally different? The answer was (and is) thought to lie in a plane that has yet to be investigated.

Subjective distortion

Over the years, many new forms of distortion have been discovered. Each discovery was thought to be at least part of the answer to some of the nagging old questions. These tests usually met with great acclaim and caused some rather drastic rethinking on the part of electrical designers.

Some of these new discoveries include slew-induced distortion (SID), transient intermodulation distortion (TIM) and phase distortion. At the time of their discovery and resultant popularity, these were heralded as the answer to the never-ending question, "How can two components sound so different?" But are these new distortions really the answer?

To find out, you must look at what these tests really measure. SID and TIM are nothing more than means to find out if there is some frequency and level that will cause a circuit to become non-linear.

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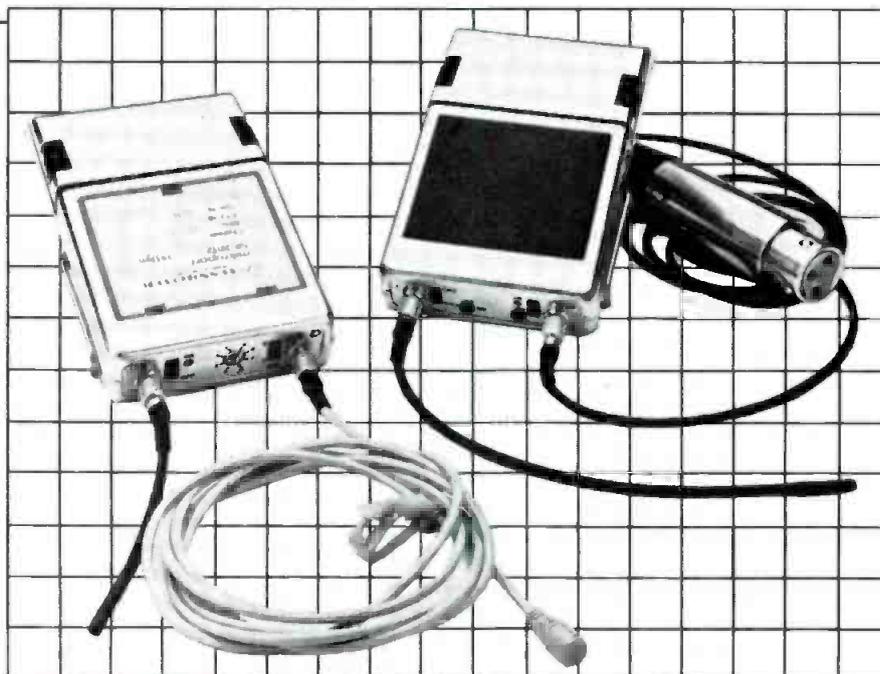
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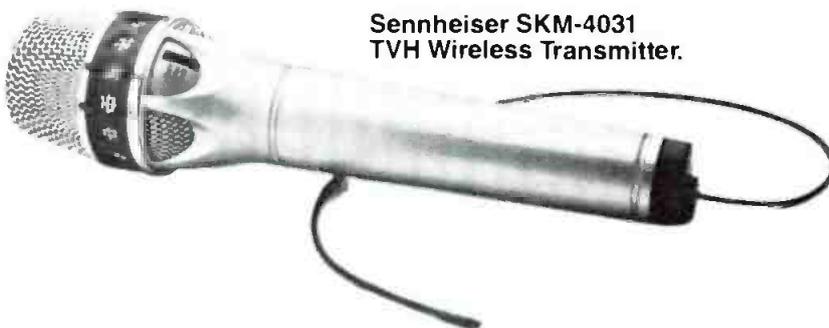
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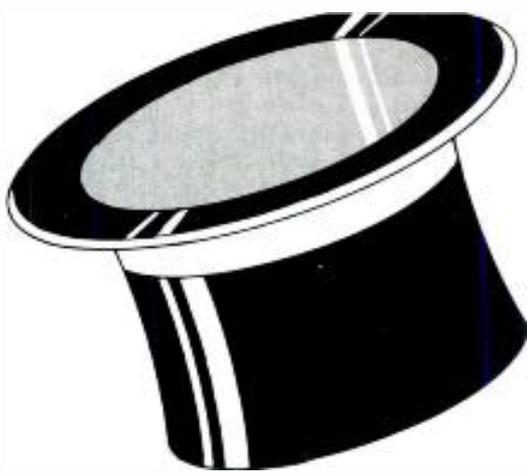
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In a truly blind test, an evaluator can rarely achieve even a 50% accuracy rate in selecting a favorite piece of equipment.

Every linear electronic device has a frequency/magnitude point at which it will become less linear than is acceptable. Usually, this is well outside the design window.

Virtually every commercially available audio power amplifier will pass a 20kHz sine wave distortion test at full power without any indication of slew rate limiting or slew-induced distortion. If the sine wave input is increased in frequency far enough beyond 20kHz, all amplifiers will reach a point at which they no longer perform in a linear fashion. The only difference among amplifiers of different designs, when tests are applied for SID or TIM, is the margin between satisfactory 20kHz performance and the frequency at which they no longer perform properly.

If an amplifier is forced to exceed its slew rate limit, it will sound miserable throughout the audio spectrum. Lower frequencies will be severely distorted along with the high-frequency culprits. This is by no means a subtle phenomenon. SID and TIM were, however, used to explain some of the *very* subtle differences between amplifiers. These distortions were used to account for *openness* of amplifiers, *roundness* of instruments or a subtle *sheen* that one amplifier might have over another. This is impossible. An amplifier slew limiting for even a few microseconds sounds more like a close-range blast from a howitzer than a *lack of roundness*.

As further proof, consider the quality of digital audio. Some argue the sonic merits of this medium. However, assume for the sake of this example, that it is as pure as most agree it is (or at least as it can be).

In order for digital storage of analog material to function linearly, a steep filter to band-limit input material is required. These filters typically cut off from 1kHz to 2kHz above the highest desired frequency. The resulting cutoff frequen-

cy is between 21kHz and 22kHz. Is it, therefore, necessary to require an amplifier to produce anything above its full-power, 20kHz limit? If, to the reader, digital audio sounds satisfactory, then the previously mentioned bandwidth restrictions must not be getting in the way of your enjoyment.

Equipment reviews

Audio equipment reviewers have, for years, been writing about the subtle differences encountered when judging the relative merits of different pieces of hardware. One often encounters such terms as *gritty*, *shrill* and *tubby* as typical examples. Personal experience has shown that presuggestion and personal bias play a greater role in these evaluations than anything concrete. In a truly blind test, an evaluator can rarely achieve even a 50% accuracy rate in selecting a favorite piece of equipment. The true believer, on the other hand, will always argue that this form of test is not valid. It must be understood that there is no absolute way of settling the debate. Personal faith and belief cannot be *settled*.

Objective quality

Our job as professional engineers is to provide the most accurate sound possible for our audience. In order to do so, we need to make judgments as objectively as possible. There are four primary elements about which we should be concerned: frequency response, dynamic range, ambience and linearity.

Frequency response may be the easiest quality to evaluate and adjust, if necessary. Sufficient equipment and test sources exist to allow you to measure and correct the frequency response of almost any type of equipment.

Preserving dynamic range—or worse, trying to recapture it—is a bit more difficult. Recently, digital audio has provided the most cost-effective and readily available means of accomplishing this feat. Unfortunately, if dynamic range has been lost, it cannot be fully reconstructed to everyone's satisfaction. Again, this is a function of personal perception.

Ambience is another contested function of realistic performance. Ambience is almost always compromised to some extent by microphone placement. Anyone who has ever tried to totally maintain the ambience of a live program can attest to the difficulty of such a task.

Preserving the linearity of a live performance can be even more difficult. The moment acoustic energy reaches the diaphragm of a microphone, distortion begins. This type of distortion is often overlooked by critics and reviewers. Most of them prefer to look for this

phenomenon in the easier-to-analyze electronic devices. When was the last time you saw a speaker or phono cartridge review that specified 20Hz to 20kHz distortion at several levels?

The reason for this lack of attention is primarily due to the high magnitudes of distortion resident in these devices. A 10kHz sine wave, if it could be faithfully cut on vinyl, would look more like a triangle or chopped sawtooth than anything resembling sinusoidal. A 10W distortion analysis performed on most loudspeakers results in measurements of several percentage points.

The audio design community should turn its attention to these critical areas rather than the ongoing, subjective arguments about the relative merits of an unmeasurable or non-existent subtlety.

Preference dictates the answer

If you have come to the conclusion that this author likes digital audio, and if you do not, then you will tend to discount most of what has been said. Because you do not share the author's religion, most of what is said is subject to your criticism and doubt. If, however, you tend to agree, it is most likely because you had made these same determinations beforehand.

Maybe you prefer the *tube sound* to that of the *silicon sound*. If so, you probably have the idea that the author is one of those Philistines who thinks tubes are silly, and that they use too much energy and are better suited to making glass beer bottles. You probably will not believe much of what has been said.

It is not logic or fact that dictates our perceptions; rather, it is personal conviction and faith. Discounting the scientific and factual observations of others, without personal unbiased examination, is the cause of much of the dissension in the professional audio community today.

Manufacturers of audio equipment for professional use must continually be aware of the foregoing truths. All must realize that what is perceived is not usually directly related to what is heard. Perception is a modification of reality—a modification that is based on bias. Humans are not perfect. They are victims of emotion. Emotion and logic do not mix any more than science and theology mix. Audio designers must be aware of this fact, or they will fall prey to the same frailties as anyone else. Designs should, therefore, be based on the best available, solidly grounded technology—and a healthy dose of common sense.

Editor's note: This material was adapted from an Audio Engineering Society paper presented by Pennington at the 79th AES convention, Oct. 12-16, 1985.

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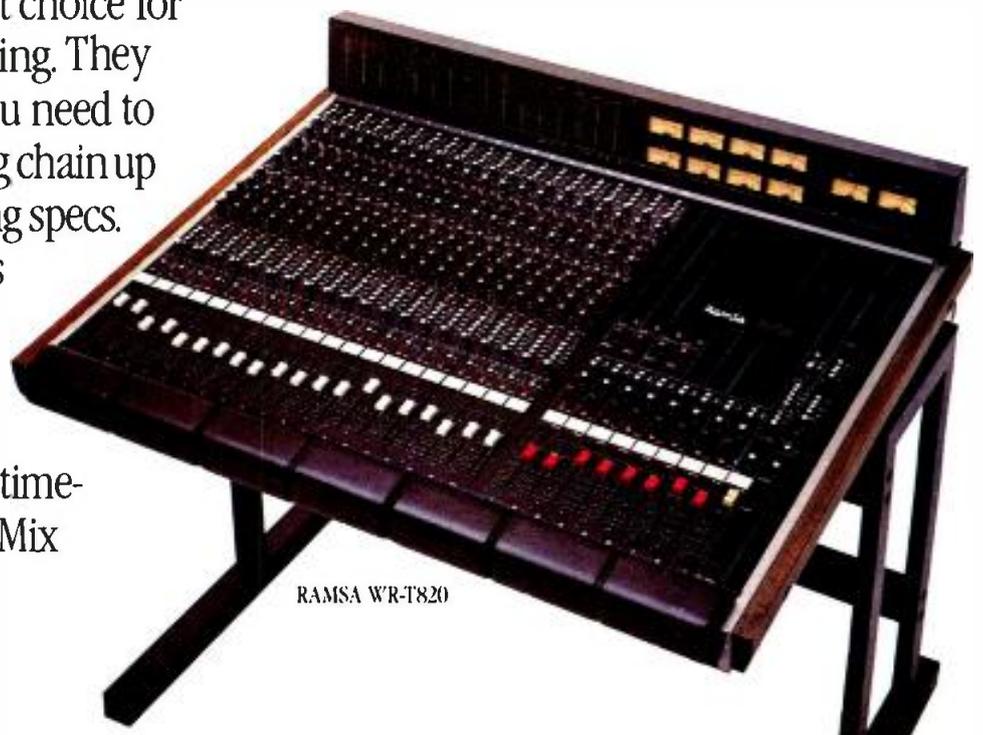
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Harris Phase Fixer

By Ronald McGrew

For years, video broadcast and production facilities have taken time base correction for granted. It's the accepted method for improving picture quality and stability. For audio applications, however, the use of time base correction is relatively new. One device that corrects for phase errors in audio channels is the Harris Phase Fixer.

System description

The Phase Fixer is a closed-loop digital device. Its proper use requires that material be recorded with a special encoder and then decoded prior to broadcast. Typically, a single decoder is located just before the audio processing. Encoders are used with each stereo production tape recorder that produces on-air material.

The encode-decode process relies on digital processing to accomplish the phase correction. A stable-phase 19kHz reference signal is first recorded onto each audio channel. When the tape is decoded, the original phase reference signal is detected and used to adjust the delay of one of the two variable digital audio delay lines.

In order to prevent the decoder from locking onto an incorrect signal the pilot tone is amplitude-modulated with a low-frequency 297Hz tone. The tone is used because it is high enough in frequency that phase detection can be accurate and sensitive, yet low enough that the lower sideband of the pilot remains inaudible. The encoder block diagram is shown in Figure 1. The pilot tone is recorded at a level that does not cause a degradation in the system's total signal-to-noise ratio. For most tape formulations, this level is 27dB below 250nW/m fluxivity.

Decoder

In addition to the pilot signal that is added to the left and right audio channels, some method is needed to delay the audio if the phase error is to be eliminated. The system's decoder (see

Performance at a glance

- Corrects to within 16.6 μ s of absolute correct interchannel delay
- Capable of greater than a 4:1 reduction in flutter
- Frequency response 30Hz-15kHz \pm 1.5dB
- Distortion less than 0.2%, 30Hz-15kHz at +4dBm
- Noise better than 70dBm below output, 20Hz-20kHz
- Automatically senses pilot tone and switches to bypass when necessary
- XLR input and output connectors

Figure 2), uses 16-bit linear analog-to-digital converters with a sampling frequency that centers near 78kHz. This high sampling rate allows the use of gently sloping, anti-aliasing low-pass filters with a fairly high cutoff frequency.

A linear 16-bit successive approximation A/D converter outputs complementary offset binary data words to a 16-bit wide 2Kb random-access memory (RAM). The memory address is incremented after each complete conversion. The system creates an overall maximum delay of approximately 27ms, which can be continuously varied by changing the clock frequency. The original waveform is reconstructed by

the D/A converter, which is followed by a de-glitcher and anti-imaging low-pass filter.

The decoder may be locked out of the active mode through a front panel switch or by a command signal from the console. The latter is useful when the announcer wants to talk over encoded tapes without the 27ms echo effect that can distract board operators.

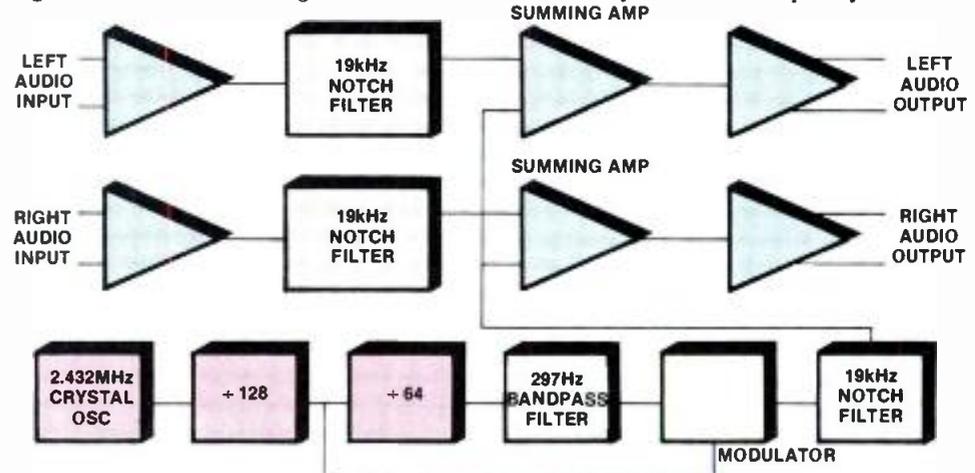
Pilot detection

The system uses a sophisticated pilot detection circuit. Each output channel is first high-pass-filtered by a second-order 15kHz HPF, removing unnecessary low-frequency information. The signal is then applied to an AGC amplifier with 15dB of gain control range. The pilot can be as low as 15dB below nominal level and still be detected.

After the pilot is detected in both channels, the AGC threshold is lowered an additional 10dB, producing a strong hysteresis effect. The AGC amplifier output is then bandpass-filtered at 19kHz. The pilot signal is now amplitude-stabilized and heavily filtered. The 297Hz AM modulation is envelope-detected and bandpass filtered.

The absolute phase difference of the 297Hz pilot is detected with a zero-crossing phase detector, which develops a control voltage. This voltage is then used to vary the clock frequency of one

Figure 1. Encoder block diagram.



McGrew is engineering supervisor for WBNS-AM, Columbus, OH.

Figure 2. Decoder block diagram.

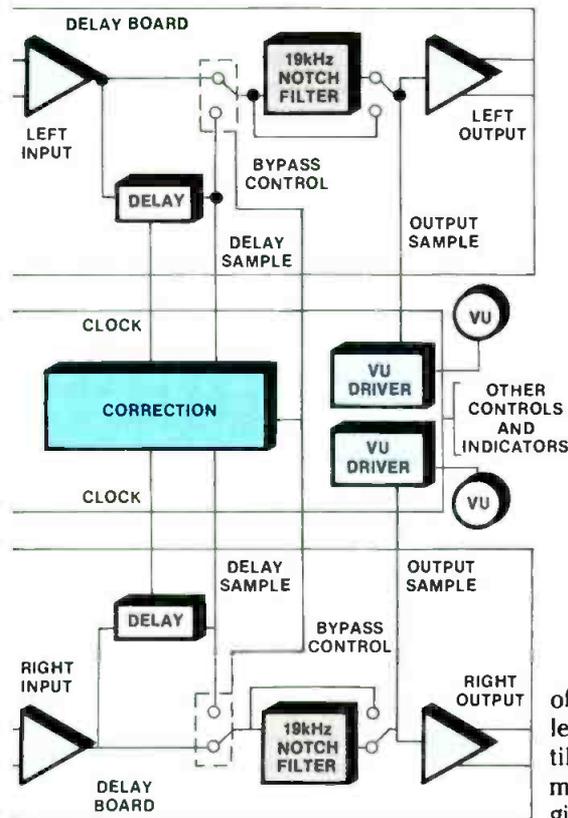
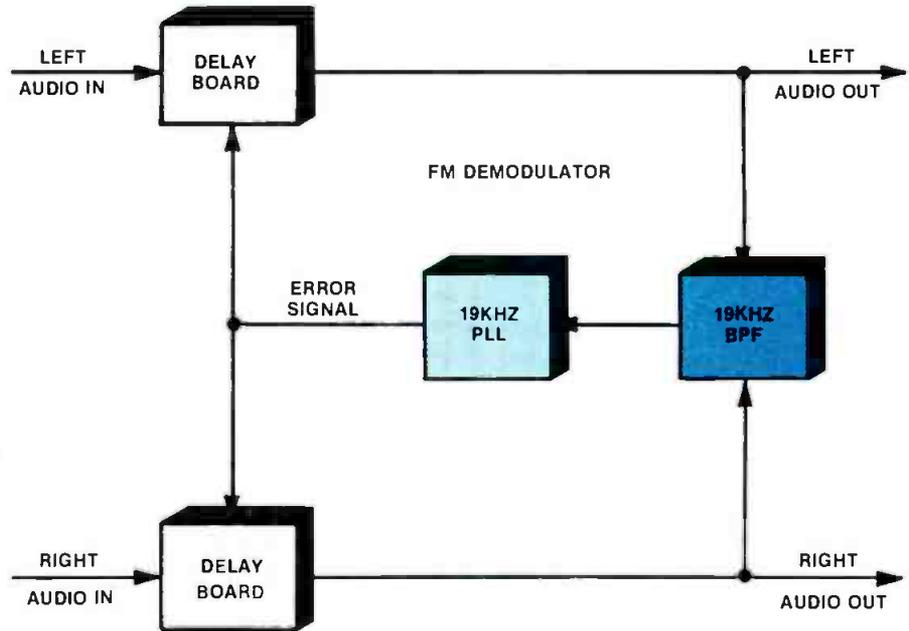


Figure 3. Wow and flutter correction circuit block diagram.



Wow and flutter

of the two digital audio delay lines. The leading channel is therefore delayed until the phase of its reference signal matches the reference signal of the lagging channel.

Wow and flutter is a common problem with cartridge machines. Most stations use cartridge equipment that is several years old and perhaps not capable of high-quality performance. With this type of cartridge equipment, a time base cor-

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Circle (85) on Reply Card

INPUT IMP.	BRIDGING			BRIDGING			BRIDGING			BRIDGING		
OUTPUT IMP.	600Ω			600Ω			600Ω			600Ω		
INPUT LEVEL	0dB			0dB			0dB			0dB		
OUTPUT LEVEL	0dB			0dB			0dB			0dB		
MODE OF OPERATION	BYPASS			BYPASS			DELAY IN			DELAY IN		
OUTPUT	LEFT CHANNEL			RIGHT CHANNEL			LEFT CHANNEL			RIGHT CHANNEL		
	N/A			N/A			N/A			N/A		
C.P.S.	F	D	N	F	D	N	F	D	N	F	D	N
30	-0.1	0.009		0	0.008		0	0.06		0	0.08	
40	0	0.011		0	0.008		0	0.06		0	0.08	
50	0	0.01		0	0.008		0	0.07		0	0.08	
100	0	0.009		0	0.008		0	0.06		0	0.07	
400	0	0.009		0	0.008		0	0.06		0	0.08	
1,000	0	0.01	-84	0	0.009	-83	0	0.07	-68	0	0.07	-67
2,500	0	0.01		0	0.008		0	0.06		0	0.07	
5,000	-0.1	0.013		0	0.008		-0.1	0.06		0	0.06	
7,500	0	0.011		+0.1	0.008		0	0.06		+0.1	0.06	
10,000	+0.1	0.015		+0.2	0.008		-0.2	0.06		+0.1	0.06	
15,000	-0.15	0.012		+0.1	0.007		-0.2	0.06		0	0.06	

Figure 4. Performance measurements.

rector (TBC) can be particularly useful.

The wow and flutter signals usually manifest themselves as frequency modulation of the desired program signal. With the unit, any wow and flutter phase-modulates the pilot signal. The TBC detects the phase modulation with a PLL (see Figure 3), and develops a correction signal that simultaneously varies the clock frequency of both delay channels. This process typically reduces the wow and flutter in the audio signal by a 4:1 ratio.

Measurements

Figure 4 shows the results of a performance test made on our delay unit. As with any digital product, there is a direct relationship between the operating level and the resulting S/N. If the tests had been conducted at +4 operating level, the S/N would have measured approximately 72dB. If it was tested at a +8 operating level, the S/N would measure approximately 76dB.

Likewise, the distortion level would drop from the 0.06% area at zero operating level to approximately 0.0025% at a +8 operating level. In general, all of the audio test data is significantly better than that shown on the manufacturer's data sheet.

User comments

At our station, the decoder is connected to the output of the on-air console, which drives the telephone lines. We couldn't mount the delay unit at the transmitter because the phone lines can't pass the 19kHz pilot tone.

In order to prevent confusing the announcers, all studio monitoring is prior to the delay. In the air studio, a different approach is needed. Here, we monitor the off-air signal via headsets. When the microphone is turned on, the delay is turned off. The switch between delay and bypass is smooth and unnoticed by the staff or listeners. When the microphone is turned off, the delay is again switched on.

It may be difficult for some engineers to believe in the need for a phase correction device. If, however, you simply tune around the dial you may notice a number of stations with phase problems. They often manifest themselves as a loss of highs or a moving back from the microphone by vocalists. Sometimes the signal seems to be lacking punch.

At our station, the elimination of phase errors has made a noticeable difference.

We immediately saw an improvement in the AM signal's high-frequency content. Our station does not broadcast in stereo, so we combine the left and right outputs of the phase correction device into a monaural signal. The resulting signal is bright, clean and includes everything up to approximately 13,000Hz.

Fortunately, it is not necessary to encode all of your material at one time. Because the device detects the presence or absence of the pilot tone and switches to the correct mode, conversion can take as long as you want. We have 2,000 carts and have converted about 60% of them to the encoded format.

We have been using the Phase Fixer for more than 18 months. During that time, I have become convinced that it is the best method available for correcting our phase and wow and flutter problems.

Editor's note: The field report is an exclusive BE feature for broadcasters. Each report is prepared by the staff of a broadcast station, production facility or consulting firm.

In essence, these reports are prepared by the industry and for the industry. Manufacturer's support is limited to providing loan equipment and to aiding the author if support is requested in some area.

It is the responsibility of Broadcast Engineering to publish the results of any piece tested, whether positive or negative. No report should be considered an endorsement or disapproval by Broadcast Engineering magazine. [:-(-)]]]]

Show preview

10 Wednesday
September
1986

*To Orleans
New Orleans
Radio '86*

Wednesday, September 10

Radio '86 features seminars and exhibits

By Brad Dick, radio technical editor

The 1986 NAB/NRBA radio convention is scheduled to be held Sept. 10 to 13 in New Orleans. This marks the last time the show is listed as a joint convention of NAB and National Radio Broadcasters Association (NRBA).

For the past two years, NAB and NRBA have co-sponsored the convention. Earlier this year, the groups joined to form a united organization.

Gary Owens, vice president of creative services, Gannett Radio Division, Los Angeles, will receive the Radio Award at the Sept. 12 luncheon. Owens, morning personality on KKGQ-FM, Los Angeles, will receive the award for his long-term involvement and continuing contribution to the radio industry.

Also highlighting the convention will be John Naisbitt, chairman of The Naisbitt Group, Washington, DC, and author of the international best-seller *Megatrends*. Naisbitt will deliver the Friday luncheon address.

Sessions

The convention continues to emphasize management, programming and sales. Engineering sessions also have been planned. This year's convention begins on Wednesday with a welcoming reception and registration.

For the engineers, a special 1-day seminar on non-ionizing radiation will be

held Wednesday. The fee for this session depends on whether you are registered for the Radio '86 convention. Those wanting to attend the non-ionizing radiation seminar but not Radio '86 will be required to pay \$250 or \$150, depending on whether their stations belong to NAB. For those engineers attending Radio '86, the fee will be \$150 or \$50, again depend-

ing on NAB membership. For non-members of NAB, registration for Radio '86 is \$495. For NAB members, registration is \$345.

The engineering topics include: communicating with program directors and managers, new studio technology, FMX, AM stereo, FCC forum, and using a Smith chart. Using AM stereo, FM antennas and studio design and new studio technology also will be discussed.

Based on the number of sessions planned, the Radio '86 convention will again address the needs of many managers and program directors. A total of 40 sessions for managers and programmers is scheduled. Thirteen sessions are on tap for engineers. Further information on the convention is available from NAB.

Exhibits

As of early May, a total of 71 exhibitors were scheduled to appear at the show. Radio '86 is planned as one of the largest radio products exhibitions anywhere. The exhibitors include manufacturers, distributors, syndicators, program suppliers and consultants.

The convention is expected to host about 2,500 registrants over the 3-day affair. Those registering early automatically qualify for a chance to win a trip for two to the Virgin Islands. [:-)]]



Agenda

Wednesday, September 10:

12 p.m.-6 p.m. Early Bird Registration
6 p.m.-8 p.m. Welcome Reception

Thursday, September 11:

7:30 a.m.-5 p.m. Registration
7:30 a.m.-8:45 a.m. Concurrent sessions
9 a.m.-10:15 a.m. Opening session
10:15 a.m.-6 p.m. Exhibits open
11 a.m.-12:15 p.m. Concurrent sessions
12:15 p.m.-1:45 p.m. Exhibit hall lunch
1:45 p.m.-3 p.m. Concurrent sessions
3:15 p.m.-4:30 p.m. Concurrent sessions
4:45 p.m.-6 p.m. Concurrent sessions
6:30 p.m.-8:30 p.m. Reception/entertainment

Friday, September 12:

7:30 a.m.-8:45 a.m. Concurrent sessions
7:30 a.m.-5 p.m. Registration
9 a.m.-6 p.m. Exhibits open
9 a.m.-10:15 a.m. Concurrent sessions
10:15 a.m.-11 a.m. Exhibit coffee break/prizes
11 a.m.-12:15 p.m. Concurrent sessions
12:30 a.m.-2:15 p.m. Radio awards luncheon
2:30 p.m.-3:45 p.m. Concurrent sessions
4 p.m.-6 p.m. Syndication show case & champagne party
3:45 p.m. Free time to visit exhibit hall and hospitality suites

Saturday, September 13:

7 a.m.-8 a.m. Fun run
8 a.m.-9:15 a.m. Concurrent sessions
8 a.m.-11 a.m. Registration
9 a.m.-2 p.m. Exhibits open
9:30 a.m.-10:45 a.m. Concurrent sessions
11 a.m.-12:15 p.m. Concurrent sessions
12:15 p.m.-1:30 p.m. New Orleans theme lunch—exhibit hall
1:30 p.m.-2:45 p.m. Concurrent sessions
3 p.m.-4:15 p.m. Concurrent sessions
4:30 p.m.-5:45 p.m. Concurrent sessions
6:30 p.m.-10 p.m. Reception/dinner entertainment

IBC expands exhibits

By Carl Bentz, TV technical editor

The southern coast of England in mid-September should be a pleasant environment for the 11th International Broadcasting Convention. If you are planning to visit Brighton for IBC, you should make your plans now. A 25% increase in exhibition space, requested for this biennial event, is not expected to handle all applicants. Hotel accommodations in Brighton and the surrounding area will fill rapidly.

The fee to attend the full convention is about \$204 (£130), including a value added tax (VAT) of about \$26.62 (£16.96). Conversions are based on a July 1 dollar-to-pound ratio of 1.57:1.

For the full show fee, the participant may attend all technical sessions and social functions and will receive the convention publication and exhibit catalog.

A 1-day pass is available for Sept. 20 to 23 for about \$78.50 (£50) including a VAT of about \$10.23 (£6.52). The 1-day pass does not include social functions or publications.

Facilities

The expanded exhibit area includes space in the Metropole Hotel Conference Centre, the Brighton Centre and the renovated Grand Hotel. Satellite receiving equipment will be displayed on the Esplanade in front of the three buildings.

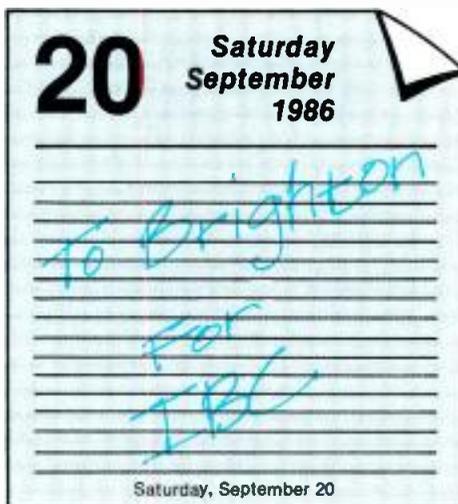
More than 154 exhibitors are expected to take part, some making their first appearance at this international trade show. In addition to many established products, new introductions and specialty products will also be displayed.

The technical program

Technical presentations are still tentative, but more than 85 papers have been scheduled. Due to the number of presentations, concurrent sessions will be held.

The program will begin on Saturday, Sept. 20, with *Evolving Technology—Applications and Economic Aspects*. Speakers will represent Tyne Tees Television (U.K.), Telegen (U.S.), CCETT (France), NHK (Japan) and Philips Laboratories (U.S.).

Concurrent sessions on Saturday afternoon will focus on *Direct Broadcast Satellite Systems and Recording and Telecines*. The DBS topics will review DBS today and the system in use in Australia with the B-MAC transmission format. Reconfigurable satellites and



ways to ensure HDTV satellite capabilities are to be discussed.

In recording topics, enhancements and technical advances in signal processing for type C VTRs will join with a review of 4:2:2 digital component recording. Advances on 1/2-inch technology, a phase domain approach to scene-by-scene color correction and photographic recording of component TV signals will complete the informative session.

Sunday's schedule will include concurrent sessions during the morning only. One will focus on *Broadcast Information Systems* and will detail studies of data transmission via broadcast carriers. Information is to include activities in England, Germany, Japan and Rumania.

The alternate Sunday program, *Television and Radio Systems*, will cover digital audio techniques, emphasizing signal equalization, routing and distribution. Stereo and multichannel TV sound will complement a presentation on assignable audio control systems.

High-Definition Television has been slated for morning and afternoon sessions on Monday, Sept. 22. EBU studies on HDTV, a 72-frame/second system and HD-MAC will highlight the presentations. Papers on HDTV telecines, subsampling techniques, HDTV-to-PAL conversion, motion-adaptive bandwidth reduction and noise characteristics will provide additional information. A perspective of the events of 1986 in regard to HDTV will be enlightening.

The alternative schedule on Monday morning will consider *Transmitters and Antennas*. High-power, high-efficiency broadcasting through single sideband techniques, AM companding and efficiency for TV transmissions will be highlighted. Other papers will discuss applications of computers and automation to transmitter control and monitoring. New concepts in wire antennas also will be investigated.

One of two sections of the Monday

afternoon concurrent schedule will cover *Propagation and Service Planning*, looking at VHF-FM radio, problems of reflection and signal scattering by wind turbines and electromagnetic compatibility with medium-frequency broadcasting. The *Receivers and Displays* session will involve downconversion for DBS receivers and automatic setup of professional video monitors.

Tuesday will follow a similar schedule with *Studio and Outside Broadcast Facilities* sessions in the morning and afternoon. A wide range of subjects will include modular studio construction, acoustics in the mobile vehicle and component video designs for mobile units; signal and control interfacing; CCD imaging technology; MAC applications for ENG and filters for component video signals.

A Tuesday morning concurrent schedule will consider *Satellite and Cable Services* with Australian satellite reception, C-MAC distribution via CATV and international satellite news gathering. The concurrent program for Tuesday afternoon is to be *Measurement Technology*, covering the gamut of audio, video and RF. Topics will include the analog component domain, TV intermodulation, zone plate generators, HDTV, digital processing in TV oscilloscopes and leased music lines.

Making connections

Contact with the IBC secretariat in regard to the convention and exhibition should be made by telephone 01-240-1871 ext. 222; telex 261176 IEE LDN G or fax 01-240-7735.

British Airways is the official agent for travel arrangements, but various airlines will get you to England. Travel to Brighton from Gatwick Airport is approximately 30 minutes by train or 24 miles (38km) by car. From Heathrow Airport, an air shuttle is available to Gatwick. You also may take the bus or underground from Heathrow into London and board the train to Brighton.

Sponsors for IBC-86 include the Electronic Engineering Association, the Institute of Electrical Engineers, the Institute for Electrical and Electronic Engineers, the International Association of Broadcasting Manufacturers, the Society of Motion Picture and Television Engineers and the Royal Television Society.

Incorporation to be realized

By Bob Van Buhler

The Ennis Educational Foundation Inc. moved a step closer to reality as Chris Imlay, SBE Washington attorney, completed the foundation's articles of incorporation and proposed bylaws.

According to the proposed articles of incorporation, the foundation's purpose is to promote, study and contribute to the certification of technical skills in communications engineering. One of its tasks will be to promote and disseminate educational materials for broadcast communications engineering. The foundation also will establish and administer scholarships, educational grants and apprenticeship programs. Finally, the foundation will help develop other programs that may be needed to promote the purposes of SBE.

The foundation's first board of directors will consist of Richard Rudman, SBE president; Roger E. Johnson, immediate past president; and Jim Wulliman, SBE certification and education committees chairman. Wulliman also is a member of the SBE executive committee. The SBE board of directors will elect five additional foundation directors to 1-year terms at the next board meeting. Three of the five elected will be SBE national officers or directors. The other two foundation directors will be elected at large. Any vacancies occurring on the foundation board of directors will be filled by individuals appointed by the SBE board of directors for the remainder of the term.

The Ennis foundation bylaws provide additional details with regard to duties and responsibilities for the foundation's officers. Specific reporting requirements, identification and liability of the officers and meeting requirements also are detailed. As in any legally constituted corporation, the bylaws are required to agree exactly with the articles of incorporation. The Ennis bylaws specify that any disagreement between the two will be resolved to reflect the provisions of the articles of incorporation.

SBE members who want to review the proposed bylaws or articles of incorporation may send a written request to Bob Van Buhler at: WBAL Radio, 3800 Hooper Ave., Baltimore, MD 21211. A copy will be returned to you as soon as possible.



Congress of Broadcast Organizations

On May 15th, Richard Rudman represented the society at the meeting of broadcast organizations, hosted by NAB at its national headquarters in Washington, DC.

NAB organized the meeting to provide an opportunity for the various broadcast organizations to get to know each other and to foster communications between the groups. The political nature of the meeting was apparent in discussions about the ability to influence political action through cooperative, yet separate, group action.

The Congress of Broadcast Organizations has 16 official members, but 41 organizations have expressed interest in the group. A total of 47 people representing 28 organizations attended the meeting.

Election date considered

The SBE national board is considering shifting the election date for officers and directors from April to October, beginning in 1987. The change would allow the election to remain tied to the annual meeting, which will now be held in conjunction with the new national SBE convention.

The SBE bylaws tie the election of officers and directors to the annual meeting, not a specific calendar date. Therefore, simply moving the annual meeting to October appears to solve the problem. More information will appear next month in "SBE Update."

Moving the annual meeting to the SBE national convention is expected to result in greater meeting attendance than has been seen at the NAB convention. One problem with holding the SBE meeting in conjunction with the NAB convention is the number of competing activities. Holding the SBE annual membership meeting at the national SBE convention should allow more members to attend and participate.

SBE national convention

Time is running out so make your reservations now to attend the first SBE

national convention. Special discount air fares are available through Apex Travel, St. Louis. To qualify for the special 40% discounted rate on TWA, you must make your reservations through Apex Travel Service. In Missouri call 800-392-1473. Outside Missouri call 800-325-4933. Give the operator the SBE profile number, 99-10405, and you will be given the discount convention air fares.

Exhibit space is selling well, with more than 37 exhibitors purchasing space since the NAB convention. The convention committee expects approximately 225 booths to be filled in time for the convention. Most major broadcast manufacturers will be represented at the SBE convention.

The national convention committee is particularly interested in accommodating college class groups. Special accommodations, at reduced costs, have been identified in the St. Louis area. The additional savings will make the convention an attractive and feasible event for students. Anyone interested in group discounts should contact Sam Caputa at 314-727-2160.

Why attend the convention?

Anyone with an interest in broadcast engineering or broadcast-related equipment should attend the SBE convention. One advantage of visiting this convention is the opportunity to interact with the exhibitors. You will have sufficient time to get all of your questions answered by the exhibitors' staffs. With the events carefully planned, you will not find yourself running from one end of the convention center to the other just to attend a session or see a piece of equipment. This show has been carefully designed to provide maximum opportunity for you to see the equipment and attend the technical sessions.

Another important reason for attending the show centers on SBE validity and credibility. SBE has reached the point where it can stand on its own, in terms of membership participation. SBE needs to hold a well-attended national convention so the rest of the broadcast industry will see that we do represent a significant number of professional broadcast engineers. Like so many other professional organizations, SBE needs to grow. The national convention is only one part of that growth process. See you in St. Louis. | : (:) | | | | |

Van Buhler is chief engineer for WBAL-AM and WIYY-FM, Baltimore.

THE TEKTRONIX SPG-170A. ITS FEATURES AND VALUE CAN'T BE MATCHED.

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Testing high-power diodes

By Robert K. Dye

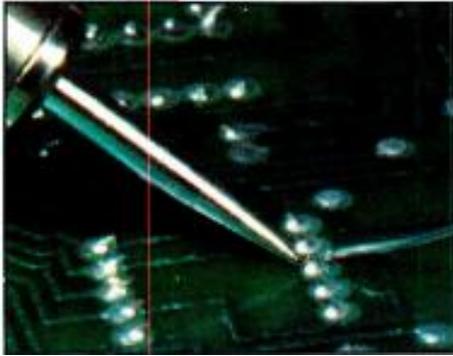
After installing a new 36kW TV transmitter, we experienced a number of problems with arcing in the final cavities. After many hours of troubleshooting, we traced the problem to the 6kV power supply.

The transmitter's main high-voltage power supply consists of a 3-phase to 12-phase transformer, associated diode rectifier stacks and a single oil-filled capacitor. While troubleshooting the arcing problem, we designed a special circuit to help locate malfunctioning components in the solid-state rectifier stacks.

Diode failure

Power diodes are not always what they appear to be. Diode failure is seldom due to excessive current. More often, diodes fail through high-voltage breakdown. Even new diodes cannot always be expected to meet their specifications. Through testing we found that not all new diodes will withstand their rated reverse voltages when placed in a typical high-voltage circuit.

This startling fact became evident to me while I was working on my amateur radio transmitter. The high-voltage stack failed several times in an erratic fashion. After spending a number of hours testing the power supply, I decided to build a device that would dynamically measure



the performance of the rectifiers. Experience told me that a resistance check with a VOM was insufficient.

Common diode stacks used in amateur and commercial power-supply circuits are usually rated in several amperes forward current and reverse voltages of several thousand volts. With these conditions in mind, a circuit was designed to test each diode section in our transmitter out to its full rated voltage. The test circuit is shown in Figure 1.

Circuit operation

The test circuit is easy to operate. Connect the two test leads, T1 and T2, to the diode section under test and turn on switch S1. Increase the variac from 0V until capacitor C1 is charged to exactly 1kV through R1 as measured on the dc voltmeter.

Components CR3, C2 and R2 represent a typical section of a high-voltage rectifier stack. If we assume that CR3 and C2 are good components, the discharge path of C1 is only through the meter resistance and R2. Any additional resistance appears in parallel with these resistances. A defective diode or capacitor in the section under test will cause a lower voltage reading because of

the extra voltage loss across R1.

After the initial setup has been made on a good rectifier section, just flip the switch to the off position, watch the meter reading decrease from 1kV to zero. C1 will discharge through the meter and R2. Now move the test leads to the next diode section, turn on the power switch and look for a reading of exactly 1kV on the meter. If the meter reads anything except 1kV, you have a bad component (usually a diode) in that section.

Safety first

When using this procedure, remember that you are working with lethal voltages. Be certain the transmitter power supply is disconnected from the mains and that the rectifier stack is lifted from the load. Also, be sure that the dc meter falls to zero before you move the test leads to another diode section.

With a little practice you will find that this system works extremely well in locating defective high-voltage diodes, resistors and capacitors. The procedure is quick and easy to conduct. Most stations will be able to build the circuit from parts already available, keeping the cost quite low.

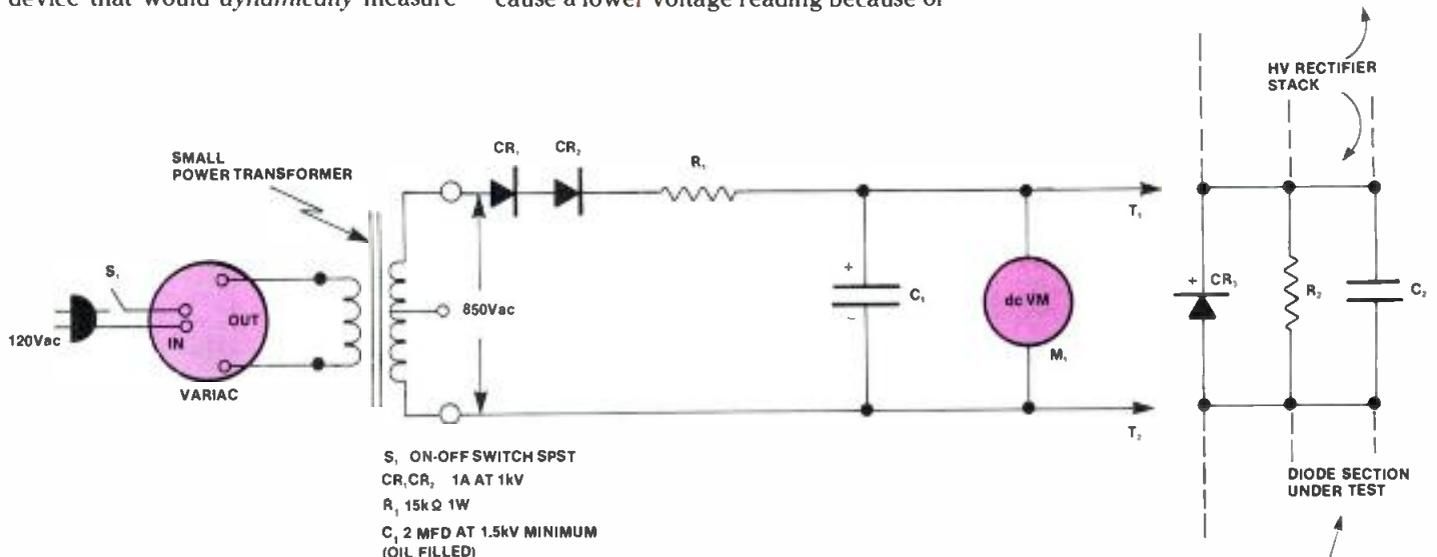
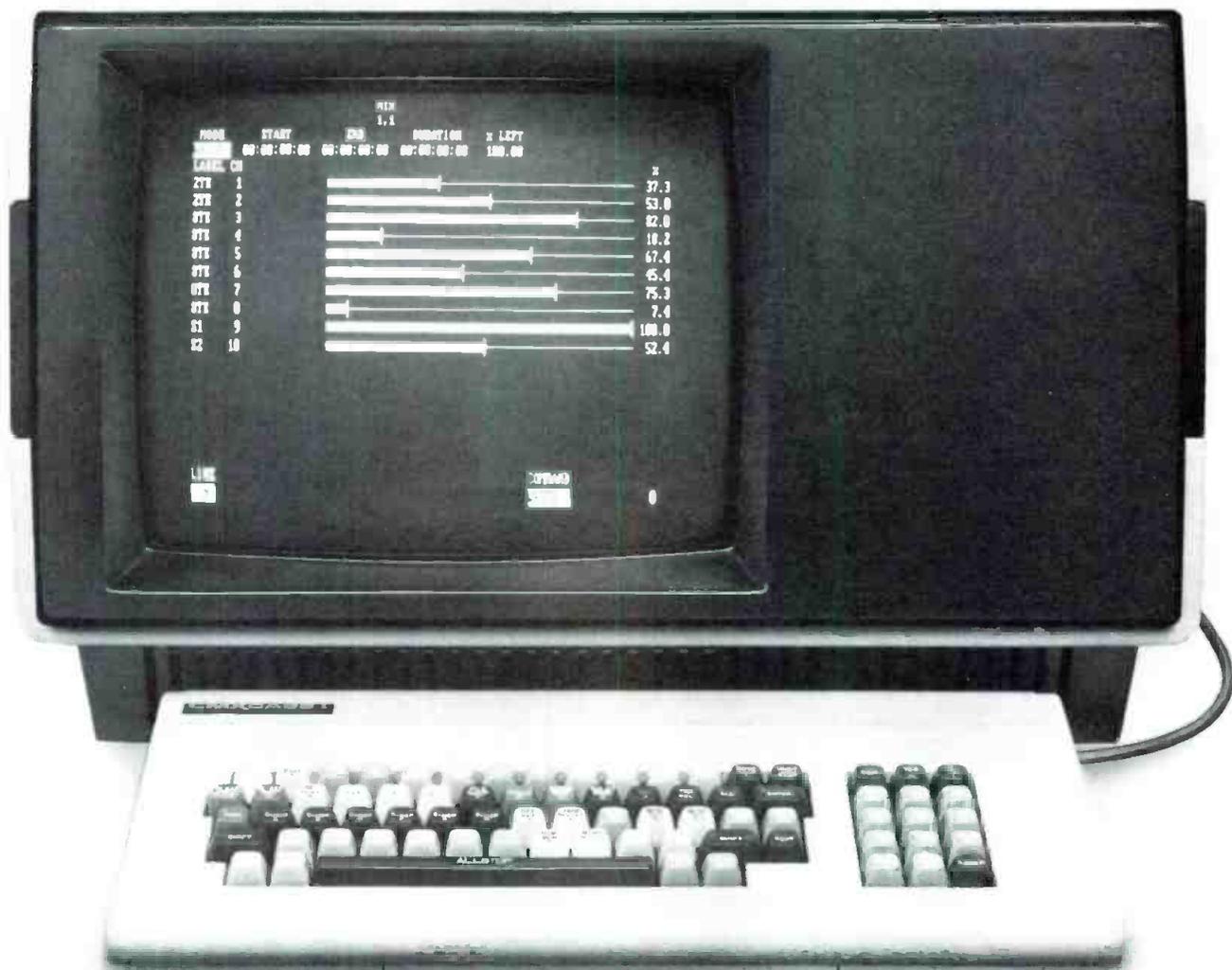


Figure 1. High-voltage diode tester circuit.

Dye is director of engineering for the Ohio Educational Broadcasting Network Commission, Columbus, OH.



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CASS 1 Computer-Aided Sound System. It doesn't look like a mixing console because it's so much more.



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Jerry Cappa and **Jim Minton** have been appointed marketing specialists in TV graphics equipment for Ampex audio-video systems division, Redwood City, CA. Cappa and Minton will act as liaisons between Ampex and graphic designers. Cappa is a former art director for WABC-TV, New York, and Minton is a former broadcast design consultant.

William H. Butler has been appointed president of The Droid Works, San Rafael, CA. Butler has extensive product development, manufacturing and sales experience in the TV industry, and has served in top management positions in several companies.

James Koehn has been appointed vice president and general manager of Harris Broadcast Division, Melbourne, FL. He joined Harris after six years with Tektronix as general manager of the instrument systems integration division.

Sherwin Becker, vice president and

director of engineering at Allied Film & Video, Detroit, has been appointed manager of engineering for the Society of Motion Picture and Television Engineers.

Charles P. Ginsburg has joined AVP Communication, Westborough, MA, as a consultant specializing in technology planning. He retired from Ampex as vice president of advanced technology and planning. Ginsburg will help provide technical advisory services to AVP manufacturers and end-user clients. He also will participate in the planning and presentation of management workshops.

Karen A. Butery has been promoted to key accounts manager for Sony's video communications products division, Park Ridge, NJ. She is responsible for sales and marketing of video products in the Northeast.

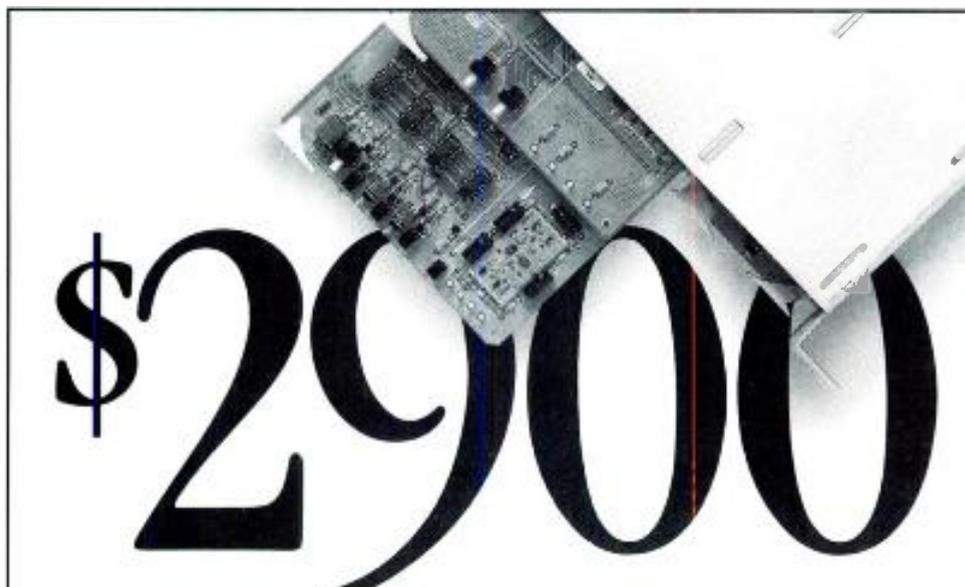
Graham Jarrett has joined AVS, Chessington, England, as managing

director. He spent the past 25 years with Thorn EMI.

Scott Bosen has been named director of market development for Utah Scientific, Salt Lake City. He is responsible for broadening the market base for the company's switching, automation and control equipment, and also will research new products. Bosen will maintain his duties as international sales manager.

Thomas R. Ransom has been appointed director of sales and marketing for IGM Communications, Bellingham, WA. He is responsible for marketing the new program automation control systems and the IGM Go-Cart and Instacart. He previously held a number of marketing positions with Harris.

Jim Gimbel has been named North Central States regional sales manager for Broadcast Systems, Inc., Austin, TX. He is a former national sales manager for RCA Broadcast Division. (:-)))))



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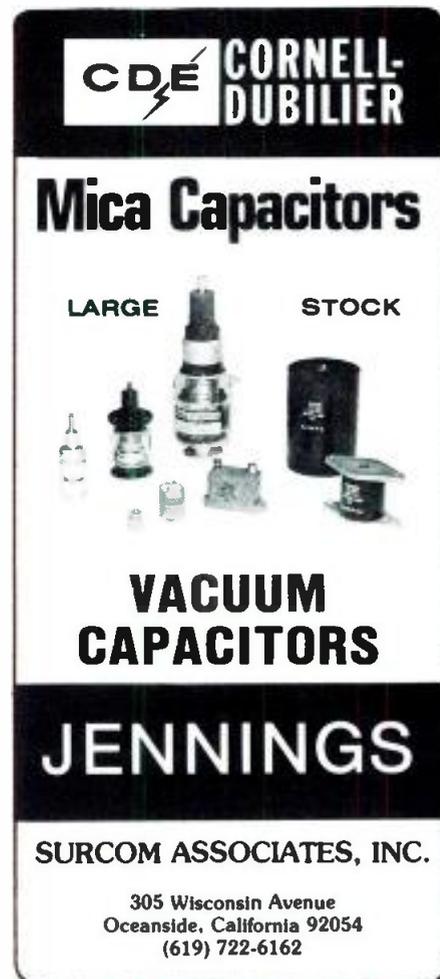
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FOR-A moves to larger facility

FOR-A Corporation of America has moved its headquarters. The U.S. marketing, research and development and service facilities are now located in Nonantum Office Park, 320 Nevada St., Newton, MA 02160. The telephone number remains the same.

Union Connector moves

Union Connector has moved to expanded facilities at 300 Babylon Turnpike, P.O. Box 14, Roosevelt, NY 11575.

Varian receives order

The Continental Electronics division of Varian Associates, Palo Alto, CA, has received an order from the U.S. government for high-power transmitters for the Radio Free Europe/Radio Liberty network. Continental will supply eight 250kW short-wave broadcast transmitters for installation at a site in Portugal.

Varian and Richardson Electronics, Franklin Park, IL, have announced the formation of a joint venture to handle the

distribution of certain types of electron tubes in worldwide commercial markets. The agreement permits broader market coverage for both companies.

The Canada microwave division of Varian has added a new facility for production of power supplies and millimeter wave satellite communications products.

ITC/3M expands facility receives order for Omega

International Tapetronics Corporation/3M has enlarged its Bloomington, IL, engineering facility to accommodate continued product development. ITC/3M has added engineers, acquired additional laboratory space, installed a new conference listening room, expanded office and secretarial space and provided additional technical library space.

Brown Institute, Minneapolis, has purchased 16 International Tapetronics Corporation/3M mono Omega playback machines for its new facility. Brown has 17 TV and radio studios in its six buildings. The institute is planning to have 21 radio studios in its new 3-story facility.

EMCEE installs ITFS networks

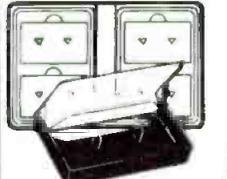
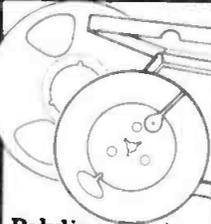
Electronics, Missiles & Communications, (EMCEE), White Haven, PA, has announced the completion of two instructional TV fixed service (ITFS) networks.

A 2-way audio-visual ITFS network links three school districts in the Adirondack Mountains. The hardware for the system enables the districts to transmit computer-generated information via the airwaves instead of through leased telephone lines. The other ITFS system was installed at Chattanooga State College. The system will use four talkback ITFS transmitters and will serve a 4-county area. The system is over the air and no landlines will be needed.

Integrated Technologies relocates

Integrated Technologies has announced the relocation of its marketing and sales headquarters to 3821-F South George Mason Drive, Falls Church, VA 22041. The new telephone number is 703-578-1811.

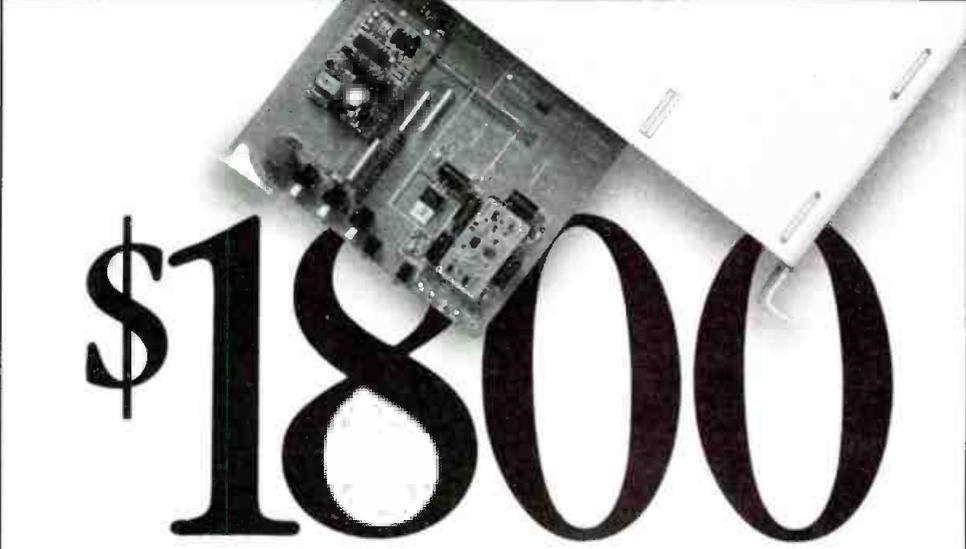
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Circle (91) on Reply Card

Sony and Faroudja sign agreement

Faroudja Laboratories, Palo Alto, CA, has announced the signing of an extensive licensing agreement with Sony in Japan. This new accord, which is the third in a series of licensing agreements over the past three years, covers the use of proprietary Faroudja patents in the field of video signal processing. This agreement gives Sony-Japan the exclusive right to sublicense other video equipment manufacturers in the consumer electronics field that want to use the patents.

Odetics accepts orders

Odetics, Anaheim, CA, has announced that KIMO, Anchorage, AK, KWHY, Los Angeles; and NBC affiliate WGRZ, Buffalo, NY, have placed orders for the TCS2000 cart machine, a computerized cassette playback and record system.

CMX upgrades facility systems

CMX Corporation, Santa Clara, CA, has upgraded the Telemation, Salt Lake City,

production houses with 3400A editing systems. CMX has also upgraded five 3400 systems.

Companies accept Neve deliveries

The National Film Board of Canada has taken delivery of its second *Neve*, Bethel, CT, custom film rerecording console. The custom console is based on the 51 series of consoles and is a 36-channel board with six subgroups, six main outputs and 6-track monitoring facilities, equipped with both NECAM 96 and VCA subgroupings.

The Bombay Broadcasting Company, New York, has taken delivery of a Neve 5432 8-input table *drop thru* video post-production console for its 3/4-inch video editing suite.

Ampex signs contracts

Ampex has announced the delivery of a VPR-3 videotape recorder to Innervision Productions, a St. Louis production facility. WXIA-TV, the NBC affiliate in Atlanta, has taken delivery of an ADO

digital effects system.

Ampex also announced that it has reached an agreement with Cubicomp Corporation, Berkeley, CA, to sell to Ampex 20% ownership of Cubicomp and to grant Ampex rights to market and manufacture Cubicomp's PictureMaker 3-D graphics animation products.

CRL Audio reactivates Dynafex line

CRL Audio has announced that it will manufacture and distribute the Dynafex line of after-the-fact noise reduction processors. CRL purchased the assets and products of the former MicMix enterprise from the trustees for the company after it ceased operations in 1985.

BSI completes construction

Broadcast Systems, Inc. has completed construction of the technical and studio facilities for KTHT-TV, Alvin, TX, an independent station serving the Houston metropolitan area. BSI also constructed a technical facility for WCAJ-TV, Birm-

The answers to a radio engineer's pressing audio problems:



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ingham, MA, and supplied all the equipment, including the transmitter and antenna.

BTS becomes official

A cooperative venture, announced in January, between Robert Bosch GmbH, Darmstadt, West Germany, and N. V. Philips' Gloeilampenfabrieken, Eindhoven, the Netherlands, was approved on July 2, 1986. The company, *Broadcast Television Systems GmbH (BTS)*, will be headquartered in Darmstadt.

Philips Television Systems, Mahwah, N.J., expected United States approval of the change to Broadcast Television Systems Inc. by late July. Robert Bosch Video Equipment Division, Salt Lake City, will not assume the BTS name until January 1987.

The product line will include all equipment from Bosch (Darmstadt and Salt Lake City) and Philips (Mahwah and Breda, the Netherlands). In addition, BTS will represent Philips and Pye TVT transmitter products. Future products will be created from this merger of company technologies.

The business move creates a wider technology base, strengthens international competitiveness and extends the market position of the product line. In addition, both Bosch and Philips predict improved service to their clients around the world.

Conus supplies satellite news-gathering vehicles

The Kansas State Network has become the first consortium of local TV stations to share a satellite news-gathering newsvan, from *Conus Communications*, Minneapolis. KSN is also the first to receive the second-generation low-boy vehicle. The network is comprised of three NBC-affiliated TV stations and three smaller satellite stations.

Conus also announced that it has begun a \$300,000 expansion of its Ku-band satellite news center master control that will double the capacity of the center for Ku-band satellite news-gathering vehicles.

KOMO-TV, Seattle, and KELO-TV, Sioux Falls, SD, have become members of Conus Communications.

Cubicomp moves headquarters

Cubicomp Corporation has moved its corporate headquarters to 21325 Cabot Blvd., Hayward, CA 94545. The new telephone number is 415-887-1300.

Mitsubishi adopts standard, makes deliveries

Mitsubishi Pro Audio Group, San Fernando, CA, has adopted the new proposed standard RS-422 protocol. The standard will help relieve the burden placed on studio facilities having to develop complicated interfaces. The standard will apply to all of the Mitsubishi digital audio recorders and Westrex Film Master motion controllers.

A number of companies have taken delivery of Mitsubishi equipment. Soundworks Studios and Multitrack Hire have received the X-850 digital multitrack recorder. The Readers Digest Association and Digital Music Products have added X-80 digital master recorders to their facilities. The Florida Production Center has acquired six Quad-Eight model 248 audio consoles. !:~:~))]]

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New products

Boundary microphone



Audio Technica has introduced the AT871 uniplate boundary microphone. It is a unidirectional condenser mic with a hemi-cardioid polar pattern. It may be powered from an external 9-52Vdc phantom power supply or from a NEDA-type

910 1.5V "N" cell supplied with the microphone.

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Audio equipment and expander

Telex Communications has announced the addition of a series of 4-channel master stations and 2-line remote stations and a programmable matrix option for the 4-channel master stations. The IC-4M 4-channel master station with built-in power supply provides four separate channels for 2-way conversations. The master station operator also can feed an auxiliary audio source to any channel by using the aux input and aux channel select switch. The programmable matrix option switchboard, model IC-4SX, uses microprocessor circuitry. It leaves all controls including channel selection at the master station.

Circle (351) on Reply Card

Serial communications adapter

Generic Designs has introduced a serial communications adapter designed to provide an RS-422 serial port to type 5 and other 1/2-inch and 3/4-inch VCRs. It consists of a microprocessor, dual asynchronous serial receiver/transmitter, high-speed SMPTE time-code reader and a universal parallel I/O module.

Circle (352) on Reply Card

Audio test software and stereo analyzer/monitor

Sound Technology has introduced the following products:

- New audio test software intended for use with the 1500A or 1510A audio test system and IBM compatible computers.

A COMPLETE VIDEO PROCESSOR

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The VC-2000P is perfect for videotape editing, duplicating and for use as a camera control unit. It automatically regenerates all sync, blanking, and color burst signals which will correct most instabilities (such as jitter, bending, and rolling.)

As a camera control unit the video, color, and hue adjustments allow camera matching and correct

levels. In tape editing these controls provide scene to scene matching and fade to black.

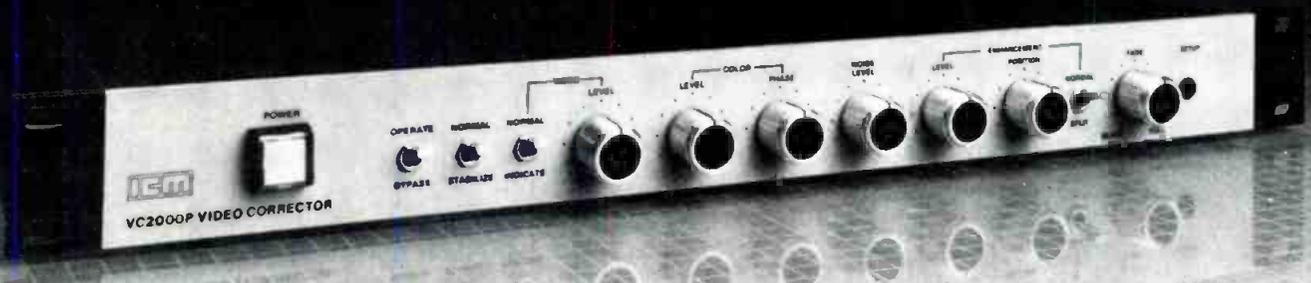
Enhancement and noise reduction controls provide dramatic picture improvement and reduce tape duplicate generation loss. Additional features include four video and four audio outputs, and optional plug in RF modulator.

The rack mountable VC-2000P is only \$780.00.

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The software measures 2-channel ac volts, azimuth, second, third and total harmonic distortion, frequency response, weighted and flat noise, maximum operating level and channel separation.

- The 1530A MTS stereo analyzer/monitor accepts discrete left and right channel signals that have been demodulated from the aural carrier. It measures 2-channel level, swept frequency response and narrowband channel separation, phase error, composite and spectral noise, as well as performing wave and IMD analysis.

Circle (353) on Reply Card

Audio time base/phase corrector

Howe Audio has announced the series 2300 Phase Chaser. It is a stand-alone audio time base/phase corrector and can detect and correct time skew up to ± 150 ms between the left and right channels of a stereo signal. It can detect and correct 180° channel inversion, employing a 30ms soft cross-fade technique; and can detect and correct a missing channel condition, using user-preset parameters for dropout level and mono fill-in attack and release times.

Circle (354) on Reply Card

Audio switcher

Conex Electro-Systems has introduced the AS-101 audio switcher. It allows any one of 10 stereo sources to be switched to the stereo output. The switcher includes program line source selection from multiple studios, recorder input selec-

tion, DJ live-assist, newsroom control operation and general audio routing applications. Distortion is less than 0.01% THD and noise at -80 dB.

Circle (355) on Reply Card

Serial control panel and switcher system



The Grass Valley Group has announced the following broadcast products:

- The TNX-SCP serial control panel can be set via an internal dip switch to control one or two switchers or up to 10 switchers in an X-Y fashion. It features RS-232 or RS-422 data and baud rates are selectable from 45.5 to 38,400.
- The TEN-XTM routing switcher system incorporates all the

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THE DAWN OF A NEW GENERATION IN VIDEO

By replacing conventional gears which control the zoom and focus servos with modern nylon belts, Angénieux has made yet another breakthrough in the design and construction of its broadcast lenses.

Substantially lighter, mechanically quicker, and dramatically quieter, with sophisticated internal hood soundproofing, recessed hood handles, an internal heater, digital readouts for iris position, extender position, and a three lamp diascope all standard, Angénieux's New Generation of broadcast lenses are at the crest of the industry's future wave.

Among Angénieux's New Generation of ENG zoom lenses are the 14x7 ultra wide angle, the 14x8 with a non-rotating front focusing element, and the 14x9, all with a maximum relative aperture of $f/1.6$ —the fastest in the industry.

For studio and outside broadcast use Angénieux's New Generation includes the new 15x HP series—15x13 HP 1" format and 15x17 HP 1 1/4" format—and the high quality studio/O.B. 18x12.5 1" format and 18x16.5 1 1/4" format lenses.

And that's not all. Angénieux's highly skilled engineers are working harder than ever before to meet the industry's demand for more and better broadcast lenses.

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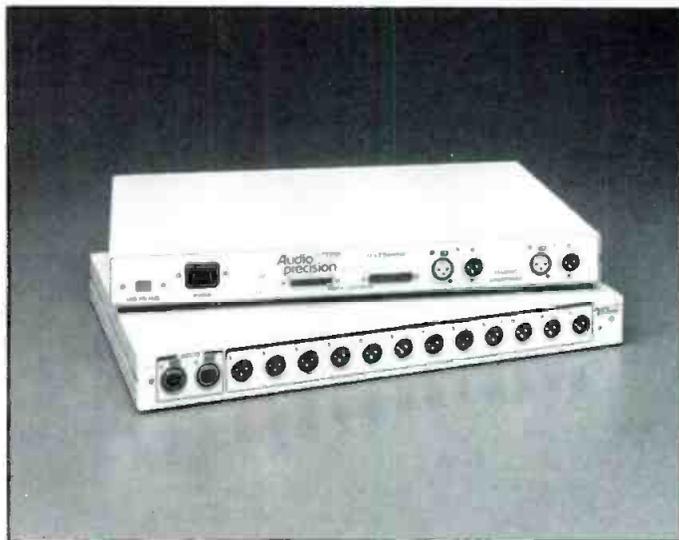
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Telephone: (203) 384-1266

Circle (93) on Reply Card

features of the earlier TEN-XT, and also provides audio VU/peak metering and a built-in audio monitor/speaker combination.

Circle (357) on Reply Card

Routing switcher modules



Audio Precision has introduced the SWR-122, a balanced 12 x 2 audio routing switcher to be used with the System One. The modules can be stacked up to 16 units of inputs and outputs (192 channels). The switchers are controlled from the software panels of System One. The switchers are fully balanced and each module contains two common and 12

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Klystron amplifier



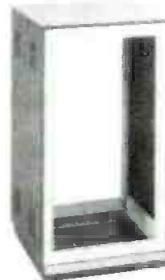
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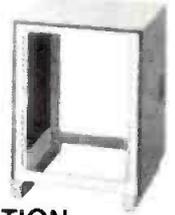


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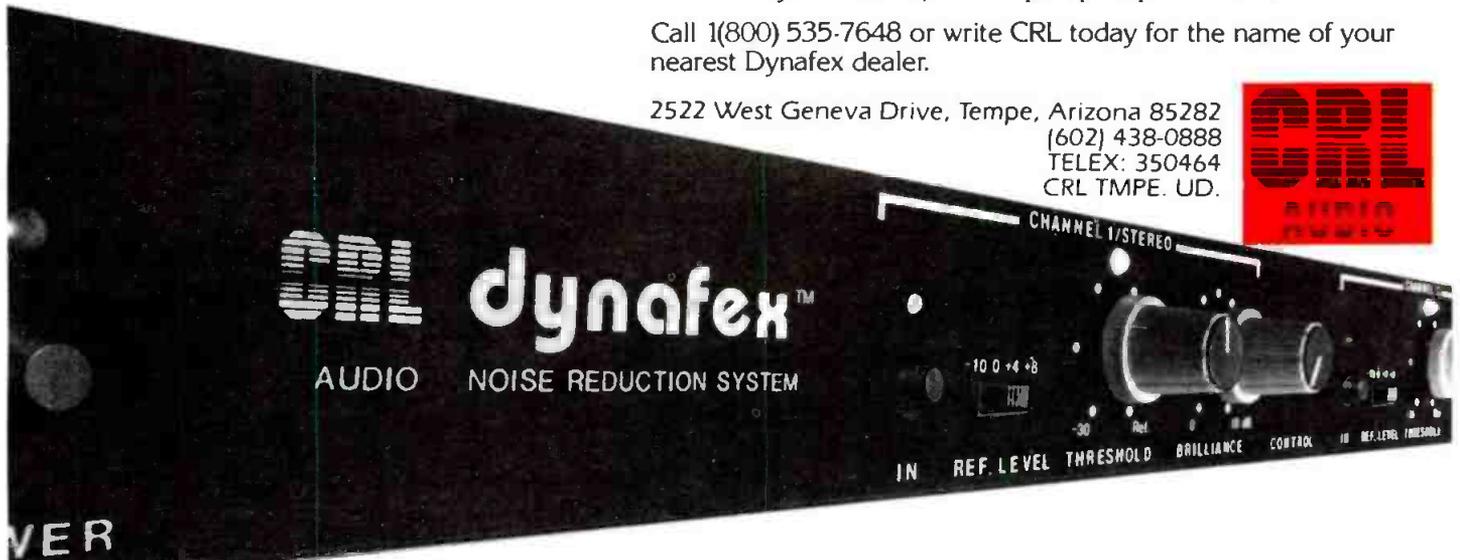
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QEI's 695 offers features that the competition has never even dreamed of. A peak counter with LED display, modulation measurements on the front panel, and a measurements grade linear demod built in. It is synthesized, has wideband circuitry, a 3-color LED bar graph for modulation display, a 10-position meter, and many other features that are best described in our new brochure.

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Circle (94) on Reply Card

(model 10600-3.5kW C-band). It has a beam supply drawer and a hinged EMI shielded panel that contains the system logic board.

Circle (359) on Reply Card

Character generator



3M Broadcasting and Related Products Division has announced the model D-6000 Panther graphics generator. It combines the features of a character generator with those of a paint system. Features include 35ns resolution, built-in downstream keyer, four planes of 1,024 x 512 pixels per plane, multispeed roll and crawl, real-time clock and timed sequencing.

Circle (360) on Reply Card

RF microphones

Sony Professional Audio has introduced a VHF wireless microphone. It uses frequency synthesis in both transmitters and receivers. The microphone can transmit on any of 48 separate frequencies and each receiver can operate through the entire 174MHz to 216MHz range. It features a built-in microprocessor and helps prevent multichannel intermodulation distortion problems.

Circle (361) on Reply Card

Commercial receiver

R.L. Drake Company has announced the ESR2240, a commercial earth-station receiver. It features block downconversion, dual signal inputs, a 950MHz to 1,450MHz IF loop-through output, a SAW filter for maximum adjacent channel and interference rejection with minimum signal distortion.

Circle (362) on Reply Card

Video switching system control panel

Dynair Electronics has introduced the PCA-902A, a 10-key control panel for video switching systems. The panel is a versatile switcher control with status display on an 8-digit LED panel. It functions as an audio-follow-video control of switching systems up to 1,000x1,000.

Circle (363) on Reply Card

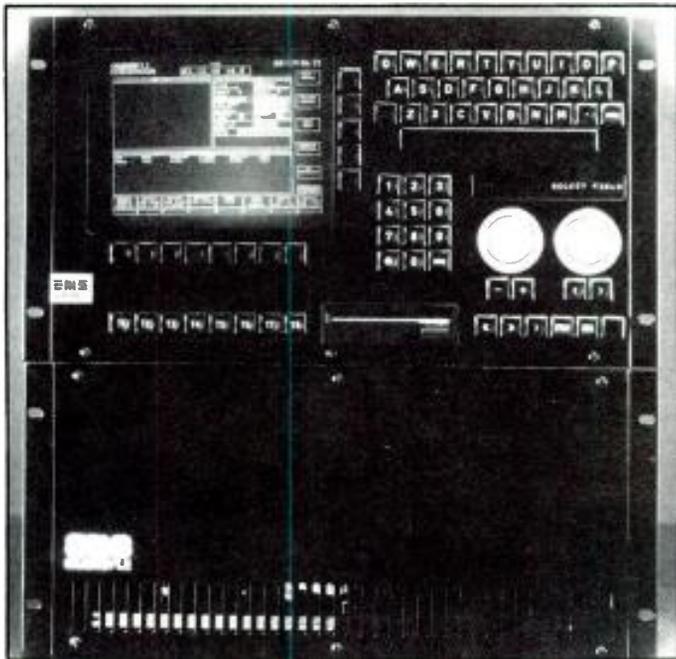
Battery powered 6-light

The Great American Market has introduced the MicroBrute

12V6 battery powered micro 6-light. It accepts 65W or 75W MR 16 cool beam lamps. Each lamp is switched separately and the two swivel stick lamp housings offer flexibility.

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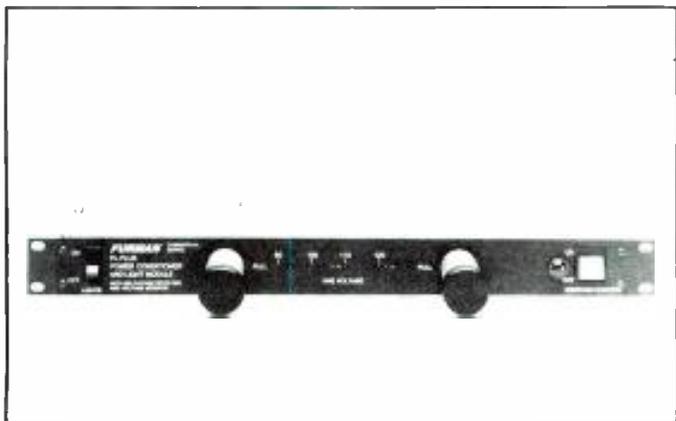
Audio recording and editing system



Advanced Music Systems has announced the AudioFile, a digital audio recording and editing system. It features stereo capability and dynamic range greater than 90dB, eight output channels, digital ports and a high-resolution graphics screen. Cues can be recorded into the system, edited and assembled into a cue playlist executed to SMPTE time code.

Circle (365) on Reply Card

Digital reverb system and power conditioner/light module



Furman Sound has introduced the following products:

- The RV-3 digital reverberation system has a total of 512 distinct preprogrammed settings. It features two rotary controls, push-button control predelay, room position and filtering. The system is a mono-in, stereo-out device featuring a 79dB dynamic range and 14kHz bandwidth.
- The PL-Plus power conditioner and light module features eight switched ac outlets with heavy-duty spike and surge suppression for power distribution. Features include a multistage filter and a voltage monitor. The unit is rated at 15A capacity.

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Acoustic Products for the Audio Industry

Circle (92) on Reply Card

Stereo distribution amplifier

DYMA Engineering has announced a new version of the 815 series of stereo distribution amplifiers. It features individual channel gain controls, individual module powering, high head room and frequency response and common mode rejection. It has one stereo input and four stereo outputs.

Circle (367) on Reply Card

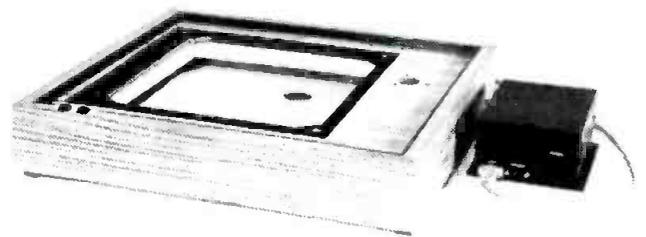
Audio level meter and stereo mixer



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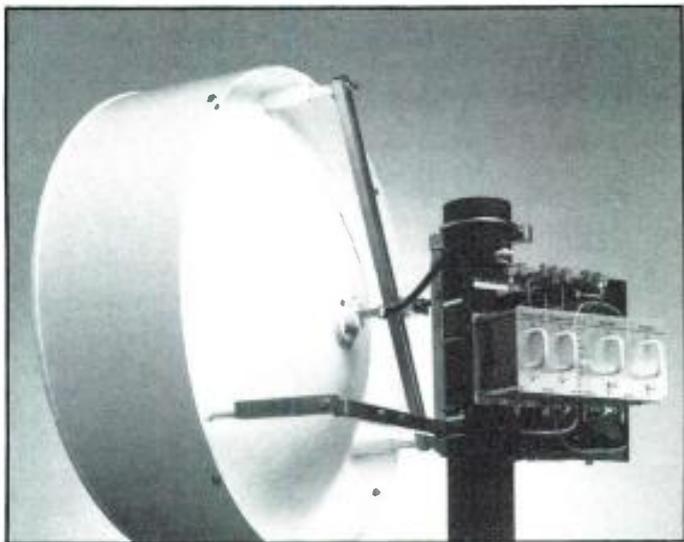
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- The ATS-100 stereo dual channel, extended range audio meter features VU meters that conform to ANSI specifications and resolution of 1dB steps from -60dBm to +30dBm. Bridging inputs are provided with 600Ω and 150Ω front-panel selectable terminations.
- The AMS-210 audio stereo mixer features 12 stereo inputs, comprehensive monitoring, separate stereo metering, RS-422 interface, five transition modes and audio-follow-video switcher and audio-follow edit.

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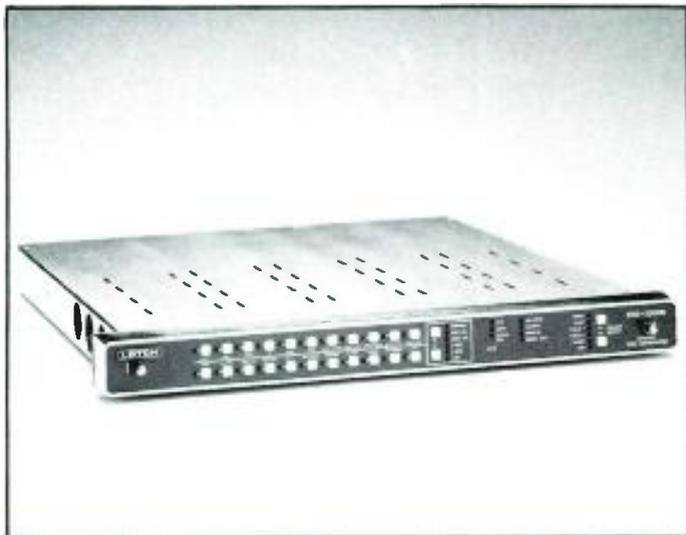
Microwave radio



Harris Broadcast Microwave has announced the Microstar 23, a 23GHz video microwave radio that meets EIA RS-250B TV standards. It features simplex or duplex operation in non-protected or hot-standby modes; temperature-compensated frequency sources that hold a frequency tolerance of ±0.01%; conformal-coated printed circuit boards; and an enclosure with sunshields.

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Transmitter and studio test generators



Leitch Video has introduced the XTG-2500N NTSC transmitter test generator and the STG-2500N NTSC studio test generator. They both provide 22 computer-generated video test signals and three VITS packages per FCC, CCIR (NTC-7) and CCIR plus VIR. Test signals are stored in EPROMs. An RS-170A gen-lock sync generator allows accurate phasing and

Our Premier Pneumatic Pedestal Has Found Its



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Performance and price place our ITE-P1 in a class by itself. But now it has found its match. Our new ITE-P2 is a "lowboy" version of its older sibling. But with minimum height to cam head mounting surface reduced to 24.5" – comparable to pedestals priced twice as much!

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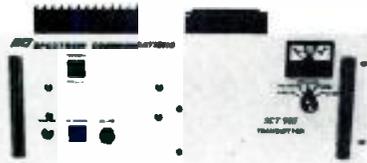
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maintains zero SCH on all color signals. Sync, blanking and subcarrier outputs are provided.

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AXII aural exciter upgrade

Aphex Systems has developed a MAX circuit for its aural exciter to improve sound quality. The circuit also will have greater control of sibilance caused by audio source material.

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Tape analyzer

Jasoni Electronics has introduced the TAS-1000 tape analyzer system. It aligns, calibrates and sets up tape gear and will read noise down to -70dB. It features a sine oscillator, distortion less than 1%, frequency response ±1dB, built-in monitor speaker, stereo termination switch, balanced inputs and outputs, and is transformer-powered.

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Video graphics systems

Ampex has introduced the Creative Graphics Center, an integrated, modular family of video graphics systems. It consists of the ESS-3 composition graphics system, the AVA-3 video art system, and the PictureMaker system.

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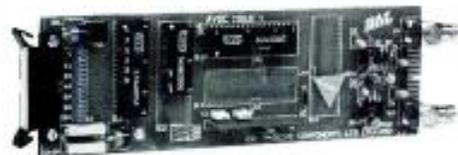
Automatic cart machine

Broadcast Systems Inc. has announced the DC-8/EP automatic cart machine. It is microprocessor-controlled and has many of the same features as the DC-8 including 2-second preroll, antihead clogging, auto eject, auto cue recording and balanced +4dBm audio input and outputs.

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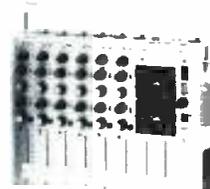
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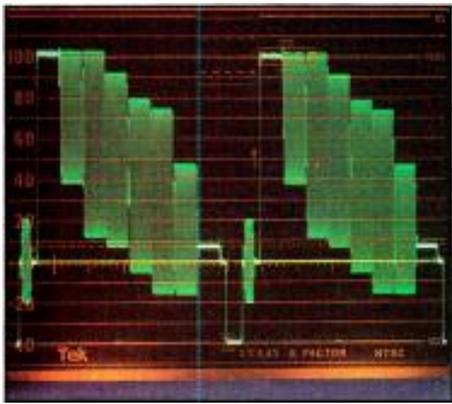
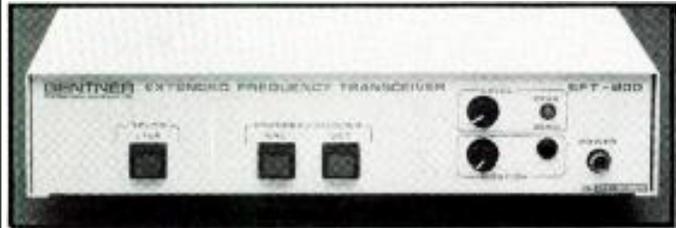


Figure 1. Color bars on a waveform monitor, 75% amplitude, 100IRE white, 2H sweep.



Figure 7. Color bars on a vectorscope.

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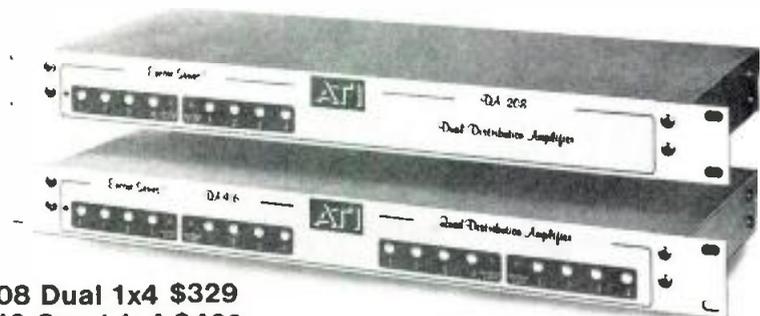
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USED 20 KW FM TRANSMITTER. Preferably Harris 20H3 with MS-15 exciter. Contact Chief Engineer at WXKC Radio, (814) 868-5355. 8-86-1t

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REGIONAL SALES MANAGER: A TBC manufacturer seeks Sales Manager in New York and Los Angeles areas. Sales experience or technical background in TBC needed. Please contact: Hotronix, Inc., 1210 S. Bascom Ave., Ste. 128, San Jose, CA 95128. 8-86-1t

ASSISTANT CHIEF ENGINEER: Major market PBS affiliate has opening for A.C.E. Familiarity with studio and UHF transmitter necessary. Excellent salary, excellent benefits. Chicago residency required. Send resume to: Columbus Jenkins, Business Operations Manager, WYCC-TV/Channel 20, 7500 S. Pulaski Rd., Chicago, Illinois 60652. City Colleges of Chicago is an Equal Opportunity Employer. 8-86-3t

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TV ENGINEER—Experienced in design and maintenance of TV systems. Opportunity to work in a friendly relaxed non-urban college environment. Send resume to: Personnel Office, East Texas State University, Commerce, TX 75428. EAST TEXAS STATE UNIVERSITY IS AN EQUAL OPPORTUNITY AFFIRMATIVE ACTION EMPLOYER. WOMEN AND MINORITIES ARE ENCOURAGED TO APPLY. 8-86-11

MAINTENANCE ENGINEER for established New York production and post production facility. Must have at least one year experience maintaining 1" video tape machines (Sony BVH preferred). Knowledge of any of the following equipment is important but not essential—GV300 switchers, Sony BVE500 editors, Sony BVU800, Sony BVW40, Ikegami HK312 cameras, MK II DVE, ADO, Chyron 4100. Salary commensurate with experience. Send resume to: International Production Center, 514 W. 57th Street, New York, NY 10019, ATTN: Bill Jarett 212-582-6530. 8-86-11

PRODUCTION OPERATIONS ENGINEER: Immediate opening for a qualified individual to assume responsibility for day to day maintenance and operations of a post-production and studio facility. Should be thoroughly familiar with CMS 340X, NEC Optiflex, Sony BVH 2000, 1100A and Beta Cam, GVG 300 switcher, CDL switcher, and Thompson Graphics V. Send resume to Human Resources Dept., Flite Three Recordings, Ltd., 1130 E. Cold Spring Lane, Baltimore, MD 21239. 8-86-11

RADIO ENGINEER POSITION: SHAMROCK BROADCASTING is seeking a very special radio engineer. This people-oriented individual must be able to supervise the engineering department for a leading AM & FM in Pittsburgh, PA and must have extensive experience with AM directional systems. EOE, send resume to Bert Goldman, 8500 W. 63rd Street, Shawnee Mission, KS 66202, (913) 722-2866. 8-86-11

IMMEDIATE OPENING for Chief Engineer Sunbelt VHF, CBS. Great opportunity to maintain first-class facility. Must have transmitter experience and enjoy hands-on maintenance of studio and E.N.G. Excellent pay and benefits with group owner. Engineering Department, Box 32488, Charlotte, NC 28232. E.O.E. 8-86-11

MAJOR GROUP OWNED high-power FM/Stereo AM has immediate opening for self-starter Chief Engineer. Applicant must have concern for high quality audio and workmanship. Some background in digital electronics necessary. Please contact Leeann Lewis, General Manager, KEEL/KITT, P.O. Box 20007, Shreveport, La. 71120. Multimedia is an Equal Opportunity Employer. 8-86-11

CHIEF ENGINEER: Seeking Chief Engineer for small midwestern market TV station with well established broadcast company. All new equipment. Responsible for maintenance of transmitter and studio equipment, supervise engineering operations, FCC compliance. Send resumes to: Broadcast Engineering, P.O. Box 12901, Dept. #669, Overland Park, KS 66212. 8-86-11

STUDIO AND UHF TRANSMITTER maintenance technician. Must have UHF transmitter maintenance experience. Contact Ken Preston, KSEE (209) 237-2424, P.O. Box 24000, Fresno, CA 93779. EOE M/F. 8-86-21

DIRECTOR OF ENGINEERING: Exciting opportunity in Las Vegas for Engineer with management skills and long term planning expertise. Minimum of five years television experience. An excellent position for an assistant chief who wants to move up. Degree in electrical engineering desirable. Contact Rolla Cleaver, General Manager, KVBC (TV), 1500 Foremaster Lane, Las Vegas, Nevada 89101. 8-86-11

WPAT JOB OPPORTUNITY: WPAT HAS AN OPENING FOR THE FOLLOWING POSITION: Technical Supervisor. New York station has opening for highly qualified technical supervisor. Maintenance experience required for all phases of broadcasting. Contact Kenneth Stout, WPAT AM/FM, 1396 Broad Street, Clifton, New Jersey 07013. 201-345-9300. AN EQUAL OPPORTUNITY EMPLOYER. 8-86-21

VIDEO ENGINEER: Growing Chicago post-production facility seeks video engineer. Minimum 3 years experience in problem solving, maintenance and systems design. Good opportunity to apply technical expertise in a creative, quality-oriented TV facility. Knowledge of Sony 1", Betacam, CMX and Digital Effects a Must. Reply in confidence to: Thomas K. Shea, senior engineer, Independent Programming Associates, 1208 Webster, Chicago, IL 60614. Telephone (312) 871-6033. 8-86-11

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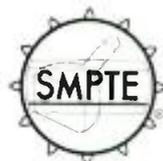
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1986 Broadcast Engineering Conference

Tuesday, October 14:

- 10 a.m. Opening remarks, John H. Battison, conference chairman
- 10:30 a.m. *The New FCC/FAA Tower Marking and Lighting Rules*, Lew Wetzel, Flash Technology
- 11:05 a.m. *The Travelers Information Service*, Richard Crompton, LPB
- 11:40 a.m. *Audio Specifications—What Do They Really Mean?* Irv Joel, Irv Joel & Associates, consulting engineers
- 12:30 p.m. Lunch
- 1:30 p.m. *The FCC Answers Back*, John Reiser, FCC, Chris Imlay, attorney
- 2:45 p.m. Coffee break
- 3 p.m. Consultants round table, moderated by John H. Battison (Panelists: Don Markley, John F.X. Browne, Lawrence Behr, Wally Johnson, Irv Joel)
- 4 p.m. *Engineering Management*
- 5 p.m. National Membership meeting
- 6 p.m. Ham Radio Reception

Wednesday, October 15:

Radio Sessions

- 8:30 a.m. *The Care and Feeding of Folded Monopole Antennas*, Lawrence Behr, Consulting Radio Engineers
- 9:05 a.m. *Fine-tuning FM Final Stages*, Geof-

frey Mendenhall, Broadcast Electronics

- 9:40 a.m. *Tuning and Adjusting Pulse-Modulated Transmitters for Optimum Performance*, Steve Claterbaugh, Continental Electronics
- 10:15 a.m. Coffee break
- 10:30 a.m. *Grounding to Eliminate Hum and RFI*, L. Scott Hochberg, Logitek
- 11:05 a.m. *Synchronizing AM Transmitters*, Oscar Reed, P.E., consulting radio engineer
- 11:40 a.m. *Digital Audio Basics*, John Woram, Digital Audio Reports

TV Sessions

- 8:30 a.m. *Switchless RF Combiner for TV*, Greg Best, Harris
- 9:05 a.m. *Recent Developments in Klystron Technology, Including Practical Applications*, Nick Ostroff, Comark
- 9:40 a.m. *A Review of Videotape Formats*, Jerry Bauman, 3M
- 10:15 a.m. Coffee break
- 10:30 a.m. *Tuning and Adjusting TV Antennas with a Spectrum Analyzer*, Don Markley, P.E., consulting engineer
- 11:05 a.m. *Stereo TV Measurement Techniques*, Mike Coleman, Tektronix
- 11:40 a.m. *Enhanced NTSC Transmission and Spectrum Sharing with the*

Land Mobile Service, John F.X. Brown, P.E., consulting engineer

- 12:30 p.m. Tom Keller, NAB, and Jim McKinney, FCC, will speak at joint TV/radio luncheon
- 2 p.m. Question/answer session with Jim McKinney for TV and radio
- 3 p.m. *Zero Setup for Video*
- 5 p.m. SBE Chapter Chairmen Meeting for TV and radio
- 7 p.m. Reception for TV and radio

Thursday, October 16:

- 8:30 a.m. *Transformer Rewinding Techniques*, Peter Dahl, Dahl Transformer Company
- 9:05 a.m. *RF Radiation and the Broadcaster*, Richard Tell, EPA
- 9:40 a.m. *FM Allocations and Application Processing*, Harry C. Martin, Chris Imlay, attorneys
- 10:15 a.m. Coffee break
- 10:30 a.m. *The Effect of Antenna Bay Spacing on Downward Radiation*, Robert Surette and Peter S. Hayes, Shiveley Labs
- 11:05 a.m. *A Variable Speed CD Player*, Bill Sacks, Straight Wire Audio
- 11:40 a.m. *Computerized Engineering Information*, Robert Kircher, Data-world

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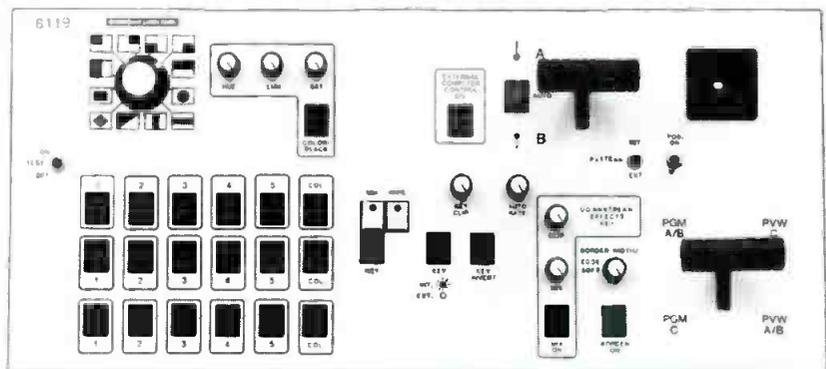
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