BROADCAST engineering®

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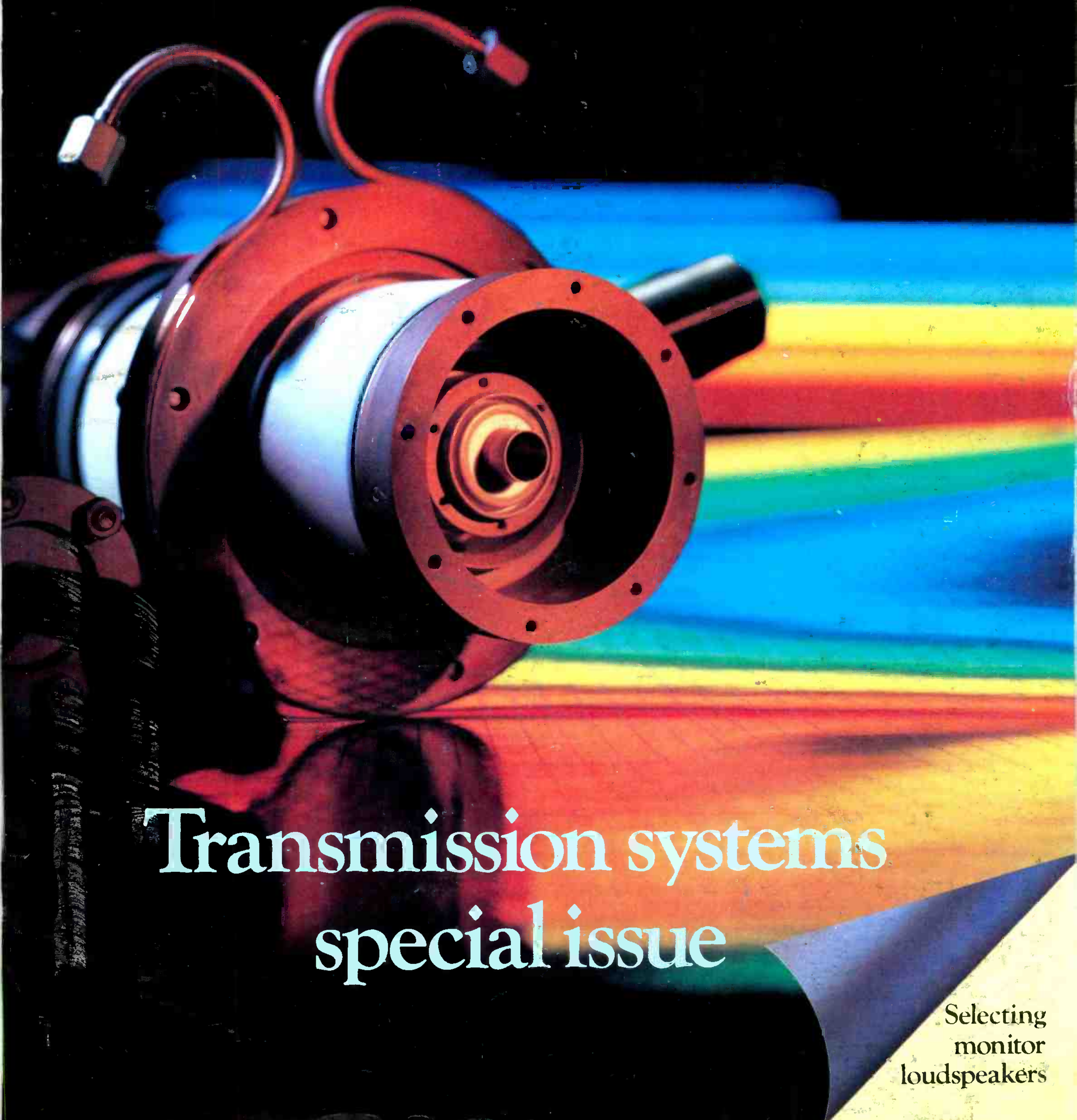

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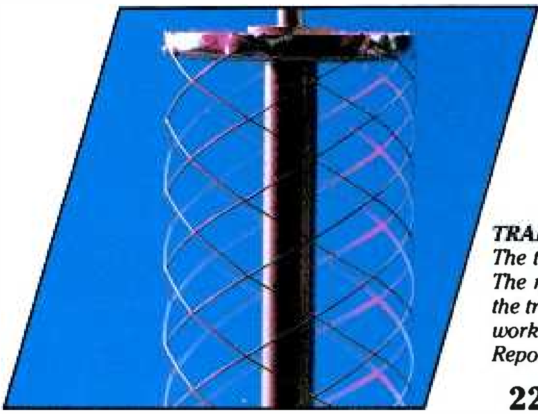

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BROADCAST ENGINEERING

TRANSMISSION SYSTEMS SPECIAL REPORT:
The transmission plant is the heart of any radio or TV facility. The most basic requirement of the engineering staff is to keep the transmission system—from the STL to the antenna—in good working order. Our first annual Transmission Systems Special Report examines this critical area of station operation.

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ON THE COVER
New power devices are giving broadcasters new ways of generating RF power. Advancements in tube and solid-state designs have revolutionized transmission technology for radio and television. Shown on our cover this month is a Klystrode device intended for application in UHF TV transmitters. The Klystrode represents a marriage of klystron and tetrode technology to achieve high efficiency in the UHF TV bands. (Photo courtesy of Varian EIMAC).

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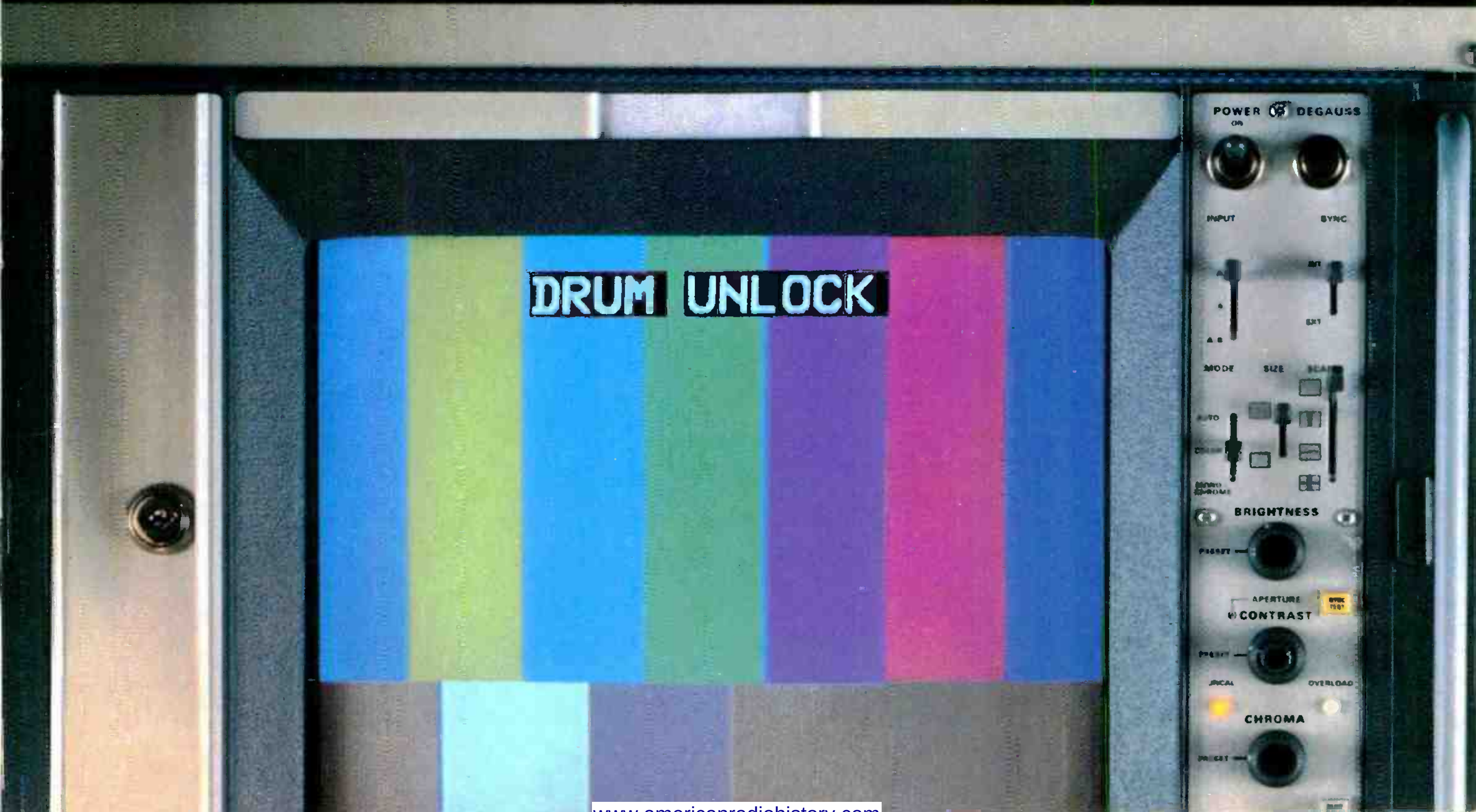

News

NAB requests federal pre-emptions

The NAB has asked the FCC to federally pre-empt state or local RF radiation regulations that arbitrarily restrict broadcast and other interstate communication services. In a growing number of instances, non-federal authorities have placed restrictions on placement and/or use of broadcast facilities. Such a federal pre-emption would ensure the FCC goal of interstate communications. The lack of pre-emptory action may see those goals thwarted by non-federal regulatory or legislative action.

In particular, the NAB has called for a commission policy statement that pre-empts state and local standards more stringent than those of ANSI non-ionizing radiation guidelines. No additional scientific evidence showing potential harm by public exposure to RF radio frequency energy below ANSI levels has been provided. The FCC adopted ANSI guidelines for its own regulatory purposes.

A stronger TVRO policy also has been requested by NAB. Previously, the FCC announced pre-emption policies for satellite master antenna TV (SMATV) operations and amateur radio. Those policies stated that local regulation generally must not interfere with the delivery of interstate signals, and that regulations directly conflicting with federal objectives should be pre-empted.

The NAB indicated that a major federal objective is to diversify the means of program distribution to radio and TV stations. A stronger policy toward non-federal zoning and other restrictions applied to broadcast and auxiliary facilities would further the objective.

BE goes electronic

Publications from the Intertec Electronics Group — **Broadcast Engineering, Video Systems, Sound & Video Contractor, Recording Engineer/Producer** and **Land Mobile Product News** — have been added to information services on the CompuServe Network. Initial material provided includes highlights of feature stories and column topics. Additional information is planned for the future.

In order to take advantage of this service, you must have a CompuServe membership. A membership package can be obtained at most any computer store across the country. To access the professional publications area, enter GO INCUE at any (!) prompt.

Readers also may wish to enroll with Broadcasters Data Base (BDB). **BE** has already provided several computer programs to the Houston-based data service. For more information about BDB, call 713-623-4011 or write BDB, 3935 Westheimer, Ste 305, Houston, TX 77027.

EBU panel views MUSE

Demonstrations presented by RAI and NHK (the Italian and Japanese national broadcasting networks) compared MAC and MUSE HDTV transmission systems for an EBU technical panel in March. MAC (multiplexed analog components) is the British-developed encoding system proposed for DBS broadcasting of 625-line TV signals for Europe. MUSE (multiple sub-Nyquist sampling encoding) is a development of NHK.

The tests compared MUSE-encoded pictures to the original HDTV pictures, as

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BROADCAST ENGINEERING

Editorial and advertising correspondence should be addressed to: P.O. Box 12901, Overland Park, KS 66212-9981 (a suburb of Kansas City, MO); (913) 888-4664. Telex: 42-4156 Intertec OLPK. Circulation correspondence should be sent to the above address, under P.O. Box 12937.

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BROADCAST ENGINEERING is edited for corporate management, engineers/technicians and other station management personnel at commercial and educational radio and TV stations, teleproduction studios, recording studios, CATV and CCTV facilities and government agencies. Qualified persons include consulting engineers and dealer/distributors of broadcast equipment.

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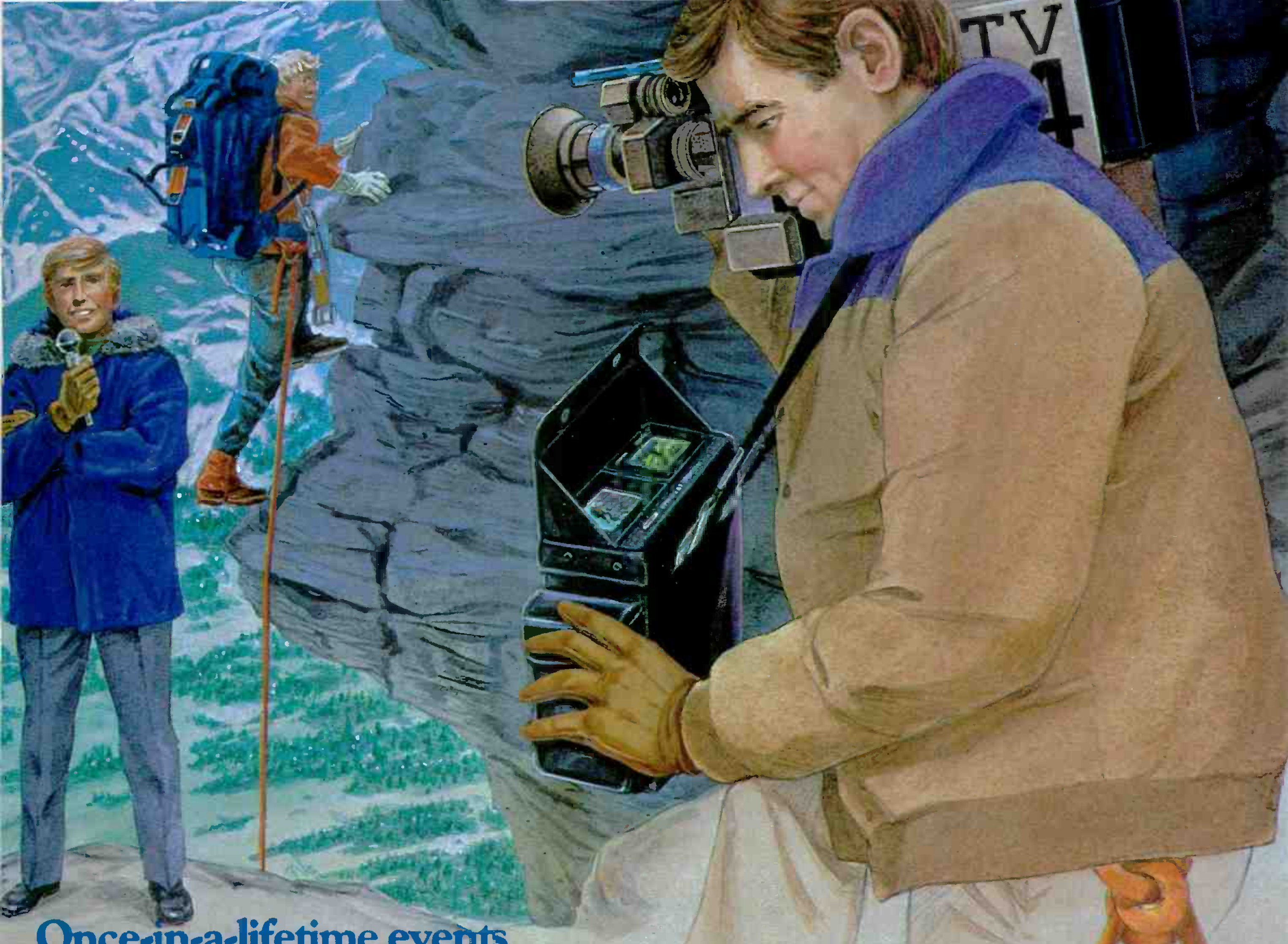

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Standards: Do we need them?

Belief in the value of technical standards for the equipment that we use ranks right up there with motherhood and apple pie. Most everyone is in favor of it, both broadcasters and equipment manufacturers. However, when the free market enters the scene, a different picture often develops. On one hand, we see manufacturers developing equipment that may not meet the requirements of a particular standard, but on the other hand, the new equipment may meet a critical need for the broadcaster. This situation raises the question: *Are industry standards impractical in this era of rapid technological development?*

The history of broadcasting is riddled with examples of manufacturers offering equipment based on their own technology. In fact, most of the engineering achievements that we've come to take for granted developed from manufacturer-generated ideas, rather than industry standards. So which is the better route to take? Let's examine the record.

Probably the best case for the standards-making process is the AM stereo fiasco. In retrospect, the FCC's marketplace solution to the AM stereo question—a complicated technical matter still plaguing the industry today—can only be described as an unqualified flop. AM broadcasters have been waiting for an AM stereo standard for four years, with no definite end in sight. There is no question that the commission's indecision and unwillingness to tackle the complicated and politically charged issue of AM stereo has seriously set back implementation of this new technology.

In contrast to the marketplace mania that has surrounded AM stereo, consider the development and implementation of multichannel TV sound (MTS). The track record of this new technology is a textbook case of how to arrive at an industry standard. The background work conducted by the EIA (Electronic Industries Association) and the NAB was thorough and represents what should have been done with AM stereo. MTS has emerged to be a significant force in the TV marketplace just two years after the FCC authorized transmission of the EIA/NAB system.

Currently, there are several other standards questions still up in the air that could have serious implications for our industry. For one, a battle appears to be brewing regarding direct broadcast satellite (DBS) transmission. European broadcasters favor one type of system, while U.S. broadcasters are divided over which of five DBS systems should be adopted. Like the AM stereo battle, DBS faces the threat of years of delay while the different proponents fight with each other.

And then there is the difficult question of a digital video recording standard. One of the highlights of the winter SMPTE show and the NAB convention was the introduction of a composite digital cart machine. While the new system offers broadcasters many exciting features and advantages, it does not conform to CCIR recommendation 601 for digital recording. However, any company has the right to propose new technology to the market, regardless of whether it meets current or proposed industry standards.

The CCIR recommendation on digital video recording took years to develop and is based on the work of some of our industry's most knowledgeable engineers. In fact, a working model of a 601 compliant D-1 format digital component system was shown at the recent NAB convention. The 601 recommendation would allow broadcasters and manufacturers to reap the benefits of improved video quality, with compatibility among machines made by different companies. While all of the issues surrounding the CCIR proposal are not yet resolved, it represents a significant step forward.

These conflicting approaches to digital video recording present our industry with some difficult choices. The divergence of technology raises the question of whether one approach is right and the other is wrong. It also raises the question of whether we need standards at all.

We believe that in some cases, there is room for more than one *standard* and the division should be made depending on whether the standard or recommended practice affects the transmission of broadcast signals. Standards are an absolute necessity for over-the-air broadcasting. The AM stereo problem and TV stereo success attest to this fact. In the realm of non-transmission technology, however, strict adherence to a single standard may do more to stifle innovation than promote it. Broadcast equipment users and manufacturers always should strive for compatibility, but they also should never be timid about exploring new applications of technology. It is this innovative spirit that has brought us to the level of technical sophistication that we enjoy today.

FCC update

Deregulation affects business practices

By Harry C. Martin

The commission noted that the harmful effects of fraudulent billing and network clipping practices are *de minimis* to consumers and viewers. Thus, the commission reasoned, there is a strong incentive for the business entities that are victimized by such practices to monitor station activities and protect themselves. With a wide range of remedies available for resolution of business disputes, the commission decided the public interest does not mandate the retention of its rules in these areas. However, the commission indicated it would refer allegations regarding fraudulent billing and network clipping to the Federal Trade Commission or the U.S. Attorney, where appropriate.

The most significant policy change is in the area of combination advertising rates and joint sales practices. Up to now, the commission has prohibited competing stations from using the same sales personnel and does not permit stations in the same region, except commonly owned AM/FM operations, to offer advertising rates in combination with other stations in the same community or market.

These rules have been eliminated by the commission's deregulatory move. However, stations wishing to engage in combination advertising rate setting and joint sales with other stations should check with antitrust counsel to make sure federal law is not violated by specific combination agreements.

The commission said that licensees that engage in the previously prohibited practices in the future will not be subject to FCC scrutiny unless there is a final adjudication, civil or criminal, that misconduct has occurred.

UHF-UHF and VHF-VHF channel exchanges permitted

The commission has adopted rules that will permit channel exchanges between commercial and non-commercial educational TV stations that are intra-banned: UHF for UHF or VHF for VHF.

Under current FCC rules, commercial and non-commercial licensees are permitted to exchange channels, but any interested party is free to apply for any channel newly made available for commercial use. Because existing commercial stations fear they will lose their authorizations in resulting comparative hearings, few channel switches have ever occurred.

The commission believes that permitting exchanges without subjecting the parties to competing applications will result in more efficient use of the spectrum and the initiation of new services on both commercial and non-commercial channels.

The commission has placed certain restrictions on exchanges, however. Agreements involving payments to non-commercial stations will be scrutinized to make sure that proceeds are used only for the purpose of improving broadcast operations. The commission said it would be self-defeating if funds obtained through a channel exchange were used for other purposes, because the new rules are intended to help educational stations improve their facilities, not to fund outside projects.

In this connection, the commission will examine not only proposed changes in the signal reach of non-commercial stations, but also the extent to which signal quality will be affected by a channel change.

Under the new rule, commercial or non-commercial stations assigned to different communities in the same market would be permitted to exchange channels. The commission saw no reason to limit the scope of the proposed rule to situations where both channels are assigned to the same community. However, under no circumstances will the commission permit a channel exchange arrangement to go forward if it involves a net loss of one or more allocations reserved for non-commercial use.

To take advantage of the rule change, it will be necessary for parties agreeing to an exchange to submit a formal petition for rulemaking. The standards discussed above will be applied during the resulting rulemaking proceeding.

Forfeiture proceedings

Even in the era of deregulation, commission enforcement actions continue. If anything, commission-assessed fines for rule violations are now even higher.

The commission recently ordered a Pompano Beach, FL, station to pay $10,000 for repeated violations of the commission's rules regarding fraudulent billing practices. This fine was imposed even though the commission, as noted here, now has eliminated the rule on which it was based.

In another case, the commission issued a notice of apparent liability to a La Plata, MD, AM/FM combination for $10,000 for failing to originate a majority of its non-network programming from its main studio (or elsewhere within the community of license), failing to maintain its main studio in the community of license, failing to apply to the commission for approval to relocate its main studio outside the community of license and failing to make its public inspection file available during business hours.

Issues/programs lists still required

The commission still requires all commercial and non-commercial broadcast stations, on a quarterly basis, to place in their public inspection files lists of public issues and the programs broadcast to address such issues. The lists must be placed in the public inspection file by the 10th day of each calendar quarter (January 10, April 10, July 10 and October 10).

The commission requires that the lists contain a brief description of at least five to 10 significant issues to which the station gave particular programming attention during the preceding quarter. A broadcaster may list as few as five issues, but the FCC's staff recommends that more than five be listed. There is no maximum limit on the number of issues a broadcaster may list.

The list must include, but is not limited to, the broadcast time, date and duration of each program, and the title and type of program in which the issue was treated (i.e., public service announcements or call-in program).

All programming broadcast for each issue need not be listed. However, licensees should maintain a record of any unlisted programs aired to meet a specific problem in the event a question is raised at renewal time regarding responsiveness to community problems.

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

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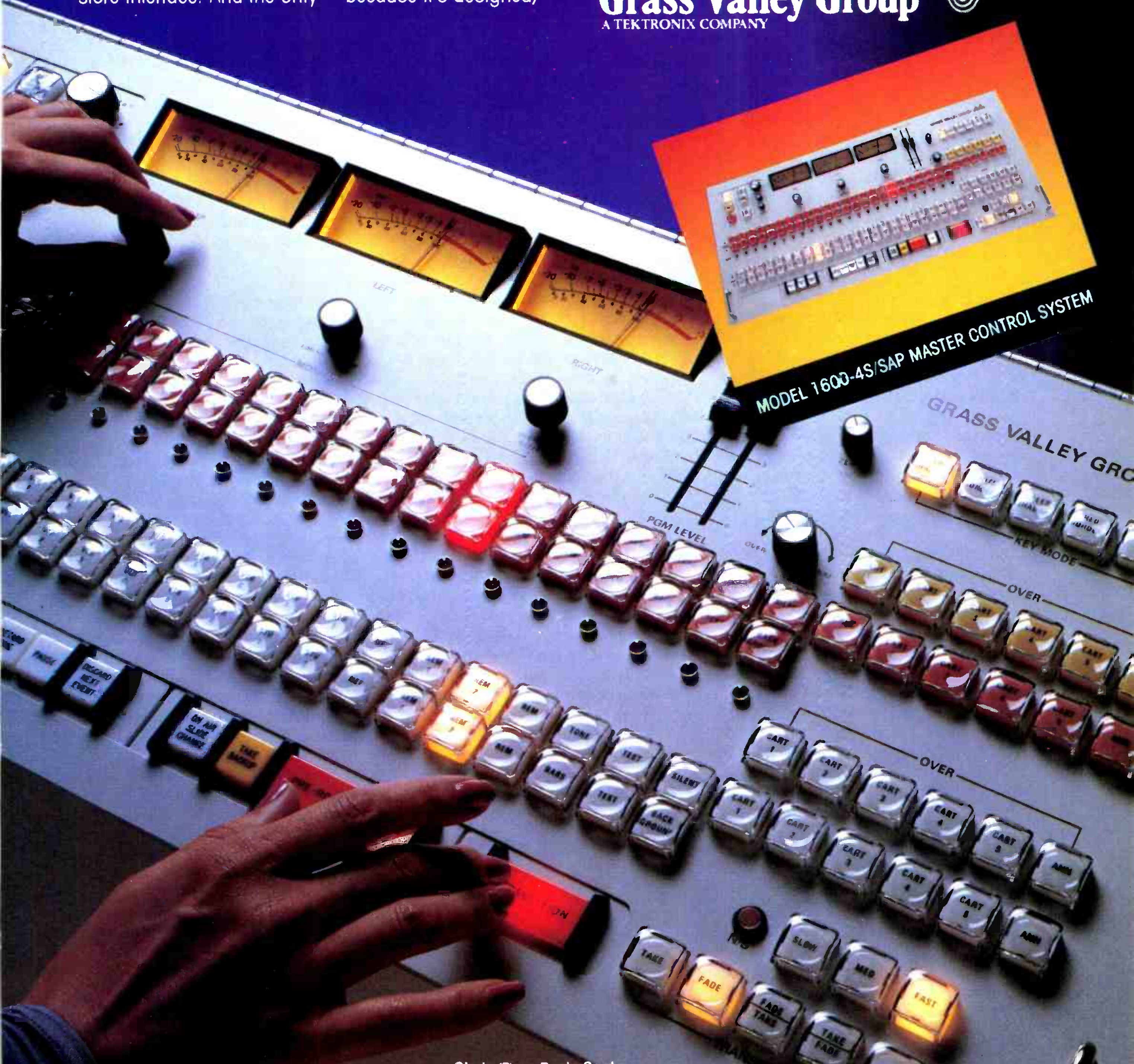

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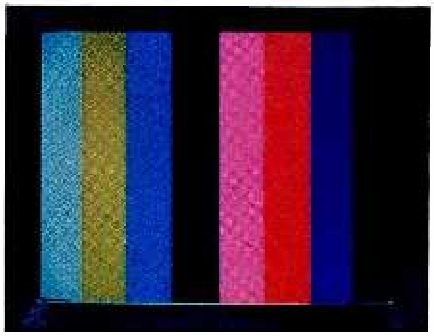
By the book

By Carl Bentz, TV technical editor



Few TV stations will find difficulty in complying with the recently adopted rules regarding electromagnetic non-ionizing radiation. In case you need to consider antenna or tower alterations, be aware that changes in location, overall height and directional radiation characteristics of the antenna system must be reported to the FCC.

The transmitting antenna should be the most reliable element of the entire transmission system. If not, it is certainly one of the most difficult elements to work on. Subject to year-round weather and a certain amount of stress from the RF energy being transmitted, antennas generally present fewer problems than other parts of the transmitting plant.

Pattern proof

When the original documents for your station were filed with the FCC, the manufacturer and model number of the antenna were included. An exhibit showing the directional pattern may have been required as well. Full-power VHF stations seldom use directional antennas. If any type of pattern control is employed (including mechanical beam tilt) to provide improved coverage of a particular area, the directional plane cannot exceed 10dB. The variation for UHF transmissions over 1kW is 15dB maximum.

Now that temperatures have moderated, a check on signal strengths radiated from the antenna might prove interesting. You may discover that the pattern has changed, perhaps the result of ice damage. In theory the VSWR of the antenna will have changed as well, but preventive observations won't hurt.

Low-power TV stations should check the accuracy of the pattern in order to comply with their license. Because the directional characteristics are specified to avoid interference with other stations, maintaining the correct pattern is essential. Remember that weather does not differentiate between a full- and low-power station.

Painting and lighting

If an FCC inspector pays a visit to your station, he will be particularly interested in the condition of the tower and the visibility of the structure in terms of the paint and lighting. Any antenna support structure exceeding 200 feet above ground must be painted and lighted. In general, the paint must be aviation surface orange and white in alternating bands. FCC rules specify that the uppermost and bottom bands must be orange. The widths of the bands must be equal and approximately one-seventh of the structure height.

Tower lighting is determined by the height. In all cases, however, a code beacon equipped with two 620W or 700W PS-40 lamps and aviation red color filters must be located at the top of the tower and antenna structure. Both lamps are to illuminate simultaneously at a rate of at least 12 flashes per minute, but not more than 40 flashes per minute. The period of darkness should be approximately one-half the luminous period.

Additional beacons are required on towers greater than 450 feet in height, and at least one set of two continuously burning lamps of 116W or 125W rating are required at intermediate levels. (See Table 1.) These running lights also must have aviation red filters.

FRACTION OF HEIGHT	ANTENNA AND SUPPORT STRUCTURE HEIGHT					
	450-600	600-750	750-900	900-1,050	1,050-1,200	1,200-1,350
BEACONS	1/2	2/5	2/3 1/3	4/7 2/7	3/4 1/2 1/4	2/3 4/9 2/9
RUNNING LIGHTS	3/4 1/4	4/5, 3/5 1/5	5/6, 1/2 1/6	6/7, 5/7 3/7, 1/7	7/8, 5/8 3/8, 1/8	8/9, 7/9 5/9, 1/3 1/9

FOR TOWERS LESS THAN 450 FEET AND GREATER THAN 1,350 FEET, REFER TO FCC RULES, PART 17.

All tower lighting must be operating continuously or controlled by a light-sensitive device. The device should activate the tower lighting when north sky illumination falls to 35fc. The lighting system should remain in operation until north sky illumination rises to 58fc.

High-intensity white obstruction lights may be used instead of incandescent beacons and running lights. When such equipment is authorized by the FCC, the flashing units at the top of the structure must produce an effective intensity of 200,000fc during the day, 20,000fc at twilight and 4,000fc at night. Intermediate units will produce an effective intensity of 20,000fc during the day and twilight with 4,000fc at night. As with incandescent units, the number of intermediate flashers depends upon the structure height.

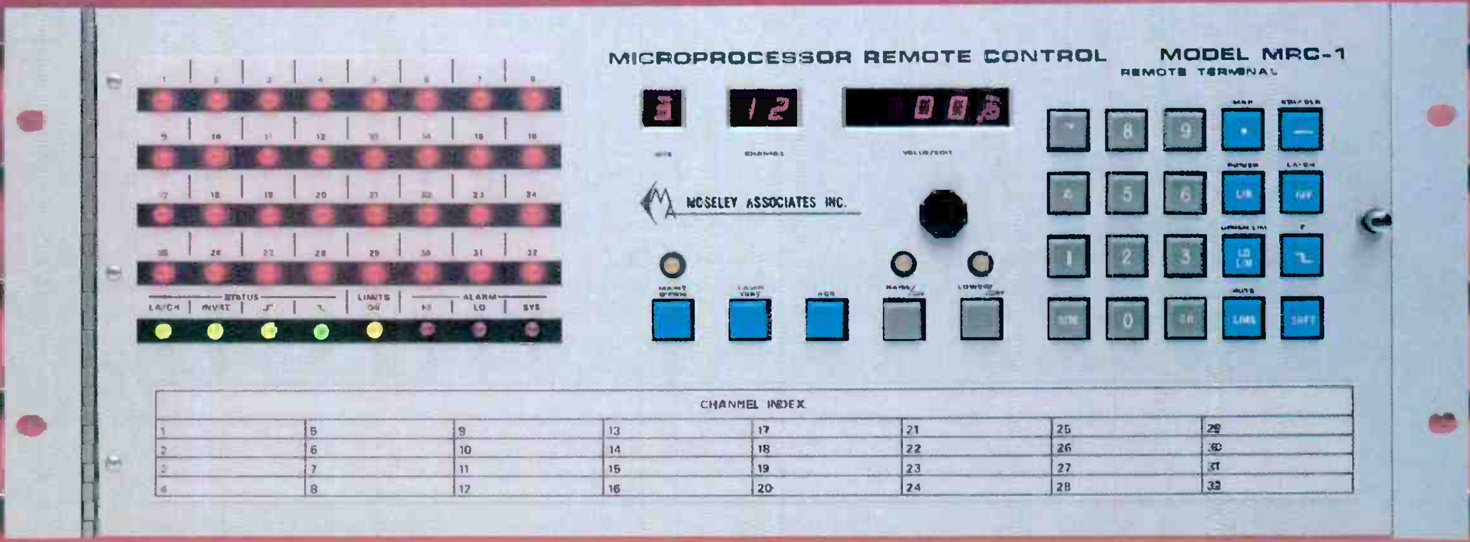
The tower lighting should be inspected at least once every 24 hours to assure proper operation. An automatic monitoring system may be used. Alternatively, an alarm system that will detect any failure of the tower lighting is acceptable. At intervals not exceeding three months, all portions of the lighting-control system and alarms must be inspected for proper operation.

In the event that any flashing beacon or top steady burning light fails or is extinguished and cannot be repaired or re-illuminated within 30 minutes, the operator on duty must contact the nearest Federal Aviation Administration office or Flight Service Station.

Notification also should be made when improper lighting conditions have been corrected. For the convenience of the operator, the telephone number of the appropriate aviation office should be posted at the master-control operating position.

Station records should reflect any failure of the tower lighting system. The entry of such reports should include the nature of the failure, the time and date the failure was first observed and the date, time and nature of repair made to the system.

When several stations use the same support structure for their transmitting antennas, the owner/licensee of the structure should provide copies of the quarterly tower inspection report to the other occupants of the tower. If all users share in ownership of the tower, one licensee will be designated to provide the quarterly inspection report.



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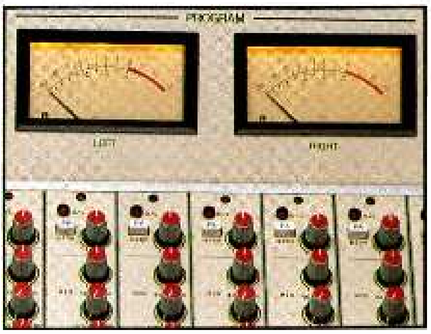
re: Radio



The FMX system

By Emil Torick

Last month we looked at some of the reasons why stereophonic transmission causes a loss in S/N and a reduction in stereophonic reception range. Although simply companding the audio would help the coverage and S/N problem, standard receivers would not be able to properly decode the signal.

One proposed companding system, FMX, developed by the author and Ed Keller at NAB, resolves the incompatibility problem. A companded audio stereophonic (L−R) signal is transmitted in quadrature with the normal stereophonic channel (Figure 1). A 10Hz pilot tone identifies the availability of the companded signal and properly equipped receivers can decode the encoded stereophonic signal.

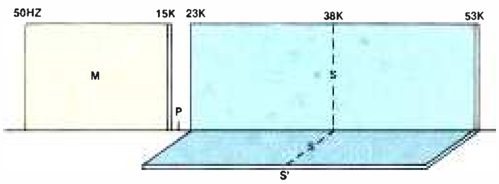


Figure 1. An effective FMX system lies in transmitting a second (companded) subchannel in quadrature with the normal stereo subchannel.

Noise reduction by companding

Companding systems achieve noise reduction by compressing the dynamic range of an audio program before transmission and expanding it to its original dynamic range at the receiver. Companding systems have achieved success in various audio applications, including tape and disk recording. Because of recent, significant improvements in companding system technology, there is new interest in broadcast applications.

The recently adopted MTS standard for stereophonic TV sound relies on companding techniques. In this system, both the stereophonic (L−R) and second audio channel (SAP) rely on companding to preserve the audio quality. Although the stereo noise penalty is less severe in television (15dB) than in radio, companding permits reception with acceptable sound quality at least to the geographical limits of acceptable picture quality.

Torick is vice president, Audio Technology, for CBS, Stamford, CT.

FM companding

Given the recent advances in the art of audio companding, it is once again appropriate to examine the potential application to FM radio broadcasting. Some broadcasters have experimented with companding in the left and right audio channels to provide modest noise reduction in receivers equipped with appropriate expanders, and through simple receivers without expanding capability, acceptable reproduction of program material.

However, the need to maintain compatibility with existing receivers inhibits the potential for truly significant noise reduction in new receivers. Alternatively, the use of companding in the S channel of an FM broadcast would allow full compatibility with monophonic reception and the potential for a significant reduction of the stereophonic reception noise penalty. Unfortunately, this process would seriously degrade the quality of stereophonic reception in existing receivers not equipped with expanders.

The FMX system provides an alternative approach that achieves better noise reduction and compatibility with existing receivers. It also avoids any modification of the audio signals in either the M or S channel. In this scheme, a companded S′ channel is transmitted, to provide noise-free stereo reception to a new class of receivers. (Existing receivers will continue to use the conventional S channel.) This new S′ channel is transmitted in quadrature with existing stereophonic subcarrier (Figure 1).

Figure 2 depicts a block diagram of the encoder for the new composite signal. A conventional audio matrix is used to derive the sum and difference signals. A carrier generator provides the 19kHz pilot tone and the sine and cosine functions of the 38kHz subcarrier. The L−R difference signal modulates the sine carrier. The same L−R difference signal—but compressed—along with an identification tone of approximately 10Hz, modulates the cosine subcarrier producing the new stereophonic (S′) signal. The monaural, stereo and companded stereo signals and pilot are added together to constitute the complete composite signal.

The reception benefits offered by the broadcast service may be viewed both as improving receiver S/N and extending the useful range of reception. In strong signal areas, the monophonic and stereophonic S/N ratios in most receivers are greater than 75dB, and only a little improvement can be expected. For stereo reception below 60dB S/N, the service offers a dramatic improvement for the user. Near the limit of effectiveness (less than 35dB S/N) some improvement is theoretically possible but potentially subject to audio noise modulation. In this area, a fixed blend or monophonic reproduction is preferred.

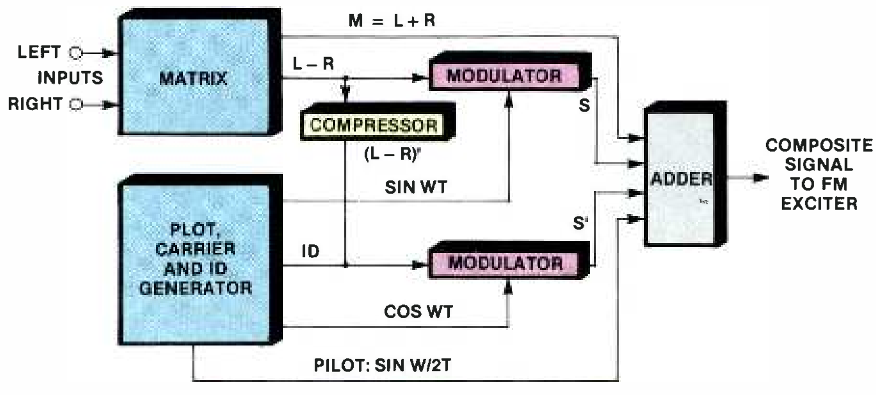


Figure 2. Block diagram of an FMX exciter.

Editor's note: This material was adapted from an Audio Engineering Society paper presented by Torick at the 70th AES convention, Oct. 12-16, 1985. Torick presented an update on the latest field tests of FMX at the 1986 NAB convention. A copy of his paper is available from the NAB.

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Satellite technology

Terrestrial interference

By Elmer Smalling, III

The greatest fear on the part of most C-band satellite earth station owners and operators is *terrestrial interference* (TI). Ku-band reception is virtually interference free, but C-band satellite downlink frequencies are co-assigned with common-carrier microwave users. If your earth station is located close to a metropolitan area, or in the path of a common-carrier microwave relay system, TI can occur, rendering your system marginal or useless.

If you have licensed your downlink with the FCC, you have some protection from interference caused by new microwave relay systems, but, in many cases, the nature and origin of the interference takes time to investigate, especially if the TI is intermittent. If you have not filed for licensing with the FCC, thereby proving you were there first, you have limited legal recourse.

Even if you have filed, interference from a licensed carrier can occur if a previously unused part of the licensed spectrum is employed to handle peak loads. Many telephone-type carriers increase their microwave bandwidth during peak hours of the day, causing time-dependent TI.

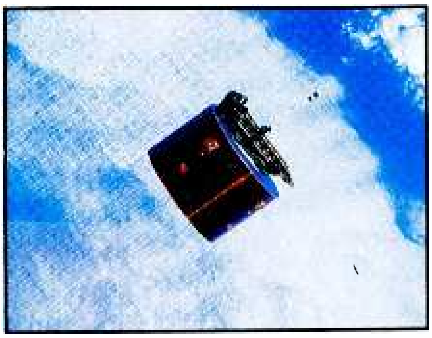
Tracing TI

How do you know if you are experiencing TI? Symptoms range from the least offensive level of interference to a level that renders your C-band downlink useless. Before you begin the search for TI, check your downlink equipment to determine that it is not causing TI-like effects.

The following signal levels are referenced to a maximum video S/N ratio of −52dB for the desired satellite signal at the output of a receiver. For instance, a decrease in the video S/N ratio of 10dB would place the output video S/N at −42dB rather than −52dB. The more positive the S/N number becomes, when measured at the output of the video receiver, the greater the noise and the worse the picture. Noise may be a combination of snow, random bright sparkles and other degradations.

- *Very light TI*

As a general rule of thumb, a decrease in the video S/N ratio by less than 5dB results in slight snow in the video. This level of TI may be overlooked as natural



signal or equipment degradation. It is usually not considered objectionable.

- *Light TI*

A decrease in the video S/N ratio of 7dB to 20dB causes noticeable snow in the video. Pictures remain stable on the screen and images continue to be recognizable.

- *Medium TI*

A 20dB to 25dB decrease in the S/N ratio causes objectionable snow and possible picture tearing. From this level of interference upward, the TI is strong enough to capture receiver AGC and/or ALC circuits.

- *Heavy TI*

A 25dB to 35dB decrease in the video S/N ratio results in an almost total loss of picture and synchronization. It is sometimes possible to see the picture of the offending signal at this level of TI.

- *Very heavy TI*

A 35dB to 52dB decrease in S/N ratio removes all vestiges of the original signal. TI at a level this high is usually bad news for an earth-station owner, because it is expensive and complicated to eliminate.

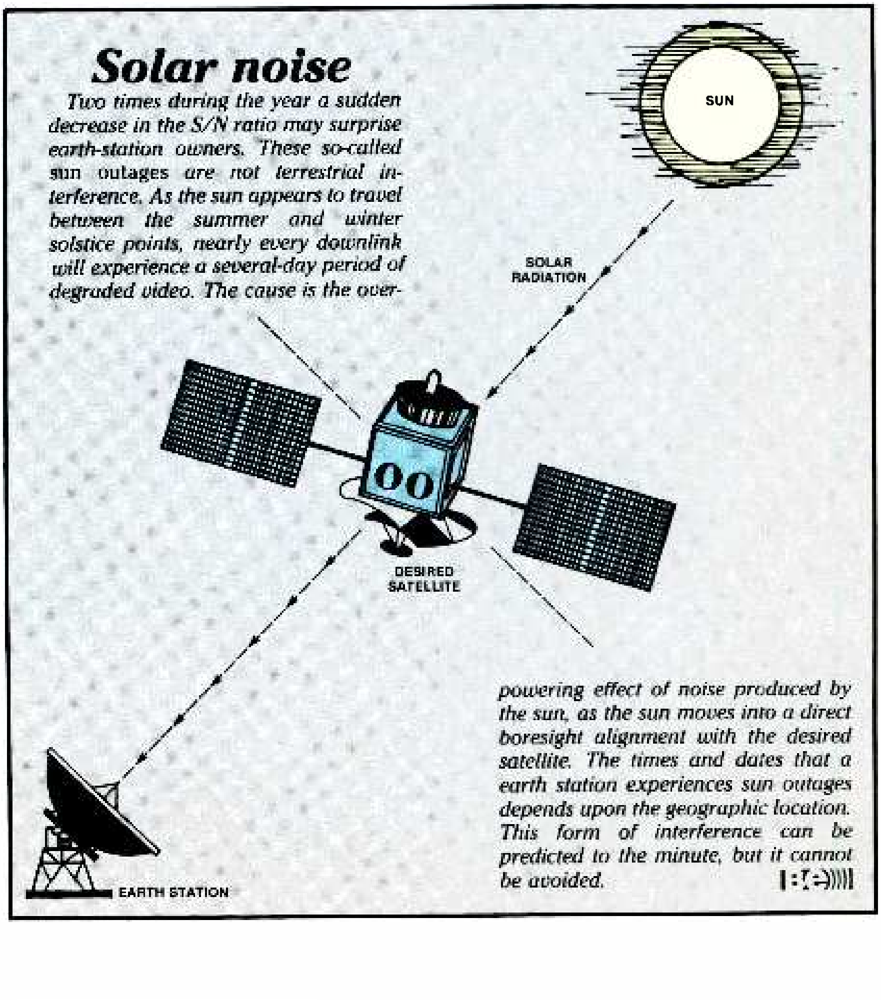
Next month we'll investigate solutions to various TI problems and discuss the costs involved in eliminating TI.

$$\text{Signal-to-noise (S/N) in dB} = 20\log x \frac{\text{100 IRE units}}{\text{peak-to-peak noise voltage}}$$

The ratio of 100IRE units (0.7V) video-to-noise voltage is multiplied by $20\log_{10}$ to get decibels.

Solar noise

Two times during the year a sudden decrease in the S/N ratio may surprise earth-station owners. These so-called sun outages are not terrestrial interference. As the sun appears to travel between the summer and winter solstice points, nearly every downlink will experience a several-day period of degraded video. The cause is the overpowering effect of noise produced by the sun, as the sun moves into a direct boresight alignment with the desired satellite. The times and dates that a earth station experiences sun outages depends upon the geographic location. This form of interference can be predicted to the minute, but it cannot be avoided.



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

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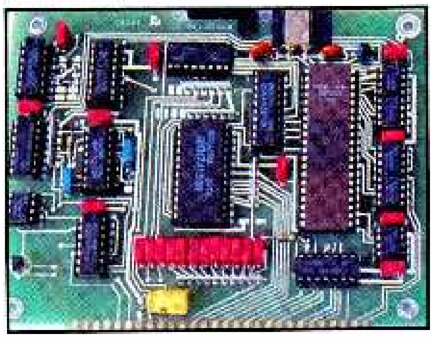
Power amplifier neutralization

By Jerry Whitaker, editor



Neutralization of power-grid tubes operating at VHF frequencies provides special challenges and opportunities to the transmitter design engineer. At VHF frequencies and above, significant RF voltages can develop in the residual inductance of the screen, grid and cathode circuits. If managed properly, these inductances can be used to accomplish neutralization in a simple, straightforward manner.

Figure 1 shows a PA stage employing stray inductance of the screen grid to achieve neutralization. In this grounded-screen application, the screen is tied to the cavity deck using six short connecting straps. Two additional adjustable ground straps are set to achieve neutralization.

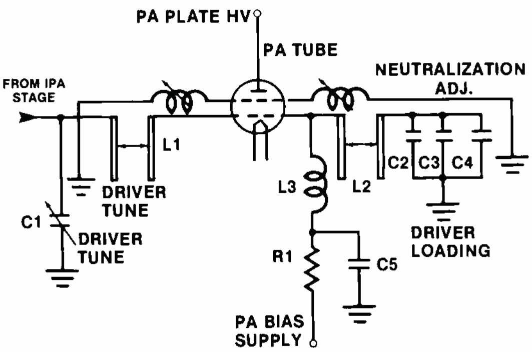


Figure 1. *A grounded-screen PA stage neutralized through the use of stray inductance between the screen connector and the cavity deck.*

Grounded-grid circuits

Triode amplifiers operating in a grounded-grid configuration offer an interesting alternative to the more common grounded-cathode system. When the control grid is operated at ground potential, it serves to shield capacitive currents from the output to the input circuit. Typically, provisions for neutralization are not required until the point at which grid lead inductance becomes significant. This point is determined by the frequency of operation and the mechanical construction of the stage.

Two methods of neutralization are commonly used in grounded-grid RF amplifiers. The first method requires an inductance between the grid and ground or between the grids of a push-pull amplifier. This inductance can be used to compensate for the internal capacitance of the tubes and cancel out coupling between the input and output circuits.

The second method involves connection of the grids of a push-pull amplifier to a point having zero impedance to ground. A bridge circuit of neutralizing capacitances is then added that is equal to the plate-to-filament capacitances of the tubes, thus achieving neutralization.

These two neutralization schemes behave quite differently. They are special forms of neutralization in which the neutralizing capacitors have values differing from the internal capacitances of the tubes, and in which an appropriate reactance is inserted between the control grids.

The purpose of neutralization is to make the tube input and output circuits independent of each other with respect to reactive currents. Isolation is necessary to ensure independent tuning of the input and output circuits. If variations in the output voltage of the stage produce variations of phase angle of the input impedance, phase modulation will result.

A circuit exhibiting independence between the input and output circuits is only half of the equation required for proper operation at RF frequencies. The effects of incidental inductance of the control grid must be cancelled out for complete stability. This condition is required because the suppression of coupling by capacitive currents between the input and output circuits is not, by itself, sufficient to negate the effects of the output signal on the cathode-to-grid circuit. Both conditions, input and output circuit independence and compensation for control grid lead inductance, must be met for complete stage stability.

Symmetrical RF stages

Figure 2 illustrates a common symmetrical or push-pull RF stage that is grid-driven with grounded cathodes. If the inductance of the leads is negligible, because of either operating frequency or circuit construction, neutralization can be accomplished by simply cross-coupling the stage. The value of C_n from each grid to its opposite plate is equal to the internal grid-to-plate capacitance of the power tubes. As pointed out in last month's column, this capacitor can consist of a simple wire probe that is positioned near the plate of the opposite tube in the push-pull pair.

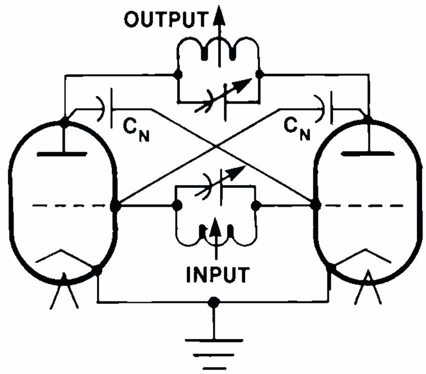


Figure 2. *Push-pull (symmetrical) stage neutralization for a grounded-cathode circuit.*

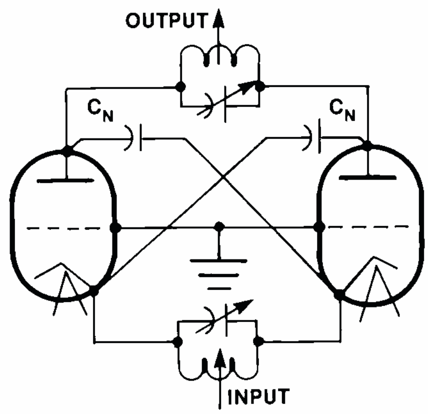


Figure 3. *Symmetrical stage neutralization for the grounded-grid circuit.*

A similar method of neutralization can be used for cathode-driven symmetrical stages. (See Figure 3.) Note that the neutralization capacitors, C_n, are connected from the cathode of one tube to the plate of the opposite tube. The neutralizing capacitors have a value equal to the internal cathode-to-plate capacitance of the PA tubes. This neutralization method is used for applications in which the lead inductance of the circuit can be considered negligible.

Editor's note: This column is based on information contained in the publication, "The Care and Feeding of Power Grid Tubes," prepared by the laboratory staff of Varian EIMAC, San Carlos, CA.

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Troubleshooting

Using power tubes

By Jerry Whitaker, editor

There are many variables that can affect the life of a PA tube in a transmitter, including tuning, filament voltage and cooling system efficiency. Heat is a frequent source of trouble for a transmitter, resulting from degradation of the internal cooling system or poor design of the air intake and output ports and ducting.

Cooling system design

The layout of a transmitter room HVAC (heating, ventilation and air conditioning) system can have a significant impact on the life of the PA tube(s) and the ultimate reliability of the transmitter.

Air intake and output ports must be designed with care to avoid airflow restrictions and back-pressure problems. This process, however, is not as easy as it may seem. The science of airflow is complex and often requires the advice of a qualified HVAC consultant.

To help illustrate the importance of proper cooling system design and the real-world problems that some stations have experienced, consider the following examples taken from actual case histories:[1]

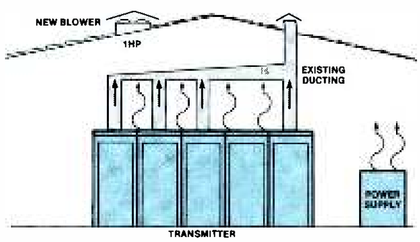
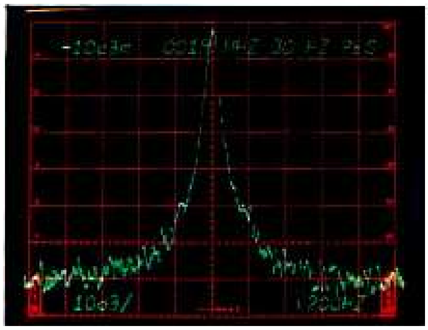


Figure 1. A case study in which excessive summertime heating was eliminated through the addition of a 1hp exhaust blower to the building.



Case 1:

A fully automatic building ventilation system (Figure 1) was installed to maintain room temperature at 20°C during the fall, winter and spring. During the summer, however, ambient room temperature would increase to as much as 60°C.

A field survey showed that the only room exhaust for the system was through the transmitter. Therefore, air entering the room was heated by test equipment, people, solar radiation on the building and radiation from the transmitter itself before entering the transmitter.

The problem was resolved through the addition of an exhaust fan (3,000 cfm). The 1hp fan lowered room temperature by 20°C.

Case 2:

A simple remote installation was constructed with a heat recirculating feature for the winter (Figure 2). Outside supply air was drawn by the transmitter cooling system blowers through a bank of air filters and hot air was exhausted through the roof. A small blower and damper were installed near the roof exit point. The damper allowed hot exhaust air to blow back into the room through a tee duct during winter months.

For summer operation, the fan was activated, roof damper switched open and tee damper closed. For winter operation, the arrangement was reversed. The station, however, experienced short tube life during winter operation, even though the ambient room temperature during winter was not excessive.

The solution involved moving the roof damper 12 feet down to just above the tee. This significantly reduced cavity exhaust back pressure. With this relatively simple modification, the problem of short tube life disappeared.

Case 3:

An inconsistency regarding test data was discovered within a transmitter manufacturer's plant. Units tested in the engineering lab typically ran cooler than those at the manufacturing test facility.

Pride would have it that design engineers tune better; however, an investigation showed otherwise. Figure 3 shows the test station difference, a 4-foot exhaust stack that was used in the engineering lab. The addition of this stack would increase airflow by 20% because of reduced air turbulence at the output port and result in a 20°C decrease in tube temperature.

These examples point out how easily a cooling problem can be caused during HVAC system design. All power delivered to the transmitter is either converted to RF energy and sent to the antenna or becomes heated air. Proper design of a cooling system, therefore, is a part of transmitter installation that should not be taken lightly.

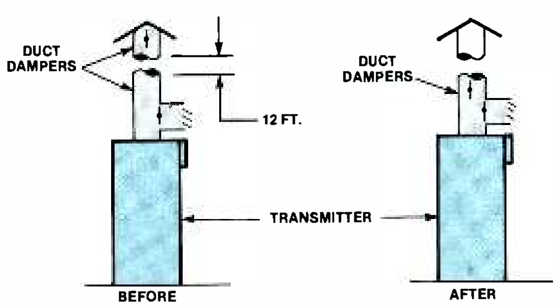


Figure 2. A case study in which excessive back pressure to the PA cavity during winter periods (when the rooftop damper was closed) was eliminated by repositioning the damper as shown.

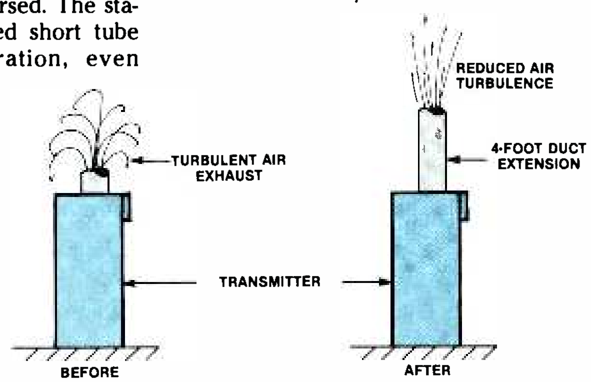


Figure 3. A case study in which air turbulence at the exhaust duct resulted in reduced airflow through the PA compartment. The problem was eliminated by adding a 4-foot extension to the output duct.

Acknowledgment: 1. The examples included in this column were adapted from the Harris Corporation engineering department paper, "Keeping Your Cool."

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Working with others

By Brad Dick, radio technical editor

Joe was aware there were problems between the programming and engineering departments. However, it seemed that ever since the new program director was hired, things had gotten worse. Now, both departments were engaged in a constant battle about something. The problems, when viewed later, seldom seemed to be serious. Unfortunately, at the time, everyone thought so. Recently, Joe spent most of his time playing fireman, putting out equipment-related brush fires.

The problem

As director of engineering, Joe was responsible for a staff of engineers and operations people. It was his responsibility to keep the technical side of the station in good condition and see that his operations staff kept up with the needs of other departments. The latter task appeared to be the major part of the problem.

One of engineering's jobs was to record the numerous network feeds from the satellite system. While the task appeared simple enough, a week seldom went by without a glitch.

In recent months, several special feeds had been missed. When Joe inquired why, the operational staff said that the recording schedule was wrong. The special feeds were not listed. The program director stated that yes, the printed schedule had not called for the recordings. This was because notification of their availability wasn't received until later in the week. However, she noted that she had personally talked with the recording engineer about the late feeds and assumed, that based on the verbal request, the programs would be recorded. Unfortunately, they weren't.

Different personalities

This scenario is not that different from what happens in many radio and TV stations. Although the particular circumstances may be different, the conflict is typical. Many engineering and programming departments seem to be constantly at war with each other, usually for reasons not easily identified.

Engineers often place great faith in their equipment. If a failure occurs, an engineer will often blame a person before he blames the equipment. A non-technical person may look at the same problem in exactly the opposite manner. A programmer may blame the equipment before blaming a person.

Working toward a solution

The first step in resolving a problem like the one described is to establish a friendly relationship with the other department manager. Even if you don't have many personal common interests, station activities make it possible for you to communicate on business matters of mutual importance. Make a point to drop by the other person's office on a regular basis. Perhaps you occasionally can arrange to go to lunch. These encounters allow both of you to develop lines of communication that may help to reduce conflicts and prevent future mistakes. At the very least, they can help tear down the wall of distrust that often develops.

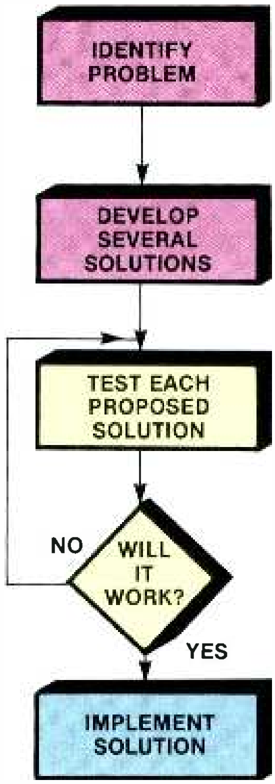

Figure 1. *Visualize a step-by-step resolution process for interdepartmental or employee conflicts.*

As a departmental manager, it's vital that you make it evident to your staff that you are trying to work *with* the other department. Your staff also should be told that its cooperation is not an option, but rather a requirement.

Make it clear that you are not interested in attaching blame for mistakes. Rather, that you want to identify what went wrong so that a similar problem can be prevented in the future. The other department staff may have heard this line of reasoning before and may be skeptical. Even so, follow through on your promise. Attack the problem, not the person.

When problems occur, despite your best efforts, hold a special meeting. The meeting should be organized by you and the other department head. Make it plain that the meeting is being held to examine a specific incident, not as a general gripe session.

Mutual resolution

It's important that any proposed resolution be developed by those who will have to implement it. It makes little sense to mandate a change if that change will have to be carried out by people who don't want it to occur. Better results will be obtained when you involve those who will implement any change in the decision-making process.

Be flexible. When you open yourself up to this type of decision-making process, the specific results may be different than you anticipated. Granted, you are still the manager, but you get your work accomplished *through* the efforts of others. If you want to complete your tasks, you need their cooperation.

Mutual cooperation

Studies show that when members of disparate groups see the need to cooperate with each other for mutual survival, they usually will do so. In other words, if you make it plain to your staff that cooperation is necessary for the benefit of each person, positive results are likely. Without being threatening, let your staff know that you feel strongly on this matter. Be visible in your dealings with others and show your own cooperation. Don't be guilty of preaching one line while practicing another.

Initial results probably will not be spectacular. Bad feelings and bad habits are difficult to overcome and difficult to break. However, if you make the effort, you can succeed in resolving the type of problem that too many stations tolerate. The results will be worth the effort.

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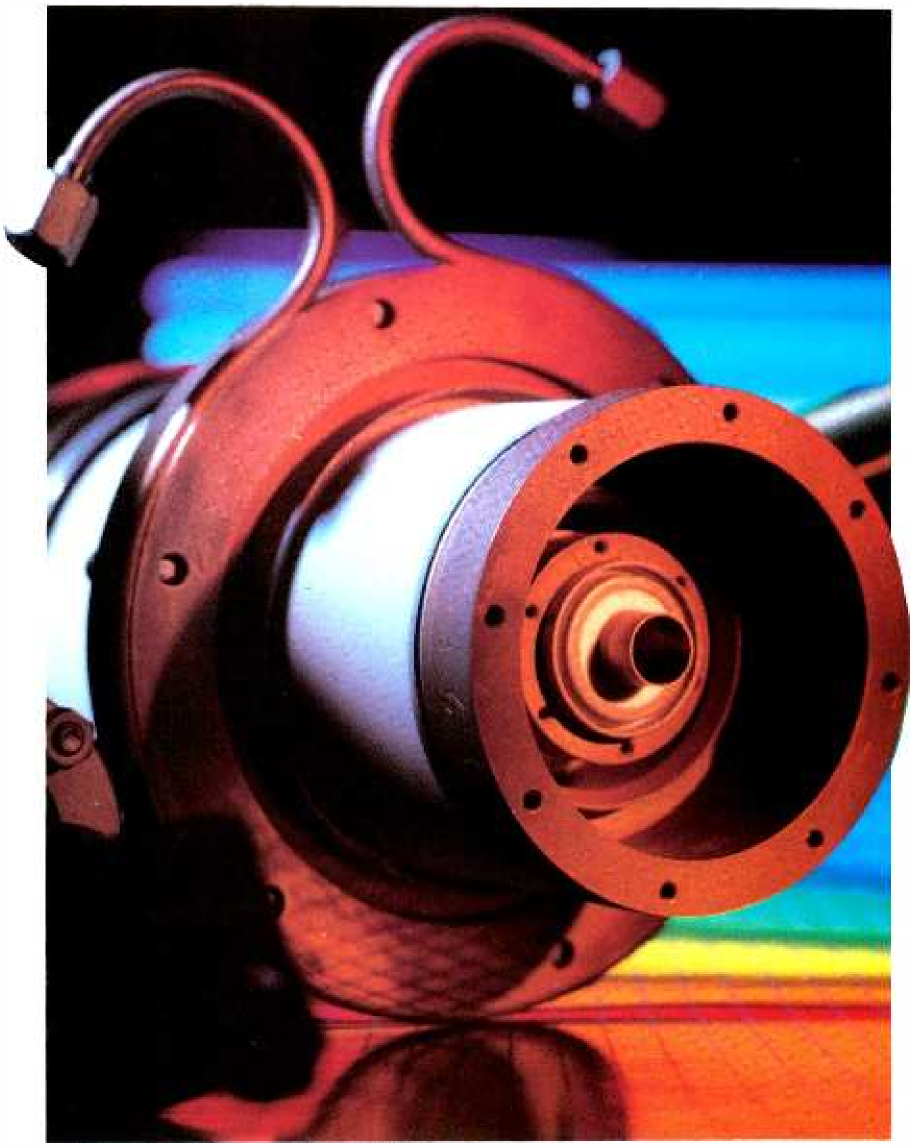
New developments in RF technology

By Brad Dick, technical editor

High-performance klystrons, Klystrodes and solid-state RF amplifiers are reducing operating costs and improving broadcast transmitter quality.

High-power transmitter tubes are critical to the operation of most stations. FM and VHF TV transmitters usually operate with power-grid tubes. UHF TV transmitters often rely on klystrons. It is only the AM and low-power FM broadcaster who has recently been able to reap the advantages of semiconductor development through all solid-state transmitters.

VHF transmitters were developed and in service long before the first UHF transmitters came along. When the first UHF transmitters were designed, special power-grid tubes had to be developed. Unfortunately, the performance and reliability of early UHF transmitters were far from satisfactory. Because of the high frequencies involved, UHF tubes had to be physically smaller for a given power level than their VHF counterparts. The high power density in these small tubes stressed the elements to the limit, severely compromising the reliability and life of the tubes.



As a result of market demand, the klystron was developed and perfected for broadcast applications. The refinement efforts on the part of klystron manufacturers continue, with the objectives of increased operating efficiency, higher operating power, longer life and improved reliability.

High-power klystrons

In the United States, UHF TV transmitters tend to be sized at 30kW, 55kW and 110kW power ratings. Until recently, the only way a transmitter could reach the 110kW and 220kW power levels was through the use of multiple 55kW klystrons. In these systems, each 55kW tube requires its own dedicated high-voltage power supply, command and control circuitry, interlocks, heater supplies, focus magnet supplies and other support circuits. This added complexity increases the cost of the transmitter.

The key to reducing the price tag for such high-power transmitters is to reduce the number of tubes, hence the need for high-power klystrons. Today, it is possible to build a transmitter around a klystron that is capable of producing 110kW of output power.

Klystron design

The principle of *velocity modulation* is the basis on which klystrons operate. The concept describes how a long continuous electron beam is converted into a density-modulated beam at UHF frequencies.

Velocity modulation applied to a long continuous electron beam gives the klystron an important feature: high gain. Klystron design also uses a collector that can be made large and independent of the operating frequency. In addition, the power density is kept low throughout the tube, which provides long life and reliability. These advantages were so significant that, historically, the klystron soon dominated UHF broadcasting. Of the more than 500 UHF TV stations in the United States, at least 90% use klystrons.

Figure 1 is a simplified diagram of a typical integral cavity klystron used as the final amplifier in a UHF TV transmitter. The RF input signal is coupled into the input cavity by an inductive loop. The RF voltage impressed across the cavity's capacitive gap applies an RF component to the beam current. The intermediate cavities enhance this process until, at the output cavity gap, the electron plasma is formed into more or less tight bunches. By judicious design of the output cavity, output cavity gap, and output loading loop, the energy in the bunched beam can be efficiently extracted and delivered to the RF transmission line.

The physical advantage of the klystron over the tetrode is that it makes the cathode-grid-collector structure virtually independent of the transit time effects. Therefore, the cathode can be made large and the electron beam density kept low. The result is high grid reliability and long tube life with a simpler structure.

High conversion efficiency requires the formation of electron bunches, which occupy a small region in velocity space, and the formation of interbunch regions with low electron density. The latter is particularly important because these electrons are phased to be accelerated into the collector at the expense of the RF field. Studies show that the energy loss due to an electron accelerated into the collector can exceed the energy delivered to the field by an equal but properly phased electron. Herein lies a key in improving the efficiency of the klystron: recover a portion of this wasted energy.

Low perveance

The *perveance* of an electron beam is defined by the equation $I_b = k(E_b^{3/2})$ where I_b is equal to the beam voltage in kV and k is a constant called microperveance, which is a function of the dimensions of the electron gun. It has been recognized for some time that klystrons with lower perveance are more efficient than tubes that operate at low voltage and high current.

High efficiency in low-perveance beams is mainly due to the charge density in a bunched electron beam, which is limited by the mutual repulsion of the electrons in that bunch. This mutual repulsion tends to deform the bunches, causing low efficiency.

Table 1 summarizes the perveance of three klystron tubes available today. Notice that the 110kW klystron has a perveance one-half that of an older style klystron. Unfortunately, the bandwidth decreases and the linearity degrades with decreasing beam current for a constant output power. There are other practical reasons to limit the operating beam voltage to manageable levels. Attempting to reduce perveance just to enhance efficiency is really a matter of design tradeoffs.

Another important element in the design of high-power klystrons centers on the tube's external circuitry. Although excellent bandwidth can be obtained from a 5-cavity klystron design, it requires significant amounts of *precorrection.* The precorrection is necessitated by the higher levels of differential phase and gain generated within the low-perveance tubes. Additional drive is also needed to meet the tube's input requirements.

Phased electrons

Other changes in klystron design can produce additional gain. The phase or degree of bunching of electrons in the beam current holds an answer for increased efficiency, and hence, more output power.

Studies show that by properly phasing the second-harmonic fields, an electron density distribution pattern can be established at the output gap and can produce additional RF energy. This condition can be established by replacing the harmonic cavities with the extended *drift tube* in the pre-buncher region. The idea works because the second harmonic of the spacer-charge acts upon the inter-bunch region in a manner similar to

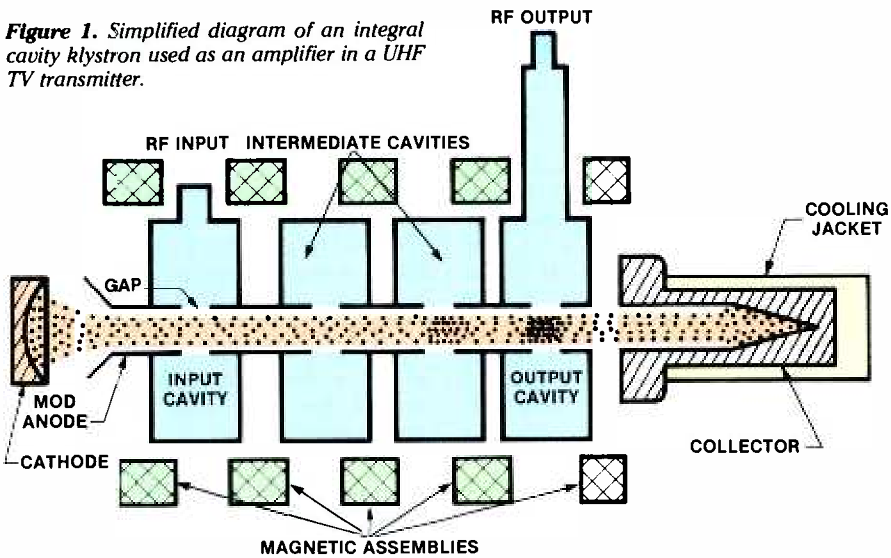


Figure 1. *Simplified diagram of an integral cavity klystron used as an amplifier in a UHF TV transmitter.*

Table 1. *Perveance of three commonly used klystrons.*

$$I_b = kE_b^{3/2}$$

WHERE:

I_b = KLYSTRON BEAM CURRENT – A
E_b = BEAM VOLTAGE – kV
k = MICROPERVEANCE CONSTANT WHICH IS A FUNCTION OF THE DIMENSIONS OF THE ELECTRON GUN

TYPE	DESCRIPTION	PERVEANCE
VA-953-H	COMMONLY USED 55kW KLYSTRON	2.0×10^{-6}
VKP-7553S	NEW HIGH-EFFICIENCY VARIANT OF VA-953H	1.5×10^{-6}
VKP-7853	110kW KLYSTRON	1.0×10^{-6}

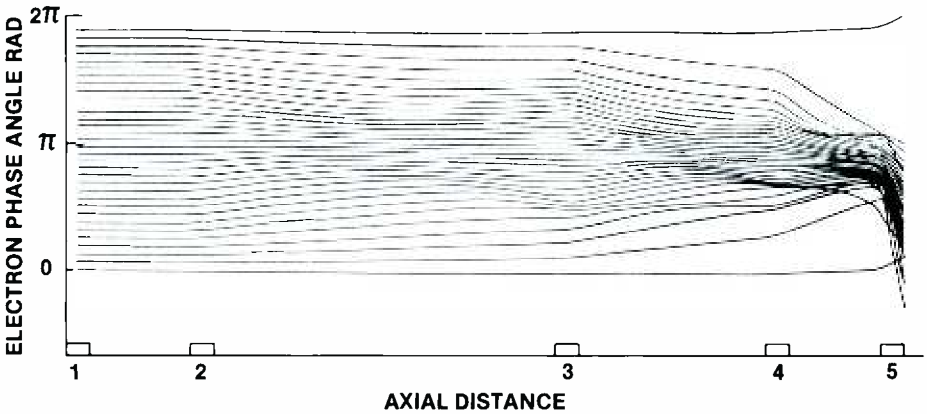


Figure 2. *Plot of the relative phase of the reference electrons as a function of axial distance in a high-efficiency klystron.*

second-harmonic RF fields. The significance of the discovery is that wide-band klystrons for TV service can be designed using this technique.

A phase-space diagram for a high-power klystron is shown in Figure 2. The curves represent a plot of the relative phase of the reference electrons as a function of axial distance along the tube. Electrons having negative slope have been decelerated. Electrons having positive slope have been accelerated with respect to unaccelerated electrons parallel to the axis. The diagram shows how the electrons are nicely grouped at the output cavity gap while the interbunch regions are relatively free of electrons.

This interaction can be viewed another way, as shown in Figure 3, a plot of the normalized RF beam currents as a function of distance along the tube. The curves show that the fundamental component of the plasma wave has a negative slope at the third gap. This normally would be a poor condition, but because of the drift of the interbunch electrons, the fundamental current peaks at nearly 1.8 times the dc beam current. The theoretical limit for perfect bunching in a delta function is 2. The second harmonic of the plasma wave also peaks at the output gap, which adds to the conversion efficiency.

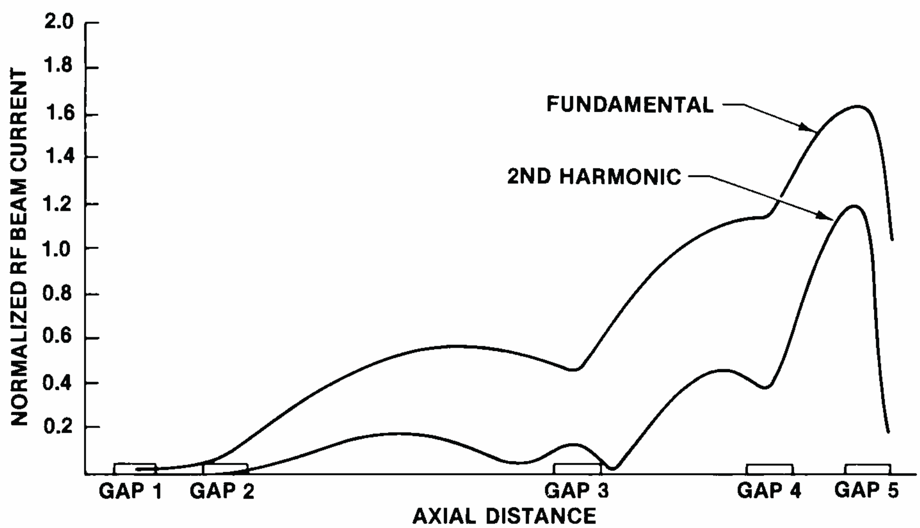
Typical operating parameters for this klystron are 33kV beam voltage and 6.2A beam current. Gain at saturation output power is 37dB, requiring 50W of RF drive power. Conversion efficiency at saturation is typically 58%. Under pulsed conditions, peak-of-sync efficiency is approximately 70%. Other performance characteristics are shown in Table 2.

The primary advantage of this design is that it can help UHF TV stations reduce their power-consumption costs. The tube may also bring down the overall cost of new transmitters because of the reduction in the required number of final amplifier tubes and associated support circuits for high-power (110kW and above) systems.

The Klystrode

As the name implies, the Klystrode is a hybrid between a klystron and a tetrode. The high reliability and power-handling capability of the klystron results, in part, from the fact that electron beam dissipation takes place in the collector electrode, quite separate from the RF cir-

Figure 3. *Plot of the normalized RF beam currents as a function of distance along the length of a high-efficiency klystron.*



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BEAM CURRENT	6.2	A
CONVERSION EFFICIENCY	58	%
INSTANTANEOUS BANDWIDTH (1dB)	6.5	MHz
LOAD VSWR	1.1	—
MOD ANODE VOLTAGE	27	kV
BODY CURRENT	50	mA
HEATER VOLTAGE	7.5	V
HEATER CURRENT	20	A
VAC ION PUMP VOLTAGE	3	kV
COLLECTOR COOLANT FLOW	50	GPM

Table 2. *Typical performance characteristics for a high-efficiency klystron.*

The Klystrode is really a hybrid of the klystron and tetrode.

cuitry. The electron dissipation elements of a tetrode are the anode (primary) and screen grid (secondary), both of which are an inherent part of the RF circuit and must, therefore, remain small at UHF frequencies.

In the Klystrode, shown schematically in Figure 4, the electron beam is formed at the cathode, density-modulated with the input RF signal by a grid, then accelerated through the anode aperture. In its bunched form, the beam drifts through a field-free region, then interacts with the RF field in the output cavity. Power is extracted from the beam in the same way as in a klystron.

In operation, an alternating RF voltage is applied between the cathode and grid. The resulting bunched, or density-modulated, electron beam then accelerates toward the aperture anode at high potential and passes through without being intercepted. Continuing through a field-free region at a constant velocity, the beam then passes through an output gap in the resonant cavity as the electric field induced by its passing is decelerating.

Finally, the beam passes through a second field-free region (tail pipe), again with minimal interception, and then crosses the gap between the tail pipe and the collector.

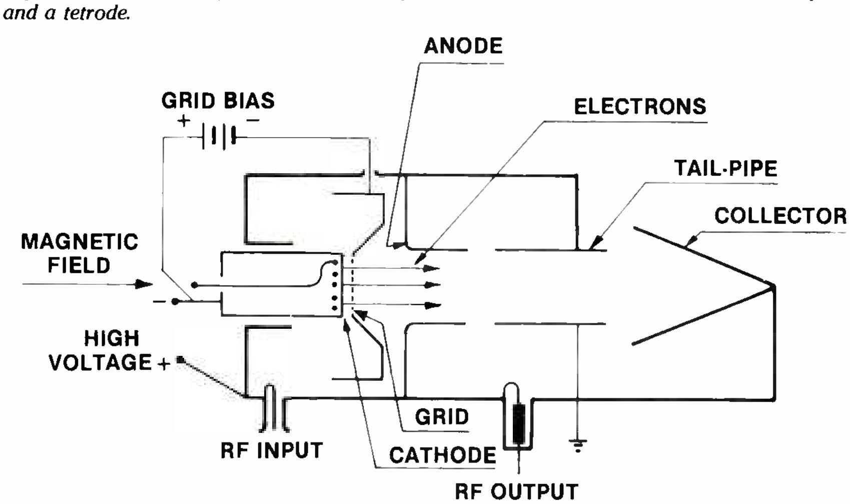
The difference between the Klystrode and a conventional tetrode can be demonstrated graphically in a comparison of their potential electric fields and electron velocity (see Figure 5). The Klystrode acts similar to a klystron between the anode and collector, but closely resembles a tetrode between the cathode and anode. Six important differences should be noted:

- The Klystrode's anode potential is higher than the tetrode's screen-grid potential.
- There is a strong decelerating field in the output gap of the Klystrode compared with an almost-zero field associated with the tetrode at the time of maximum current flow. These different profiles for the potential and field (potential gradient) reveal fundamental differences in operation. Think of the tetrode as a switch that closes every half-cycle, allowing current to flow from the power supply through the resonant load. By taking advantage of the energy storage properties of the resonant circuit, the dc energy is converted to RF energy.

In contrast, the Klystrode (and klystron) change the kinetic energy of the high-velocity electrons directly to electromagnetic energy in the output gap. Tetrode conversion efficiency is maximized at low frequencies, and efficiency is decreased markedly at higher frequencies when the screen-grid voltage must be made high to supply sufficient electron beam velocity.

- The field-free regions before and after the Klystrode output gap ensure that the output interaction space is isolated from the input space (grid-anode) as well as from the collector. In practice this isolation is important because, without it, input circuit conditions could be affected adversely by variations in tuning or loading of the output circuit.
- The Klystrode tail pipe is essentially non-intercepting when compared with the tetrode's anode, which also functions as a collector. The Klystrode's collector can then be made large (unlike the tetrode's anode) and, therefore, can be operated at lower power density and greater power output.
- With the Klystrode, there is no need for a blocking or bypass capacitor,

Figure 4. *Schematic representation of a Klystrode, which combines the features of a klystron and a tetrode.*



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because there is no dc voltage across the output gap. The high-voltage dc and RF fields are separated; therefore the gradient in each gap is about half the gradient in the output space of a conventional tetrode. This, coupled with the fact that no blocking capacitor is needed to carry the RF circulating current in the output cavity, is an advantageous operational feature of the Klystrode.

- Unlike the tetrode, the Klystrode uses a magnetic field. Although the Klystrode would perform well without such a field, the advantages of a magnetic field are considerable. The beam's natural tendency is to spread out and the magnetic field prevents this from happening. Also, without focusing, the tail pipe would have to be much larger in diameter to avoid interception of the beam. If interception took place, secondary electrons could cross the gap in a direction opposite that of the main beam and tap energy from the main load. A larger tail pipe would also increase the output gap capacitance and decrease bandwidth. Finally, the beam-to-gap coupling coefficient between the beam and cavity fields would be reduced, decreasing conversion efficiency.

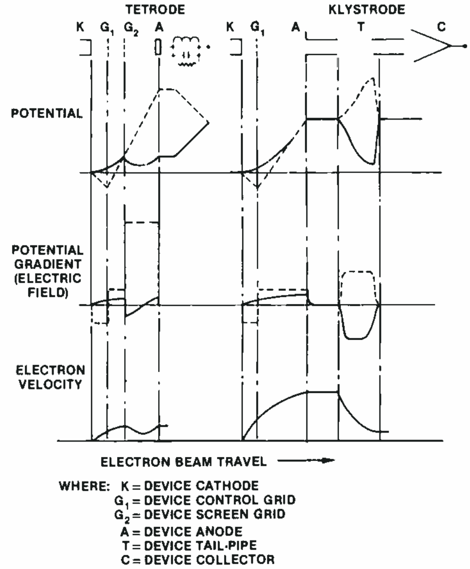

Figure 5. *The potential, potential gradient and electron velocity vs. beam distance for a tetrode and a Klystrode.*

Operating class

The klystron requires class A operation. In a class B amplifier, the power taken from the power supply is a function of the signal level. In a class A amplifier, power-supply current is constant and must be high to support the peak power output.

High-power VHF TV transmitters are typically built with power-grid tubes operating in class B. This is the reason VHF transmitters are smaller, less costly and less expensive to operate than UHF transmitters of the same power class.

Modern UHF transmitters use klystrons operating in class A, with the tube biased to draw a continuous dc current equal to the highest value necessary to meet instantaneous RF output requirements. The Klystrode, on the other hand, can operate as a class B amplifier.

Beam pulsing

In class A operation, the tube is biased to draw high current whether or not RF drive is applied and regardless of the drive level. Successful attempts have been made to reduce this inefficient mode of operation by applying a pulsing technique to the tube bias. The technique switches the tube bias between peak sync and black level operating points coincident with the video drive requirements. The most successful effort this technology has achieved is a 77% beam efficiency or *figure of merit.*

Beam pulsing the klystron involves the external control of beam current and its improvements are limited to the ratio between black level and peak sync power. Some thought has been given to full-time beam modulation of klystrons, but the linearity correction requirements, including frequency response change and ICPM generation, are currently beyond

the state of the art.

In class B operation, because of the klystron's geometry, the RF drive power automatically controls beam current. Thus, when the video is at white level, the beam current is low and as the picture power increases toward black level, the beam current automatically follows. For a 64kW peak sync power output, the instantaneous beam current will be 3.9A. At black level, it will be 2.7A and at middle gray levels, the beam current is only 1.4A.

Under these conditions, the figure of merit will equal 123%, where:

$$\text{Figure of merit} = \frac{\text{Peak RF sync power out}}{\text{Average picture power dc input including sync and blanking}}$$

Class B operation, therefore, gives the UHF broadcaster a power cost that is based on *actual* transmitted RF power output, not on a fixed dc tube power consumption.

The figure of merit is more meaningful than other measures of transmitter performance. The broadcaster is not interested in the average power output of the transmitter or in many of the other parameters important to tube engineers. A broadcaster is only interested in the peak sync power output of the transmitter and the power bill that arrives each month. Any expression used to accurately measure these elements need only include two parameters, the peak sync power output and the average power input. For our discussions, we will rely on the figure of merit for comparisons between tube performance.

The Klystrode uses a convergent-beam gun to form the electron beam. This beam, being self-focusing to some extent, requires relatively low focus power. In fact, only one air-cooled focus coil is employed. The focus power is 50Vdc at 6A maximum for a 64kW tube. This represents another power savings over a klystron with a similar power rating.

In class B operation, the Klystrode will have a turn-on non-linearity at small signal levels. This effect can be corrected by providing enough idle dc current to place the tube on its midrange characteristic. At 64kW, an idle current of less than 200mA is sufficient. Then, the Klystrode is actually operating as a class AB amplifier.

Other Klystrode features

The Klystrode has other potential advantages over the klystron. For one, the Klystrode is expected to be easier to tune. With the Klystrode, you need only to observe the beam current while sweeping the drive frequency and adjust the input circuit to provide a flat frequency response over slightly more than the required band. Then, the output cavity can be adjusted to provide symmetrical response centered on the mid frequency of the pass band.

Another important characteristic of the Klystrode is the high isolation between the input and the output circuits. The drift tube effectively isolates the input and output circuits because of its length and narrow diameter.

A comparison of the class A klystron and the class B Klystrode shows that today's UHF broadcaster can expect to reduce the part of the power bill attributable to the tubes by up to 50%. UHF transmitters are expected to be supplied with Klystrode amplifiers capable of figures of merit that exceed 120%.

Depressed collector

Another change in klystron design may be in the near future. The depressed collector klystron, introduced in Europe as early as 1961, has found its most practical application in radar. Beam electrons impacting the collector revert to heat, making cooling systems mandatory. For a device designed for TV service and rated at 50kW, using a 25kV cathode-

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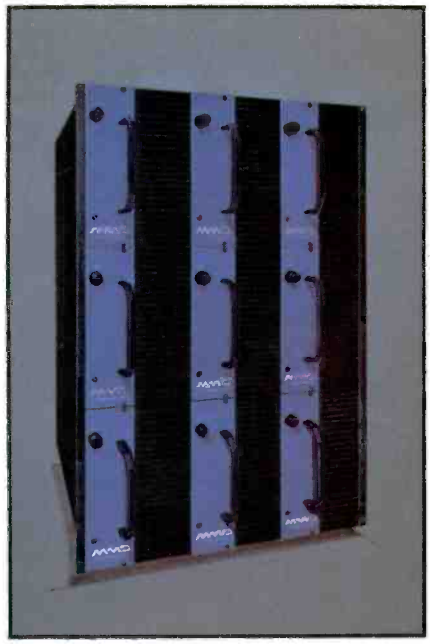
collector potential difference and a beam current of 6A, 100kW of heat energy remains after the final cavity extracts the RF signal.

The residual beam consists of electrons of varying velocities, most being much less than the equivalent 24kV collector potential. If the collector voltage matched the velocity still in the beam, reduced collector dissipation would result. A multistage collection process with various potentials would logically be more effective.

Once past the final cavity and magnetic assemblies, electrons in the beam diverge. Slower electrons diverge more quickly to the positive collector field than faster ones because of the inertia. If the slowest electrons carried a 5kV potential, then a section of the collector at 5kV could dissipate them with less heat loss. Faster electrons might require a 10kV section of the collector to be used. Not every electron would be collected at its most favorable potential, but a significant change would result.

Depressed collector devices serve airborne radar equipment well, an application in which efficiency is more critical than in broadcasting. Two- and even



A 4kW solid-state FM amplifier.

3-stage devices are in use, although the operating powers are significantly less than a full-power UHF TV station. The power levels required for TV service have kept depressed collector klystrons in the computer model stage, but such units could appear relatively soon, perhaps within two or three years.

Solid-state devices

Tubes are not the only RF power devices that have undergone changes in the past few years. Solid-state devices also play an important role in modern broadcast transmitters.

Several currently available FM transmitters rely on solid-state amplifiers. These amplifiers are typically used as driver stages for the final amplifier tube. In FM applications that do not require more than about 4kW of output power, a completely solid-state transmitter is attainable. Both FM and TV transmitters regularly use solid-state IPA modules, and solid-state AM transmitters have now reached the 50kW level.

By combining modules, almost any power level could conceivably be obtained. In practice, however, current technology limits the output level to approximately 10kW of power in VHF broadcast equipment.

Combining networks

In order to obtain the needed RF drive levels for high-power transmitters, several semiconductor devices are usually assembled together in a single module. The 50Ω modular building blocks can then be combined to provide whatever power level is required.

One design, shown in Figure 6, uses eight 125W FETs combined into a single chassis. This particular configuration

Continued on page 36

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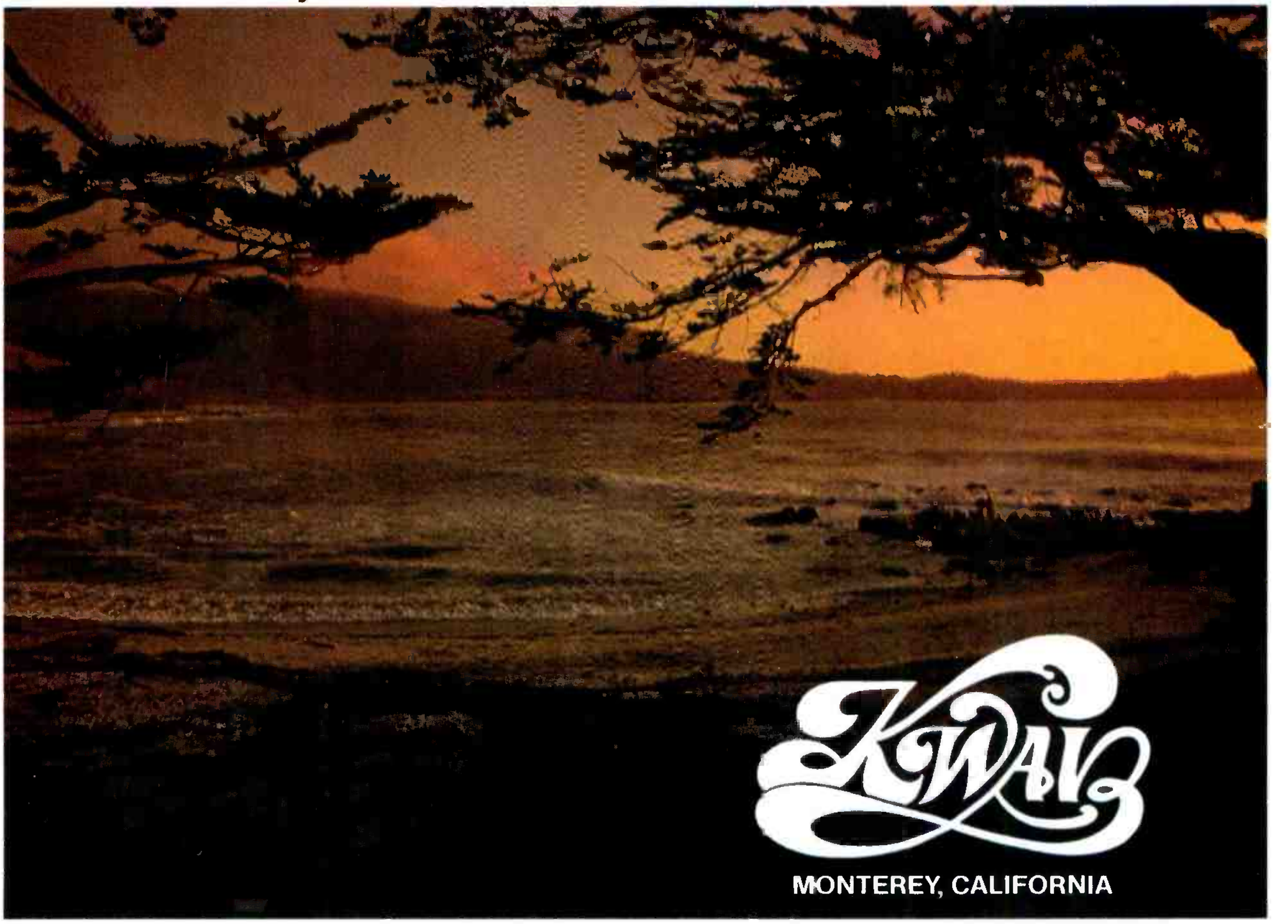

Ken Warren, Chief Engineer at KWAV reports that their 10 kW FM transmitter went on the air in November, 1972, equipped with EIMAC power tubes. The original tubes are still in operation after over 13 years of continuous duty!

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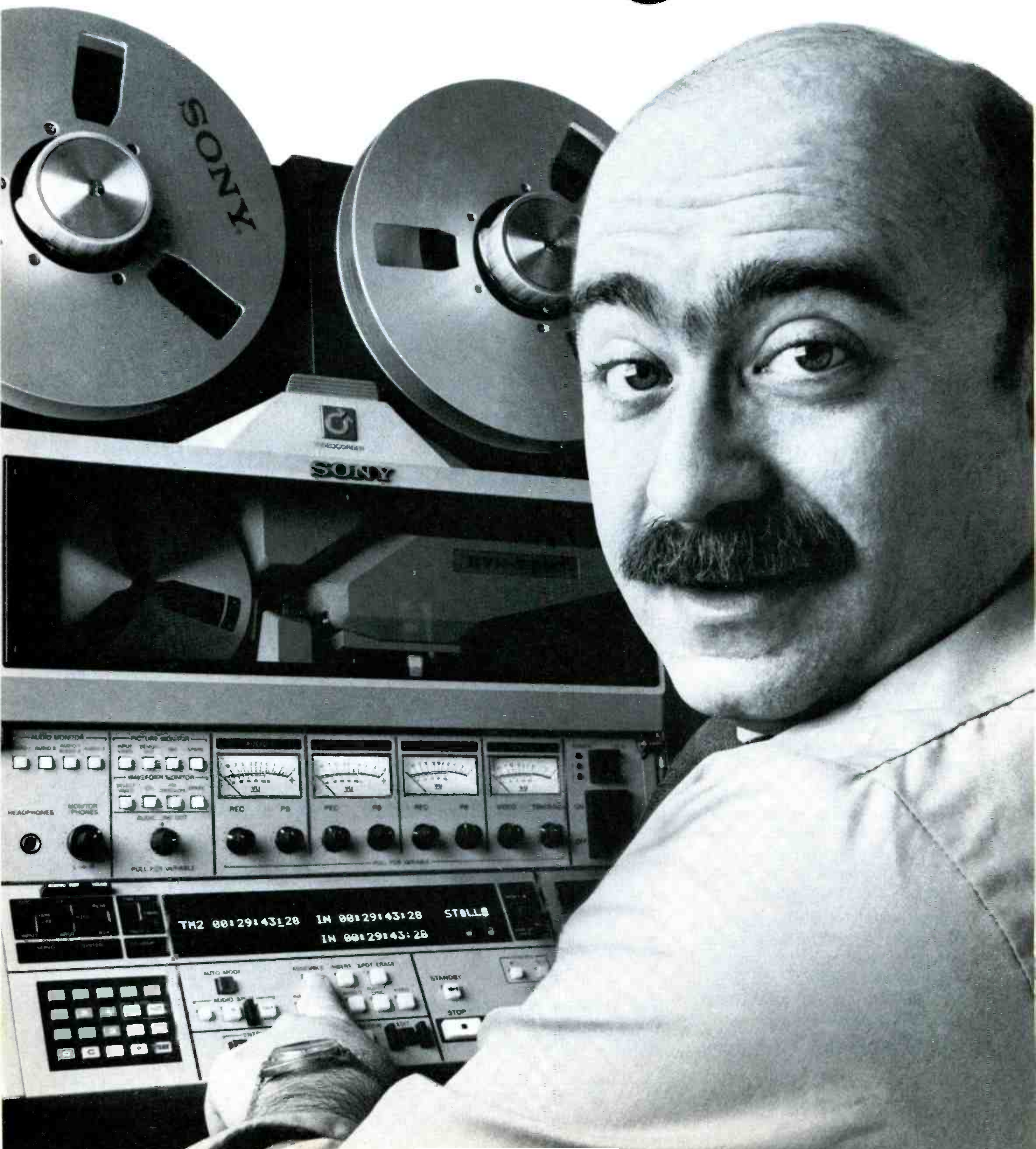

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Continued from page 32
provides as much as 600W per module. The appropriate number of modules are then combined to obtain the desired output power level.

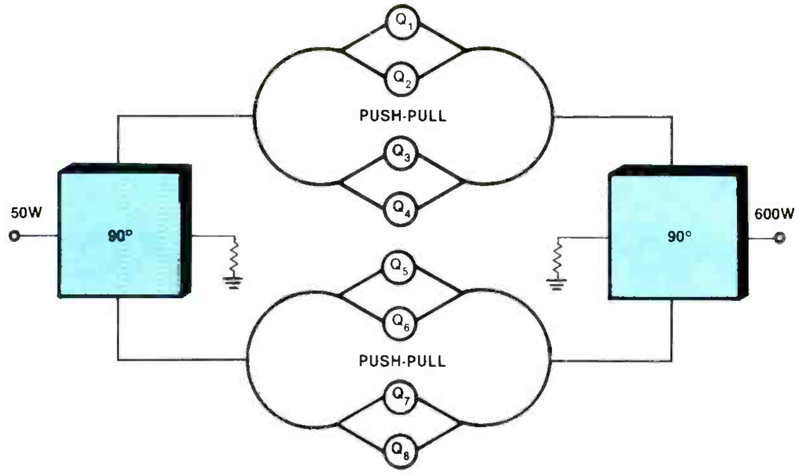

***Figure 6.** Schematic representation of an 8-FET 600W VHF amplifier.*

Protection circuits

Because of the unpredictable conditions a broadcast transmitter periodically encounters, sophisticated protection circuits are needed. Each module must be self-protected against voltage transients, thermal overloads and severe load VSWR. Some designs also incorporate a soft start-up feature. In this case, as the system is turned on, the modules do not simultaneously draw current from the power supply. Rather, each module switches on at a different time, thereby reducing the initial surge applied to the power supply. The time delay is only a few milliseconds, so it is not noticed by the operator. However, even this short time delay is sufficient to protect the supply from the initial high current demand that would otherwise be present.

One advantage of current solid-state designs is that catastrophic failure need not occur. With a tube final amplifier, if the tube fails, the station is off the air. With a well-designed solid-state system using combined power devices, the failure of a single semiconductor usually will not shut down the station. Instead, only a small reduction in radiated power results (typically less than 1dB).

Each of the modules in a typical design is combined through a high-power combining network. In addition to coupling the devices together to obtain higher power levels, the networks also protect the modules. Failure of any of the modules does not affect the other modules but simply reduces the output power by a fractional amount. Repairs can usually be completed by unplugging

A 600W solid-state VHF module.

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the defective module and installing a replacement unit.

Advantages

There are a number of advantages to solid-state amplifiers. Reduced power consumption is one that broadcasters look for. Another advantage is that they usually provide wider fixed-tuned bandwidths. For instance, an FM IPA may use a module that is sufficiently broad to cover the FM broadcast band. In this design, no tuning is required when a module is replaced. In some systems, it is not even necessary to shut down the transmitter. The modules can be replaced while the transmitter is on. This feature greatly reduces downtime from module failure.

With modern technology, it is much easier to provide reliable, and economically operating transmitters. The engineer no longer needs to be concerned about monthly—or even weekly—changes in circuit parameters. Solid-state circuits tend to be stable and, for the most part, maintenance-free.

Through the use of solid-state technology, computer modeling and manufacturing, it may not be too long before engineers see completely solid-state 20kW (or more) FM and TV transmitters. Until then, new tube designs will continue to improve the efficiency and reliability of broadcast transmitters.

Acknowledgment: Photographs used in this article courtesy of Varian EIMAC and Microwave Modular Devices.

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Inside power-grid tubes

A power-grid tube is a device using the flow of free electrons in a vacuum. It has an emitting surface called the cathode, one or more grids that control the flow of electrons, and an element that collects the electrons, called the anode.

Triodes

Most tubes used today are cylindrically symmetrical. The filament or cathode structure, the grid and the anode are all cylindrical in shape and are mounted with the axis of each cylinder along the center line of the tube. Some triodes (3-element tubes) are manufactured with the cathode, grid and the anode in the shape of a flat surface. Triodes so constructed are called planar *triodes. This construction technique is used when it's necessary to provide short lead lengths within the tube. The close spacing reduces electron transit time and, therefore, allows the tube to be used at high frequencies (up to 3GHz). The 3CX100A5 and 8755 series triodes are representative of this type of tube.*

Tetrodes

The tetrode is a 4-element tube with two grids. The control grid serves the same purpose as the grid in a triode, while a second grid with the same number of bars as the control grid is mounted between the control grid and the anode. The grid bars of the second grid are mounted directly behind the control grid bars as observed from the cathode surface and serve as a shield or screen between the input circuit and the output circuits of the tetrode.

The main advantages of a tetrode over a triode include:

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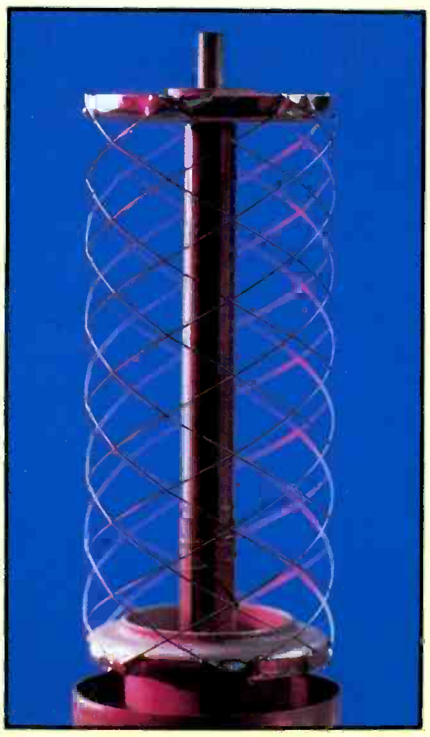
A critical part of power tube construction involves the bake-out procedure, in which residual gas is burned out of the assembly.

Testing of power-grid tubes involves both dc and RF measurements. Through careful design and construction, production variations in operating parameters can be minimized.

The production of power vacuum tubes is perhaps as much art as science. Shown is one of the glass-blowing stages used in making the envelope for a medium-power tube.



A mesh tungsten filament before mounting in the tube base. Mesh filament construction provides a rugged structure that is resistant to shock and vibration.

- *Lower internal plate-to-grid feedback.*
- *Lower driving power requirements. In most cases, the driving circuit need supply only 1% of the output power.*
- *More efficient operation. Tetrodes allow the design of compact, simple, flexible equipment with little spurious radiation and low IM.*

Pentodes

The pentode is a 5-electrode tube with three grids. The control grid and screen grids perform the same function as in a tetrode. The third grid, the suppressor grid, is mounted in the region between the screen grid and the anode. The suppressor grid produces a potential *minimum, which prevents secondary electrons from being interchanged between screen and plate.*

The pentode's main advantages are that:

- *secondary emission effects are reduced;*
- *it is well suited for linear amplifier service; and*
- *plate voltage can swing below the screen voltage without exceeding screen dissipation, allowing slightly higher power output for a given plate voltage.*

Cathode emitters

The typical production-type oxide cathode is a coating of barium and strontium oxides on a base metal such as nickel. The oxide layer is formed by first coating a nickel can or disc with a mixture of barium and strontium carbonates, suspended in a binder material. The mixture is approximately 60% barium carbonate and 40% strontium carbonate. During vacuum processing of the tubes, they are baked out at high temperatures. As the binder is burned away, the carbonates are subsequently reduced to oxides. The cathode is now activated *and will emit electrons.*

The typical oxide cathode operates CW at about 1,000°K and is capable of roughly 200mA to 300mA per cm^2 at a typical emission efficiency of 200mA to 300mA per watt of heater power. The high emission current capability for each watt of heating power is one of the main advantages of the oxide cathode. Other advantages include high peak emission capability for short pulses and a low operating temperature.

A thoriated tungsten filament is one form of an atomic-film emitter. Thorium is added to the tungsten in the process of making tungsten wire. Typically, about 1.5% of thorium in the form of thoria is added. By proper processing during vacuum pumping of the tube envelope, the metallic thorium is brought to the surface of the filament wire, and emission increases approximately 1,000 times.

At a typical operating temperature of approximately 1,900°K, a thoriated tungsten filament will produce a specific peak emission of about 70mA to 100mA per watt of filament heating power. This is normally 5mA to 10mA of CW plate current per watt of filament power.

Thoriated tungsten filaments can be assembled in several different configurations. The spiral filament is used extensively in lower-power tubes. As the size of the tube increases, mechanical considerations dictate a bar-type filament construction technique with spring loading to compensate for thermal expansion. A mesh filament can be used for both small and large tubes. It is more rugged than other designs and less subject to damage from shock and vibration.

Gun-type emitters

Some power tubes are designed as a series of electron gun structures arranged in a cylinder around a center line. This construction allows large amounts of plate current to flow and to be controlled with a minimum amount of grid interception. With reduced grid interception, less power is dissipated in the grid structures. In the case of the control grid, less driving power is required for the tube.

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Broadcast transmission systems

By Carl Bentz, TV technical editor

Constructing a broadcast transmission system involves critical engineering-intensive design considerations.

The tower is the most visible part of the broadcast transmission system that supports the TV or FM antenna or forms the AM antenna. Many aspects of tower design and construction, however, are not as obvious.

Tower types

Planning the transmission system is usually more critical to a successful operation than planning the studio. Not only must the system work right, it must withstand years of constantly varying weather conditions and present the fewest possible hazards to the surrounding area and population.

The choice of tower type—self-supported or guyed—is made primarily upon the basis of the available real estate at the tower site. Self-supported towers do not require as much space as guyed structures. However, the non-guyed tower must be structurally heavier because its stability is a function of design and the foundation provided. The cost of a self-supported tower will be greater than a guyed type by a factor of two or more, increasing with the height. If properly designed, a self-supported tower is no less or more reliable than a guyed tower.

To achieve the necessary strength, all structural members must be heavier than those of guyed counterparts. When wind strikes the tower, side-mounted antennas or attachments may cause torque. The tendency to twist is counteracted by the strength of the legs and the manner in which bracing is attached between the legs. At the same time, the entire height of the tower tends to pivot around the leeward side of the base. The center of balance and foundation attachment keep the tower from tipping.

Guyed designs

Guyed structures present a different set of problems. Considering only static forces on a tower without wind, the designer is presented with a complex closed mechanical system. (See Figure 1.) Adding dynamic forces caused by wind and variations from seasonal conditions increases the complexity.

The lower portion of the tower itself must be capable of withstanding the weight of the material above it. The entire length of the tower also must sustain the downward compression force resulting from the weights and tensions of several sets of guys. Naturally, top- or side-mounted antennas add to the total weight, along with feedlines for those antennas. The base pier and surrounding earth must withstand and support the entire downward force of the tower.

Tensions presented by guy cables differ with the height at which a set of guys is attached. In the simplest case, the lengths and tensions of all guys attached at a particular level should be equal. (Some engineers will allow variations from guy to guy of less than ± 10%. Unequal tensions may result in non-linearity of the tower along its length and lead to a tower that is out of plumb.

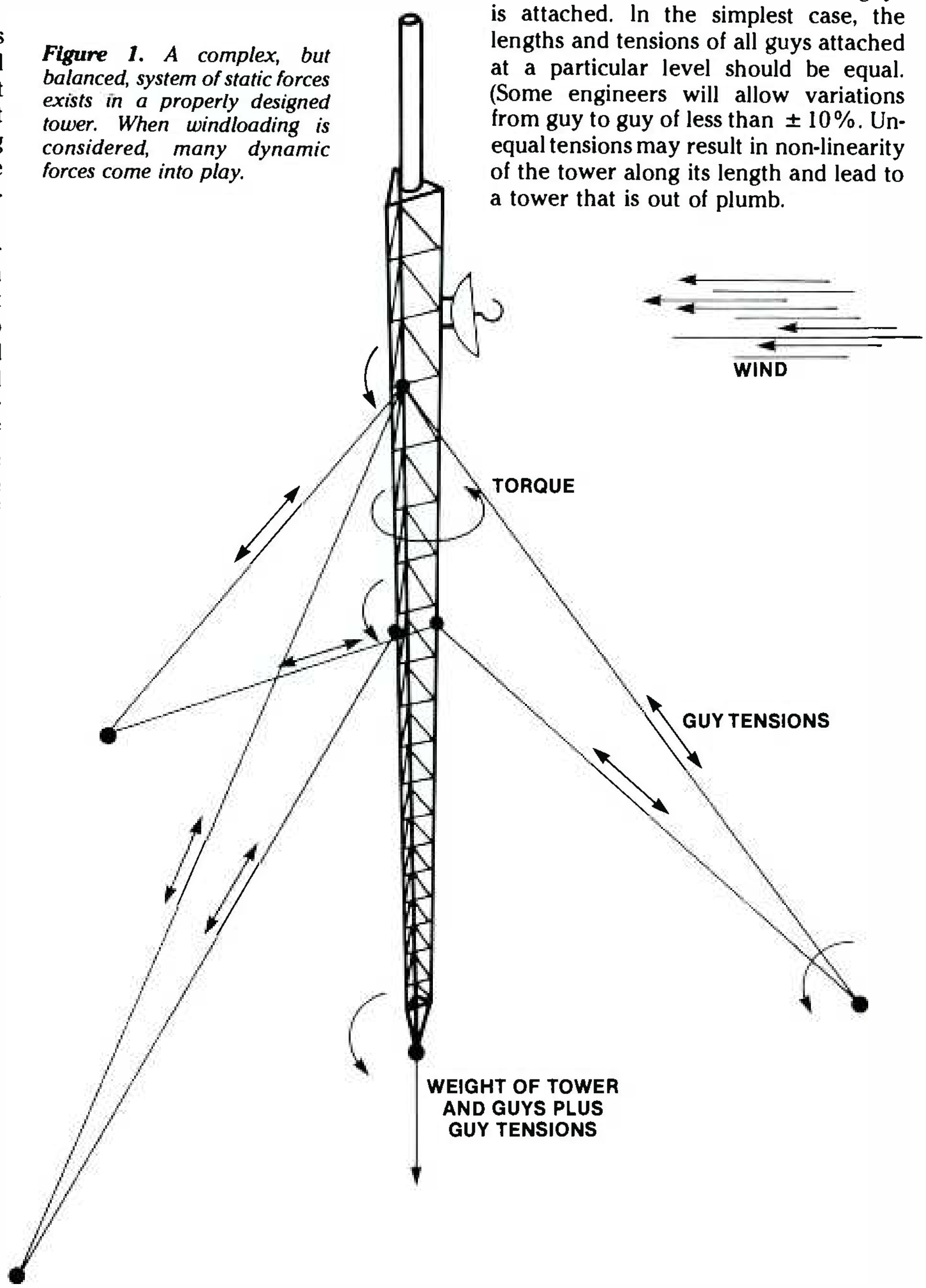
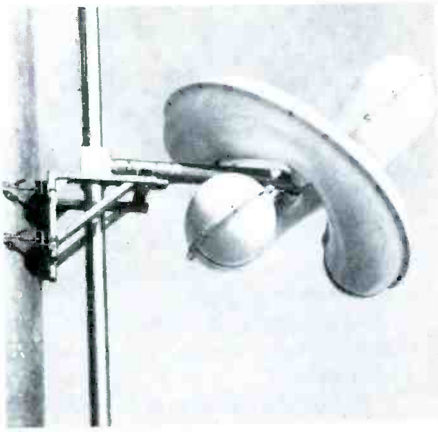
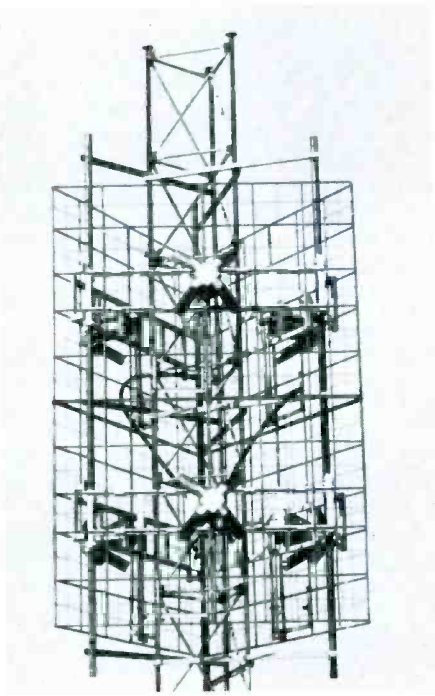


Figure 1. A complex, but balanced, system of static forces exists in a properly designed tower. When windloading is considered, many dynamic forces come into play.





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Tension also depends upon the distance of the guy anchors from the base, ranging from 50% to 100% of the tower height. The greater the distance of the anchor from the base, the less tension that must be placed on the guy for the desired amount of tower stability. However, towers with distant anchors require longer and heavier guy cable.

The number of guying levels needed is based upon the tensile strength of the tower itself, and the need to control end-to-end linearity. Curvature in the tower can add stress to one or two legs, leading to buckling.

The *plumb* of the tower also is controlled largely by guying and should be as close to zero deviation as possible. A leaning tower places stress on the base and guys. If not corrected, this can lead to catastrophic failure of the structure.

Icing of a tower presents an entirely different picture. How ice collects depends upon many factors, including height and wind direction. Icing is included in the EIA RS-222C standards for tower structures, but the unpredictability of ice collection on the tower and guys allows only approximations of its effects. The increase in loading by ice uses a factor of ⅔ for the width added to rectangular or circular tower members. Design calculations sum this amount to the clean tower windload values.

Tower designs require temperature considerations as well. For any location, maximum and minimum average temperatures determine approximately how tight (in winter) or loose (in midsummer) guys at a given tension will become. Guy weight is not changed, but forces on the tower are increased in cold weather, because of the greater tension on each guy.

Because changes in guy length occur with temperature, the natural resonant frequency of the guy cables also experiences seasonal change. (Iceloading of guys also alters the natural resonance.) Although a resonant or vibrating guy is usually not a critical factor, it should be noted in the design.

Twist

When wind is brought into the design model, dynamic forces are added. Side attachments of any kind cause torque or a twisting of the tower. The torque may be reduced by adding torque arms to the structure. (See Figure 2.) Because the torque arms extend beyond the faces of the tower, they effectively add to the torque.

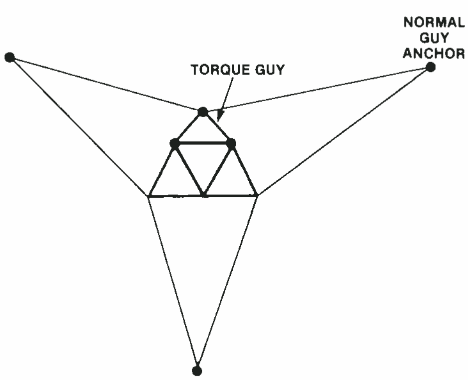

Figure 2. *Torsion guys, extending from tower faces, aid in reducing tower twisting.*

Torque is important in all situations because of the stress it places on the structure. Torque has other significance for towers supporting microwave antennas and reflectors. The half-power beam width of an STL antenna, for example, is relatively narrow. The angular width of the beam is determined from the frequency of operation (λ) and the parabolic reflector diameter (D), that is:

$$2\theta = (70\lambda)/D.$$

The angle is approximately 1.5° for a 6-foot dish on a 7MHz video radio STL link. Twisting of the tower by more than 0.75° in either direction from the no-wind condition degrades signal reception.

When passive reflectors redirect the signal from a ground-mounted transmitting or receiving dish, the allowable tolerance of the tower-twisting rotation is further reduced. Additional factors of angular tower sway and linear displacement also must be minimized for reliable link operation.

Turning moments around possible pivot points (that is, any guy level on the tower) are additional stresses placed on the tower by wind. The entire tower tends to pivot around the base. The portion above the lowest guy tends to pivot around that point, and so forth. This additional set of dynamic forces significantly increases the complexity of the design project.

Tower non-linearity may increase the effect of such moments, increasing the likelihood of buckling. The collapse of a tower from the failure of one guy is probably more related to turning moments, increased by the sudden inequality of tensions at the guy point involved, than any other single factor.

Additional moments may result when wind blows against the tower. The entire structure, acting as an extension of a guy, attempts to pivot around the guy anchor, creating an additional downward force on the base pier.

Other attachments

Coaxial feedlines and circular or rectangular waveguides provide additional weight considerations to the entire design model. They also increase torque and straight windload forces. If the feedline is placed in the angle of a leg, both types of loading are increased, with torque being the greatest. If the feedline is nearer the middle of a tower face, windload will be greater than torque.

The type of feedline also will change the amount of force. Rectangular (including square) waveguide produces a larger windload factor than circular feedline. Circular material causes only two-thirds the load of rectangular material.

Cross-bracing in the tower for KTZZ-TV 22 (Seattle) adds structural strength to faces and the cross-section.

Wind also can have an effect on the operating characteristics of the waveguide. Because wind tends to deform the shape of either type of waveguide, it may be desirable to provide some type of protection for the feedline. In this case, windloading by the protective material will take precedence over the feedline itself.

Construction

Just as the final tower specifications should be handled by a qualified design engineer, the actual construction should be contracted to a reputable and insured tower builder. As chief engineer for the station, however, you must take part in every phase of the project. Even if the tower, antenna and feedline installation is a turnkey project, you or another member of the engineering staff should monitor the progress.

Monitoring the project requires the ability to interpret specifications and to observe each step. Any deviation from good engineering practices should be pointed out to the contracting foreman and to station management. Be familiar with the EIA RS-222C publication.

As each guy point is reached during the project, observation of tower linearity, plumb and twist should be noted and corrected. All three factors may result from incorrectly manufactured materials as well as improper construction procedures. Guying tensions, as the tower grows, should be accurately set to avoid creating new linearity and plumbness

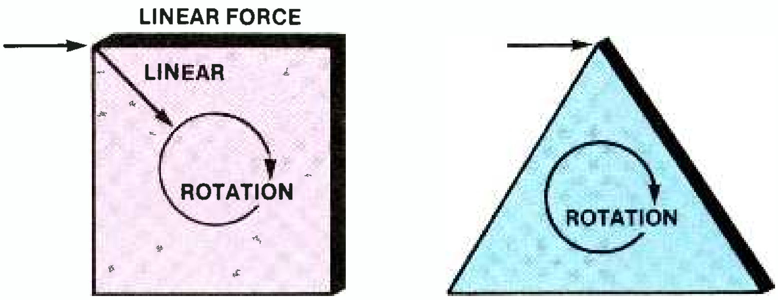

Figure 3. *Without cross-bracing, the rectangular form is structurally less rigid than the triangular form. Tendencies toward rotation and a flattening deformation of the rectangular structure are caused by external forces applied to an edge. In the triangular structure, the force is translated primarily to rotation. These tendencies apply for such structures either as tower face bracing or as tower cross-sections.*

problems as the height adds more stress.

Any deformation of tower members should be noted and discussed with the designer prior to putting the element into place. It is possible that a bent element will not have an effect upon the final project. However, any bending of metal may signal a point of metal fatigue that could result in a disaster.

Every fastener in the tower structure should be securely tightened. A conscientious foreman will cooperate by having each fastener rechecked by the crew.

If you have any question about progress of the project, request an explanation and proof. The tower presents the greatest liability for which the station is responsible. Concerns during the construction phase are more easily answered and dispelled at the time they occur, rather than later, when a failure produces court hearings, insurance investigations, a loss of public confidence in the station, property damage and possible injury or death.

Rules for safety

A number of regulations in regard to towers and support structures must be observed. In Volume 1, Part 17, the FCC spells out painting and lighting requirements for towers ranging from less than 250 feet to more than 2,000 feet.

By naming paints, colors, lamps and lighting filters, the FCC provides the greatest measure of safety in conjunction with aircraft. The Occupational Safety and Health Administration focuses on personnel safety matters. OSHA's main concern is for the people who must work on and around the tower structure.

Many cities have statutes applying to broadcast facilities in regard to antennas and towers and safety of the general public. In some cases, the local regulations may be far more stringent than any demands from the FCC and OSHA.

The various tiers of regulations may seem to be overkill to some. Yet, the tower represents a liability for which the broadcaster is solely responsible. The regulatory efforts at each level are intended to aid the broadcast industry in reducing such liability.

On the tower

The majority of work to be done on existing towers will be limited to two projects: replacing lamps and/or colored lighting filters and occasional painting. Ideally, a reliable tower service company will be contracted to perform these tasks. Replacement lamps should be kept in stock to assure that any failures can be corrected quickly.

Painting is a long-term project. Even if a known service company is contracted to do the work, the station engineer should oversee the project. Not only must the paint and its application answer FCC and FAA requirements (see FCC 17.53), but painting may have a direct effect on the longevity of the structure. Galvanized metal usually does not require painting as non-coated metals do. Even so, the zinc coating of galvanizing will eventually wear away.

Seven points are suggested by NAB in regard to contracting the tower painting project:

- purchase the paint yourself, in accordance with FCC rules;
- require brushing, scraping and priming of the structure before the final coat of paint is applied;
- require painting to be done only when the tower is dry and the relative humidity is low;
- require painting to be done only if the *tower temperature* is at least 50°;
- apply paint as specified by the manufacturer;
- inform the painters that the job will be inspected as the work progresses; and
- require evidence of insurance coverage of the painting company for its employees. The coverage should include worker's liability, contractor's public liability, contractor's protective liability, automobile liability and direct-damage insurances. Request your insurance representative to investigate the evidence of coverage.

Inspections

As with other equipment around the station, preventive maintenance may aid

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in avoiding tower problems. In theory, a stainless or galvanized steel tower should stand for an extended time without causing concern. Frequent fluctuations in weather and its varied effects on out-of-door segments of broadcast facilities significantly shorten the time that a tower should go without attention.

Insurance requirements often specify that complete inspections of the tower be made annually as a requisite for renewing coverage. In some areas, local statutes also require inspections to be made and the results approved by a professional engineer. During such inspections, search for any sign of wear, stress or corrosion of the tower, all attachments and hardware.

Check guys, guy attachments on the tower, guy anchors and insulators (if used). Greasing the guys may be desirable if a trend toward excessive rusting is noted. Include all ladders, catwalks, ice bridges and other ancillary parts of the tower in the inspection. Pay special attention to concrete foundations, the ball gap of AM towers and weep holes on base insulators.

In addition, check guy tensions, linearity and plumb of the tower. These factors can be checked occasionally by station personnel, if the proper equipment is available. Your tower structural consultant should be able to assist in developing an inspection plan. Checks throughout the year and especially after storms or high winds can help you to locate a potential tower failure and prevent it.

Tower security

Security at the tower site is essential in regard to a station's liability. AM towers, for example, require that locks are provided both on the tuning house and fence at the base. See section 73.40(b). Failure to keep the area secured violates the FCC regulation. Even more critical, however, is the liability of the station, if an unauthorized person enters an unsecured area and is injured or killed. An unlocked gate or insufficient fence makes the station directly responsible.

If proper security of a compound at the base of the tower is breached by unauthorized personnel, the responsibility and liability of the station should be minimal. The station may have to show that the security arrangements were sufficient. However, if the individual broke or climbed the fence for access, the case would most likely be considered burglary.

Guy points should also be secure. Because the tower structure and its guys form a complex system of forces, any change in the system produces an imbalance that may be disastrous. There are a number of cases in which guys have been cut by vandals, social fanatics or disgruntled employees.

Many remote-control systems include control and feedback channels that may be used for security monitoring purposes. Sensing for such applications can be expensive, but the cost is insignificant when compared with the investment that a transmitting tower represents.

From transmitter to antenna

The link from the transmitter to the antenna is the feed or transmission line. The type of line used depends upon several criteria:

- How much power will the line be expected to carry?
- What is the frequency of operation?
- What efficiency is desirable?

From these questions, a choice between coaxial line and rectangular or circular waveguide can be made.

Current designs for VHF TV and FM broadcast use coaxial feedline almost exclusively. UHF TV may use either coax or waveguide, although a preference for waveguide is noted for higher UHF channels. Microwave frequencies are more efficiently carried through waveguide.

Coax

The power to be carried by a coaxial line dictates the size of the cable. The greater the power requirement, the larger the diameter. At a given power level, increasing the operating frequency

Continued on page 52


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Continued from page 48

also means increasing the size of the coax to reduce attenuation.

Coaxial feedline is manufactured to meet a characteristic impedance (Z_0), which is used throughout the system. The characteristic impedance results from either a voltage and current or from lumped capacitive and inductive values;

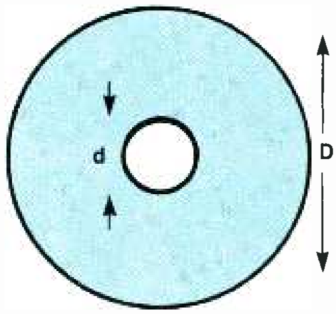
$$Z_0 = (L/C)^{1/2} = V'/I'.$$

L and C are reactively related to frequency. As frequency increases, inductive reactance increases, while capacitive effects are reduced, according to the formulas:

$$X_L = 2\pi fL \text{ and } X_c = (2\pi fC)^{-1}$$

The change in attenuation with frequency also is related to the skin effect of conductors. At higher frequencies, the signal penetrates less deeply into the center and outer conductors of the coax. Because the signal current must travel through a smaller cross-sectional area of the conductor, more resistance is, in effect, observed.

The outside diameter of the center conductor and the inside diameter of the outer conductor also relate to the Z_0 of the line. Any variation in the relationship between the two dimensions and the spacing of the center to outer conductor results in a change of Z_0. Such variations may occur at joints in a rigid coax run, a mismatched load (antenna) or dents in the feedline.



$$Z_0 = 138\log_{10}\frac{D}{d}$$

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Figure 4. *The outside diameter of the inner conductor and the inside diameter of the outer conductor determine the characteristic impedance of the coaxial material line.*

VSWR

Variations in Z_0 are the cause of the phenomenon of standing waves. The amount of power sent toward the load and the amount of power reflected (the return loss) by the load forms the standing wave ratio (VSWR). Reflections occur at any time that Z_0 changes, forcing some portion of the RF energy to be returned toward the transmitter. At the transmitter connection, the signal is reflected again toward the antenna. Because of the delays caused by reflection times, the reflected signal will not be in time with the primary signal. In television the results are echoes or ghosts in the picture. In radio, VSWR problems cause a degradation in stereo separation and subcarrier performance.

Burnout

The constant motion of coaxial feedline, as a result of wind and temperature, can have a *grinding* effect upon the connections of the transmission line sections. In severe cases, a powder

Main article continues on page 56

Metallic particles, collecting on this coaxial spacer over several years, finally resulted in a feedline burnout.

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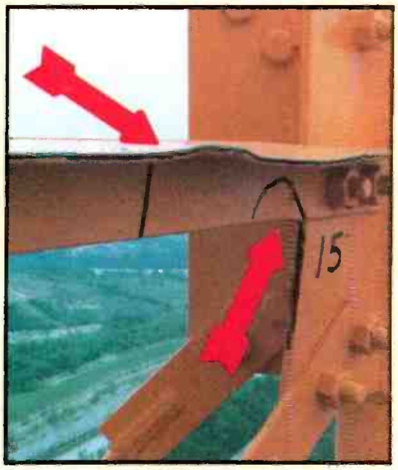
IMS 7729

Upon closer inspection

Are you planning changes to your transmission system? If such changes will alter the loading of the tower in any way, you should first have the structure thoroughly inspected. A number of reliable professional engineers provide such inspection services. You may discover that structural work is required before any additional stresses are placed on the tower. If prevention of a catastrophic collapse results, however, every penny of the inspection and repair cost is well spent.

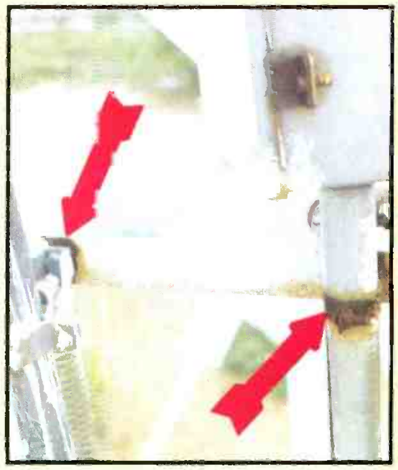
The tower shown here was originally erected in 1969. When the initial owner was forced off the air in 1972, the channel assignment of the new owner required an antenna change. An inspection was made in 1973. The next inspection occurred in 1980, at which time these photographs were taken.

This damage may have resulted during the tower construction or during the 1972 antenna installation. Deformation indicated by the top arrow is obvious. The bottom arrow indicates bending of the vertical portion of the horizontal member.



Have these bolts been loose since the 1969 construction? The tower was painted at least once between the inspections, but the painting crew would not have been looking for this type of problem.

Rusting of ungalvanized fasteners holding the electrical conduit might not have major consequences. However, if rusting continues, weakening the feedline hangers, the coaxial line could become detached and, subsequently, suffer wind damage.



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Hardening the tower

The tower will stand, no matter what. That, in short, was one of the prime specifications for the Gannett site 441 tower just outside Miami. The 1,045-foot structure serves WINZ-FM and eight other FM stations using a community antenna, and supports two side-mounted UHF TV antennas as well.

Miami broadcasters and others situated along the Atlantic and Caribbean shores have a problem that the rest of the United States doesn't usually face. When hurricane season comes, even early warnings can't help a station to weatherproof the tower and antenna. However, these broadcasters have already taken precautions against these winds, which can exceed 120mph.

The Gannett tower design specified a windload factor of 100psf on the flat 12-foot faces. Circular forms exhibit a 66.7psf loading factor. Using the standard equation to relate wind pressure and velocity:

$$P = KV^2,$$

a 100psf pressure results from a wind of 158mph. K = 0.004 and includes a gust factor and drag coefficient for flat surfaces.

An original design for the structure included a candelabra top arrangement of three masts. One would support two FM antennas, a Class C1 at the 984-foot level and a Class C above at 1,010 feet. The other two masts were planned for television.

This design was dropped because the structure would compromise the FM vertical characteristics that were desired. The tower was intended primarily for FM and TV, therefore, would take second place with side-mounted antennas below the top. Meanwhile, all FM stations would be handled by a 6-bay directional antenna that would allow the signal to be shaped to cover the coast of Florida and the Bahamas.

The second plan involved two 6-bay arrays, one for the C's and one for the C1s. The system consultants determined a third plan that simplified structural design even more. The FCC approved allowing the C1 stations to operate at 96kW ERP and the C's at 100kW ERP, all stations using a single antenna capable of a 180kW input.

The tower, as constructed, includes 10-inch-solid steel legs, supported by a base, almost 2.4 feet in diameter, that allows the tower to rotate. The base pier cap is 16 feet square and five feet thick, poured over an array of 25 37-foot pilings.

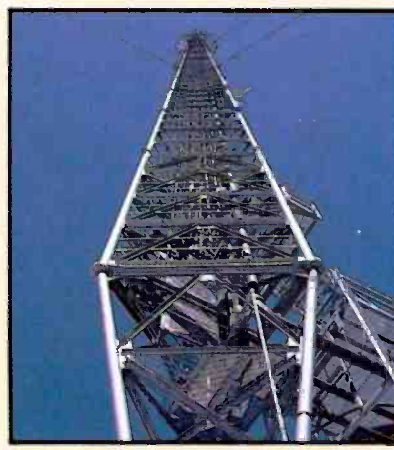
Six guy anchor points provide three inner and outer attachment locations for the five sets of 3-inch guys. Inner anchor points for level one and two guys include 10'x13' pile caps over eight 37-foot piles. Outer points are 16 feet square, poured over 16 37-foot piles. Post-tensions arrangements are provided on outer points.

The directional characteristics of the transmission pattern require that excessive twisting of the tower is minimized. While the stress of torque on the tower structure is reduced by the rotatable base, guys at levels four and five (767' 6" and 962' 6", respectively) include dual guys attached to torque guy points. In addition, the anti-torsion controls avoid communication failures to the several STL microwave dishes mounted below the 500-foot level.

The WINZ-FM transmitting facility stands between Miami and Fort Lauderdale, away from high-rise congestion.

Three million pounds of tower are supported by a base structure that is approximately 2' 8" in diameter. Unseen is the 16-foot-square cement base pier. The legs are 10-inch-solid steel.

To the side of the tower, a bridge structure supports and protects the feedlines. The topmost guys can be seen attached to a torque arm.



Courtesy of Lewis T. Fineman

Continued from page 52

of copper forms inside the line, settling on the non-conductive spacers that keep the center and outside conductors properly separated. As the copper dust collects, it changes the characteristic impedance and VSWR of the line.

VSWR indicates inefficiency and may result in heat being generated at the point of the mismatch and other points along the line. Arcing also may occur, particularly if a partial electrical path is created by such copper dust on the spacer. When an arc occurs, heating at the point of the arc may establish a conductive path. The heat of the arc may melt or even char the spacer, allowing the two conductors to come in contact with one another. This mechanism results in a burnout failure in FM and TV transmission systems.

Waveguides

Signal propagation in waveguide occurs much differently than in coax. A radio signal in free space exists as electrical and magnetic fields oriented at right angles to the direction the signal is traveling. An RF signal confined to waveguide travels in much the same manner, although different modes may exist.

The *propagation mode* in waveguide defines the electrical and/or magnetic fields that may be at 90° angles to the path of signal travel. Each mode has characteristics that may be advantageous to or detrimental to signal transmission. A detrimental mode means reduced efficiency and possible heat generation.

The frequency and mode applicable to waveguide are determined by the dimensions of the material. For higher frequen-

Part of the 9-station combining network for the Gannett site 441, Miami. All stations are Class C or C1.

cies, smaller dimensions may be used to prevent wrong modes from occurring.

Just as with coax, changes in dimension of a waveguide run may produce changes in the system VSWR. The pressure of wind blowing on the waveguide may be sufficient to cause a deformation. A varying VSWR along the run may produce reflections in the same manner as coax, but another reflection produced by mismatched polarization also may occur.

When signals leave an antenna, they are given a characteristic polarization by the antenna design. When signals enter the waveguide from the transmitter, they also are given a certain polarization. As the signals reach the antenna, signals in the waveguide of the proper polarization are transferred to the load. Changes in polarization result from dimensional changes in the waveguide.

Transmission lines are usually pressurized primarily to keep the air inside the line dry. Rectangular waveguide cannot withstand the same amount of pressure that circular waveguide allows. As a result, deformation from outside forces, such as wind, may have a greater effect on rectangular material.

Care must be used when installing any type of feedline system. Because any change in the shape of the line alters the operating characteristics, dents should be avoided. Connections between sections must be properly seated and secured with the specified number of bolts. For more information on circular waveguide, see the article, *"Using Circular Waveguide,"* page 74 in this issue.

RF combining

The FCC's 80-90 decision regarding FM power levels has resulted in a significantly increased interest in constructing tall towers and operating several stations into a single transmitting antenna. The primary requirement of such combining systems is isolation from input to input. Insufficient isolation may result in high-power intermodulation or conversion products that radiate on frequencies not assigned to any of the stations. Intermodulation and signal spurs must be at −80dB, relative to the transmitter output power.

Filtering circuits used to achieve the required separation must be linear across the passband of any one FM channel, and the overall combiner linear across the entire FM band used by the stations. Filters, by nature, usually cause some phase-shifting or group delay and bandpass reduction. Such phase shifts result in degradation to stereo separation and subcarriers of the individual carriers.

Filters are characteristically frequency-selective. In a combiner, however, the frequency response of the network must remain flat over an FM channel. Significant signal amplitude changes of individual channels, as well as throughout the entire network, should be avoided.

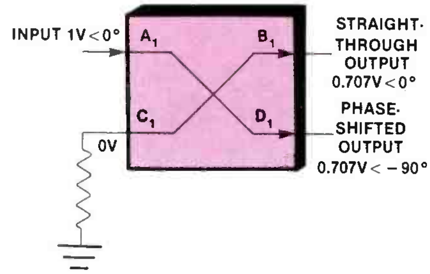


Figure 5. *The operation of a generalized 3dB coupler.*

Directional coupling

The method currently found most applicable for multiple FM signal combining uses the *balanced* or *constant impedance* approach. A series of high-power hybrid 3dB directional couplers allows an efficient combining of several individual signals into a single feed to the community antenna.

In essence, the directional coupler consists of a low-loss through-path between an input and the output. A second input, the *tap*, allows an additional signal to be injected into the through-path without letting energy from the through-path leak back toward the tap input.

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TRUTH: A lot of monitors "color" their sound. They don't deliver truly flat response. Their technology is full of compromises. Their components are from a variety of sources, and not designed to precisely integrate with each other.
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TRUTH: All 4400 Studio Monitors feature JBL's exclusive Symmetrical Field Geometry magnetic structure, which dramatically reduces second harmonic distortion, and is key in producing the 4400's deep, powerful, clean bass.
CONSEQUENCES: Conventional magnetic structures utilize non-symmetrical magnetic fields, which add significantly to distortion due to a nonlinear pull on the voice coil.

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CONSEQUENCES: For reasons of economics, monitors will often use stamped rather than cast frames, resulting in both mechanical distortion and power compression.

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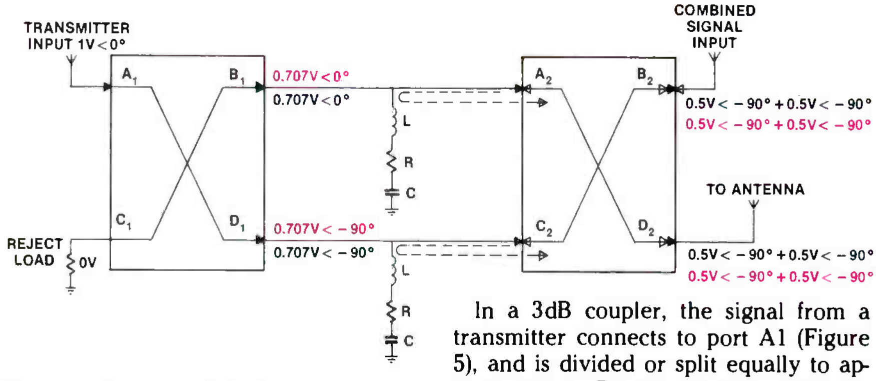

Figure 6. *Two cascaded 3dB couplers allow separate signals to be injected at ports A1 and B2 with a combined output at port D2.*

In a 3dB coupler, the signal from a transmitter connects to port A1 (Figure 5), and is divided or split equally to appear at ports B1 and D1. The signal appearing at port D1 differs from that at port B1 by a phase lag of −90°. Any signal appearing at port C1 is attenuated by 30dB, if ports B1 and C1 are terminated with the correct impedance. By connecting a second coupler section, as in Figure 6, through frequency-selective LRC circuits, the signals entering port A2 and C2 are again split and phase-shifted. At B2, the resultants, being −180° out of phase, cancel; at D2, two signals, which are each −90° shifted, add.

For an FM multiple transmitter combiner, individual station inputs are made through port A1 of each combiner section. Signals from an emergency transmitter or previous combiner sections enter the network through port B2. The output sum is developed at each port D2, for connection to the next section or to the antenna feedline. (See Figure 7.)

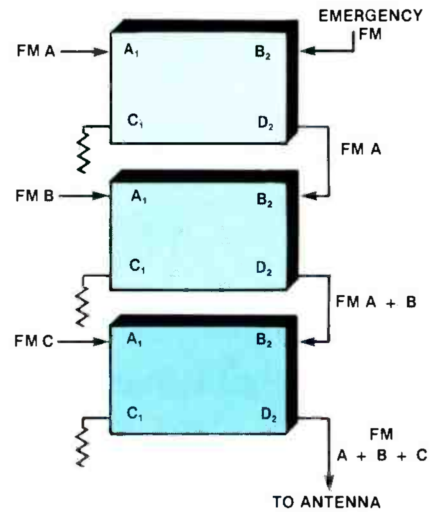

Figure 7. *A number of dual-coupler blocks may be connected to combine several FM transmitters for application to one antenna.*

By using this configuration, handling of increasing RF power levels is necessary only in the second portion of each coupler section. The LRC networks in the coupler sections must each deal only with a small bandwidth.

Group delay specifications of less than 50ns between ±150kHz from an FM carrier can be achieved, even with only 800kHz carrier separation. Corresponding frequency response values at ±200kHz from the FM carrier have been measured from 0.08dB to 0.5dB as a worst-case figure. Insertion loss for each section of the entire system can be held to 0.4dB or less.

The engineering expertise needed to specify, design and install the complete transmission system covers several engineering disciplines. Careful attention to detail in the integration of RF and structural requirements, however, results in a reliable, long-lasting facility.

Acknowledgments: Technical assistance was provided by Lewis T. Fineman, Miami; Gannett Broadcasting Systems, Atlanta; D.L. Markley & Associates, Peoria, IL; NEC Broadcast America, Elk Grove Village, IL; Shively Labs, Bridgton, ME; Structural Inspections, Blue Springs, MO; Matthew J. Vlissides & Associates, McLean, VA; KCPT-TV19, Kansas City, MO; KTTZ-TV22, Seattle; EIA; and NAB.

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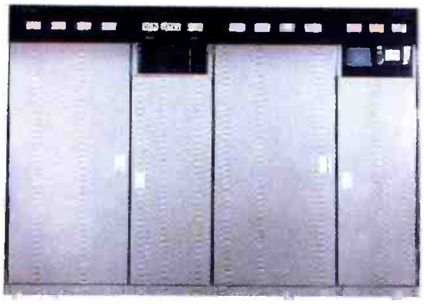

Naturally when it came to choosing the transmitter for his next station in Omaha, Nebraska, there was only one choice: Comark's "S" Series 240kW rig.

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Television on ice

What do you do when your world crashes down around your ears?

Many people find winter enjoyable. But for broadcasters, winter brings inevitable travel inconveniences and the ever-present possibility of storm-related damage to transmission facilities. The item most prone to winter damage, excluding vehicles, also is one of the most expensive necessities of the station: the transmission tower.

Towers are exposed to potentially damaging winds throughout the year. Winter icing, however, adds to the windloading, increasing the vulnerability of the structure.

No station is ever really prepared for the disaster that is a tower collapse. The following accounts of two ice-related incidents tell the effects of such a loss.

The 58-hour miracle

By Robert Dean

At 9:38 a.m. on March 11, 1983, the 1,295-foot WCSH-TV transmitting tower collapsed under an unprecedented iceload. For several days before the incident, the Portland area experienced mist, freezing rain and temperatures at or just below 32°.

We were aware of problems at the antenna site atop the 1,300-foot Winn Mountain, but poor visibility prevented our knowing just how bad the icing really was. Our only clue at the time was rising VSWR, forcing us to operate at greatly reduced power and resulting in a multitude of calls from irate viewers. Later, we would find chunks of ice up to 10 inches thick amid the wreckage of our transmitting tower.

When the tower fell, both WCSH-TV and WMEA-FM, an NPR affiliate, were immediately knocked off the air. Fortunately, our transmitter building, with the transmitter engineer inside, escaped nearly unscathed, as did a newly constructed earth station. As the structure collapsed around the downlink, the dish sustained only slight damage and remained operational. Two loggers, working about 200 feet from the base of the tower, heard the guys snapping and took refuge under their truck.

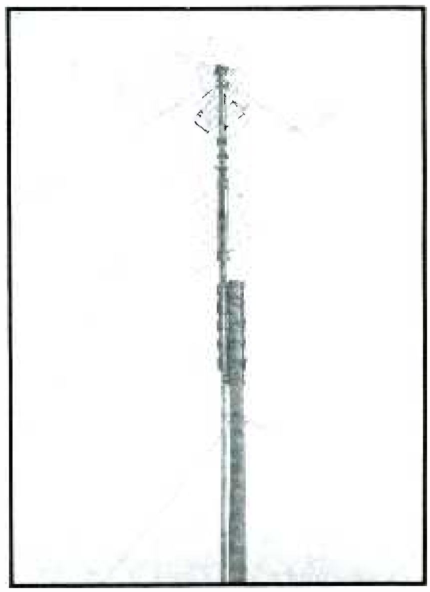
Rebuild preparations

After assessing the situation, we were faced with two immediate problems: first, getting some type of antenna operational as quickly as possible, and second, re-establishing the microwave link to our Portland studio.

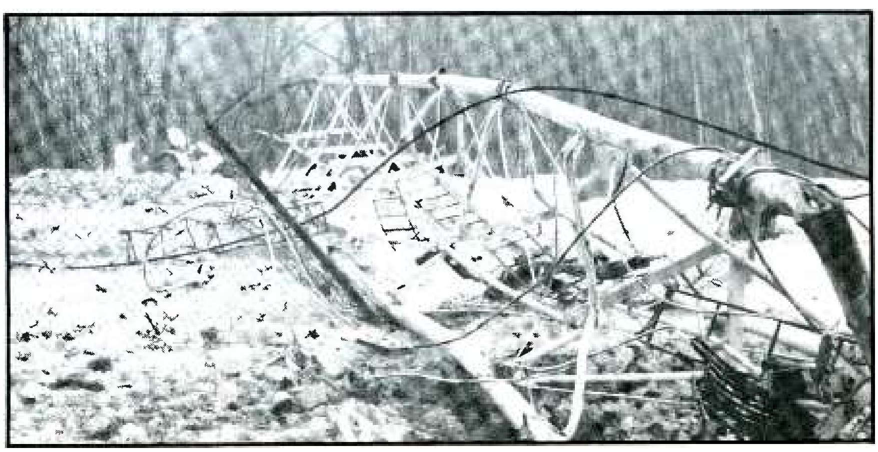
Three telephone calls brightened the day. The first successfully arranged for

Dean is the former assistant chief engineer at WCSH-TV, Portland, ME.

Part of the 1,295-foot tower on Winn Mountain that served WCSH-TV and WMEA-FM.



The temporary turnstile antenna with its custom-built utility pole mount.



Little was salvageable from the twisted wreckage.

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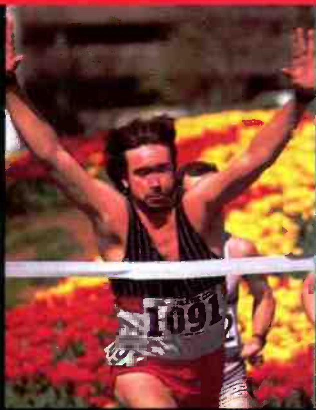

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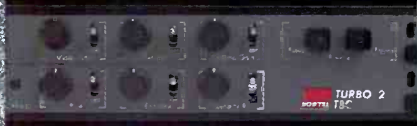

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an available superturnstile antenna and a hybrid coupler to provide the necessary dual 90° line feed. The antenna was to be at the transmitter site the following morning.

The second call located a 100-foot tower and a crew available to begin its construction at dawn the following day. Concerned whether the tower would support both the microwave and TV transmitting antennas, we decided to mount the antennas on separate structures. The tower could easily hold the microwave dish. Meanwhile, the power company confirmed that a 70-foot utility pole would support a 3,000-pound antenna and offered an installation crew to set the pole with only an hour's notice.

The third call went to our sister station, WLBZ-TV, Bangor, ME, which came to the rescue with the needed microwave equipment.

Hard at work

Workers were hampered by more sleet, rain and fog throughout the day following the collapse. However, by nightfall the tower was nearly completed and the notch diplexer was replaced with a hybrid coupler. The wreckage was scavenged for usable parts. The sales staff and some of the talent brought food to the site, while other staffers stayed at the station to answer telephones and explain the situation. The news department provided their 4-wheel-drive vehicles in what became a stationwide effort to get back on the air as soon as possible.

Welders worked throughout the night preparing a custom utility pole mount for the antenna. At dawn the power company arrived and the process of mounting and erecting the pole and antenna began.

Meanwhile, others salvaged the old microwave dish mount from the rubble and adapted it to the reflector provided by WLBZ. Finally the top section of the tower, with the microwave antenna attached, went into place. The old radome had survived the fall and was installed to reduce windloading on the temporary tower.

By 2:40 p.m. on the second day after the tower had fallen, microwave signals with the studio were re-established. We could now turn our attention to the antenna.

Only six 20-foot sections of transmission line were available, which created definite restrictions on placement of the antenna and pole. A spot about 18 feet from the transmitter building was selected, giving a couple of feet of leeway inside the building. As the pole was being installed, workers stood by with a backhoe and chainsaw to help with any necessary height fine-tuning.

By 6:30 p.m., after many challenges to our ingenuity, the transmitter engineers turned on the filaments and exciters for the parallel transmitter system. An hour

Continued on page 70

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Continued from page 64
later, power was slowly applied to the untested, temporary antenna and feed system. With constant checks for signs of arcing or heating, power was increased to the full rated output.

At 7:42 p.m., all tests had positive results and a telephone call to the Portland studio brought normal program signals back on the air. Only 58 hours after disaster struck, teamwork successfully put us back in business.

Gone in 30 seconds

By Gary L. Krohe

The tower was only nine months old, and although it was orginally built to hold one UHF-TV and two FM antennas, the FM equipment was not yet installed. We thought a wide safety margin existed. But sometime between midnight and 4 a.m. on March 19, 1984, the 1,439-foot tower was reduced to a pile of rubble, the victim of ice.

Problems arose the previous afternoon, and by 4:30 p.m. icing had become too heavy for the radome to shed, causing the aural VSWR to rise slowly. Responding to the call for assistance, I proceeded to the transmitter site about 6:15 p.m., noting on my way that the power lines were already showing signs of strain from ice.

A half-hour later, one leg of the 3-phase ac service failed, shutting the transmitter down. Without power, deicing was impossible. Not long after, the other two phases failed as well, leaving no power at the transmitter site.

Krohe is the director of engineering for KLDH-TV, Topeka, KS.

The morning after

We had waited at the transmitter site in hopes that power would be returned. By 11:30 p.m. the maintenance engineer and I left, planning to return at 5 a.m. to restart the system and check for damage.

On my return to the site at 4:45 a.m., power line and tree damage told me that there was little chance of power being restored. I didn't expect to see the tower lights as I approached the site. I also didn't expect to find the top plate of the tower and the bottom of the antenna lying across the access road 400 feet inside the KLDH property line.

As I approached the site, I found a 10-foot-high pile of steel where the tower base pier once stood. The transmitter building appeared undamaged. Later, however, we would find that the collapse

Within 30 to 45 seconds, approximately 900 feet of the tower collapsed into a 100-foot-long pile of rubble. Guys remained intact through most of the fall, forcing a near-vertical position of the tower.

The top section and antenna from the 1,439-foot tower landed 400 feet away from the base. One of the top guys apparently caught on the rubble, causing the top part to fall in the opposite direction.

With its radome partically removed for inspection, the antenna shows a bend in the body resulting from the fall. Damage to the climbing ladder occurred as it was moved. Rectangular-to-circular transition at the tower top plate had been twisted badly.

From the 800-foot level, flanges were broken from the WC-1500 waveguide and the solid tower leg.

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had placed stress on the waveguide, causing extensive damage to the RF plumbing.

In daylight, the site looked like an ex- into the ground. The process continued with limited movement toward the south and southwest until about 900 feet of tower had come to the ground. Painted suffered no structural damage.

Inside the building the force exerted on the waveguide caused breakage of bolts on the diplexer. Washers were pro-

Using circular waveguide

By Gary L. Krohe

A look inside circular waveguide, how it works and how it can be used.

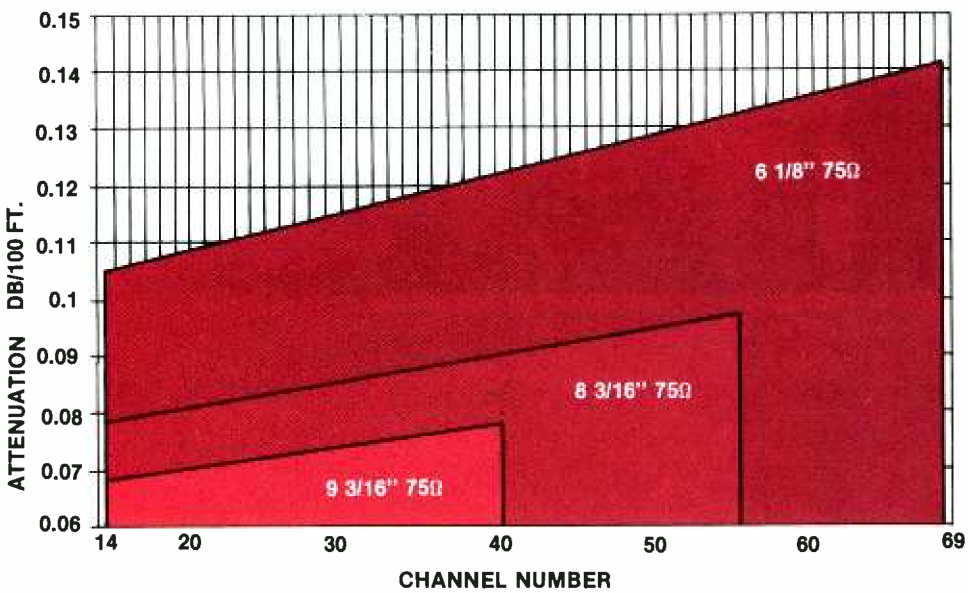

Figure 1. *Attenuation vs. UHF TV frequencies for different coax materials.*

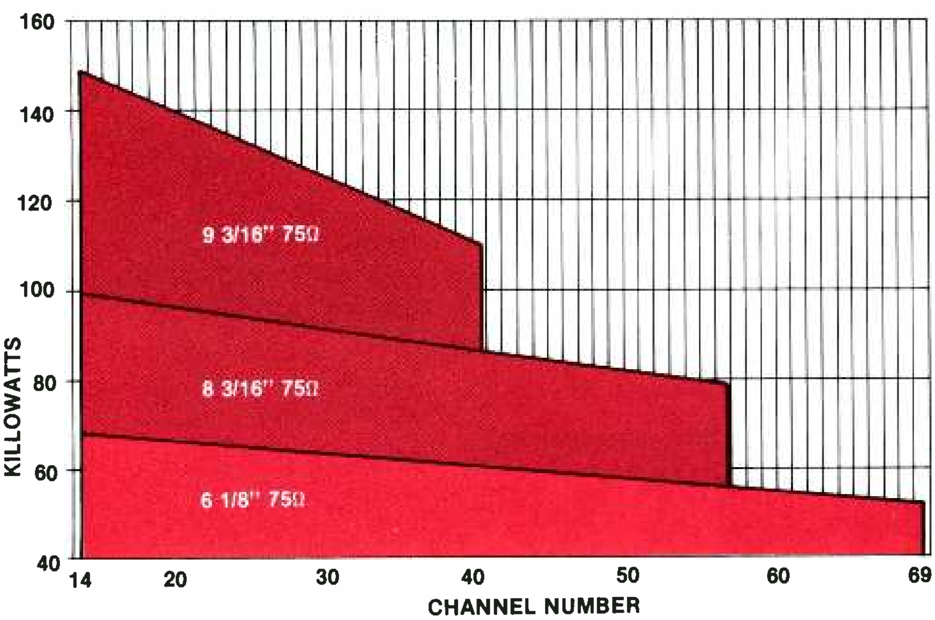

Figure 2. *Power handling vs. UHF TV frequencies for different coax materials.*

Although considered a new technology in broadcasting, circular waveguide systems have worked successfully for 20 years in telephone communications. Since the 1930s, when the attenuation characteristics of *overmoded* waveguide were discovered, Bell Labs has been exploring its applications. Currently, most AT&T long-lines facilities use circular waveguide to carry three frequency bands in two polarizations to feed one broadband horn antenna. In Japan, extremely long runs of circular waveguide have carried intra-city communication signals successfully. With the advent of fiber-optical systems, however, waveguide is being phased out in telecommunications applications.

The first application of circular waveguide to feed a UHF broadcast antenna was at WLFL-TV, Durham, NC, in November 1981. Currently, more than a dozen stations have installed circular transmission systems.

Feedline types

Three types of feed systems are used to drive UHF TV broadcast antennas: rectangular and circular waveguide and coaxial transmission line. Coaxial line is the most conventional, but it has several drawbacks. A transmission line with a center conductor may be subject to burnout through natural or induced causes. As the operating frequency increases, the power-handling capacity decreases.

Coax also has a frequency limit, where high-frequency operation can cause higher-order moding problems (the line tries to act as if it were waveguide). Finally, as frequency increases, so does line attenuation with a decrease in efficiency. On the positive side, transmission line, although weighing more than waveguide, presents the smallest cross-sectional windload of the three methods.

Rectangular waveguide offers several advantages over coax, but has inherent problems of its own. Rectangular

Continued on page 78

Krohe is director of engineering for KLDH-TV, Topeka, KS.


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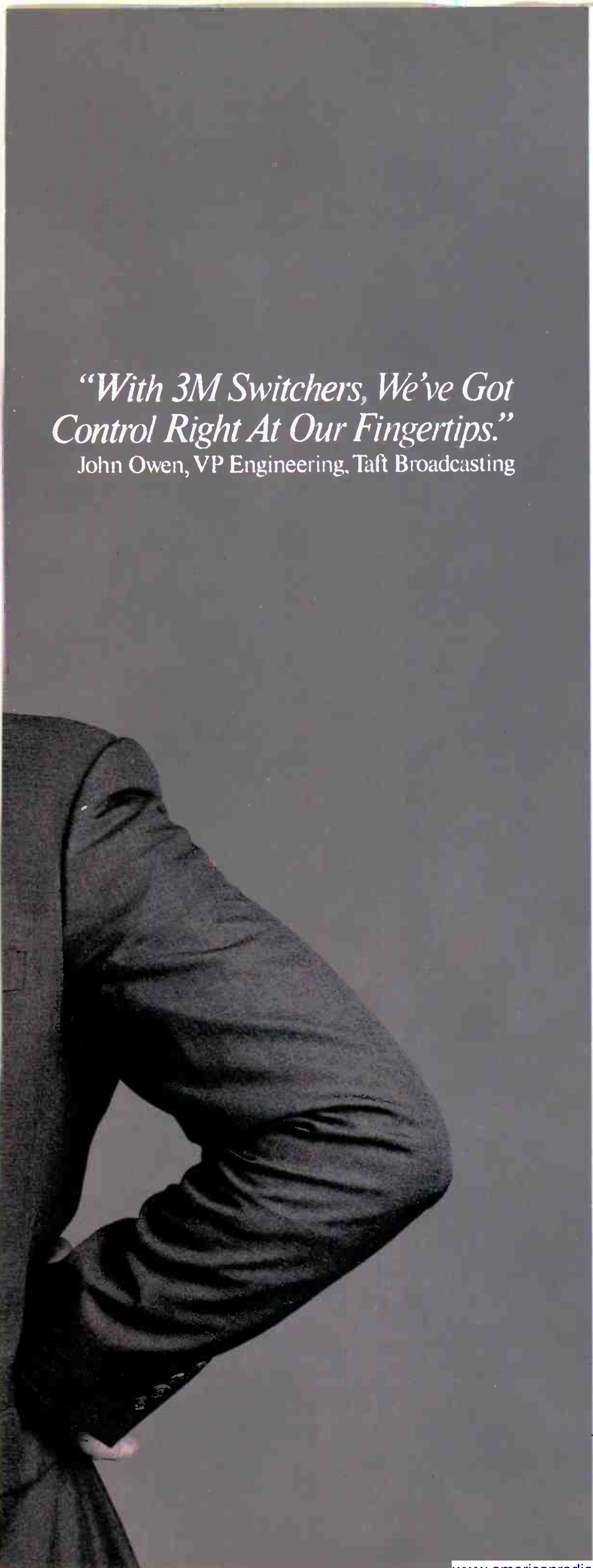

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Continued from page 74
waveguide, unlike coax, can carry more power as the operating frequency increases and will generally handle a minimum of 150kW using WR-1150 on channel 40, compared to a maximum of 150kW for 9 3/16-inch coax on channel 14. System efficiency is significantly better with rectangular waveguide at higher frequencies.

Rectangular waveguide, however, presents a large, non-uniform windload surface, which places additional demands upon the tower. Rectangular waveguide can only be pressurized to 0.5psi. Any greater pressure will deform the guide shape and result in an increasing VSWR. Wind also may cause deformation and ensuing VSWR problems.

Circular guide improves on the advantages of rectangular guide, by yielding higher power ratings and lower signal attenuation. It can be pressurized to 2.5psi, like transmission line. The antenna may be pressurized through the guide, rather than through a separate pressure line, as rectangular guide requires. As the pressure inside the waveguide increases, the shape tends to become more uniformly circular, improving guide characteristics. Finally, circular waveguide presents lower and more uniform windloading than rectangular waveguide, thus reducing tower structural requirements.

The same physical properties of circular waveguide that give it superior power handling and low attenuation also are the cause of its electrical complexities. Circular waveguide has two potentially unwanted modes of propagation, the cross-polarized TE_{11} and TM_{01} modes.

Circular waveguide, by definition, has no short or long dimension and, consequently, no method to prevent the development of *cross-polar* or *orthogonal* energies. Cross-polar energy is formed by small ellipticities in the waveguide. If the cross-polar energy is not trapped out, this parasitic energy form can recombine with the dominant mode energy to cause ghosting. Manufacturers of circular waveguide for broadcast incorporate some form of cross-polar filter or attenuator in their systems.

More on modes

In a discussion of waveguides, some understanding of the modes of propagation is necessary. There are four common modes in coax and waveguides: TE_{01}, TM_{01}, TE_{11}, and TEM. Each mode has a cutoff frequency, the lowest frequency at which a particular type of guide will propagate a signal without undue attenuation.

TE_{01} mode, or *transverse electric* mode, has an electric field transverse (at right angles) to the direction of propagation. Of the four modes, it also has the highest cutoff frequency.

TE_{11} also has an electric field that is transverse to the direction of propagation. In circular guide, however, TE_{11} develops a more complex propagation pattern with electric vectors curving inside the guide. This mode exhibits the lowest cutoff frequency of all modes, which allows a smaller guide diameter for a specified operating frequency.

The third mode, TM_{01}, unlike TE modes, has its magnetic field transverse to the direction of propagation. TM_{01} also has a slightly higher cutoff frequency than TE_{11} for the same size guide. Developed as a result of discontinuities in the waveguide, such as flanges and transitions, TM_{01} energy is not coupled out by either dominant or cross-polar transitions. Such parasitic energy must be filtered out or the waveguide diameter picked carefully to reduce the unwanted mode.

The fourth mode functions in coaxial transmission line. TEM mode has both electrical and magnetic fields transverse to the direction of propagation. Signals can range from dc to a frequency where higher-order moding occurs. As a result, 9 3/16-inch and 8 3/16-inch transmission lines can't be used throughout the UHF TV band.

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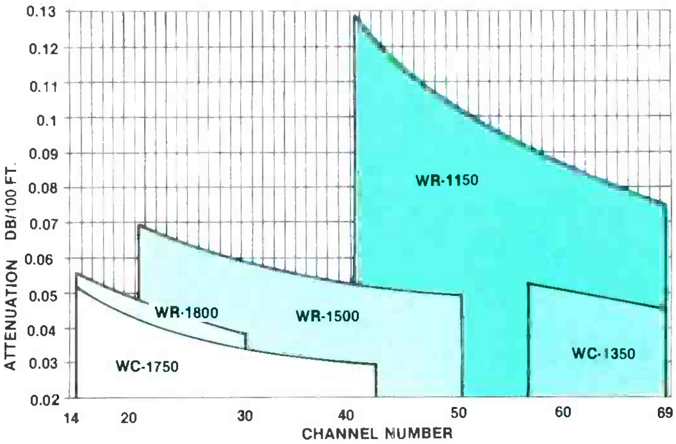


Figure 3. *Attenuation vs. UHF TV frequencies for different waveguide materials.*

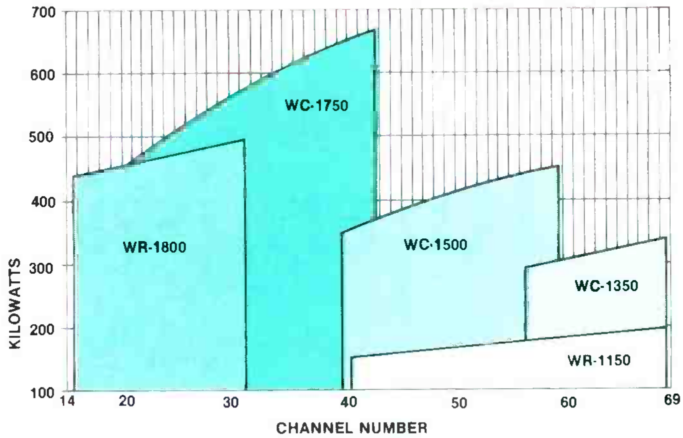


Figure 4. *Power handling vs. UHF TV frequencies for different waveguide materials.*

Waveguide pros and cons

Waveguide system installation is both easier and more difficult than traditional transmission line systems. There is no inner conductor to align, but alignment pins and more bolts are required per flange. Transition hardware to accommodate loads and coaxial-to-waveguide interfacing are required, but the additional installation requires less than a day's time.

Tuning circular waveguide is a 2-step procedure. First, the cross-polar TE_{11} component is reduced primarily through axial ratio compensators or mode optimizers. These devices counteract the net system ellipticity and indirectly minimize cross-polar energy. The cross-polar filters are also rotated at this time to achieve the greatest isolation between the dominant and cross-polar modes. Cross-polar energy manifests itself as a net signal rotation at the end of the waveguide run. The perfect system would have a net rotation of zero.

In the second step, tuning slugs at both the top and bottom of the waveguide run reduce the overall system VSWR. Tuning the waveguide can be a several-day procedure, but normally, once set, tuning does not drift and must be redone only if major components changes are made.

As more UHF stations move toward the full 5MW ERP power limit, change to circular polarization and experience rising costs of electricity, the efficiency and cost effectiveness of circular waveguide make it an attractive option.

Complying with RF emission standards

By Donald L. Markley

Is your station in compliance with the FCC's new guidelines on non-ionizing radiation?

When broadcasters were notified by the FCC that they would have to comply with standards for non-ionizing radiation, they raised a great cry. Many feared that new and significant restrictions upon broadcasters would be expensive to meet.

The commission has issued further information allowing engineers to evaluate their compliance with the guidelines. The good news is that most stations will find few problems meeting the required standard. The bad news is that some local governments are issuing their own versions of the standard.

NEPA mandate

The National Environmental Policy Act of 1969 required the commission to place controls on electromagnetic or non-ionizing radiation. The purpose was to prevent possible harm to the public at large and to those who must work near sources of the radiation.

Action was delayed because no hard and fast evidence existed that low- and medium-level RF energy is harmful to human life. Also, there was no evidence showing that radio waves from radio and TV stations did not constitute a health hazard.

During the delay, many studies were carried out in an attempt to identify those levels of radiation that might be harmful. From the research suggested, limits were developed by the American National Standards Institute (ANSI) and stated in the document known as ANSI C95.1-1982. The protection criteria stated in the standard are shown in Figure 1.

The energy level criteria were developed by representatives from a number of industries and educational institutions after performing research on the possible effects of non-ionizing radiation. The projects all concerned the absorption of RF energy by the human body, based upon simulated human body models. In preparing the document, ANSI attempted to determine those levels of incident radiation that would cause the body to absorb less than 0.4W/kg of mass (averaged over the whole body) or peak absorption values of 8W/kg over any one gram of body tissue.

From the data, the researchers found that energy would be absorbed more readily at some frequencies than at others. The absorption rates were found to be functions of the size of a specific individual and the frequency of the signal being evaluated. It was the result of these absorption rates that culminated in the shape of the *safe curve* of Figure 1.

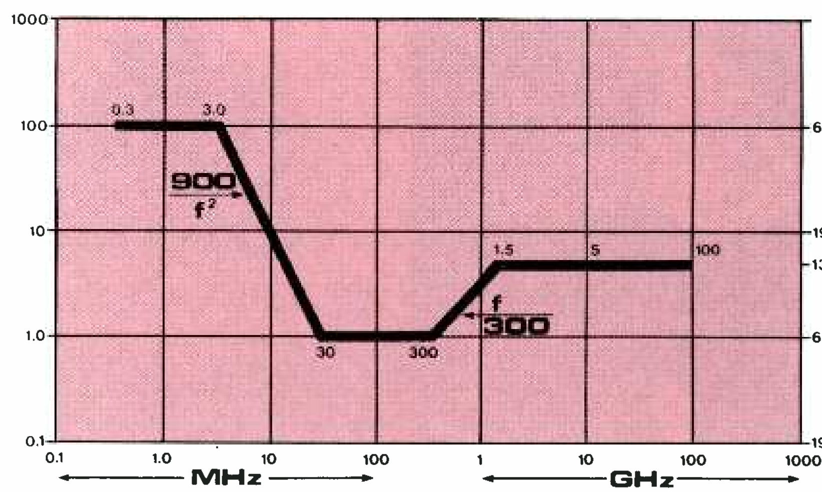
ANSI concluded that no harm would occur to individuals exposed to radio energy fields, as long as specific values were not exceeded when averaged over a period of 0.1 hours. Also, higher values for a brief period would not pose difficulties, if the levels shown in the standard document were not exceeded when averaged over the 0.1-hour time period.

FCC action

The commission adopted ANSI C95.1-1982 as a standard that would provide adequate protection to the public and to industry personnel who are involved in working around antenna structures. The regulation provides the industry with established criteria to protect the population at large, as well as broadcasters. As long as a broadcast facility complies with the ANSI document, a reasonable response can be offered to those who express fears about the possible effects of a station's operation.

Unfortunately, not all communities have agreed with the ANSI standard. In several areas, specific communities are attempting to enforce their own standards, which involve less realistic and far more stringent values. The eventual outcome of this action is still in question, as

Figure 1. *For compliance with ANSI C95.1-1982, the electromagnetic radiation level encountered by an individual must fall below the heavy line at any frequency. For quick reference, particular frequency segments are noted.*



FCC POWER DENSITY LIMITS (EFFECTIVE 1-1-86)

AM BAND (535kHz-1,605kHz)	: 100mW/cm²
FM BAND (88MHz-108MHz)	: 1mW/cm²
VHF TV (54MHz-216MHz)	: 1mW/cm²
UHF TV (470MHz-806MHz)	: 1.6 to 2.7mW/cm²
SHF BAND (1.5GHz-100GHz)	: 5mW/cm²

Markley, BE's consultant on transmission facilities, is president of D. L. Markley & Associates consulting engineers, Peoria, IL.

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the commission appears to be reluctant to become involved in local disputes.

To the broadcaster

In adopting the standard, the commission has placed a requirement on all broadcast stations to comply with ANSI C95.1-1982. Existing stations are grandfathered without having to show compliance until a major action occurs with regard to that station. A *major action* is defined as a renewal or modification that requires a new application to be filed with the commission. Therefore, all stations must eventually show compliance.

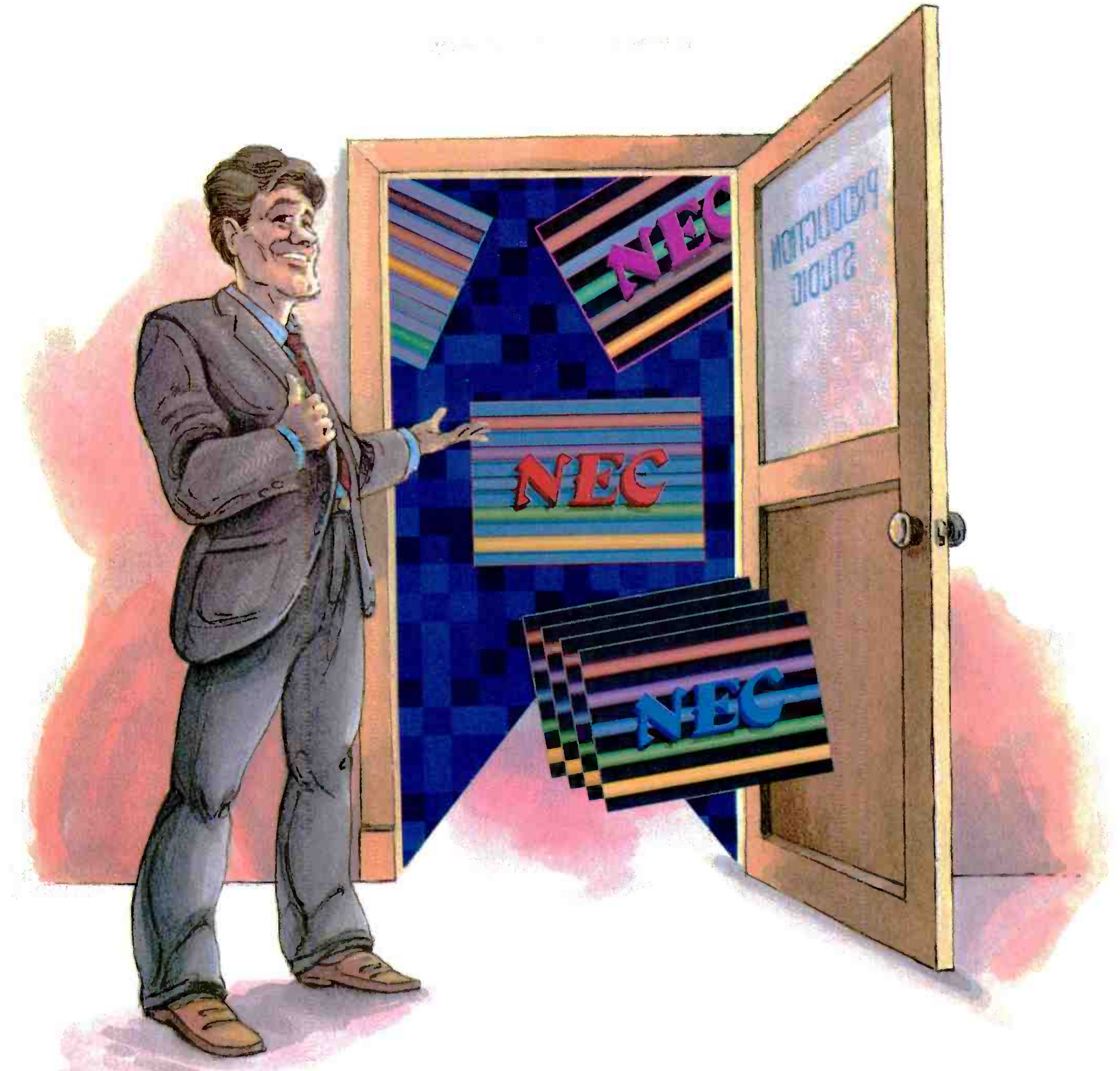
The commission has ruled that compliance with the standard will be handled through self-certification. That is, if station personnel believe that they have complied with the regulations, it is necessary only that they mark a box on the application to indicate that it is not a major environmental action. A brief statement of explanation must be filed with the application. Then, unless an objection is filed, or the commission has reason to believe that the operation does not comply, no further action will be necessary.

To assist individual stations, the commission has published a series of curves and graphs for engineers to use as rough guidelines to determine compliance status. Any assumptions that have been made in the preparation of the tables and

		NUMBER OF BAYS					
		2	4	6	8	10	12
TOTAL H+V POWER (ERP) IN KILOWATTS	0.5	4.1	4.1	4.1	4.1	4.1	4.1
		1.9	1.2	1.0	1.0	0.9	0.9
	3	10.0	10.0	10.0	10.0	10.0	10.0
		4.7	2.9	2.6	2.4	2.3	2.2
	10	18.3	18.3	18.3	18.3	18.3	18.3
		8.6	5.3	4.7	4.4	4.2	4.0
	25	28.9	28.9	28.9	28.9	28.9	28.9
		13.6	8.4	7.4	6.9	6.6	6.3
	50	40.9	40.9	40.9	40.9	40.9	40.9
		19.3	11.9	10.5	9.7	9.3	8.9
	75	50.0	50.0	50.0	50.0	50.0	50.0
		23.6	14.6	12.8	11.9	11.4	10.9
	100	57.8	57.8	57.8	57.8	57.8	57.8
		27.3	16.9	14.8	13.8	13.1	12.6
	125	64.6	64.6	64.6	64.6	64.6	64.6
		30.5	18.9	16.6	15.4	14.7	14.1
	150	70.8	70.8	70.8	70.8	70.8	70.8
		33.4	20.7	18.1	16.9	16.1	15.4
	175	76.4	76.4	76.4	76.4	76.4	76.4
		36.1	22.3	19.6	18.2	17.4	16.7
	200	81.7	81.7	81.7	81.7	81.7	81.7
		38.6	23.9	21.0	19.5	18.6	17.8

Notes: 1. The supporting tower base is at approximately the same level or higher than the surrounding terrain.
2. For each entry, the higher number represents the *worst* case (dipole element); the lower number represents the *best* case achieved with currently available antennas.

Table 1. *Minimum height to center of radiation for single FM antennas. (Values are given in meters.)*



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graphs have been weighted toward greater amounts of protection.

As an example, for AM directional arrays, total power is assumed to be radiated by each element of the array. Because the total power is actually determined from the combined powers of all elements, it is obvious that the assumption affords far more protection to people in the vicinity of the array than is realistically required. However, if the station complies with the standard based on the assumption, there can be no serious question concerning compliance when a more realistic set of factors and assumptions is applied.

Compliance can be determined by means other than the curves or tables in the guidelines. If the station's operation does not comply according to the tables, compliance may be shown through a more detailed analysis. Such an analysis requires calculations or measurements with an explanation of the assumptions or data upon which the calculations are based.

FM

Consider a standard Class B FM station operating a 20kW transmitter and driving a 6-bay antenna mounted on a 500-foot tower. For this full-power station, the effective radiated power is the sum of the horizontally and vertically polarized components, totaling 100kW.

In Table 1, the absolute worst-case installation using the worst transmitting antenna would require the example 6-bay antenna's center of radiation to be 57.8m (190 feet) above ground. Because the vast majority of Class B FM stations have their antennas at heights greater than 190 feet, even the most offending antennas pose little problem.

TV

Table 2 applies to a VHF station. A lowband VHF station operating with 100kW visual and 10kW aural ERP levels would not exceed the ANSI standard at any point more than 40.9m (134 feet) distant from the center of radiation.

As with FM stations, few channel 2 through 6 TV stations have antennas that close to the ground. As a result, the impact of the regulation for lowband VHF TV will be minimal.

Because the effects of electromagnetic radiation decline at frequencies above 300MHz, highband TV VHF channels 7 through 13 and UHF stations face less of a problem in meeting the ANSI standard. However, the impact of higher ERP, particularly for UHF operations, must be considered when determining compliance with the exposure limits.

AM

For standard broadcast stations, the ANSI guidelines require that the *electric field strength squared* is less than 400,000 or that the *magnetic field strength squared* is less than 2.5. Assuming that all energy is radiated from the bottom of the antenna, Table 3 shows the necessary distance from an AM tower for compliance with the field-strength limits.

An electric field strength of 40,000V/m² corresponds to a magnetic field strength of 632V/m. For a 1kW station, this distance is 3m (9.8 feet). Because most 1kW stations probably have fences around the tower at that distance (or at a greater distance), such stations are probably already in compliance with the guidelines.

For a 50kW radio station, the safe measurement is 39.4 feet. This distance is normally either on, or close to, the ground screen that surrounds the tower.

From these examples, it is apparent that the vast majority of normally operated AM, FM and TV stations will not be affected by the ANSI standard.

Special cases

It should be noted that the standard concerns only areas that are accessible and where excessive levels may exist. For stations where problems are found, it may only be necessary to construct a fence around the tower at the required distance. In addition, no unauthorized personnel may be permitted inside that fence. For engineers who need to enter the area for a brief period, the exposure

	AURAL POWER (% OF MAXIMUM VISUAL ERP)						
		5	10	12.5	15	20	22
	5	8.7	9.1	9.4	9.6	10.0	10.2
	25	19.4	20.4	20.9	21.4	22.4	22.8
	50	27.4	28.9	29.6	30.3	31.7	32.2
	75	33.6	35.4	36.3	37.1	38.8	39.4
	100	38.8	40.9	41.9	42.9	44.8	45.5
	125	43.4	45.7	46.8	47.9	50.1	50.9
MAXIMUM VISUAL POWER (ERP) IN KILOWATTS	150	47.5	50.1	51.3	52.5	54.8	55.7
	175	51.3	54.1	55.4	56.7	59.2	60.2
	200	54.8	57.8	59.2	60.6	63.3	64.4
	225	58.2	61.3	62.8	64.3	67.2	68.3
	250	61.3	64.6	66.2	67.8	70.8	72.0
	275	64.3	67.8	69.5	71.1	74.2	75.5
	300	67.2	70.8	72.5	74.2	77.5	78.8
	316	68.9	72.7	74.4	76.2	79.6	80.9

Note:
1. Values are given for total visual ERP. For circularly polarized antennas, the sum of horizontal and vertical ERPs must be used.

Table 2. Minimum worst-case distances from single VHF TV antennas. (Values are given in meters.)

is averaged over 0.1-hour intervals.

On the other hand, there may be locations where compliance with C95.1-1982 will prove to be expensive or difficult for broadcast licensees. In particular, multistation sites located on large towers and large buildings may require auxiliary antennas mounted at a second level to allow adjustment and maintenance of the primary systems. Also, problems may be encountered on mountaintop facilities where the tower is only tall enough to keep the antenna clear of the transmitter building.

The complete radiation report, prepared by the FCC Office of Science and Technology, is detailed and lengthy. However, it is recommended that engineers obtain and read a copy of this, as well as the ANSI C95.1-1982 document. By reviewing both documents, you can obtain a full understanding of

Table 3. Distance from AM station at which fields fall below various electrical field strengths. (Values are given in meters.)

	TRANSMITTER POWER (kW)									
		50	25	10	5	2.5	1.0	0.5	0.25	0.1
	10	202	171	113	87	67	49	38	30	23
	25	104	80	57	45	35	27	22	18	13
	50	62	49	35	28	23	18	14	11	8
	75	47	37	27	23	18	13	11	8	6
	87	42	33	25	21	17	12	10	7	5
	100	38	30	23	19	15	11	9	7	5
ELECTRIC FIELD STRENGTH (V/m)	150	29	24	18	15	11	8	6	5	4
	194	25	21	15	12	10	7	5	4	3
	200	25	20	15	12	9	7	5	4	3
	275	21	17	12	10	7	5	4	3	<2
	300	20	16	11	9	7	5	4	3	<2
	400	16	13	9	7	6	4	3	<2	<2
	500	14	11	8	6	5	3	3	<2	<2
	632	12	9	7	5	4	3	<2	<2	<2
	750	11	8	6	5	4	3	<2	<2	<2
	1,000	9	7	5	4	3	<2	<2	<2	<2

the thoroughness with which the standard was determined and the reasonable approach that the commission has taken in allowing the self-certification process.

The sad part of the story of non-ionizing radiation is not that some broadcasters may have a financial liability. It is that some communities have refused to acknowledge reasonable standards that are based upon research and facts. Rather, they are rushing to proclaim their own standards that are based not upon safety or environmental considerations, but rather, upon unrealistic, incomplete or incorrect information.

Reducing downward radiation

By Robert A. Surette

Although protecting human health is one important aspect of the new guidelines, there are other important concerns. RF interference with computers and information systems could cause endless confusion and misunderstandings. RF interference with medical equipment, control systems and communication systems can be a serious matter. Interference with any of these areas also harbors the potential for a serious threat to the public safety.

For stations that don't comply with

Surette is manager of RF engineering at Shively Labs, Bridgton, ME.

The graph at left represents the theoretical elevation pattern for a 6-bay antenna with conventional spacing. The graph at right represents the same antenna with ½-wavelength spacing.

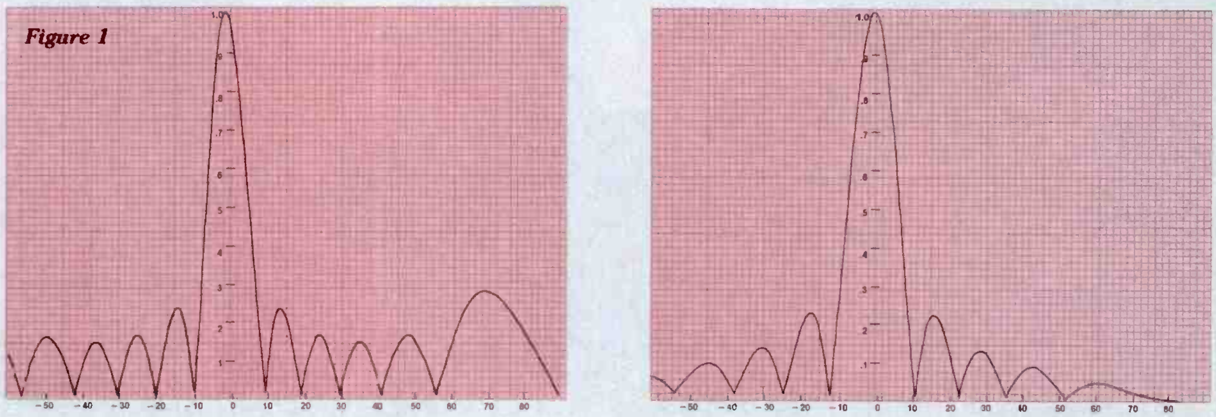


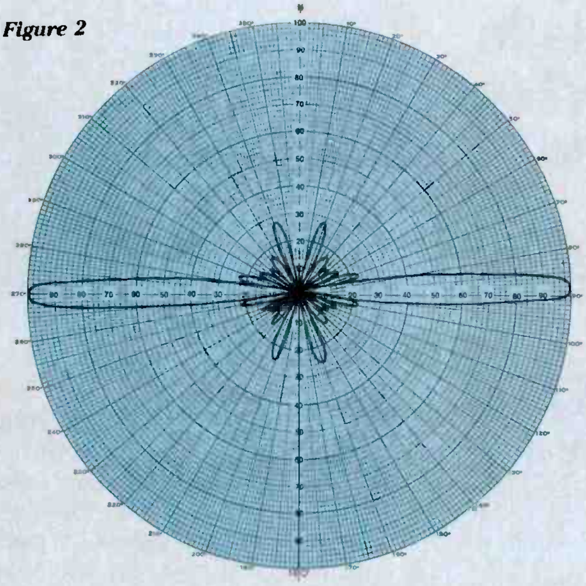
Figure 1

the new RF exposure requirements, what are the possible solutions? Although there may be several ways to resolve a non-compliance problem, building a new tower or moving to another location may not be options you want to choose.

New antennas

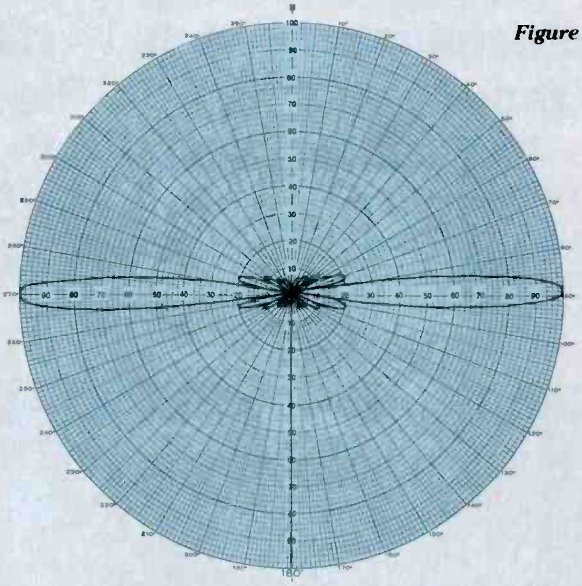
Studies have shown that some types of antennas possess more desirable radiation characteristics (smaller downward components) than others. In some instances, these antennas can be used to replace existing antennas that are producing excessive downward radiation. In general, cycloid-type ring antennas, which are uniformly and symmetrically fed, produce

Figure 2



Radiation pattern for a 6-bay antenna with conventional spacing. The downward radiation from the antenna is obvious, especially at the 70° points.

Figure 3



Radiation pattern for a 10-bay antenna with ½-wavelength spacing. Note that the downward radiation problem has been significantly reduced.

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smaller downward radiation lobes than those fed non-symmetrically.

Perhaps the most effective solution consists of modifying the antenna pattern through element spacing. Here, element spacing is changed from the normal one-wavelength to ½-wavelength spacing. Figure 1 illustrates the effectiveness of this.

The graph on the left shows the theoretical elevation pattern of a 6-bay antenna using conventional spacing. The graph on the right is the measured elevation pattern for an identical antenna but with 10 bays spaced at ½-wavelength intervals. The resulting dramatic reduction in downward radiation is perhaps better shown in Figures 2 and 3. Here, the patterns are translated into an artist's representation (vertical profile) of signal densities radiating from a typical tower.

Although the technical basis for ½-wave spacing is well known, some features of the technique are less obvious and may need some elaboration. In Office of Science and Technology bulletin No. 65, Dr. Cleveland notes that ½-wave spacing results in an overall gain loss for a particular antenna. To maintain gain, the number of bays must be increased. Fortunately, due to the reduced spacing, virtually identical gain can be achieved in the same aperture as that occupied by a conventionally spaced antenna.

Referring again to Figure 1, observe that the gain for the 10-bay ½-wave-spaced antenna is nearly equal to that of the 6-bay antenna. In addition, the 10-bay array actually occupies approximately six feet less space on the tower. Obtaining the equivalent gain in the same aperture results from reshaping the array pattern and redirecting the downward radiation into the main beam.

The effect of ½-wave spacing is even more obvious in Figures 4 and 5. The downward radiation from a 1-wavelength-spaced 2-bay antenna is apparent at the 55° points in Figure 4. The same antenna with ½-wave spacing is shown in Figure 5. In this case, the downward radiation is practically eliminated.

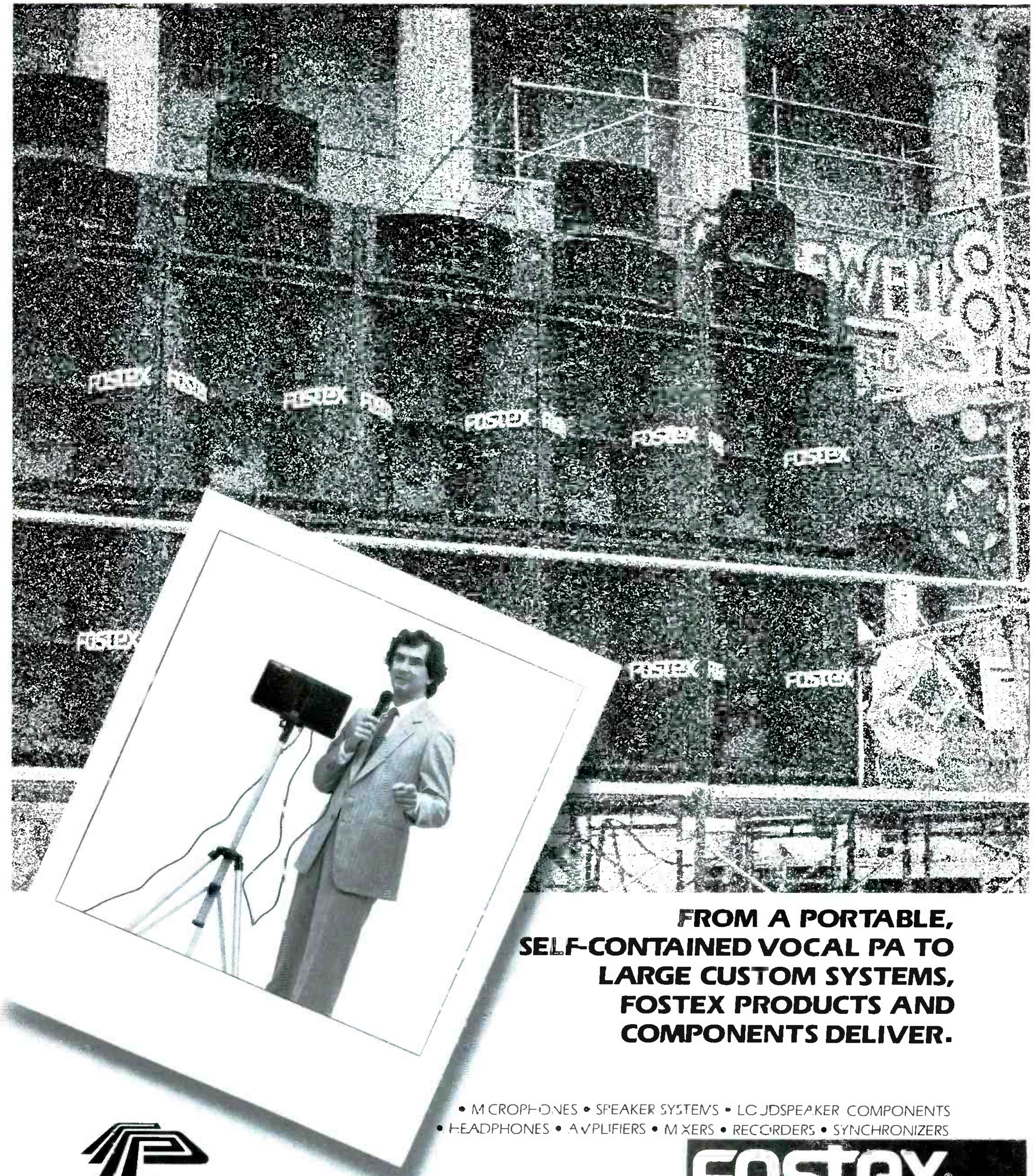
Another important fact to those considering ½-wave spacing is the simple reality that not all antennas really lend themselves to the technique. Antennas that use direct-coupled-feed or those with non-symmetrical feeds will require either cumbersome mechanical feedline re-arrangement or some power-dividing scheme to maintain proper phasing.

On the other hand, antennas that are inductively loop coupled are relatively simple to manipulate into a ½-wave configuration. Usually a shorter feedline and a simple repositioning of the inductive loop is all that is needed.

Another advantage of inductive coupling is that odd numbers of antenna elements are possible. This not only yields a significant cost savings if gain figures can be satisfied, but also can be of great value if windload or tower considerations are critical.

This method of reducing downward radiation may not be possible for all situations. It does, however, provide another tool for the station unfortunate enough to be required to take corrective action under the new rules.

Station engineers should become familiar with their station's particular situation with respect to the new radiation standards. Even if your station is not exceeding the standards, you need to understand how the ANSI requirements apply to your station. As more publicity results from the FCC action, residents around your transmitter site may raise legitimate questions. You should be prepared to answer any questions that might be raised. In this way, you may save the station from any misunderstandings by a misinformed public.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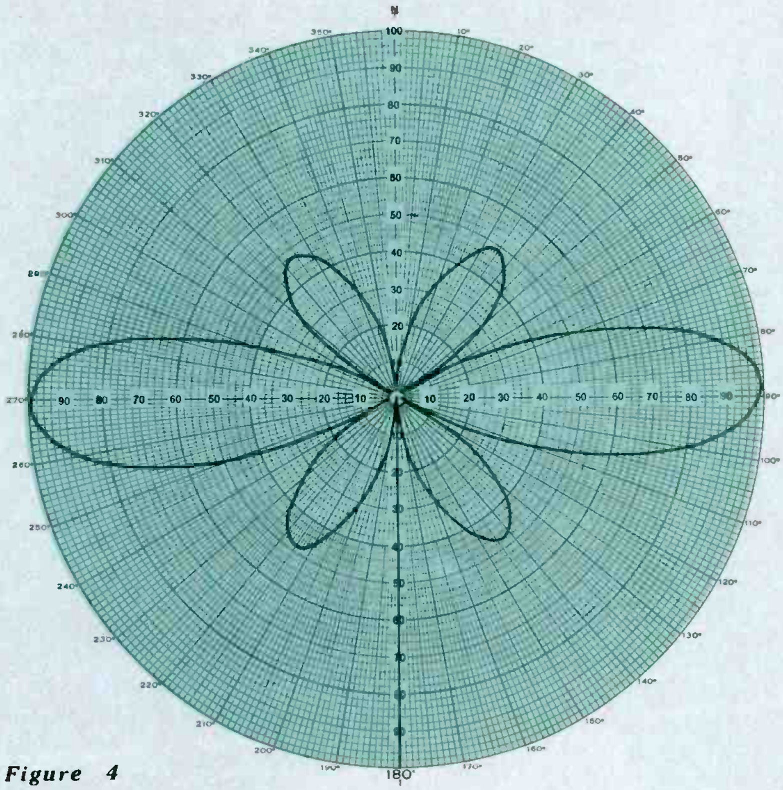

Figure 4

A 2-bay antenna with normal, 1-wavelength spacing exhibiting severe downward radiation.

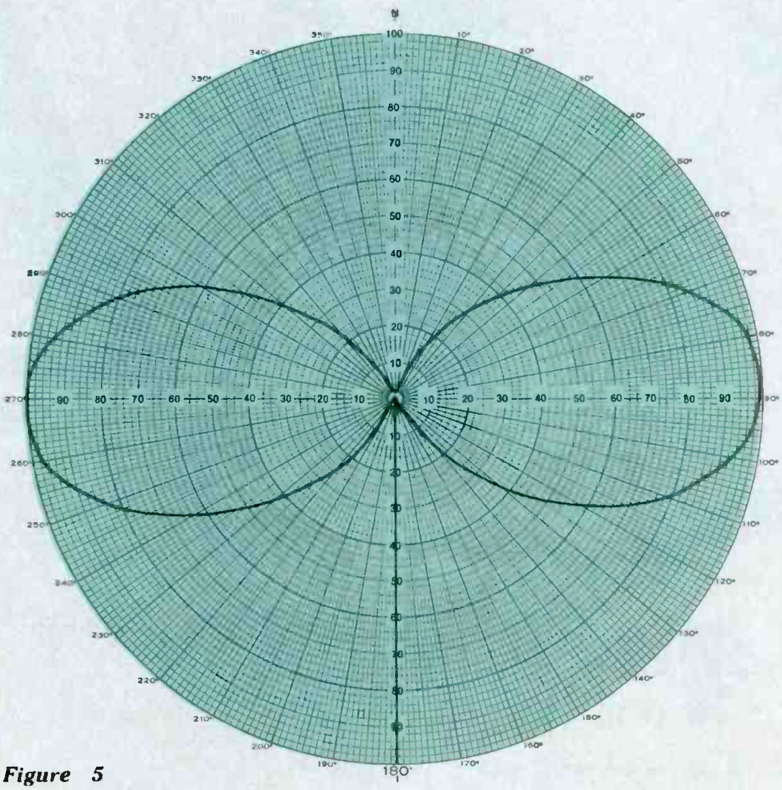

Figure 5

The top antenna with ½-wavelength spacing. Note that the troublesome downward lobes have been eliminated.

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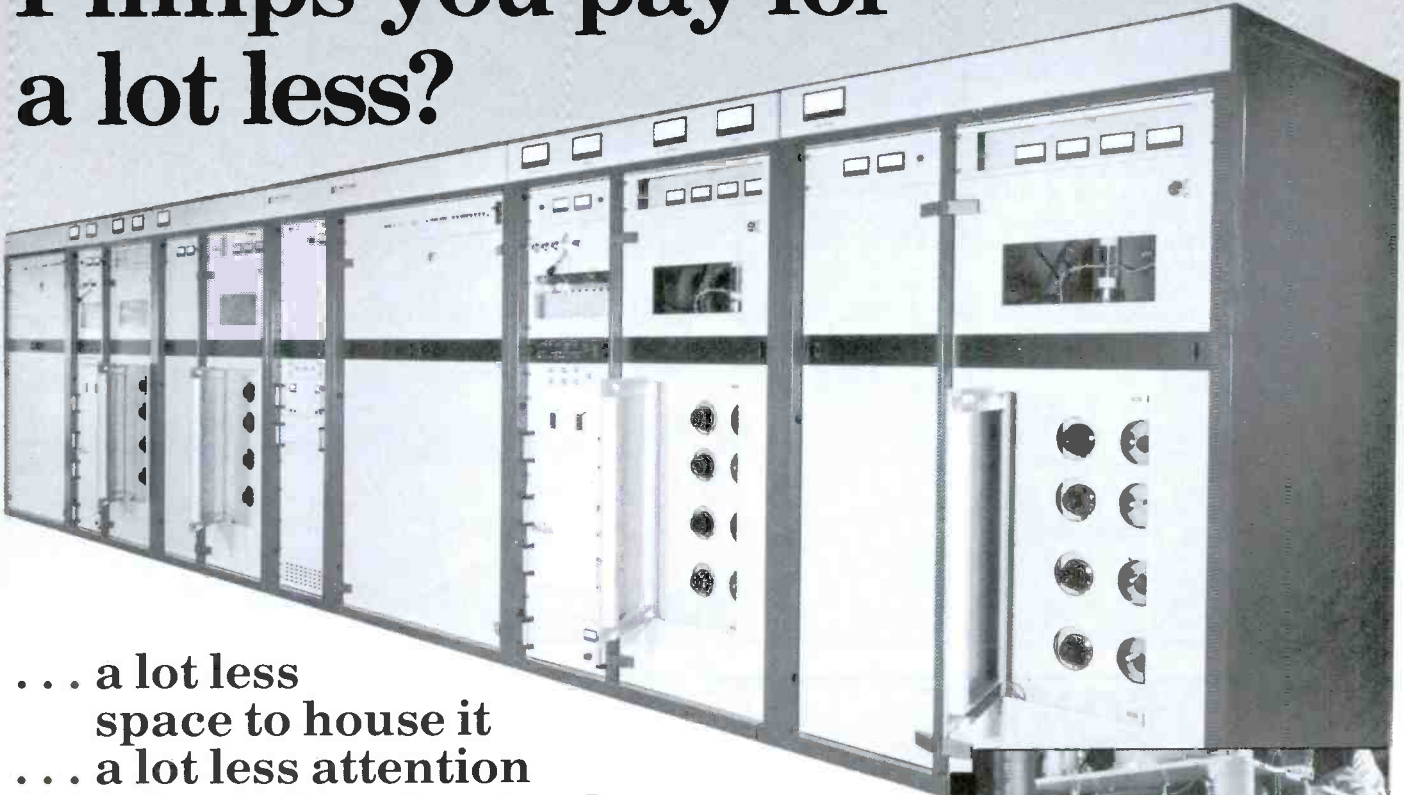

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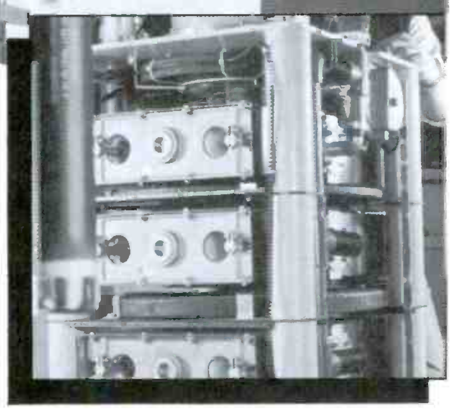

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FM/TV power density analysis

The power density at any point within the RF field of a TV or FM transmitting antenna may be calculated by determining the parameters shown in the diagram below and following a simple procedure. Outlined by TV Ontario in Toronto, this method may be applied to U.S. stations as well.

First, determine the dimensions E_1, E_2, h_2 and d. From these, calculate the vertical angles V_1 and V_2 for direct and reflected RF rays from formulas 1 and 2. Then, from antenna radiation patterns, determine the antenna relative vertical field at V_1 and V_2 and relative horizontal field in the direction of the test point.

Next, calculate the path distances D_1 and D_2 for the direct and reflected rays by using formulas 3 and 4. The direct and reflected field intensities Fd and Fr are found from formulas 5 and 6, using values found in formulas 1 through 4. Finally, calculate the maximum power density at the test location with formula 7.

For installations with multiple antennas, the calculations must be performed on each antenna separately. Additional information is available in FCC publication OST-65.

1. Calculate vertical angle, V_1, for direct ray:

$$V_1 = \text{Tan}^{-1}\left[\frac{E_1 - (E_2 + h_2)}{d}\right] \text{degrees}$$

2. Calculate vertical angle, V_2, for reflected ray:

$$V_2 = \text{Tan}^{-1}\left[\frac{(E_1 - E_2) + h_2}{d}\right] \text{degrees}$$

3. Calculate path distance, D_1, for direct ray:

$$D_1 = [d^2 + (E_1 - (E_2 + h_2))^2]^{1/2} \text{meters}$$

4. Calculate path distance, D_2, for reflected ray:

$$D^2 = [d^2 + E_1 - E_2) + h_2)^2]^{1/2} \text{ meters}$$

5. Calculate direct ray field intensity (Fd) at test point location:

$$Fd = \frac{7 \times F(V_1) \times F(H)}{D_1} \times (\text{ERP max})^{1/2} \quad \text{V/m}$$

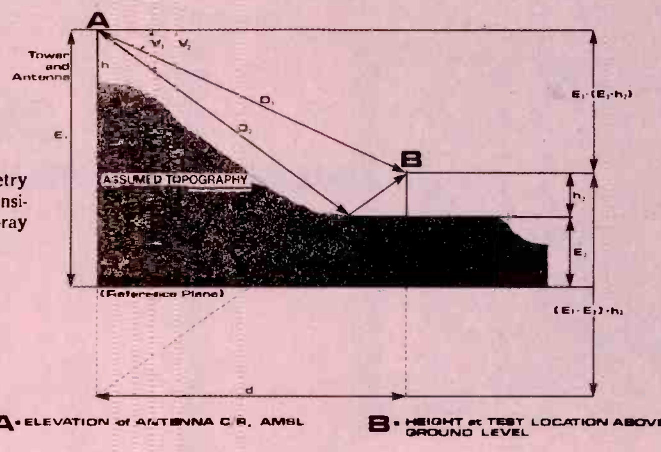
6. Calculate reflected ray field intensity (Fr) at test point location:

$$Fr = \frac{7 \times F(V_2) \times F(H)}{D_2} \times (\text{ERP max})^{1/2} \quad \text{V/m}$$

7. Calculate *maximum* power density at test point location:

$$\left[\frac{(Fd + Fr)^2}{(\pi \times 1{,}200)}\right] \text{mW/cm}^2$$

Repeat steps 1-7 for other locations, as required.



Generalized geometry for FM/TV power density analysis, using 2-ray method.

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Selecting speakers for TV stereo

By Thomas Sahara

If you are going to broadcast high-quality TV stereo, you must first be able to properly monitor it.

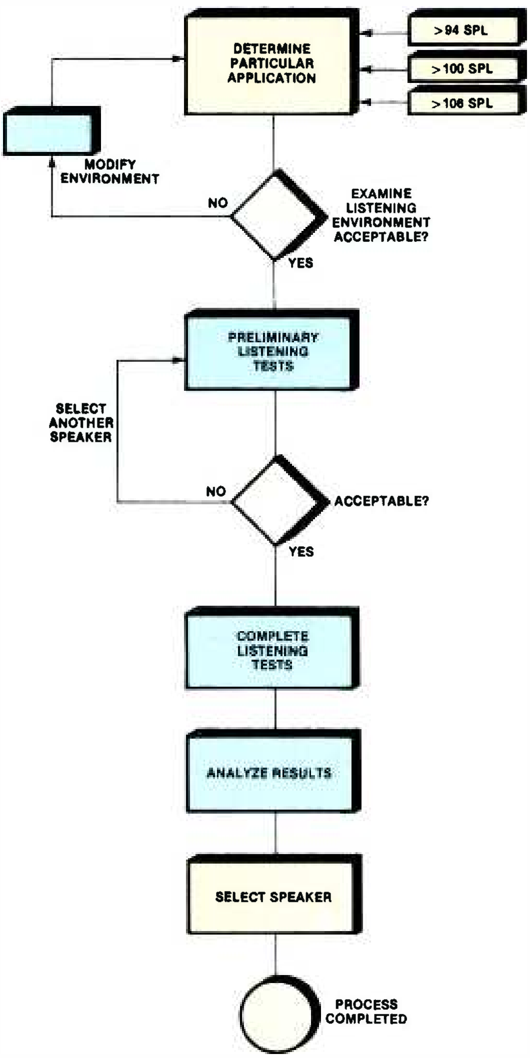

***Figure 1.** The process of selecting monitor speakers.*

Sahara is an audio engineer for KITV, Honolulu.

The advent of TV stereo has placed additional responsibility on TV audio engineers. And these engineers must be more concerned than ever before about the quality of the speakers used for monitoring audio. The selection of the proper speakers for mixing and monitoring stereo TV requires time and effort if the best results are to be obtained.

Procedures

Choosing a monitor loudspeaker system is probably one of the most difficult tasks an audio engineer will encounter. The system you choose must sound good to everyone involved with audio production. Although it may seem next to impossible to obtain general agreement on speaker selection, by following a few procedures, a universally accepted loudspeaker system can usually be found.

Even though there are no standard practices established for selecting monitor loudspeakers, a few guidelines are available. Many of the following definitions and procedures are based on the recommendations of David Bennet of the Canadian Broadcast Corporation and Floyd Toole of the National Research Council. Their research and experimentation will be used for the tests.

Types of rooms

The first step in selecting a monitor loudspeaker system is to determine the particular application. There are three classifications of loudspeakers, each classification defining a different application. This ensures that the loudspeakers are being compared with others intended for similar applications and that the loudspeaker selected will be capable of delivering what you expect.

The first application is the small control room where the maximum sound pressure level generated by the loudspeaker is greater than 94dB at one meter. This application also includes remote vans and other small environments. Most of the so-called *mini monitors* and compact loudspeakers fall into this classification.

The second application is the small-to-medium-sized control room, where the desired maximum sound pressure level is more than 100dB at one meter. A few of the mini monitors fall into this category, but most loudspeakers in this application are the larger bookshelf and medium-sized loudspeakers.

The third application is the large control room or music production facility, where the maximum sound pressure level is greater than 106dB at one meter. This application includes all of the large monitor loudspeaker systems and a few of the higher-powered medium-sized systems.

Three sizes of rooms have been defined by Bennet. A small room has a volume of less than 50 cubic meters, or approximately 1,765 cubic feet. The medium-sized room has a volume between 50 cubic meters and 150 cubic meters, or approximately 1,765 cubic feet to 5,300 cubic feet. The large room has a volume of more than 150 cubic meters, or 5,300 cubic feet.

These room sizes cover a wide range of room environments. But no distinction is made with regard to the acoustical environment of each room classification. It is assumed most control rooms within a station will exhibit somewhat similar acoustical characteristics.

Once you have determined the class of loudspeaker required, you can start specifying loudspeakers for comparative testing. In most stations, each listening area may have slightly different acoustical characteristics. For this reason, you must keep in mind that the loudspeakers specified must be able to provide acceptable performance in each area. If there is any doubt, then a

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- ✓ Flat, peak-free frequency response within narrow limits throughout the audible range. A loudspeaker that does not have a flat anechoic response may have a fairly flat response in the acoustic environment. Conversely, a loudspeaker that exhibits excellent free-field frequency response may produce large frequency anomolies in the acoustic environment.
- ✓ Broad and uniform sound dispersion to provide identical sound over the entire listening area.
- ✓ Low harmonic, intermodulation and transient distortion throughout the audible range at all listening levels.
- ✓ Sufficient output level capability to meet the requirement of each class of monitor.
- ✓ Electrical and mechanical durability to assure continued service without changes in the sound characteristics over long periods of time and under heavy use.
- ✓ Loudspeaker-to-loudspeaker uniformity to guarantee identical sound characteristics from any two units.

Table 1. *In order to provide a high-quality monitoring system, the speakers must meet several important criteria.*

series of preliminary tests should be conducted to ensure that all loudspeakers meet minimum requirements.

The ideal loudspeaker, according to Toole, must meet several criteria (see Table 1). These criteria define the basic performance that can be obtained from the speaker. Unfortunately, even these criteria are not absolute in that two loudspeakers can have similar specifications and yet have different sonic characteristics. This is the reason why the only reliable method of choosing a monitor loudspeaker is to audition a number of units. Once you know what your specific requirements are going to be, you are in a position to make an informed choice.

There have been numerous listening tests performed on almost every loudspeaker on the market, with each test having its own objective results. However, it has been determined that many of the tests are not without their share of questionable data. Data that have been collected or analyzed in an inconsistent, uncontrollable manner may cause the test to favor a particular outcome. It is this inconsistency and uncontrollability that the following procedure seeks to minimize.

Listening tests

A panel of listeners must be assembled to perform the actual listening tests. Select the panel with caution. It is important that a fair representation of all factions contributing to the evaluation of the audio quality be included. This helps prevent unintentional bias toward a particular outcome because of over-representation by a particular group.

There is some evidence that a listener with impaired hearing can cause significantly higher variations in responses than a listener with normal hearing. Also, a listener with previous experience in critical listening may produce a more consistent set of responses than a person without any previous critical listening experience.

A preliminary test should be carried out to ensure that every loudspeaker selected for testing will meet the minimum performance requirements. This is called the *coarse filter*. Loudspeakers that do not rate as high as

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Selecting speakers for a video production studio requires careful planning.

the other units should be removed from further testing. This helps limit the number of loudspeakers to a manageable number. The remaining loudspeakers are then subjected to a more rigorous test sequence of longer listening sessions with various program materials.

The source material used for the evaluation process should be representative of that used within the facility. For example, do not use only rock music to evaluate a loudspeaker if the majority of the applications do not contain rock music. Use as wide a variety of program materials as practical.

All of the testing material should be monophonic. This helps eliminate inconsistencies in the data resulting from variations in the stereo image caused by room acoustics, listener position or some other uncontrollable phenomenon. It is reasonable to conclude that a loudspeaker exhibiting a high degree of fidelity with monophonic program material will also perform well with stereophonic program material.

The setup

Conduct the listening session in a location that is free from extraneous noises and activity. Make the test period long enough that the setup won't have to be changed or moved for the duration of the evaluation. It is important that all loudspeakers be evaluated in a stable environment.

Each test session should last for about 30 minutes so each listener has sufficient time to formulate a response. If several sessions are needed, then a 30-minute rest period between tests will help prevent listener fatigue.

To prevent bias in the results because of a familiarity with a particular monitor, all loudspeakers must be hidden from view. Use an acoustically transparent screen and match the output levels with pink noise and a sound-level meter. Because of variations in speaker radiation patterns, measure the sound pressure at ear level near the center of the listening area.

A double-blind procedure, in which neither the person conducting the listening session nor the listeners know what loudspeaker is being tested, is recommended. The listeners should not discuss their listening experience with others. This helps prevent any one person from influencing the responses of other panelists. To prevent inconsistencies in the results, all of the listeners should be given identical and complete instructions on the objectives and procedures to be used in the test.

Obtaining the data

Direct the participants to rate each loudspeaker on a uniform scale. The lowest possible score is zero, which represents the worst possible reproduction. The highest possible score is 10,

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representing the best possible reproduction—the ideal loudspeaker. A rating of five represents the midpoint of the scale. On the rating form, be sure to label the loudspeakers by numbers, not by brands or names. This prevents any preconceived notions of quality from influencing the results because of familiarity with a particular brand or model.

After all of the test data have been collected and analyzed, the loudspeakers receiving the highest ratings should be subjected to a final round of testing. This step helps validate the test results. The final round is more of a check of the procedure than a test of the loudspeakers. If there are large variations among the test results, there is a possibility that an outside influence was introduced somewhere in the test procedure.

If, however, there is a high degree of consistency among the test results, the engineer is assured that the loudspeaker receiving the highest rating is capable of reproducing almost any material without introducing coloration or masking subtle details of the material.

Analyzing the data

After all of the test results are in, the task of interpreting the test data begins. Record the test data by test group, noting the order of the loudspeakers being auditioned and the program material used in the listening tests. By comparing the results among groups, trends and tendencies are noted and variations in individual ratings are analyzed.

If there are significant differences among test groups reviewing the same loudspeaker/program material combination, a determination must be made regarding the validity of the test. Is the variation because of a listener variable or is it a fault in the test method? If you determine that there is a fault in the test procedure, you must determine how much of the variation is due to this procedural defect.

After the test data are compiled, several speakers may have similar high ratings. If so, then secondary considerations such as size, efficiency, impedance characteristics and long-term availability will play a more significant role in the final selection. Minor differences in the sonic character of the loudspeakers may rate a lower priority than speaker availability. Factory support should also play a role in the selection process.

By following a set procedure and taking the necessary precautions, you can select a monitor speaker that will be accepted by all involved in the audio process. The advantages of going to this effort extend across departmental boundaries, which of itself may prove advantageous. If you follow the basic guidelines, your station will have a monitoring system adequate to meet the critical audio demands of a high-tech audience.

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

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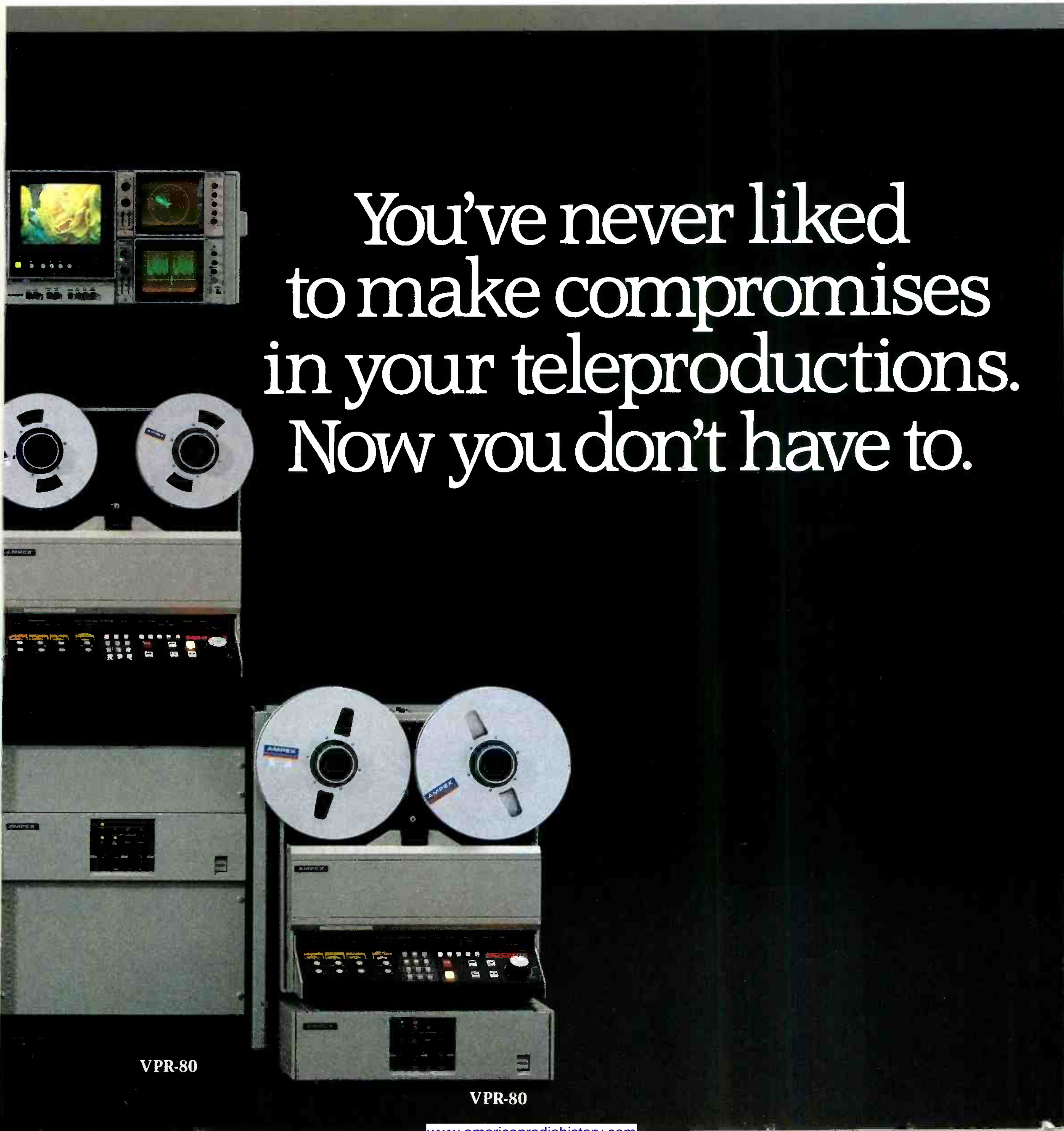

Stereo audio production techniques

By Todd A. Boettcher

Producing quality stereo audio involves more than just adding another microphone.

With the advent of MTS (multichannel television sound), a number of concerns need to be addressed to ensure consistent audio quality for locally originated stereo programming. With programming originated both in-studio and on-location, all areas of station operation are involved in the move to MTS.

This article will not discuss wiring standards, signal distribution and routing or the recording medium. It will assume that the wiring and recording equipment is properly installed and maintained. The scope of this article is limited to the audio production engineer's operational concerns. It seeks to help develop an understanding of stereo audio concepts and values, while leaving the final choice of microphones and microphone placement up to the creative abilities of the individual audio engineer.

Compatibility

Just as with stereo broadcast on radio, the primary concern with MTS stereo is monaural compatibility without signal degradation. The most severe form of signal degradation occurs when the two program channels are 180° out of phase. This causes nearly total loss of the monaural (summed) signal and an undefined stereo image.

More subtle, yet just as important, are phase cancellations caused by improper microphone placement. These phase differences can cause a loss of high-frequency response, erratic stereo imaging and a *swishing* (or comb filter) effect in the monaural summed signal. This can be a difficult problem to uncover when monitoring in stereo because the phase differences can be interpreted creatively as an *airy* or *open* sound.

Boettcher is a staff engineer at WTMJ radio and TV, Milwaukee.

Appropriate monitoring is critical to the production process. The environment should be quiet enough to allow critical monitoring decisions. When loudspeakers are used for monitoring, the units should be located to the front of the audio mixing engineer, and elevated to approximately ear level or slightly above. They should develop an arc of approximately 60° (30° to either side of the center axis line) for best monitoring of stereo imaging. (See Figure 1.)

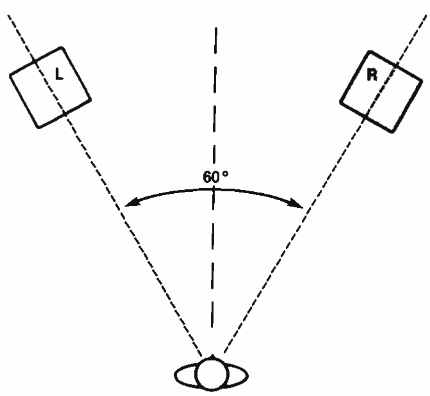

***Figure 1.** Regardless of the distance from the speakers to the audio engineer, the angle between the speakers should be about 60°.*

If the angle is greater than 60°, the listener tends to hear the monitored audio as two independent sound sources rather than as a panoramic wall of sound between speakers. This is known as the *hole-in-the-middle effect.* This condition makes correct stereo imaging difficult.

If the angle is too small (because the speakers are too close to each other), the sound sources tend to be heard as a single point source. Again, this makes proper stereo imaging difficult because there is little perceived stereo spread. Ideally, the monitor speakers should be ⅓-octave equalized to the room to reduce resonant room peaks. This also helps smooth out the room-response curve.

Alternatively, high-quality stereo headphones can be used for monitoring. However, stereo imaging tends to exaggerate the spread toward extreme left and extreme right. This is because the left and right channel information remains segregated until mixed within the engineer's head. When speakers are used for monitoring, some acoustic blending takes place prior to reception at the mixer's ears, tending to centralize the stereo image.

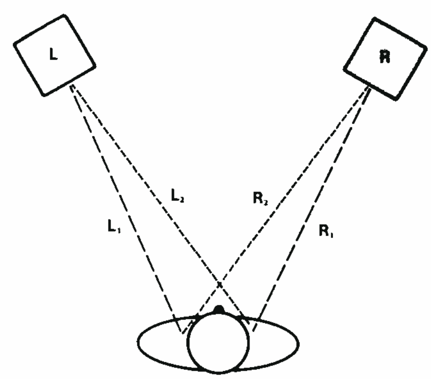

***Figure 2.** Because sound travels at a uniform speed, the different distances traveled (L_1, L_2 and R_1, R_2) result in a sense of directionality.*

Technically, when speakers are used for monitoring, the left ear hears full left channel, plus the right channel delayed and at a slightly reduced intensity because of a slightly longer path length. The right ear hears full right channel, plus the left channel delayed and at a slightly reduced intensity. (See Figure 2.)

The distance between the eardrums (approximately 19cm to 21cm) is


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microphone by one-half for every 3dB of difference in source-sound level in order to maintain the same degree of compatibility. Alternatively, the sources and their respective microphones could be separated by a greater distance. A third choice would be to insert some type of sound-absorbing baffle between the sources to maintain the needed acoustical separation. A fourth option, if the sound sources must be in close proximity to maintain visual production values, is to have these sources share one microphone.

Near-field imaging

Stereo imaging involves the placement of various sound sources in the stereo spectrum to produce apparent direction and localization (hard left, left center, center, right center, hard right). This is normally accomplished through adjustment of the mixing console pan pots. By definition, near-field sound includes negligible ambient information, so there is virtually no chance for phase incoherence when placed in the stereo spectrum. This creates a sort of pseudostereo—a stereo determined only by intensity differences. Near-field stereo can regain an artificial ambience through digital delays, echo chambers or reverberation units, and other forms of signal manipulation.

As previously mentioned, near-field stereo imaging can be controlled to establish left-right directional cues. The signal can also be manipulated to provide depth, or a sense of distance from the foreground. For example, a dry (unprocessed) signal will sound *up front*, while the same signal with reverberation added will sound distant. By varying the amount of delay and reverberation to the various signals, a 3-D effect can be achieved (side to side and front to back).

Far-field sound

As its name implies, far-field sound pertains to sound that is picked up by microphones placed at a distance from the source. Because of this increased distance, room acoustics become an important consideration in actual placement of the microphones. In addition, the possibility is great for interaction among multiple far-field microphones. Far-field microphone placement is most commonly used for classical and religious music, as well as for picking up natural sound. In addition, far-field microphone placement can be used for dialogue when natural sounds are to be specifically included as part of the production. Examples are soap operas and theatrical productions.

When placing primary microphones in the far-field in a reverberant room, such as a church or concert hall, you must be careful in final placement to retain source clarity and intelligibility. However, you must include enough ambient sound to make the final product a satisfying listening experience. Such placement work requires the ability to make creative decisions. If the microphones are placed too close, the ambience is lost. The best way to determine final placement is through critical listening, first in the studio or location environment, then through the monitoring system. Experience will help you make these decisions more quickly.

Because far-field sound includes the sound of the acoustical environment, it will also include any extraneous noise, such as that from loud radiators or air-conditioning blowers, from the crew and cast, prop movements, and bleedthrough of outside noises such as trucks, trains or aircraft. Care should be taken to reduce these intrusions as much as possible.

Far-field stereo is simply picking up the sound source in stereo by placing the microphones in the far field. There are three basic ways to place microphones for far-field stereo: spaced, coincident and near-coincident.

Spaced technique

Using the spaced microphone technique, the microphones are literally spaced a distance apart from each other, possibly by several meters or more (see Figure 4). The intention is to use this distance to provide different localizations in order to provide varied information to the stereo channels. Normally, spaced stereo microphones have omnidirectional patterns. Many amateur and some professional recordings use spaced stereo, because it provides a lot of ambient information with a good amount of setup flexibility. The sound is generally airy or open. It is usually pleasing to hear in stereo.

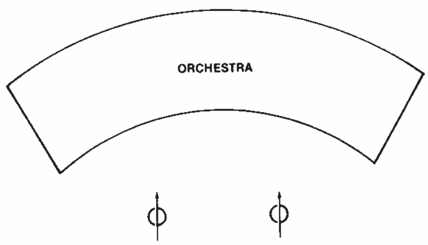
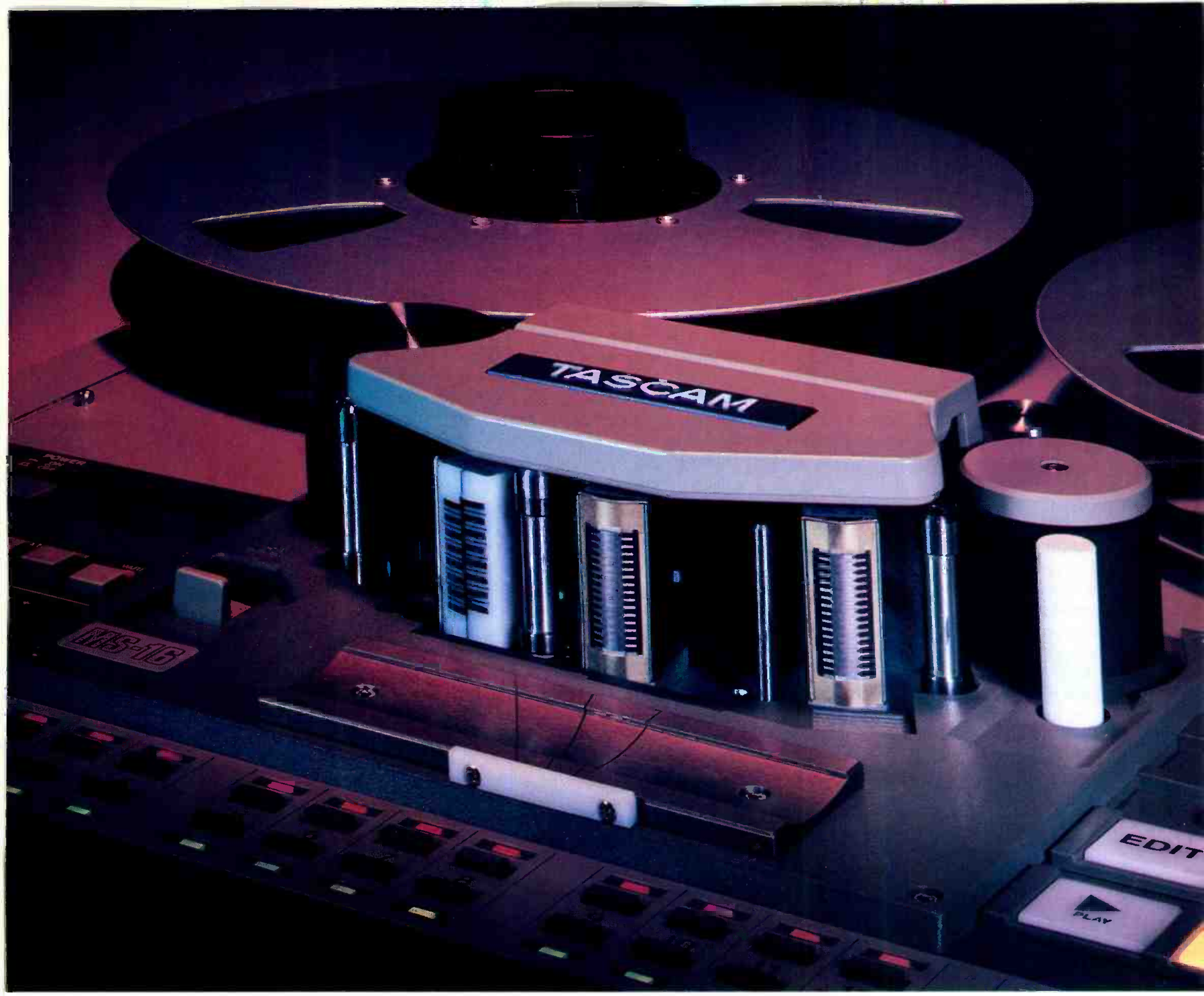


Figure 4. *Spaced stereo microphone placement produces noticeable phase cancellation in the summed-monaural signal.*

Spaced stereo microphones are acceptable for broadcast *only* when the sound source is a point source placed exactly equidistant from the spaced microphone pair. If the sound source is located off-center, the sound will reach the microphones at slightly different times. This timing (or phase) difference will add or subtract signal level in the monaural sum, depending on the source frequency, the distance between microphones and the sound arrival time difference at the two microphones. Known as *comb filter*



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effect, the result is unacceptable for broadcast because it is noticeable over a broad portion of the audio frequency spectrum.

The only situation in which spaced microphones will not create comb filter problems is if the sound source is *non-coherent*. All of the sound source pickups illustrated so far have been of *coherent sound*. Coherent sound originates as an apparent point source that has definable shape and characteristics such as a leading edge, frequency, envelope and decay. It is intelligible and can convey meaning, whether it is the sound of a hammer striking a nail, a human voice, a musical instrument or a car crash.

In contrast, non-coherent sound is a non-definable sound—one that is created by the summation of random signals originating at many points, or over a broad area. Ready examples of non-coherent sound are the rumble of an earthquake or the cheering of a crowd.

For a baseball game, the crowd could be picked up by two, three or five widely spaced microphones that can be panned across the stereo image without phase cancellation. In essence, there would be little true stereo in such a crowd pickup. Instead, it could be thought of as picking up two, three or five independent monaural crowds. The only coherent audio reaching the crowd microphones would be the sound of the public address system. Generally, any cancellation of that signal would be an advantage to the broadcaster, not a concern.

Coincident technique

The coincident microphone technique uses two directional (usually cardioid) microphone capsules placed in *perfect-time* alignment. This ensures that there will be absolutely no phase differences based on differing arrival times or sound source locations. To obtain true coincidence, both capsules are mounted in the same microphone. Because these stereo microphones have true coincidence, there is no summed-monaural cancellation, making this choice the unquestioned best form of stereo pickup for broadcast. Directionality is accomplished through intensity differences based on source location with respect to the positioning of the capsule pickup patterns. It's important that the capsules have smooth polar response curves, so that there will be no off-axis coloration of sound.

A subcategory of true coincident microphone technique was developed by Alan Blumlein of E.M.I in the 1930s. In his research, Blumlein found excellent results with a crossed pair of bidirectional capsules set at 90° to each other, with both front (positive) capsule patterns set at 45° off-axis to the center of the sound source. One microphone accepts left-front and right-back information, while the other microphone accepts right-front and left-back information. (See Figures 5 and 6.) This provides clarity and ambience even in highly reverberant rooms and improves the ambient perception of a dry room.

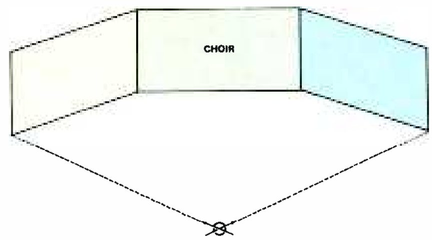

Figure 5. *Coincident microphone placement locates both capsule elements in perfect time alignment, resulting in no phase cancellation in the summed-monaural signal.*

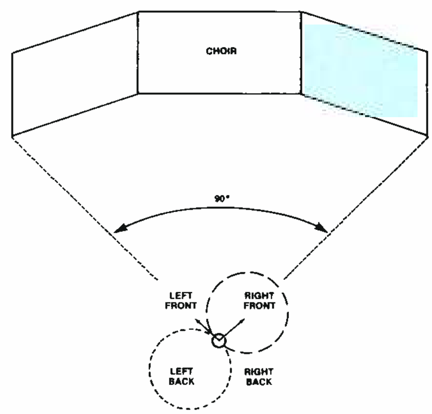

Figure 6. *The Blumlein coincident technique uses a pair of bidirectional microphones with axes positioned at 90° to each other.*

Near-coincident technique

Near-coincident technique uses two directional microphones placed in close proximity to each other, but not in true coincidence. As might be expected, this slight separation causes some minor comb filtering, but the effect occurs only at extremely high frequencies. For all practical purposes, the effect is negligible, and therefore, is not a serious concern for most broadcast programming. As a result, a wide variety of cardioid and hypercardioid microphones can be used with success. Again, smooth polar pattern response is essential to colorless pickup and smooth sound.

The most often-used near-coincident format is one developed by the Office of Radio and Television in France (ORTF). Also known as X–Y stereo, it has gained international acceptance for broadcast compatibility. With the ORTF standard, capsules are separated by a distance of 17cm. When hypercardioid microphones are used, the angle between microphone axes should be 110° to maintain constant intensity across the stereo image. (See Figure 7.) For cardioid microphones, the angle between axes must be opened up

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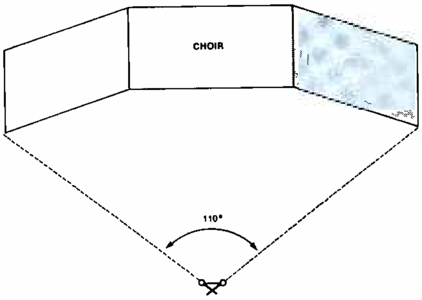

***Figure 7.** The ORTF near-coincident placement technique uses hypercardioid microphones placed together and facing 110° from each other.*

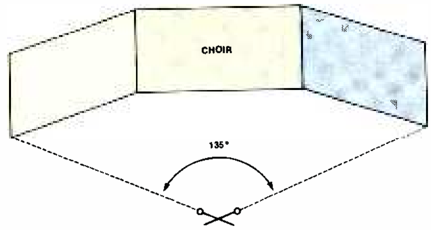

***Figure 8.** Cardioid microphones can also be used in near-coincident placement. Note that they are located closer to the sound source than in Figure 7.*

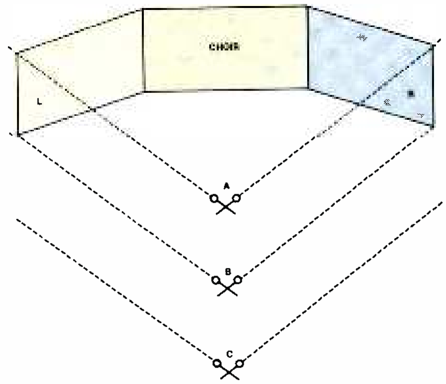

***Figure 9.** Coincident microphone placement can affect stereo imaging. In position A, the shaded areas are located only hard left or hard right. In position B, the source is evenly spread between the speakers. In position C, the stereo image will not reach from speaker to speaker, thereby reducing the size of the source.*

to 135° to maintain constant stereo image intensity because the cardioid polar lobe is much broader than the hypercardioid polar lobe. (See Figure 8.)

With both coincident and near-coincident techniques, the forward-facing axes should mark the outer limits of the sound source for even distribution of sound through the stereo image. If the microphones are backed farther away from the source, the source will tend to have less spread, while still picking up ambience. This may be desirable for a solo piano, but not for a large choir. On the other hand, moving in too close, where the source spreads beyond the axes, will tend to exaggerate the spread by placing more information hard left and hard right. (See Figure 9.)

Both coincident and near-coincident techniques provide excellent directional cues and exceptional realism. Proponents of spaced stereo claim that X–Y stereo lacks crisp, clear, intelligible sound. Because X–Y microphones are generally placed farther from the sound source than spaced microphones, the increased distance can provide the answer. Although sound travels at a constant velocity, it has been found that high frequencies are attenuated more quickly than low frequencies. Also, high frequencies are attenuated more rapidly than low frequencies with increasing humidity. Because of this, it is not uncommon to equalize the high frequencies in a far-field pickup to compensate for these losses.

Practical stereo imaging for TV

When creating stereo TV programming, consider the size of the visual medium and how it relates to the viewing room. When compared to the large viewing screens in movie theaters, where the viewing angle is wide (approaching 90° or more), the viewing angle of a TV screen in the typical home environment is narrow (normally 10° to 20°). The left-to-right visual cue is significantly smaller for television than it is for theater motion picture viewing. Theater speakers are located behind the projection screen. As a result, all directional audio cues (except for some specialized effects sounds) fall realistically within the visual perspective of the screen.

Many stereo TV sets have speakers on both sides of the picture tube, or aiming out the sides of the cabinet, or even underneath the picture tube. Some have stereo headphone outputs. Many stereo TV viewers also have stereo audio systems in the same room and connect the TV audio outputs to the audio system to benefit from the higher-quality amplifier and speakers. In any case, the stereo sound field will be moderately to considerably wider than the viewing angle. As a result, television does not lend itself to dramatic motion within the stereo field. Therefore, stereo imaging decisions need to be made that differ from traditional large-screen concepts.

Dialogue

Dialogue refers to all forms of foreground speech, whether it is news reporting, sports play by play or the spoken portions of entertainment programming.

Because of the narrow viewing angle, placement of these primary voices hard left or hard right would be visually inappropriate. In fact, nothing would be gained by placing dialogue anywhere

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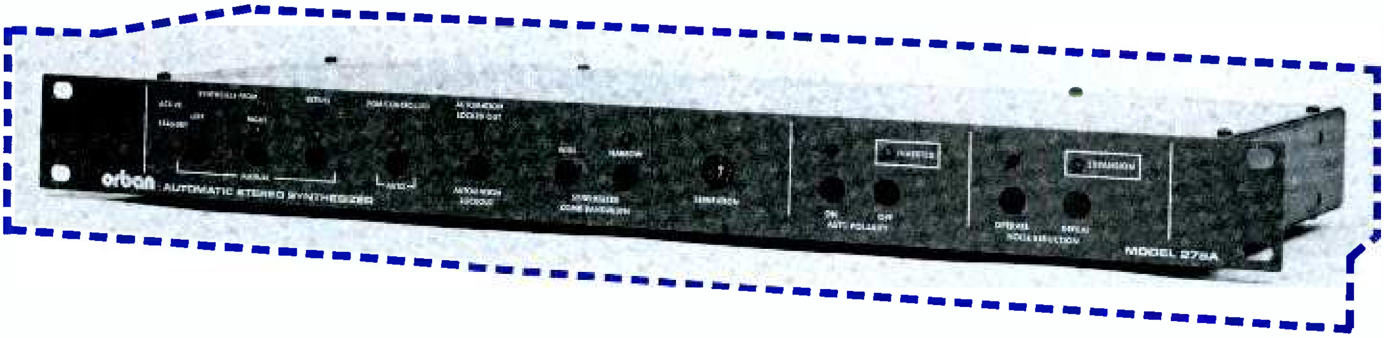
TV Stereo's Missing Link.



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other than dead center. A stereo spread of 10° to 20° is too small an angle for effective perception of directional dialogue cues. Therefore, all dialogue should be placed center channel (or very near center channel) for all programming. The only exception would be if dialogue were intentionally planned to originate off-stage (off-screen). In that case, dialogue cues could appear hard left or hard right, whichever is appropriate. In most broadcast applications, dialogue will be picked up using near-field techniques to increase intelligibility.

Music

Music includes all forms of musical pickup, including acoustic and electronic instruments, and all vocal renditions associated with the musical selection being performed. Musical production may use all the creative flexibility normally associated with music recording to enhance the final video product. The full stereo spread may be used, in addition to special processing (reverb, delay, flanging, chorusing, compressing and limiting) that is considered creatively appropriate to enhancing the final product.

For more traditional music rendition, the natural room ambience should be exploited through proper far-field microphone techniques to create a natural, pleasing product. Even though a lot of creative freedom is available, lead vocal solos are generally still placed center or near-center.

Effects

The term effects refers to the wide variety of sound effects and natural sounds that can be used to enhance the TV production's dramatic or entertainment value. This includes effects that have been prerecorded on disc or tape as well as those effects that are captured live. They could include anything, from the subtle presence of gentle wind with softly chirping crickets, to the swish of a basketball gliding through the net to the roar of the crowd, to the thunder of a passing train.

These effects help develop the character of the programming and also can exploit the full capabilities of stereo imaging. Remember that these effects need to be treated as coherent sound and should be miced accordingly, using coincident or near-coincident techniques.

Prerecorded stereo material

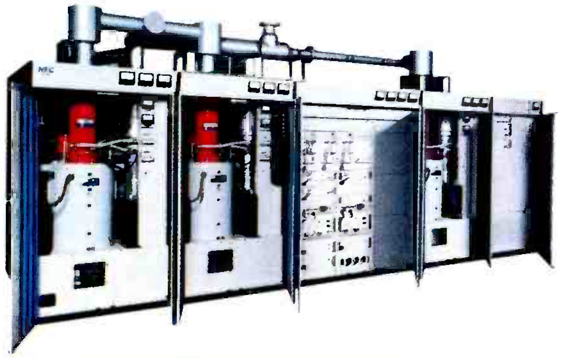
Prerecorded stereo material includes video programming from the network, syndicators or other outside sources. It also includes prerecorded music or effects on audio disc, cassette, cartridge or reel-to-reel tape. Although it seems reasonable to assume that prerecorded material has been recorded properly, experience has proved that this is not always true. One major artist, recorded on a reputable label, sounded great in stereo. However, when monitoring in summed-monaural, the singer disappeared. Clearly, this recording was not verified in summed-monaural prior to commercial release. All prerecorded sources should be verified for summed-monaural compatibility, and rejected as unsuitable for broadcast if a phase incompatibility problem is noticed.

Putting it all together

The primary concern for broadcast stereo is summed-monaural compatibility. To achieve this compatibility, stereo microphone placement should always be coincident or near-coincident, never spaced. Dialogue should always be placed center or near-center. Music and effects may exploit stereo imaging to provide a sense of width, depth and movement to the sound field.

Finally, good monitoring is essential to developing effective stereo imaging. The capability to instantly switch from stereo to summed-monaural monitoring is necessary to verify compatibility. Armed with this information, and the audio engineer's creative abilities, interesting and exciting stereo programming can be produced.

Field report



NEC PCU-780KS UHF transmitter

By Karl Paulsen

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Paulsen is chief engineer at KTZZ-TV, Seattle, and KTDZ-TV, Portland, OR.

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Inside the transmitter

As most engineering managers know, UHF transmitters are the local utility company's best friend. A UHF transmitter consumes a tremendous amount of power, especially when compared to a VHF transmitter. The selection of the PCU-780KS transmitter with mod-anode pulser was perfect for our application.

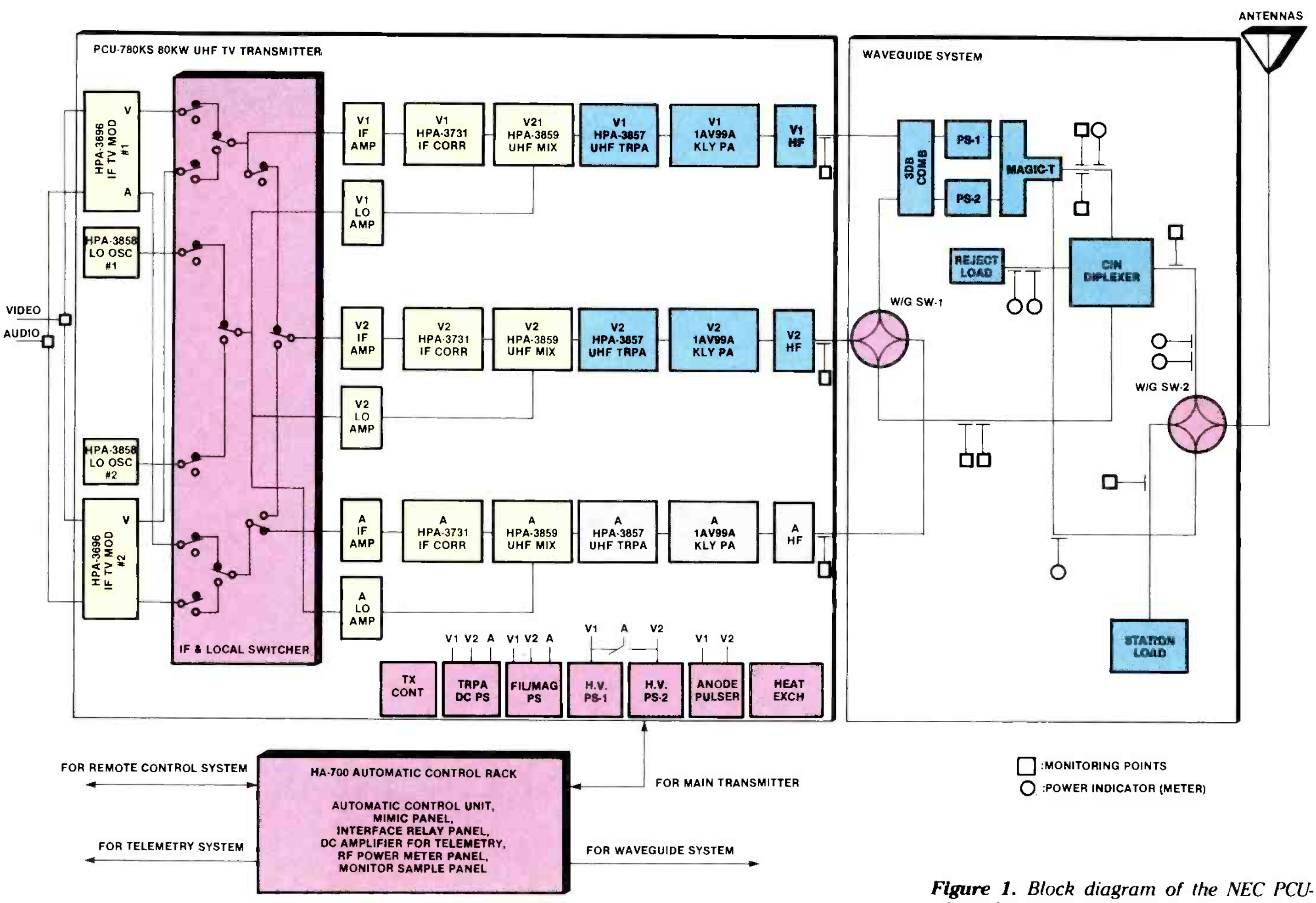
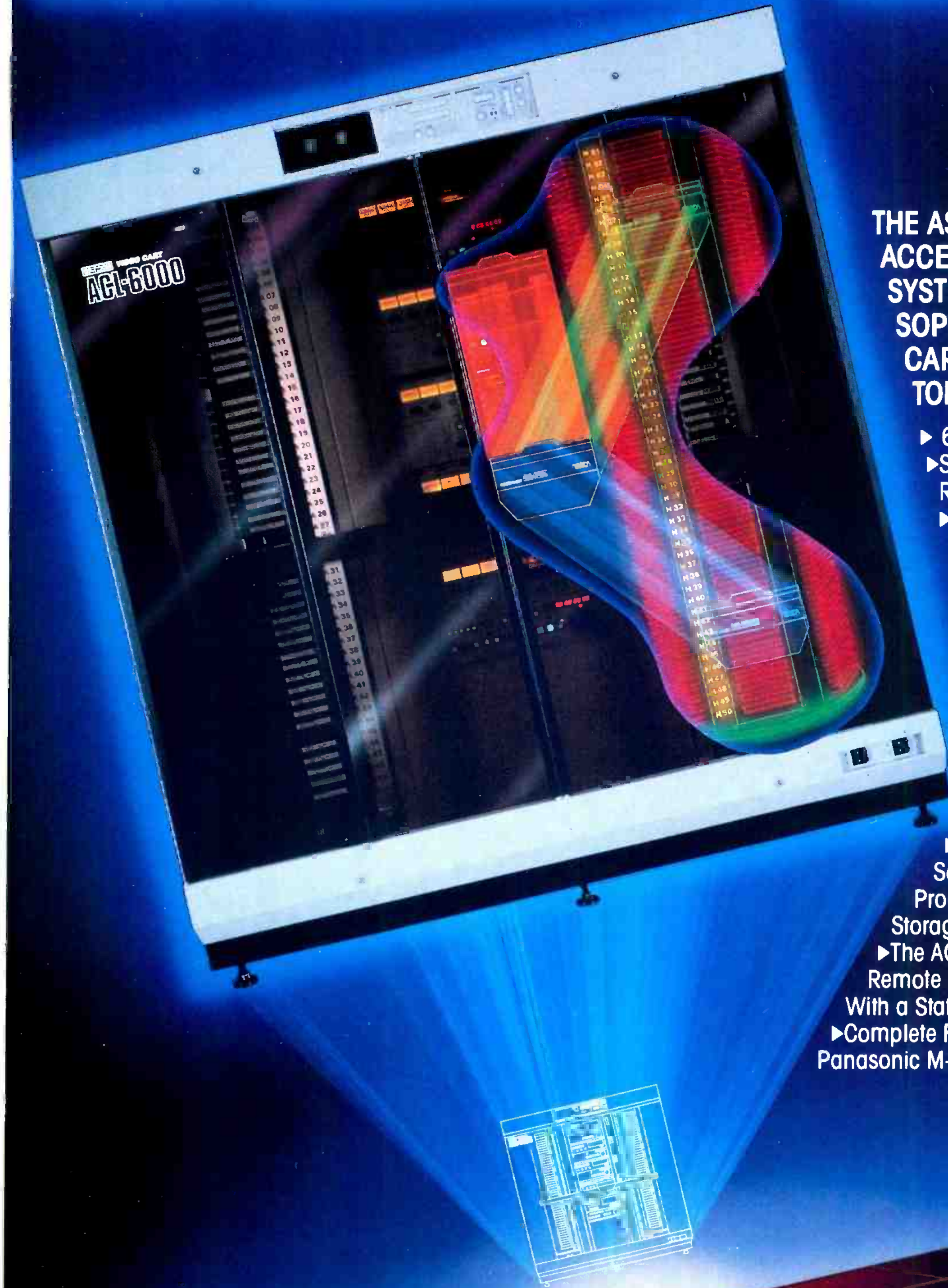


***Figure 1.** Block diagram of the NEC PCU-780KS 80kW UHF transmitter system.*

EVERY SECOND COUNTS!!



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When combined with circular waveguide, we were able to reach 5,000kW +10% aural ERP without needing a more costly 110kW or 120kW transmitter.

The transmitter (see Figure 1) is built around three 40kW vapor phase 1AV97A klystrons. Two of the klystrons are operated in parallel to provide the visual signal and one klystron is used for the aural signal. The visual amplifiers are connected in a backup configuration so that failure of the aural klystron will not force the station off the air. If the aural section fails, the transmitter drops to one-half visual power and uses either visual klystron as the aural amplifier.

The klystrons operate at 55% efficiency. The total power consumption is 213kW at 480V/3-phase. In order to obtain this efficiency, an anode pulser is used (see Figure 2). In a conventional UHF transmitter, the beam power input to the klystron amplifier is greater than actually required for most of the signal. It's only during the transmission of the sync signal that the transmitter must reach full output power. The anode pulser circuit allows the transmitter to operate with less input power during the non-sync periods of the signal. Then, when sync is transmitted, the anode pulser boosts the transmitter output to the proper level. The results of this transmission scheme are reduced power consumption and lower utility bills. Unfortunately, pulsed-anode operation does require more nonlinearity correction in the exciter. This transmitter provides ample correction within the exciter module. Furthermore, once the system has been properly adjusted, it remains stable and needs no attention. In our case, after the anode pulser circuits were properly adjusted, we left them alone. (See the accompanying sidebar on pulsed-klystron operation.)

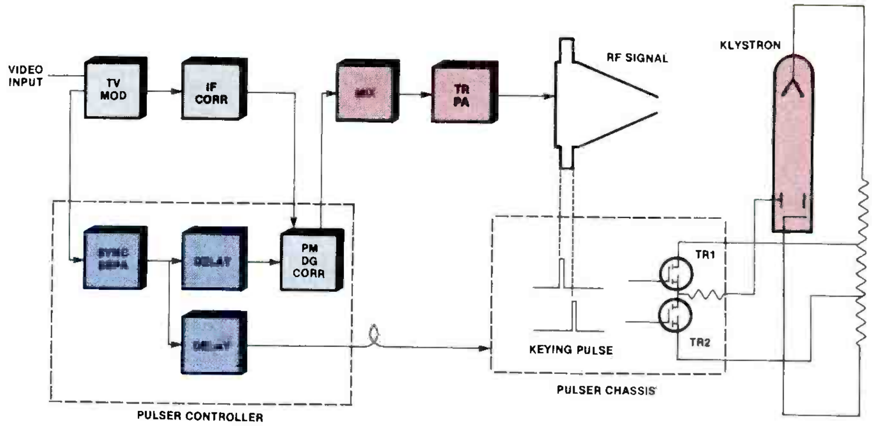

Figure 2. This illustration shows where the anode pulser is connected in the transmitter circuit to increase the output during sync.

Operation features

The transmitter uses two discrete exciter systems including separate modular oscillators, IF modulators and common buffer amplifiers. Each subsystem is designed to be transparent to the other when cross-switched. The automatic control system incorporates all of the required subsystems into one complete assembly. It also allows independent control of any subsystem in the event of failure or during maintenance.

A mimic panel provides a highlighted schematic of the actual transmission path. A warning indicator panel helps the operator identify the location of any problem. If a fault arises within the

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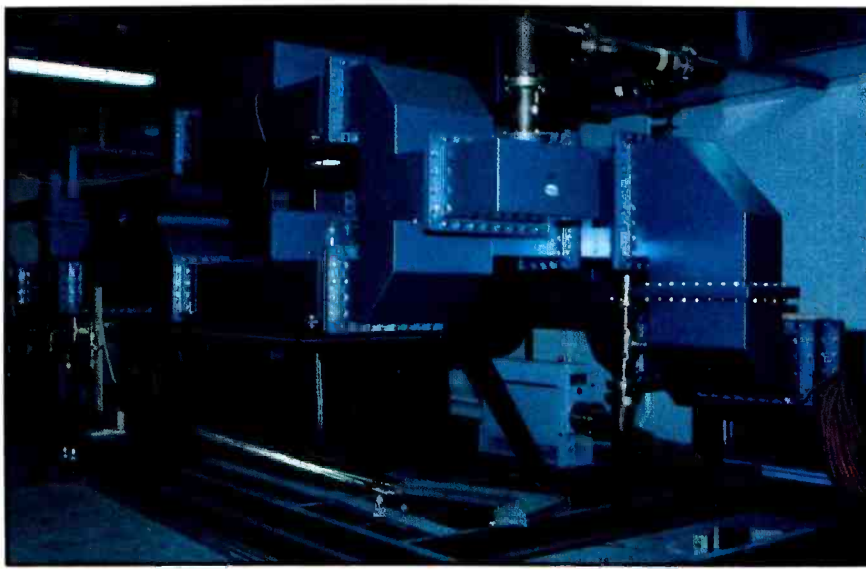
transmitter, it can automatically sense the cause, isolate that portion of the circuit and in some cases switch auxiliary circuits into the system. The defective stages are shut down and bypassed so the station can stay on the air. Of course, there are circumstances in which no backup provisions are available. In these cases, the transmitter sequences through a safe shutdown and awaits operator instructions. All telemetry and fault information is available for interfacing to a transmitter remote control.

The signal flow is diagrammed on the front of each module, making troubleshooting easier. Sample test points are brought out to the front panel for connection to test equipment. Each module also has its own internal power supply. While this may not seem to be an important feature, consider how much trouble it is to rig up several different power supplies just to bench test a module.

The transmitter employs a pedestal AGC circuit to maintain the proper power output level. The output signal is first sampled and detected through a directional coupler. The signal is then sampled at blanking intervals, producing a correction voltage that can be used to adjust the transmitter output power. The feedback circuit provides a constant blanking level and is effective through a range of ±1dB. If the output variation exceeds this limit, the transmitter automatically reverts to normal settings to prevent any power amplifier problem.



The limited available space meant the CIN diplexer, waveguide switch, Magic-Tee phaser and hybrid switching system had to be squeezed into an overhanging mezzanine.

Installation

The KTZZ engineering staff installed the transmitter with the assistance of NEC's technical engineers. We felt there was an important advantage to having the station's engineering staff involved in the installation process. The knowledge gained from participating in the installation of a transmitter is invaluable when it comes time to maintain the unit. At no other time will the engineers be able to take their time to slowly go through each section of the transmitter learning how each part works within the system.

The station's transmitter building is a 3-level, multi-user structure designed specifically to house the transmitter and

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its associated equipment. The building also supports a future office complex located directly overhead. Because our downtown Seattle location was expensive, the waveguide combiner, phaser and diplexer were stacked into an overhanging mezzanine. Another problem, caused by the limited space, required us to develop a detailed plan to receive the equipment and components in a specific order so we would not paint ourselves into a corner. A key element in this process was the information supplied by the transmitter company on component sizes. Detailed drawings were sent to us far in advance of the actual building design.

Because of the limited space within our

Pulsed anode operation

In the search for efficiency, new approaches to klystron operation have been suggested. One concerns the licensed maximum output signal power transmitted during peak of sync. The inverted polarity of video, when modulated, avoids excessive noise in the picture. With sync producing 100% modulation, noise spikes cause greater than 100% modulation, but are disguised in black. (Noise with positive polarity would result in piercing whites.) However, effective transmission of picture does not require that the same level of dc power (relative to the sync pulse) be maintained during the active video line time.

In a standard configuration, the potential on the klystron cathode is approximately −24kV (below ground). The mod anode voltage is much closer to ground, perhaps −1kV to −3kV. For safety purposes, the collector and the tube body are at ground potential.

By operating the modulating anode at about −7kV during active video, and pulsing it to the −3kV level during sync time, the average dc input beam power to the visual amplifier may be reduced. Switching to the less negative voltage for sync increases the acceleration and therefore the current. This increases beam power during horizontal sync or about 7% or 8% of the total line time. If the beam current was set to 7A initially and turned back to 5A with the pulsing, the power formula would show an immediate change of 48kW (the product of 24x24kV).

In essence, a pulser system changes the operating class of the amplifier. The klystron should be as linear as possible during active video, the most inefficient class A mode. During sync, maintaining class A biasing wastes energy. If, for the approximate 4μs period, we change the klystron bias point, we can improve efficiency. Because the sync interval is primarily a pulse, strict linearity is not necessary.

new building, the entire transmitter was delivered, uncrated and prestaged in a warehouse five blocks from the site. This process allowed us to become familiar with just how much assembly would be required after the numerous wooden crates and pallets were removed.

The station's chief operator and assistant chief engineer, Chuck Johnson, was responsible for overseeing the actual transmitter installation process. He worked with the company engineers to ensure the proper coordination of our staff and the outside support needed to complete the work.

The entire transmitter and its remote-control interface was assembled and pretested in Japan. Those familiar with other transmitter installations may recall the problems usually encountered with connecting transmitters to remote-control systems. The connection process usually requires out-board sampling units, driver amplifiers and interfaces to the transmitter. With the PCU-780KS, the entire transmitter interface from the transmitter automatic control unit (ACU) to the remote control was merely wire connections. No outside load resistors, sampling units or other devices were required.

Performance

KTZZ was NEC's first stereo UHF installation in the United States. The company is, however, familiar with the problems associated with multichannel broadcasting because Japan uses bilingual broadcasting. It was a relief to know that the transmitter was already capable of producing the wide aural bandwidth and required deviation without special modifications.

The aural bandwidth is flat out to 270kHz. The –3dB point is 320kHz. This performance is more than acceptable for BTSC operation. Modulator performance was measured both with 600Ω balanced (mono operation) and with 75Ω (stereo composite) inputs. Although we do not use the pro channel or SAP, performance measurements show that the transmitter easily meets all of those requirements.

It is important to reduce incidental phase modulation (ICPM) in order to minimize the potential for aural buzz during peak white signals. Because of our concern about providing a quality signal, we specified a maximum of 2° ICPM as measured through the entire transmitter before placing the transmitter order. Tests show that our transmitter exceeds that specification, with ICPM typically running approximately 1°.

Company support

By the time the full checkout and performance proof was completed, all automatic and transfer systems connected to the remote control and everything tested, the transmitter had been run nearly 250 hours. This burn-in period ensured that early mortality problems were caught by the factory engineers.

We haven't needed much assistance from the company since the transmitter was installed. At one point, when a glitch developed in the control-sensing system, we called for help. They were able to point us in the right direction and we quickly solved the problem. After the flow sensor was properly adjusted, they checked back with us to make sure everything was OK.

The transmitter continues to provide us with excellent service. The combination of factory support and a good product has made the NEC PCU-780KS an excellent choice for our station.

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.

Acknowledgment: Portions of this article were adapted from "KTZZ-TV (Seattle) Goes All-Stereo With NEC's PCU-780KS UHF Transmitter," printed in the Fall 1985 issue of the NEC *Synchronizer.*

Committee advocates rulemaking on LPAS

By Bob Van Buhler

Continuing a pattern of SBE advocacy before the FCC, the society filed comments on the commission's notice of proposed rulemaking (NPRM) on broadcast low-powered auxiliary stations (LPAS).

The NPRM proposed to expand the use of LPAS, which include wireless microphones and short-range production control equipment, into additional unused TV channels. Previously authorized for use on unused spectrum on channels 7 to 13, the FCC now proposes to permit them on unused channels 2 to 6 and 14 to 16.

The society's comments point out the conflict between expanding the use of LPAS into channels 14 to 36, and the recent moves to introduce land mobile licenses on channels 15 to 18. The possibility of mutual interference between these two services is great.

The SBE also suggested that additional measures be imposed on the use of wireless microphones to permit better local frequency coordination. The microphones are often rented rather than purchased. Because they are usually not labeled with operating frequencies, the user seldom knows at what frequency the units operate. This aspect can cause many problems in the field. SBE recommends that labels be required showing transmit frequency, owner's name, address and telephone number.

Other filings

During the last year SBE filed the following documents with the FCC:

•Comments on the amendment of Part 90 to allocate additional channels in 470MHz to 512MHz to public safety and other land mobile services (June 13, 1985).

•Comments on review of technical operations requirements in Part 74 regarding aural STL/ICR and TV auxiliary stations (June 28 and July 29, 1985).

•Comments on remote pickup and low-power auxiliary stations.

•Proposed rulemaking to amend frequency coordination requirements in Part 74 (September 24, 1985).

•Comments on above rulemaking (November 7, 1985).

•Reply comments on above rulemaking (November 20, 1985).

•Comments on the problem of compatibility of broadcast services and VHF aeronautical mobile equipment (December 17, 1985).

•Comments on the review of technical operations regulations in Part 73 regarding AM broadcast stations (July 1, 1985).

A total of 10 filings were made by president Richard Rudman and SBE counsel Chris Imlay on behalf of the SBE membership. This level of national activity speaks well for our organization. The FCC as well as other national organizations and companies have come to respect our opinion and seek our advice on important industry matters.

Check your status

Many SBE members may not be aware that they are eligible for upgraded membership status. Check the following criteria to see if you are eligible for an upgrade:

•Life membership—when retired from full-time employment, a person can apply for life membership. The person must have been an SBE member continuously for five years at the time of application. Life members are exempt from further dues payment.

•Senior membership—available to anyone who has been an SBE member for three consecutive years, participated in broadcast engineering for 15 years and has demonstrated professional responsibility in the areas of supervision, equipment design, plant layout or projects directly related to broadcasting for at least six years.

•Life certification—this certification level requires that a number of steps be completed in the application process. See your certification chairman or call the national office for details.

Membership

The February issue of **Broadcast Engineering** carried a full page membership application blank. So far, 56 new members took advantage of that application form. The April issue of **BE** also contained a tear-out, self-addressed application blank. If you want to pay by Visa or Mastercard, simply complete the form, stamp it and mail it. If you want to pay by check or money order, please enclose the application form inside an envelope.

Almost 200 new members were added to our ranks this year. We also gained one new life member.

Computer news

The new SBE computers were installed in mid-January by Gerry Dalton, member of the Dallas chapter who co-chairs the National Frequency-Coordinating Committee. The installation represents more than a year of work by Dalton and Jack McKain, vice president.

The administrative system uses a Compaq computer and 30Mb drive with streaming tape backup. This computer is used to store and to process all administrative work, certification information and frequency-coordination data. A second computer system, consisting of a Compaq 20Mb Desk Pro and modem, is used for certification and the SBE electronic bulletin board. Members can call the bulletin board after office hours at 317-842-0896.

Both computers are connected to a pair of printers. The dot matrix printer is used for reports and other non-letter documents. The laser jet printer is used for correspondence and reports that require high-quality output. This printer will generate all of the certification examinations, including schematics. The purchase of the computer equipment was financed by chapter rebates (40%) and sustaining membership fees (60%).

In other computer-related news, SBE can now provide members with access to CompuServe, a time-share database. CompuServe will maintain a separate database for SBE information, computer programs and listings of chapter chairmen and frequency coordinators. The information will be updated regularly by Gerry Dalton, the systems operator (SYSOP). Members of CompuServe can send messages or transmit electronic mail to other SBE/CompuServe members through the system.

SBE members who do not yet have access to CompuServe can obtain introductory kits for $21.95. This price represents a discount of $18 from the retail price of $39.95. The kits provide $25 worth of free time on the system. All of the standard CompuServe services are available to SBE members who sign up with the company. Contact the national office for more information.

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

Color character generator

ICM Video has introduced the model CG-7000P color character generator. The unit has high-resolution characters, and character fonts are generated by a plug-in module. The unit will generate an unlimited number of colors for the characters, and for the internally generated background.

The generator can gen-lock to any video source, including ¾-inch and ½-inch videotape. The characters and graphics can then be keyed over the external video with a built-in keyer. The unit contains 80 pages of built-in memory. Additional features include: program and preview outputs, four character sizes, scrolling, auto-sequencing, drop shadow, flashing effect and battery backup.

Circle (350) on Reply Card

Component downstream keyer/ RGB chromakeyer

Shintron has announced the DK3/CK3 component downstream keyer/RGB chromakeyer, a combination shadow keyer and chromakeyer built into one enclosure. It can be used as a stand-alone unit or as an accessory to a component switcher. It is compatible with all standard component formats.

The unit employs super-linear extra wideband technology, which performs key fades and program preset fades with almost immeasurable degradation in differential phase ($<0.25°$), differential gain ($<0.5\%$) or frequency response (0dB ± 0.25dB to 5MHz).

The unit can generate independent video keys on the program and preview buses. Dropshadows in any of eight different directions are possible, as well as full borders and outlines. The downstream keyer on the program bus can be independently faded into the foreground, while a new program preset fade allows 1-step fading between videos in the background.

Circle (351) on Reply Card

Demodulator adapter

TFT has announced that its 850 BTSC aural modulation monitor has been adapted to operate directly from the output of the Tektronix 1450 TV demodulator (updated versions). This configuration is the 850-1450. The adaption of the 850 makes it more universally acceptable and usable in satisfying the NAB/EIA recommended practices for measurement and monitoring of BTSC performance parameters. This configuration of the monitor is like the basic unit, without the front-end RF and IF circuits.

Circle (352) on Reply Card

Digital voice announcer system

Granite Telcom has introduced the digital voice announcer 1000 (DVA-1000), which digitally records, stores and plays back outgoing telephone messages. The unit is a microprocessor-based system with a full-fraction membrane keyboard for system control and an FCC-registered telephone interface. Features include variable voice digitizing rates, selectable announcement repeats before disconnect, call counter(s), elapsed time indicators for each message, calling party disconnect detection and self-contained system diagnostics.

Circle (353) on Reply Card

Microwave booster/UPS/and SCPC systems

Marti Electronics has introduced the MW-500 microwave booster; the UPS-12 uninterruptible power system; and the STL-10 narrowband SCPC.

The MW-500 receives, amplifies and redirects an aural STL signal over or around an obstructing object in the direct path between the transmitting and receiving antennas. The booster uses the same frequency for retransmitting and provides a maximum of 500mW output power. The booster also provides 60dB power gain at any point it is inserted in the microwave path.

The UPS-12 has a dc-dc system that provides automatic battery backup for the STL-10/R-10 radio link systems as well as the RPT-15/BR-10 automatic relay stations and TSL-15 data links. The unit is equipped with a precision constant voltage taper battery charger to maintain a 24, 36 or 60 amp-hour sealed maintenance-free battery in a charged condition.

The STL-10 uses 125kHz for mono and 250kHz for FM stereo STL.

Circle (354) on Reply Card

Condenser microphones

Shure has introduced the SM94 and SM96 electret condenser microphones. The SM94 has a flat frequency response and the SM96 has a slight presence rise and smooth low-end rolloff. Both mics have cardioid polar patterns that will not collapse at high frequencies. Both mics also feature a shock-mounting system that isolates the transducer element. The mics may be powered by any standard phantom power source (12Vdc-48Vdc), or internally by a standard 1.5V AA battery. The SM96 has a built-in 3-stage pop filter. Both mics have a nonreflective gray finish and come in a vinyl bag.

Circle (355) on Reply Card

Precision digital multimeters

Spanta has introduced models 540 and 530 4½-digit and 3½-digit hand-held digital multimeters. Both models are drop-proof and provide true rms ac readings using LSI circuitry, yielding accurate results on non-sinusoidal waveforms as well as sine waves. Model 540 provides 0.05% accuracy. The frequency measurement capability of the model 540 provides fast readings from 12Hz to 200kHz, with readings updated 2½ times per second.

With the data hold feature, the final reading of any measurement can be held on the display indefinitely. A standard feature of both models is an instant continuity test using a visible solid bar display and an audible beep signal. Other features include a diode test and triple overload protection. The model 530 provides direct reading decibel measurements for amplifiers, filters and attenuators.

Circle (356) on Reply Card

Replacement parts, repair products

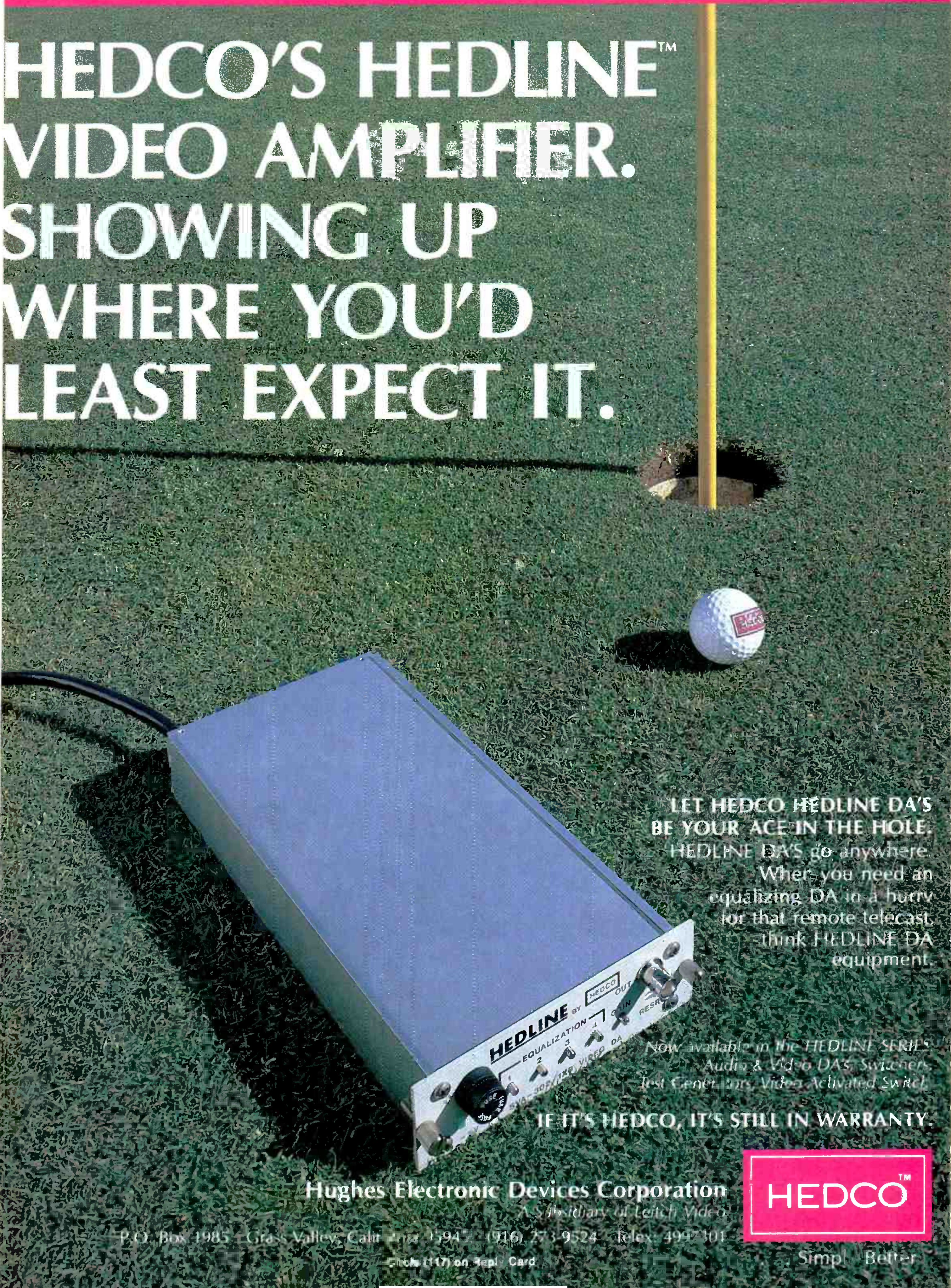
Black Audio Devices has announced a line of replacement parts and repair products for microphone booms. They are the swivel levers which replace the dumbbell on the AKG- and Beyer-type mic booms. The lockscrews replace lost or hard to find lockscrews on most makes of mic booms. They come in several styles and colors. The thread strips are used on the 5/8 to 27 threads on booms, stands and accessories.

Circle (357) on Reply Card

Color monitor system

Conrac Division has introduced the 6545 Micromatch color monitor system designed to provide automated monitor alignment. Available in 13- and 19-inch sizes, the monitor features a dot mask, precision-in-line CRT; pre-programming, American phosphor color; and automated monitor alignment.

Circle (358) on Reply Card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TBC and video switcher

For-A Corporation of America has introduced the FA-440 TBC, the FA-450 TBC and the CVM-500 video mixer.

The FA-440 TBC features 8-bit chroma signal component encoding and is compatible with all ½-inch and ¾-inch format VTRs. Digital effects include quarter-size compression with five positions. The unit also includes a built-in effects keyer, full-frame time base correction; built-in dropout compensation, full-color frame memory that provides field and frame freeze; strobe freeze and an adjustable auto freeze and procamp controls.

The FA-450 TBC is capable of transcoding signals in any format to any other format. The unit provides input and output capability for handling component RGB, YIQ; Y, R−Y, B−Y; Y/C dub and composite (NTSC) on a full cross-matrix basis. The TBC has full-frame correction and color picture freeze. Features include a gen-lock sync generator, black-burst output, comp sync and subcarrier outputs. A remote control console provides control of time base correction and video level functions.

The CVM-500 video switcher features 6-inputs plus black and color background; and reduces edge noise during keying, matting and wipe effects. A high-resolution picture is possible at all times since component VTR and component camera inputs require no decoding or encoding prior to processing.

Circle (359) on Reply Card

Lighting control console and RAM board

Kliegl has announced the Performer IV lighting control console and the P II/III RAM board.

The Performer IV has 250 control channels to drive 999 digital dimmers via 960 blocks of cue storage memory. The console offers a real time clock/calendar on screen, a local area network, and 72-hour memory retention without batteries or extra power supplies. The console has a high-resolution 13-inch color video display with direct-etched antiglare screen and is mounted on a tilt/swivel case. The unit also has a 3½-inch floppy disk drive for library storage. There are two time faders, one split-level manual cross fader and 10 submasters.

The PII/III RAM board is equipped with 32K of CMOS memory chips and is designed to replace the existing memory board of the Performer II/III. The board features 4-day memory retention. During a power stoppage, large capacitors provide enough power to sustain memory contents, eliminating the need for batteries.

Circle (360) on Reply Card

Audio/video products

Ampex has introduced a series of audio and video products.

The 467 professional U-matic digital audio cassette for PCM converters feature a cross-linked copolymer oxide binder system that withstands repeated plays without signal loss or error build-up. No realignment or special adjustment is necessary, and the cassettes can be used in all digital U-matic systems with standard factory adjustment.

The ATX-100 digital repositioner with zoom can connect to telecines with little or no modification. The unit consists of a control keyboard, computer system and a signal system and provides control of five positioning parameters. Parameters are entered via a joystick or keypad and can be stored in the system's memory for real time or recall.

Ampex ADO component input/output kit adds capabilities to standard composite ADO systems. The kit consists of three boards, two for signal input and one for signal output, and also allows the user to choose between composite and component input and output in any combination.

Circle (361) on Reply Card

Video test and measurement equipment

Magni Systems has announced the 1527 integrated measurement package (IMP) and the 1510 digital signal generator.

The 1527 IMP adds SCH phase capability to the waveform/vectorscope monitoring and test signal generation found in the 1520 IMP. The system measures absolute SCH phase of a single video signal, relative SCH phase of two signals or wrong color-frame matching between two video signals.

The 1510 digital signal generator is a new version of the 1520 IMP generator. A precision 10-bit digital test signal generator, generates 16 required signals. It contains 12-character overlay for signal source identification gen-lock capability and programmable offset of $+45\mu s$ to $-15\mu s$ to provide a time synchronous video source through a remote device under test.

Circle (362) on Reply Card

Amplifier series

LNR Communications has announced the CF7 X-band FET low noise amplifiers series offering noise temperatures of 85°K over the 7.25GHz to 7.75GHz frequency band. Designed for military satellite communications terminals, ap-

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Creating a colorful image

The **FA-430 Digital TBC** combines the best features of the component-structured FA-410 TBC with a digital image processor for full-feature processing of all color under formats. Time-Base and Color correction, Noise Reduction, Image Enhancement and Y/C Dub In and Out capability—all in a single unit for excellent program quality control.

Color Correction compensates for camera black and white levels, gamma and camera-to-camera colorimetry differences. Tint mode lets you "paint" scenes and create moods by changing picture color content. Black Stretch delivers optimum contrast in low light level scenes.

Image Enhancement combines H detail enhancement and selective noise reduction with improved V detail for sharper and subjectively more pleasing pictures.

Noise Reduction minimizes chroma noise and streaking as well as luminance noise in recorded signals to produce higher quality, multi-generation tapes. Result: lower editing and production costs.

Y/C Dub interfaces directly with VTRs to reduce ringing and distortion effects caused by cascaded filters.

Circle (110) on Reply Card

Wider bandwidth, greater resolution and sharper luminance and chroma transitions build quality into your programs.

More than a high-performance TBC, the FA-430 with Image Processing, Dropout Compensation and Y/C Dub features moves picture processing to a new level. FOR-A regional and local sales offices are ready to take you up. Now.

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East Coast: (617) 244-3223
West Coast: (213) 402-5391

plications include new terminal designs and retrofits of existing stations for improved B/T. Calculated MTBF exceeds 100,000 hours. The unit is available in single, redundant and dual-polarization Tridundant configurations. LNR offers systems engineering support in applying the unit to existing terminals.

Circle (363) on Reply Card

Interface for post-production editing system

EECO has announced an interface for its IVES II desktop post-production editing system, making the IVES II compatible with Ampex's VPR-80 1-inch, C-format videotape recorder.

In addition to the IVES II, computer controls for video production include its EMME computerized editing system with interchangeable keyboard and mouse control work stations to accommodate different editing styles, a full line of time-code generators and readers, and EECODER still-frame audio encoders and decoders for interactive laser videodisc systems.

Circle (364) on Reply Card

Videotape storage systems

The Winsted Corporation has announced its high-density tape storage system. Included in the product line are open-shelf storage systems, pull-out cabinets, high capacity systems and super density movable cabinets.

A variety of models and sizes is available, fitting different storage and space requirements. Both manual- and mechanical-assisted models are offered, as well as stationary or movable models.

Circle (365) on Reply Card

Ku-band portable uplink

Modulation Associates has announced the Ku 02, a suitcase-sized, completely portable satellite uplink designed specifically for remote broadcast and satellite news gathering applications that require quick deployment anywhere in North America.

The Ku 02 has been configured to provide continuous 2-way, multichannel communications between remote locations throughout the country and a master control center. Two-way communications is possible without interruption of the broadcast programming.

The unit comes with selective signaling, audio monitoring and telephone termination equipment. It has been designed to be used with a micro, 1.2 meter antenna.

Circle (366) on Reply Card

Headset stations

HM Electronics has introduced the HME BH720 and BH721 belt pacs, which feature a contoured aluminum extrusion housing. These belt pacs are light, compact and rugged for long-term reliability.

Both models feature soft compression limiting to eliminate distortion from high microphone input levels. A user-accessible switch allows the use of headsets with dynamic microphone or the lightweight HME 700-18 electret headset.

The single-channel BH720 belt pac is compatible with all HME 700 series intercoms and other 3-wire systems.

The BH721 includes the same features in addition to 2-channel capability over 4-conductor cable. A top panel toggle switch permits selection of either channel.

Circle (367) on Reply Card

Agile Omni, the industry's most advanced receiver designed by the most relied upon name in the business...Standard.

With the new Agile Omni, you need no other receiver.

Standard designed it for cable TV operators, broadcasters, CATV, SMATV, and business and special teleconferencing networks—now and in the future.

An onboard microprocessor permits selection of any band available from domestic satellites, including the 32-channel ANIK C2. Channel tuning provides direct reading of the transponder-assigned channel number and a format control permits selection of six frequency band formats—24-channel C-band, SBS/USAT and Spacenet already installed. Select channel and format, and the microprocessor controls frequency, channel spacing, transponder bandwidth, audio frequency and bandwidth, and antenna and video polarity—automatically.

Omni's flexible design can handle up to three separate subcarriers including stereo programming or data. Omni also will accept descrambling modules—eliminating the need for expensive add-on descramblers.

For CATV and SMATV applications, severe microwave terrestrial interference is minimized by optional internal SAW notch filters, automatically programmed to switch in. A 30 MHz low DG/DP LC bandwidth filter is standard, and a second internally installed optional filter of 18, 22, 26, or 36 MHz bandwidth can be controlled by the microprocessor, or manually switched.

Standard's proven RF loop-thru circuitry and blockdown conversion technology combine, with better image rejection and lower differential gain and phase, to provide excellent video performance. C/N threshold is an impressive 6.5 dB at the wide 30 MHz bandwidth.

Agile Omni is an affordable, flexible receiver designed to keep you in business, a commitment Standard backs with its unique 5-year warranty program. Contact us for further information.

Standard Communications
P.O. Box 92151
Los Angeles, CA 90009-2151
Toll free 800/243-1357
(In Calif. 800/824-7766, ext. 275)

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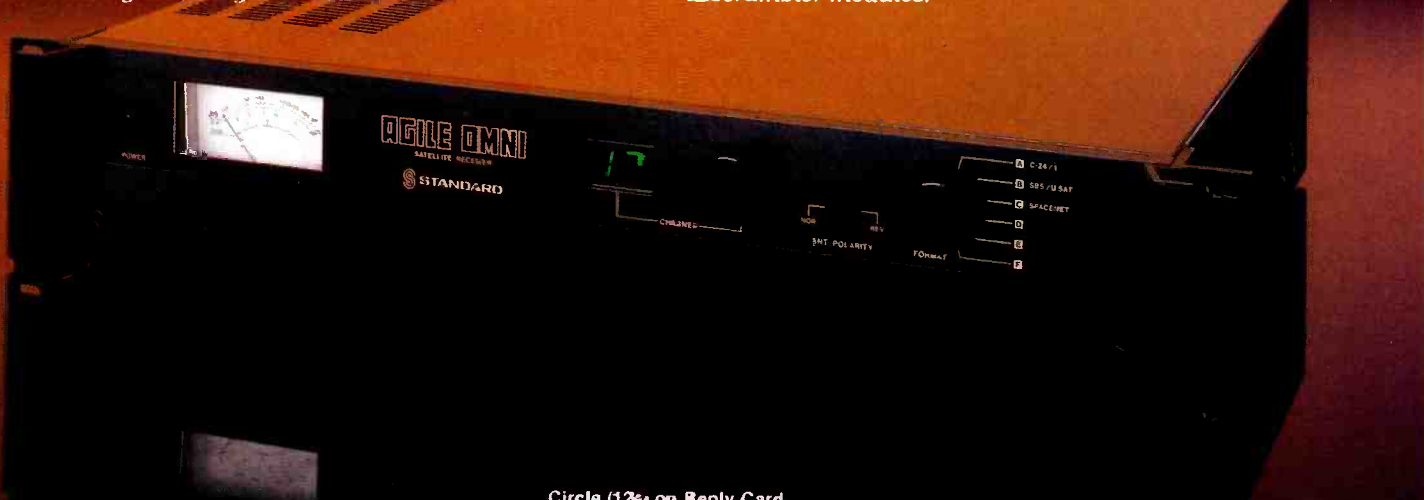
Operating functions including MGC, AGC, AFC, level sets, normal/invert video, clamp/unclamp video, skew, subcarrier frequency selection, video and IF test points are conveniently located on the front panel. Meter reads C/N ratio, signal strength or center-tune

Format control enables selections of desired satellite system. Direct-reading channel selector displays transponder-assigned channel. Second selectable subcarrier and space for optional third subcarrier or descrambler modules.



Circle (124) on Reply Card

People

Tom Phillips, Roger Lagadec and **Curtis Chan** have been appointed positions at Sony, New York. Phillips is manager of editor and time-code products. Lagadec is general manager, technical management, of the communication products group. Chan is manager of broadcast audio products.

Bob Phillips has been named sales engineer for Victor Duncan, Irving, TX. He is a former video systems applications engineer with the Detroit office.

Bill Park has been appointed vice president of marketing at Quanta, Salt Lake City. He is responsible for sales and marketing functions. Park is a former vice president of marketing for broadcast products at Sony.

Gordon Allison Jr. has been appointed marketing manager at Ross Video, Iroquois, Ontario. He has served as customer/product service representative for RCA Broadcast. Allison will be responsible for product marketing east of the Mississippi.

Adrian Bailey, Karl Walters, Karl Chapman and **Simon Bradbury** have received positions at Mitsubishi Pro Audio Group. Bailey is sales and marketing director, and will oversee sales operations. Walters is manager of the technical services division. He is responsible for installation, acceptance testing and servicing of all three product lines. Chapman is sales engineer and is responsible for the sales of pro audio products in the United Kingdom and Europe. Bradbury is a member of the technical services team.

Frank DeMayo Jr. and **Bill Phillips** have been appointed positions at Lake Systems, Newton, MA. DeMayo is president of the company after 25 years of service. Phillips is vice president in charge of international marketing and special projects.

Michael Pettus, Doug Dodson and **Fred Olimski** have been appointed positions at Convergence, Irvine, CA. Pettus is vice president of engineering after five years in software development and engineering with Acquis. Dodson is regional sales manager. His territory includes the north-central United States. Olimski is field service technician and provides post-sale service in the southern California and Los Angeles areas.

Philip J. Lantry has been named sales manager of pro products at Audio-Technica, Stow, OH. Lantry will be coordinating sales efforts with the company's national sales representatives.

Bob Bergfeld has been appointed national sales manager of the electronics division of Lenco, Jackson, MO. He is a former senior district manager of Sony Video Communications.

Ray Updike has been named sales manager at Circuit Research Labs, Tempe, AZ. Updike is responsible for limiters, stereo generators and spectral energy processors.

Kevin J. Barry has been appointed national sales manager of PRO Battery, Atlanta. He is a former telemarketing manager in the company.

do you know!

INFORMATION ABOUT SAVING YOUR ELECTRONIC EQUIPMENT

Your Broadcast Operations are in Danger!

The danger is serious and ever-present. In a split second you could be off the air...or operating with a scrambled program-control system ...or totally shut down with equipment catastrophically damaged. It's a threat you live with day after day and one that merits your closest attention.

The Threat Abnormal voltage surges that occur on AC power lines, communications lines and data lines are a major cause of misinformation and equipment failure for the broadcaster. Broadcasting equipment is especially vulnerable, with tall antennas reaching up into the skies and with electronic units of unusual sensitivity.

Difficulties manifest themselves in two ways: (1) as physical *damage*...this is obvious damage that occurs directly as the result of an electrical storm, or less obvious failures that seem to occur almost at random; (2) as *misinformation*... where the power surge is coupled into the equipment causing improper events to occur or incorrect data to be presented.

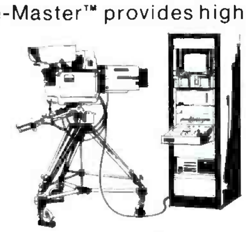
These problems are familiar ones to broadcasters. And now, with the ever-expanding dependance on computer control and the corresponding increase in the susceptibility of these sensitive devices to damage from voltage surges, overvoltages must be controlled and eliminated.

*Allen & Segall/IBM, 1974

The Causes Transient power problems originate outside buildings from lightning, ground faults, and public utility switching, and inside buildings from inductive loads, transmitters, air conditioners, fluorescent lights, etc. A study at IBM* identified transients as the cause of 88.5% of all line disturbances. Transients, sudden and extreme "spikes" in voltage, can be as short as a few nanoseconds or as long as several milliseconds. Their effect can range from total failure to the gradual degradation and breakdown of electronic components or systems.

The Solution MCG Electronics provides total protection against these transients for your broadcasting operation. AC power lines and data lines that serve your internal communications network are guarded day and night.

AC Power Line Protection MCG's Surge-Master™ provides high speed (5ns), heavy-duty protection that limits AC overvoltage spikes to safe levels. Surge-Master protectors are your first line of defense, and are available in configurations designed to meet your needs, from complete building protection to individual equipment protection.



Data Line Protection Interfaced between network equipment and data lines, MCG's Data Line Protectors provide a sophisticated blend of high speed (less than 5ns) and brute force protection against induced transient voltage surges. Available in multiple configurations, they are designed to meet your every need, and will keep your data network out of danger.

MCG Protectors Your most cost effective insurance against downtime and data loss caused by voltage surges and transients.

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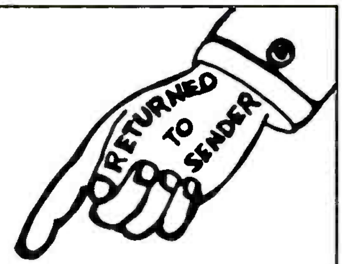

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BROADCAST ENGINEERING

Wold chooses Wegener Panda II system

Wold Communications has chosen the Communications Panda II audio transmission system from *Wegener Communications*, Norcross, GA, to deliver stereo programming over the Wold Satellite TV Network. Left channel, right channel and multilingual monaural audio are transmitted as separate subcarriers to affiliate TV stations receiving Wold stereo broadcasts through the United States. Equipment to receive this programming is available directly from Wegener.

The system provides the transparent transmission of the full dynamic range and transient properties of digital audio source material over satellite, terrestrial microwave and fiber-optic links.

Harris plans new product and services for ADDA

Harris, Quincy, IL, will provide full support of four new products as a result of the acquisition of ADDA. Parts and services for all other ADDA products are offered on a best effort basis.

The model 560 (Vision) and the model AC-20A time base correctors, the VW-3 frame synchronizer and the ESP-II still store will be manufactured and are offered for sale under the Harris name.

Dynatech acquires Quanta

Dynatech, Burlington, MA, has acquired Quanta, Salt Lake City. Quanta manufactures video character generators, video graphics systems and related products. Quanta was founded as Systems Concepts in 1974.

Quanta will add new products and marketing strengths to Dynatech's Video Communications Division. Dynatech's Video Companies include Utah Scientific and ColorGraphics Systems.

MCL relocates

MCL, La Grange, IL, has expanded and moved to the Bolingbrook, IL, Industrial Park, Wood Creek Centre. It will occupy more than six acres and more than a 60,000-square-foot building. MCL's first phase building is a 2-story office building. The manufacturing facilities will be behind the offices.

DCC installs computerized newsrooms

Data Communications Corporation, Memphis, TN, has announced two installations of its BIAS newsroom computerized newsroom system at WREG-TV, Memphis and KOB-TV, Albuquerque, NM.

The system is IBM PC-XT or AT-based. IBM PCs may serve as stand-alone units or share files with other PCs. BIAS newsroom uses modular software and hardware to allow news departments a comprehensive system, with the capacity to add on work stations, file storage and other features.

Software resides on the computer's hard disk and is self-loading when the unit is turned on. Programs are called up by means of selecting from a menu on the screen.

Professional services

CMX editing systems orders increase

Orders for CMX 3400, 340XL, and its new 3400A and 330XL videotape editing systems have been received by *CMX Corporation*, Santa Clara, CA. The following production facilities have ordered CMX 3400A systems: Riverview, New York; Sunset Post, Los Angeles; and KAET, Phoenix, AZ.

CMX 3400 systems have been sold to Century III, Orlando, FL, and Mobile Images, Toronto, Canada. CBX, Monrovia, CA, has ordered four CMX 340XL systems while individual orders have come from CBS, Los Angeles; Midwest Communications, Edgewood, KY; Korean Cultural Center, New York; KMEX-TV, Los Angeles; and WTMJ, Minneapolis.

Ordering the new CMX 330XL have been Midwest Communications, American Red Cross, Washington, DC; Busby Productions, Des Moines, IA; Loyola University, Los Angeles; and Editor's Choice, Chicago.

Tokyo Broadcasting center orders Sony equipment

Sony, Tokyo, has announced that its broadcast equipment has been purchased by ARK Hills TV Asahi Broadcasting Center in Tokyo.

Purchased equipment includes 110 Betacam video recording systems, five Betacart multicassette systems, 24 BVH-series 1-inch VTRs and three MXP-5000 audio mixing consoles, which were jointly developed by Sony and TV Asahi.

The bulk of the BVH series 1-inch VTRs purchased by TV Asahi are BVH-2180 series for up to 3-hour program recording and playback. The MXP-5000 audio mixing console has digital control and it permits the operator to preset up to 99 scene sound tracks for automated program setting.

BBC places shortwave order with Marconi

Marconi Communication Systems, Chelmsford, England, has received an order from the BBC for two B6131 250kW shortwave transmitters for a new transmitter station in The Seychelles. When completed in 1988, the station will improve audibility of BBC World Service Programs in the African and Indian Ocean regions.

News

Continued from page 4

in addition to passing through a noisy satellite transmission path. The direct comparisons were judged to be virtually equivalent to the HDTV images. Under conditions of noisy transmission paths, MUSE proved to be more resistant to poor carrier-to-noise ratios than MAC encoding with identical conditions.

MUSE transmission requires only a single 12GHz DBS channel to carry the 8.1MHz baseband signal. The MUSE signal is derived from the 1,125-line, 60-field, 2:1 interlaced HDTV studio format currently recommended to CCIR. Approval of that format is pending at CCIR meetings in Dubrovnik, Yugoslavia, this month.

Photo credits

In our February issue, photo credits were mistakenly left off photographs in two articles. We wish to correct the oversight:

Credit for photographs used in the article, "Field Report: Lake Systems LA-KART" (pages 98 and 102), should go to Jim Goodin of KATV, Little Rock, AR.

Credit for the photograph used in the digital graphics sidebar article, "Weather Systems" (page 36), should go to Jack Carlson of Alden Electronics, Westborough, MA.

Ad index

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Advertising rates in Classified Section are $1.50 per word, each insertion, and must be accompanied by payment to insure publication.

Each initial or abbreviation counts a full word. Minimum classified charge, $35.00.

For ads on which replies are sent to us for forwarding (blind ads), there is an additional charge of $35.00 per insertion, to cover department number, processing of replies, and mailing costs.

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TRAINING

ELECTRONICS DEGREE by correspondence. Earn Associate, then Bachelor's. NHSC accredited. Free catalog. Write Grantham College of Engineering, Dept. EE-5, 10570 Humbolt St., Los Alamitos, CA 90720. 8-82-tfn

FCC GENERAL RADIOTELEPHONE operators license through cassette recorded lessons at home plus one week seminar in Boston, Washington, Detroit or Philadelphia. Our twentieth year teaching FCC license courses. Bob Johnson Radio License Preparation, 1201 Ninth, Manhattan Beach, Calif. 90266, Telephone (213) 379-4461. 8-81-tfn

SERVICES

ONE STOP FOR ALL YOUR PROFESSIONAL AUDIO REQUIREMENTS. Bottom line oriented. F.T.C. Brewer Company, P.O. Box 8057, Pensacola, Florida 32506. 7-71-tf

TRANSMITTER TUBES REPROCESSED—Save 40 to 50%. 3CX2500, 4CX5000, 4CX15000 and many others. Write for details. FREELAND PRODUCTS CO., Rt. 7, Box 628, Covington, LA 70433. (504) 893-1243 or (800) 624-7626. 6-79-tfn

FOR SALE

RCA COLOR TELECINE SYSTEM, New/unused. To include: TK-66, color camera, TP-66, 16mm telecine projector, TP-7, 35mm slide projector, TP-55B, camera multiplexer. Write to: P.O. Box 23555-273, San Diego, CA 92123. 1-86-tfn

VERTICAL BLANKING INTERVAL ENCODERS: 2 EEG Line 18 Smart Encoders; 16 EEG Decoders; 8 Tele-Engineering switch frames, each with six channels of 3 input AFV switching; 2 CPM computers with software for above. Michael Conroy, (203) 736-2691. 4-86-2t

FOR SALE: R.C.A., brand new from factory. 16 mm Telecine Projectors, TP-66 with R/C and lens. Call Mr. Frank N. Bovino, S.B. Video, 201-343-6944. 5-86-1t

1—1974 MODEL "902" Schafer broadcast quality automation system equipped with six Teac reel to reel playback decks. This unit needs work, but has proven to be a very reliable unit overall. Some spare parts are included. $2000.00. Contact: Ed Smith, Audio Group, Inc., 5005 S.W. Macadam Avenue, Portland, OR 97201. (503) 227-6681. 5-86-1t

Reconfirm your involvement in the broadcast industry! Renew your subscription today.

WANTED TO BUY

WANTED: Pre-1923 radio equipment and tubes. August J. Link, Surcom Associates, 305 Wisconsin Ave., Oceanside, CA 92054, (619) 722-6162. 3-76-tf

HIGHEST PRICES for 112 Phase Monitors, vacuum capacitors and clean, one kw or greater powered AM and FM Transmitters. All duty and transportation paid. Surplus Equipment Sales, 2 Throncliffe Park Dr., Unit 28, Toronto, Canada M4H 1H2, 416-421-5631. 3-86-tfn

WANTED: McIntosh, Marantz, Western Electric, Altec, RCA, tubes, speakers, amplifiers. 713-728-4343. Maury, 11122 Atwell, Houston, Texas 77096. 5-86-2t

EMPLOYMENT OPPORTUNITIES

10,000 RADIO AND TV JOBS a year for men and women are listed in the American Radio job market weekly paper. Up to 300 every week. Engineers, DJs, Newspeople, Program Directors, Production, Sales. All markets, all formats. One week computer list, $6.00. Special bonus 6 weeks, $14.95. You save $21.00. American Radio Job Market, Dept. 3, 1553 North Eastern, Las Vegas, Nevada 89101. 7-84-tfn

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HELP WANTED

VIDEO TAPE EDITOR. Fisher Scientific, Pittsburgh, PA, is seeking an experienced Video Tape Editor to perform computerized 1" A/B roll editing. Individual must have Associate Degree in Electronics along with 2-3 years editing experience using ACE or CMX equipment. Competitive salary, excellent benefits. Contact: Mrs. Fran Sarvas, Employee Relations Supervisor, Fisher Scientific, 711 Forbes Avenue, Pittsburgh, PA 15219. Equal Opportunity Employer. 5-86-1t

MAINTENANCE TECHNICIAN—KRIV-TV, Houston, is seeking qualified studio and transmitter technicians. Must have minimum of three years experience and a FCC license. Send resume to: KRIV-TV, P.O. Box 22810, Houston, Tx. 77227. Attn: Wendell Wyborny VP/CE. E.O.E. 3-86-2t

TELEVISION BROADCAST FIELD ENGINEER

TV transmitter systems manufacturer has several immediate openings for the permanent position of engineer/technician within a growing field operations department. Experience with UHF TV transmitters using klystrons preferred. Domestic and some foreign travel will be required. Salary commensurate with prior experience. Send resume to:
Comark Communications, Inc.
P.O. Box 229
Southwick, MA 01077
ATTN: Engineering Manager

WOLD COMMUNICATINS, Corp. Engineering Dept. We are seeking a Manager of Field Services with the following minimum qualifications: 5 years of experience in the satellite and microwave communications fields; 1 year of experience in a supervisory capacity. Must be able to perform and analyze satellite link budgets and microwave path performance calculations. Hands-on working experience with fixed and transportable transmit/receive earth stations. Working knowledge of SCPC, multiple sub-carrier transmissions, video, and ditigal technologies. Ability to troubleshoot HPSs, exciters and satellite receivers to the component level. FCC General (first) class license. Please send resume to: Michael L. LoCollo, Sr. VP, Operations & Engineering, Wold Communications, 6290 Sunset Boulevard, Suite 1203, Hollywood, CA 90028. 5-86-1t

HELP WANTED: TV BROADCAST ENGINEERS. Experience with all TV Broadcast equipment. Minimum 5 years experience. FCC general class license required. Also, needed Audio remix and Maintenance engineers. Four years minimum experience. Send resume to: Jimmy Swaggart Ministries, Darell Wyatt, Chief Engineer, P.O. Box 2550, Baton Rouge, Louisiana 70821-2550. Phone (504) 768-3472. 5-86-3t

PHOENIX, ARIZONA: New Progressive Broadcast Company has an immediate opening for a Chief Engineer with a minimum of 5 years real time experience. Must be familiar with TV Transistors & Micro Wave. The job requires designing and supervising installations and overseeing maintenance. Travel. A wonderful opportunity for the right individual. Salary Commensurate with experience. Send Resume to Impact, 2515 E. Thomas Road, #16-661, Phoenix, AZ 85016. 5-86/1t

REGIONAL SALES MANAGER: A TBC manufacturer seeks Sales Manager in New York and Los Angeles area. Sales experience or technical back-ground in TBC is needed. Please contact: Hotronic, Inc., 1210 S. Bascom Ave., #128, San Jose, CA 95128, (408) 292-1176. 5-86-1t

MAINTENANCE TECHNICIAN

WBAL-TV, CBS in Baltimore, has an opening for a MAINTENANCE TECHNICIAN. Familiarity with operation and maintenance of television broadcast equipment necessary. Must have hands-on experience trouble-shooting and maintaining audio, video equipment, tape machines, cameras and digital systems. FCC license and SBE certification desirable.

Qualified candidates are invited to submit a resume to:
3800 Hooper Avenue
Baltimore, Maryland 21211
Engineering Department
An Equal Opportunity Employer, M/F

IMMEDIATE OPENING FOR SENIOR TELEVISION MAINTENANCE ENGINEER OR TECHNICIAN to provide maintenance and technical support on color equipment components and facilities. Minimum 2-3 year's experience in studio and field operations. Full benefits, salary commensurate with experience. Greater N.Y. area. Call 516-352-2251 or send resume to VPC, P.O. Box 840, New Hyde Park, NY 11040. 5-86-1t

RADIO ENGINEER, minimum two years radio maintenance experience, FCC general and SBC certification preferred. EOE. WHBC, Box 9917, Canton, Ohio 44711. 5-86-2t

THREE RCA TK-760 (B) color cameras with Fujinon TV-Z 1:17/9-108 lenses and one field conversion package. Call Victor Jugenheimer, University of Miami, (305) 284-5348 or 284-5379. 5-86-1t

E.J. STEWART has an opening for an experienced maintenance person. Qualified applicant should have working knowledge of Sony 1" and ¾" VTR'S, MIRAGE, BOSCH CCD FILM CHAIN, RCA TK-47 CAMERAS, GVG SWITCHERS. Send resume to Eric R. Address. E.J. Stewart, Inc., 525 Mildred Avenue, Primos, PA 19018 (215) 626-6500. EOE/MF. 4--86-2t

TELEVISION TRANSMITTER SUPERVISOR: We have an immediate opening for an experienced transmitter engineer with a minimum of 5 years of fulltime VHF TV experience. A thorough knowledge of RF systems, audio, video and microwave as applied to television broadcasting is required. This is a hands-on position. You must be able to troubleshoot equipment to component level. First or General Class FCC radio/telephone license is preferred. We offer an excellent starting salary and a full range of company benefits. Send resume in confidence to: Larry Pozzi, KMGH, P.O. Box 5007, Denver, CO 80217. Equal opportunity employer, M/F. 5-86-1t

VIDEO MAINTENANCE TECHNICIAN, MASS COMMUNICATION DIVISION OF EMERSON COLLEGE. Emerson College seeks qualified applicants for this current opening for a Video Maintenance Technician. RESPONSIBILITIES: Performs daily repair and operations maintenance of studio, control, editing and post production television/video facilities and equipment. QUALIFICATIONS: Bachelor's degree plus 1-2 years' experience and knowledge of U-Matic VTR, camera, switching, distribution, and monitoring equipment required. Sony school experience, SBE Certification and production company and/or broadcast engineering experience desired. Must be able to work well in student teaching environment. Emerson College offers competitive salaries and an outstanding benefits package including paid medical and dental insurance and one course per semester paid tuition. Please send resume to: Susan Rowell, Personnel Representative, Office of Human Resources/Affirmative Action, Dept. BE, EMERSON COLLEGE, 100 Beacon Street, Boston, MA 02116. (617) 578-8580. We are an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply. 5-86-1t

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