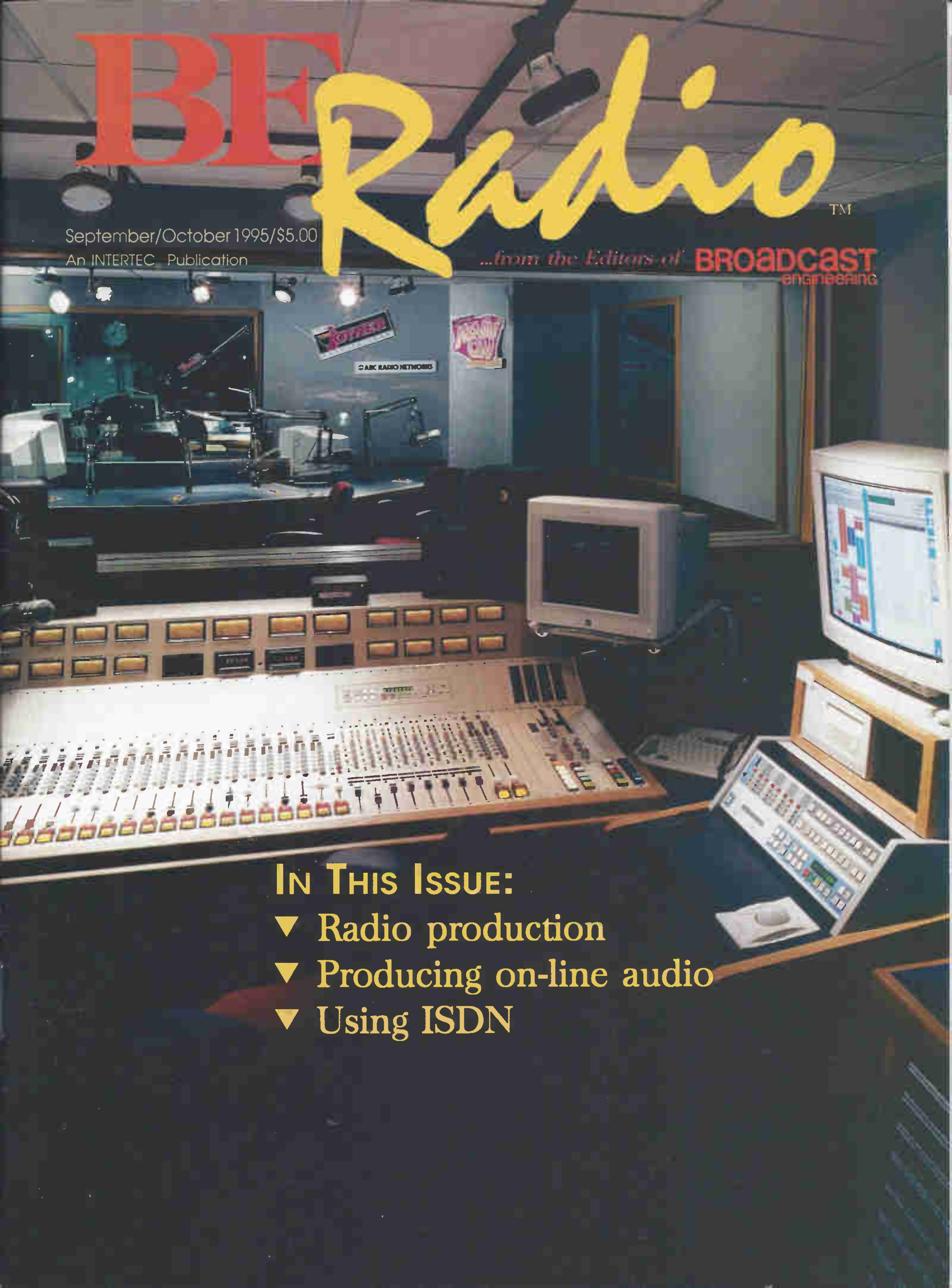

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September/October 1995/$5.00
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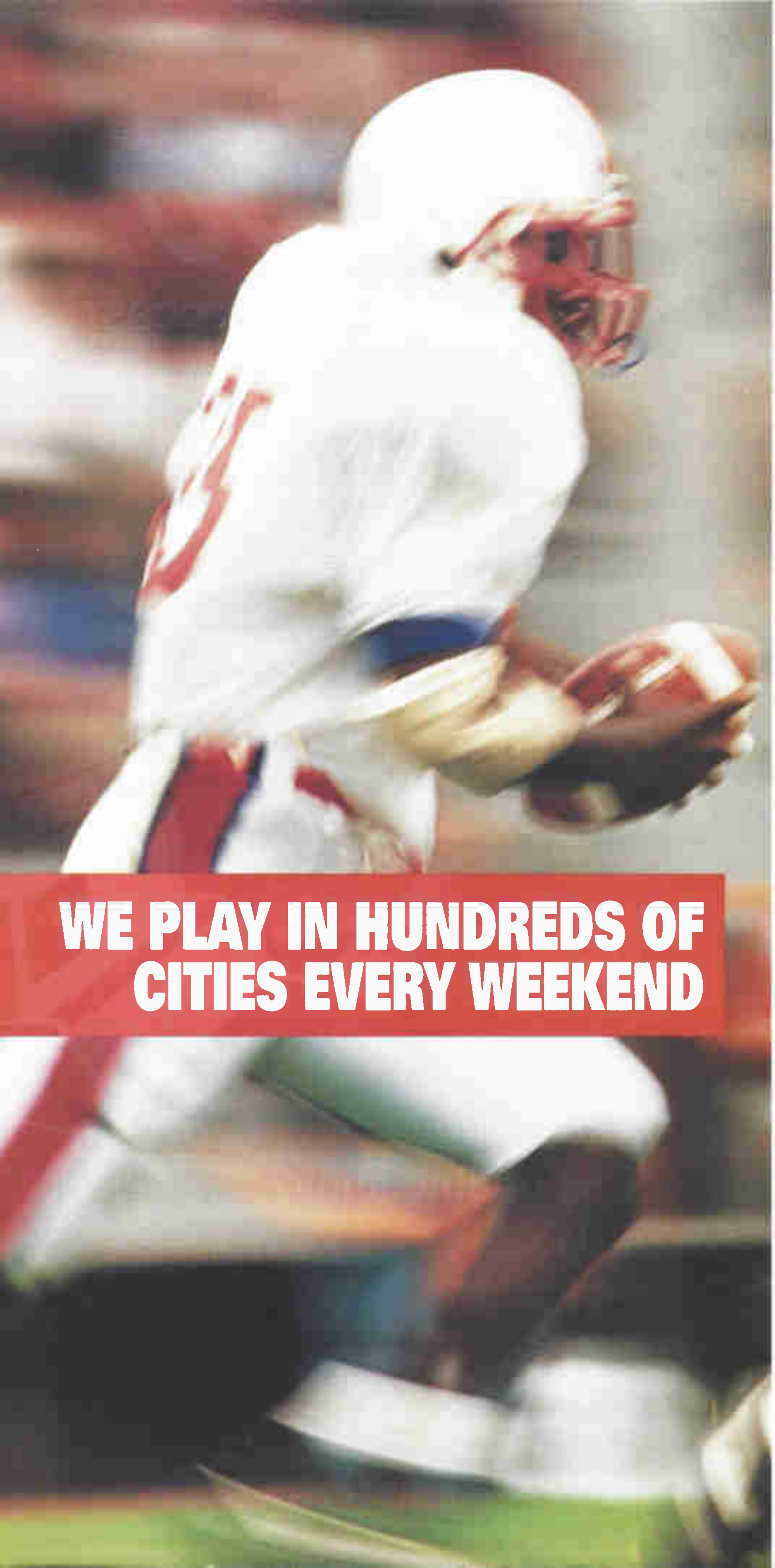
...from the Editors of BROADCAST engineering

In This Issue:

- ▼ Radio production
- ▼ Producing on-line audio
- ▼ Using ISDN



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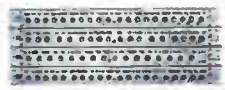

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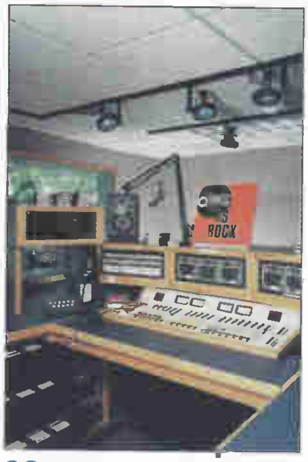

26 *Future-Proof Production Studios*

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40 *News*

ON THE COVER: The production suite at ABC Radio Networks' new headquarters in Dallas incorporates analog and digital equipment in a user-friendly and easily upgradable configuration.

Editorial:

How good is good enough?

Initial assessments of the DAB laboratory tests seem a bit disappointing for in-band systems – the great white hope of U.S. broadcasters. Various camps have put their spin-doctors to work (actually, in radio they can only afford spin-paramedics), but when the dust settles, in-band systems will undoubtedly take a back seat to Eureka 147 in at least some critical areas of evaluation.

To anyone with a decent memory, this should come as no surprise. When in-band systems were first introduced, the question was "How close to Eureka can they come?" The elegant fit of in-band/on-channel DAB into the U.S. broadcast environment made such systems so desirable that some reasonable technical compromises seemed acceptable to many broadcasters in the bargain. The laws of physics dictated that shortcomings would be inevitable when a narrowband, single-channel system was compared with a wideband multiplexed one. (Compounding this was the narrowband system's need to cope with compatibility and interference restrictions far more severe than those faced by the wideband system.)

But in the intervening years, some in-band proponents pronounced their systems' performance every bit as good, if not better, than the Eureka 147 benchmark. So convincing were their claims that now even subtly second-class ratings seem profoundly disheartening. It turns out that the laws of physics have not been repealed, and the apples-and-oranges competition in the Cleveland lab has failed to produce miraculous fruit.

This should not spell the end for in-band, however. It's simply a reality check. We're getting to know the limits of in-band DAB systems so we can make informed judgments on how to proceed. The fact that these systems held up as well as they did in the tests is actually laudatory. "How good is good enough" remains the operative question for in-band DAB.

Anyway, there may not be a reasonable fall-back position for U.S. terrestrial radio. Washington insiders say there is still little chance of getting an L-band allocation for DAB, and DBS radio services still lurk on the horizon, ready to take up the entire U.S. S-band DAB allocation. The decision for an in-band system may already have been made by default. From this perspective, the next step for U.S. broadcasters may be simply to produce an in-band technology with minimal interference to existing services and digital performance as close to Eureka 147's quality as possible.

Speaking of quality radio, it's often easy to forget in these discussions what really brings listeners to the signals of U.S. broadcasters is good *PROGRAMMING*. Ideally, this involves excellence in creative and technical domains, but when forced to choose, most listeners will pick content over fidelity every time. It's with this in mind that the *BE RADIO* issue you're reading focuses on the creative side of radio technology.

To get you in the proper frame of mind, here are a few benchmarks from the content side that tell you when you're listening to good radio:

- You keep listening in the car after you've turned off the engine.
- You feel the hair on the back of your neck sticking up.
- You see the TV coverage of something you heard earlier on the radio and the images are disappointing. (The ones in your head were better.)
- You find yourself informing, enthralling or amusing your friends at the water cooler, and realize you're just quoting something you heard on the radio that morning.
- Your favorite tape or CD sits loaded in your car radio/player, but remains unplayed for days at a time.

And so on. It's these feelings that bring listeners to a station and keep them coming back for more. So, while the battles rage on the DAB front, broadcasters should keep doing what they do best, adding incremental improvements as they continue to make good radio. New technologies should only make the experience more rewarding by providing new services, more creative production and, eventually, higher-fidelity delivery. But without high-quality content, no radio service will ever be "good enough."

Skip Pizzi

Respond via the *BE Radio* FAXback line at 913-967-1905 or via E-mail to beradio@intertec.com.

By Skip Pizzi, radio editor

Contract Engineering:

Getting new business

By Kirk Harnack

Business advisers often point out that every business is either growing or shrinking – no business just plugs along, staying the same size. Whether you're starting a contract engineering firm or expanding an existing one, advertising your services is crucial to establishing, growing and simply maintaining a client base.

Contract engineers' clients – radio stations – are changing constantly. This trend has been even more pronounced in recent years, primarily due to deregulation. There are fewer and fewer "stand-alone" operations today. Increasingly, stations are parts of groups, LMAs and duopolies. This trend will only continue to grow as further deregulation is passed by the U.S. Congress.

These changing ownership and combined-facilities arrangements also are changing the way station facilities are engineered. Opportunities abound for good contract engineers to assist the full-time engineers at consolidated facilities. In some cases, a contract engineer can effectively handle all the duties at such a facility, even while maintaining service to other stations. Several contract engineering firms are growing in size and scope because of a severe shortage of available, qualified, full-time engineering candidates for station staff positions. These growing contract firms are finding themselves hiring and training new technicians and further expanding their client base.

Some contract engineers choose not to go after new business. Often they feel comfortable or even swamped with the amount of business they currently have. Unfortunately, these engineers' client bases often erode a station at a time, typically through no fault of their own. Stations that were good clients may be sold to new owners or to other station groups with different engineering arrangements. If these clients lost through attrition or by other means aren't replaced or regained, a contract engineer's business can evaporate in a matter of months. So, whether your contract engineering firm is interested in expanding or just trying to stay at its current level, advertising and looking for new clients is continually important and deserves your attention.

Numerous options are available to contract engineers for advertising and otherwise courting new business. Naturally, localized efforts will result in local business, whereas regional, national and even international promotion will result in more remote clients. Often, doing work for out-of-town clients can add to your credibility in your home town. This is good to remember before your local clients start taking your services for granted.

Kirk Harnack is president of Harnack Engineering, Inc., an international broadcast contract engineering firm based in Memphis, TN.

Direct mail

Direct mail advertising is a good way to put printed material about your firm right into the hands of the station manager. To be effective, your direct mail piece must be eye-catching and informative, and it must raise the interest of the reader in a compelling way. It should also teem with professionalism and be devoid of sloppiness.

Creating a mailing list for a local or regional promotion effort shouldn't be too difficult. Resources such as "The M Street Directory" or "Broadcasting & Cable Yearbook" can be searched for names, addresses and phone numbers of radio prospects. For a national direct-mail effort, the services of a company specializing in such lists is well worth the cost. Firms such as The Radio Mall can supply pre-printed mailing labels or data on diskette; they can even "stuff" your brochure into one of their own regular mailings.

Follow-up to direct mail is crucial. Direct-mail recipients will rarely act upon their first introduction to you by mail. The most effective follow-up is a telephone call. This provides you with an opportunity to ask if the prospect received the mail piece. You can then briefly describe your services and how they will benefit the station.

Doing work for out-of-town clients can add to your credibility in your home town.

Telephone calls

Direct *cold calls* can be extremely effective, but they also can be disappointing. The responses will vary widely depending upon who you call, your pitch, the mood of the prospect, and whether he or she is looking for your services at the time.

When I first started as a contract engineer, I spent two full days on the phone, cold-calling about 150 radio stations. Most calls didn't pan out. However, from the 150 calls, I was able to contract right away with five radio stations.

Before making cold calls, it's a good idea to practice the process. You can have someone act as the prospect and listen to your story or pitch. You can also record yourself for self-critique. One particularly good resource is a book titled "Phone Power" by George R. Walther (Berkley Publishing, New York). The ideas presented for using the telephone effectively are widely applicable and go beyond just cold calling.

Print advertising

Print advertising effectively places your name and services before the eyes of thousands of readers. Advertising in radio-industry trade publications provides the benefit of targeting the exact people who can make a decision about contracting for your services. Because you don't know who has seen your

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In late August, registered users will be faxed a notice with complete program details. Not sure whether your units are registered? Fax us or send us e-mail to for registration forms.

All work will be performed by appointment. We'll schedule a convenient date for the work to be done and guarantee to return your units four working days later. Work will include: changing required motherboard parts; installing EPROMs with new firmware, and giving the unit a thorough factory once-over.

Initial modifications for both Layer III and Layer II operation will add compatibility with most installed Layer II units. In the future, as Telos develops more compatibility packages for Zephyr, firmware exchanges will be offered at no charge and may be performed in the field.

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advertisement, however, a follow-up call isn't really possible. Your ad must be interesting and informative enough to compel the reader to pick up the phone and call you.

A number of different types of print advertising vehicles are available:

• *National industry publications*: There are enough diverse radio-industry publications to allow you to target almost any job description in the business. Some journals concentrate on engineering issues, while others focus on management, and still others consider sales, talent, programming and ratings.

• *State association newsletters*: A good way to target stations that are in your region with print media is through your state broadcast association's newsletter. Not every state has an active association or publication, but those that do are usually well-read by station owners and managers. The display advertising rates in state association newsletters are usually quite affordable.

• *Fax-delivered newsletters*: For contract engineers who are advertising to expand or maintain an existing client base, a monthly or quarterly newsletter delivered by fax is effective. Be sure to use the newsletter as an informative and helpful bulletin. Boisterous advertising isn't really necessary here because your client can see who sent the fax and will be appreciative of any helpful information it contains.

Personal visit

Once an appointment is made to see a prospective client, be sure you're properly prepared for the meeting. Lunch meetings work quite well and give the prospect a chance to get away from the formal confines of the office.

Proper planning for the meeting includes doing some homework on what kind of technical operation the station has. Is it automated? Should it be? Does the production sound good? How about the station's on-air sound? Does the audio processing sound good and clean? Is the station off-the-air every time there's a storm? If the station does remote broadcasts, how do they sound? In other words, listen for clues as to what the station's problems might be.

> Your best long-term advertising comes from the work you do.

Try also to find areas where the station excels so you can point those out to the manager. During the meeting, ask the prospect about what's important to him or her. Remember that a station's best reason to contract with you is so you can improve its operation. Point out how appropriate preventive maintenance and proper implementation of equipment can make the station sound better and operate more reliably.

Recommendation or referral

Many contract engineers' clients come through good referrals. If you do good work, word will get around. If you treat your clients poorly, word will spread like wildfire. The point is that your best long-term advertising comes from the work you do.

Be vigilant to ensure that the quality and character of your efforts speak well of you. Every project or repair you perform bears your signature. Always consider whether you would recommend your own work to someone else.

Anyone who has worked in radio for very long has discovered that it's a fairly small industry. Quite likely, you'll work for the same people several times, perhaps even in different markets. There's not much room for bridge burning and sour grapes if contract engineering is your long-term career path.

Other good sources of referrals are equipment dealers and manufacturers. If these vendors know that you can be trusted to properly advise their customers and professionally install their equipment, they'll be willing to recommend your services. Take time to visit equipment dealers and establish a face-to-face relationship.

It's also advisable to be connected with one or more FCC consulting engineers and programming consultants. If you demonstrate to these people that you know what you're doing, they can feel comfortable in referring their clients to you when appropriate.

Business image

Collateral items, such as business cards, brochures, letterhead and envelopes, help to present a professional image for your company. It helps to have these items coordinated. This is easily accomplished with pre-printed paper items from such outlets as Paper Direct, Quill or Beaver Prints. These pre-printed "business sets" look great when personalized with your company's own laser-printed information.

> Advertising and client relations are vital to the continued success of your firm.

Whatever the stage of growth or success of your contract engineering business, advertising and client relations are vital to the continued success of your firm. Let potential clients know about you and how you can help them. Keep your existing clients informed as to your experience and capabilities. A combination of the aforementioned techniques can result in an effective, ongoing promotional campaign.

There's no shortage of work available in contract engineering these days. Even a modest effort will result in new business or expanded relations with existing clients. As the saying goes, doing business without promoting yourself is like winking in the dark: You know what you're doing, but nobody else does.

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Managing Technology:

Revised RFR rules languish

By William F. Hammett, P.E.

What is the status of long-anticipated FCC action on new RF exposure standards? In a word, *stalled.* And, at press time, there are no immediate prospects for action.

In case this subject hasn't kept you on the edge of your seat for the last few years, here's some background to bring you up to date. First, the cast of characters:

The American National Standards Institute (ANSI) is a volunteer, non-governmental organization with members from industry and academia that sets safety standards for all sorts of items, from eyeglasses and helmets to buildings. ANSI standard C95.1 covers exposure to RF energy. Its latest revision was published in 1992, but its immediate predecessor, C95.1-1982, is the current FCC standard. ANSI is widely recognized for setting reasonable standards, and many jurisdictions specify ANSI standards, thus elevating these private-industry standards to the level of government regulations.

The government agency with expert authority to set standards limiting exposure to RF energy (and other environmental factors) is the Environmental Protection Agency (EPA). At one time, the EPA was actively considering the establishment of its own RF exposure standard. But EPA management subsequently considered other matters to be of greater concern, and the agency never set any RF exposure guidelines. In fact, by 1988, the EPA Office of Radiation Protection was closed and its files transferred to the Office of Radiation and Indoor Air.

This meant that the FCC either had to declare that *it* had expert authority or else had to rely on some other body's work. So, in 1985, the FCC adopted the 1982 ANSI RF exposure standard, and the standard applied to all FCC licensees as of Jan. 1, 1986.

Current problems

In its 1985 Report and Order (R&O) to General Docket 79-144, the FCC specifically referenced ANSI C95.1-1982. Unfortunately, this means that, although the 1982 standard has since been superseded by the 1992 version, the FCC is still requiring licensees to comply with the (1982) document. In most instances, this is not burdensome to broadcasters because the 1992 standard is generally the same as or tighter than the 1982 standard. At AM broadcast frequencies, though, the 1992 standard is actually relaxed in some respects, making compliance with the earlier version unnecessarily difficult.

But the biggest problem today is one of false security. Stations should avoid thinking that because they meet FCC requirements they are protected in any litigation that might be served. Here's why:

- Your station is an intentional emitter of RF energy.
- There is a new ANSI standard for RF energy.
- It's the one that is most widely recognized.
- It has new, tighter provisions than the old one the FCC uses.
- It adopts first-time limits for induced body currents.
- It adopts first-time limits for contact body currents.
- A claim against your station will likely be evaluated against the current standard.

> FCC license renewal is not a guarantee that your station is compliant with ANSI guidelines.

Especially note that FCC license renewal is not a guarantee that your station is compliant with pertinent ANSI guidelines. Although the FCC is looking harder at broadcast applications, especially FM applications, this review is not necessarily as thorough as one that would be conducted in the event of a worker's compensation complaint, a lawsuit or even a critical review by an engineer representing "Citizens Against Everything." In addition, broadcasters are open to scrutiny by the Occupational Safety and Health Administration (OSHA), as well as other agencies, organizations and local jurisdictions that have already adopted the 1992 ANSI standard.

How does this affect broadcasters?

At present, the fact that the FCC hasn't yet adopted the 1992 ANSI standard hasn't really affected most broadcasters. In the long-term, however, it could have considerable impact if broadcasters don't ensure their own compliance with the most recent standard that sets limits for human exposure to RF radiation.

The FCC could be of considerable help to broadcasters if it adopted the 1992 ANSI standard with certain clarifications on what showings it expected. For instance, the 1992 standard requires measurement of RF current flowing through a human body (induced currents) at all low-band VHF sites and at all sites with FM stations operating on 99.9MHz and below. The FCC could, as an authorizing agency with

Bill Hammett is senior consulting engineer at Hammett & Edison, Inc., Consulting Engineers, San Francisco.

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some expertise, identify certain conditions under which a broadcaster could presume that body currents would not exceed the guidelines, thus avoiding the need for measurements at every affected site.

The FCC also could help broadcasters with regard to contact currents, by specifying conditions under which contact currents from >30MHz RF emitters need not be measured. Based on a lack of consensus in the committee that developed the 1992 ANSI standard, it does not appear likely that there will be any fraction of the *maximum permissible exposure* (MPE) for <30MHz stations (i.e., short-wave and AM broadcast) for which the necessity to separately measure for contact currents can be categorically avoided.

What's holding it up?

In 1993, when the FCC began its proposed adoption of the 1992 ANSI guidelines, a Notice of Proposed Rulemaking (NPR), ET Docket 93-62, was issued. Comments were requested on numerous issues, and the industry responded willingly. As a result, there were an unprecedented three extensions of the comment deadline, and two extensions of the reply comment deadline, which finally closed on April 25, 1994. Because the record in this docket now exceeds 5,000 pages of comments, it has taken many months for the FCC staff to work through the material. More important, though, was the fact that the EPA also responded with several of its own concerns about a literal adoption of the 1992 ANSI standard.

These comments made it clear that there were still major unresolved technical issues concerning the practical implementation of the 1992 ANSI standard. The commission, therefore, decided that it needed to fund a study to answer several troubling technical matters.

FCC-funded study

In late 1994, the FCC awarded a contract to study currently available instrumentation for measuring induced body currents, contact currents and the effectiveness of RF protective clothing (suits). A report has now been issued, and the information contained in that study should allow the FCC's Office of Engineering and Technology (OET) to issue, at long last, a Report and Order to ET Docket 93-62.

The study found that: 1) reliable induced-current meters did not yet exist; 2) existing contact-current meters worked reasonably well, but they are only calibrated for frequencies up to 30MHz (not the 100MHz limit in ANSI 1992); and 3) RFR protective cloth, made in Germany under the trade name *Naptex*, appears quite effective at VHF, FM and UHF broadcast frequencies, as well as at microwave frequencies.

Expectations

Predicting FCC or EPA actions – or even just their timing – is a crap shoot using politically loaded dice. This consultant's guess is that the EPA will eventually acquiesce and endorse C95.1-1992, and that the FCC will adopt that 1992 standard as its new set of guidelines. But it will likely add provisions that temporarily stay the enforcement of the controversial and difficult to measure induced current and contact current portions of the ANSI standard (pending the availability of instrumentation capable of reliable and repeatable measurement of those parameters).

A late-1995 release of a Report and Order still seems possible.

Folded unipoles, part 2

By John Battison, P.E.

In the last issue, this column covered the basics of folded unipole design. This time, the installation of the folded unipole will be covered.

The first thing to do before deciding to install a folded unipole at your station is to measure the base operating impedance to be sure that you are developing full power. Next, do a short field-strength study. Draw four radials at 90° intervals about 10 miles long. Run a partial proof of about 10 readings on each radial. Make a check of the antenna efficiency and field at 1km before any antenna work is done. Record this information and decide if the existing antenna system should be replaced.

> In most cases, the folded unipole should produce a noticeable improvement.

The class of your station will determine what radiation the commission requires and what your antenna was originally designed to meet. This data will be found in CFR 47, Part 73.189(B)(i-iii).

If the decision is made to change to a folded unipole, don't let the station's management get its hopes up by anticipating an amazing change in signal strength and coverage. Of course, there should be a noticeable improvement, but don't promise the moon. A station in Alaska at 640kHz with a 214-foot tower reported a 7dB improvement using a 3-drop-wire folded unipole and additional top-loading (in the form of guy loading), but this may be an exceptional case.

Basic procedures

Once you've decided to install a folded unipole, be sure that *all* the necessary parts are present at the antenna site before starting the job. It would be embarrassing to run with reduced power all day, short the base insulator and then find the job can't be finished in the time allowed.

> Be sure that all the necessary parts are present at the antenna site before starting the job.

If your tower will support them and its face is not too small, and you have the time and money, plan on using *six* drop wires spaced about 12 inches from the tower. This should give you wider bandwidth. But if you are in a heavy ice area, using three drop wires might be less risky.

The drop wires should be suspended from angle-iron bars secured to the top cross members of the tower. Where the bars intersect at the tower's corners, it will be necessary to trim their ends to allow a flush fit. The arms should be bolted together where they intersect, as well as to the top tower members near the corners. It is essential that excellent physical connections are made and maintained. It is also important to use angle-iron instead of flat-iron bars to avoid sagging arms.

The drop wires must be bonded to the tower arms and then spaced away from the tower legs by means of insulators. A turnbuckle and spring should be used at the bottom of each drop wire, and secured through an insulator to maintain tight wires that won't swing in the breeze and change the tower impedance. A set of iron arms is mounted at the tower base to anchor the turnbuckles.

Getting it done

At this point, consider the logistics of doing the job. If yours is a low-power station, say 500W or less, it may be possible to do part of the job without reducing power. If you have more power and can't find any hardy souls to climb in a higher RF field, you will have to reduce power to a reasonable level for the initial part of the installation. This portion can usually be done without shutting down completely. After the top arms are attached to the tower, the drop wires must be installed and secured in the standoff insulators and to the turnbuckles. It is important that the drop wires do not touch the tower while being installed.

The rest of the installation must be performed with the power off. After shutting down, a circular wire connecting the bottoms of the drop wires must be run around them and securely connected to each. This is the point at which drive is applied. The RF drive link should be run from this connecting ring to the feed-through insulator at the ATU.

If you have a square tower-base mounting, connect 4-inch-wide copper straps from the tower base to the ground system bus across the base insulator. Otherwise, place one copper strap down each side of the tower base. All these connections must be hard soldered, or brazed. (Again, don't do this until power is *off*.)

Remove the existing RF line from the ATU to the tower. If tower lighting power is carried through the center of the RF line, it should be rerouted directly to the tower base and then up the tower as before, but with one difference – the conduit must be carefully bonded to the tower at 20-foot intervals. A good electrical connection is

John Battison, *BE Radio's* consultant on antennas and radiation, owns John H. Battison and Associates, a consulting engineering company in Loudonville, near Columbus, OH.

DIGITAL AUDIO

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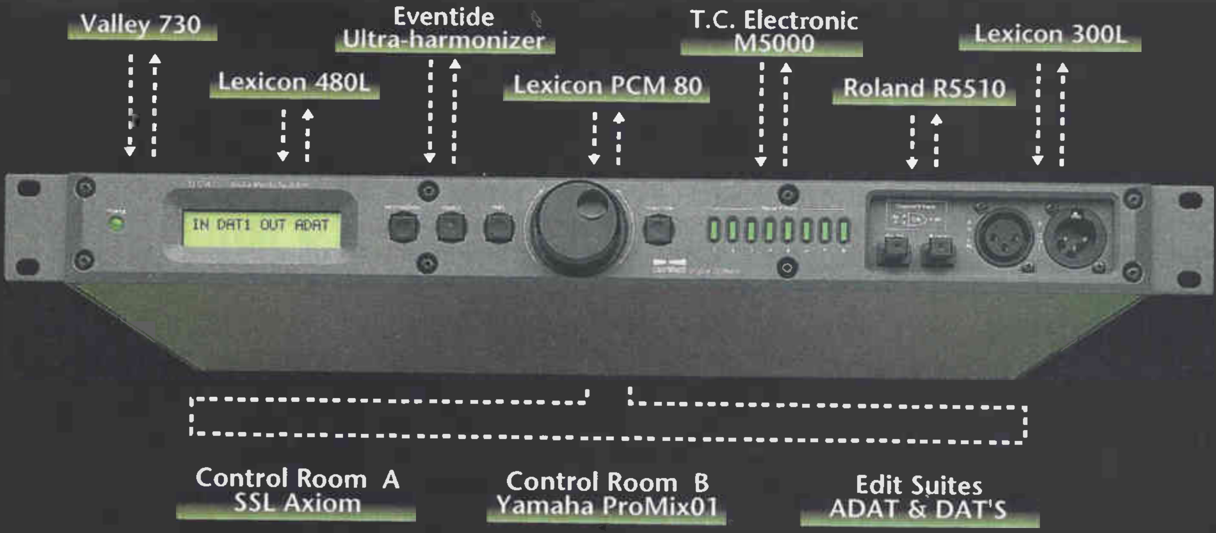

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essential.

Any wires or lines connected to the tower also must be carefully bonded to it. Remove lighting transformers and lighting chokes or static drain coils. The neutral wire of the tower and any other lighting circuit must be grounded to the tower at the base and at 20-foot intervals up the tower. All coaxial cables used for FM or auxiliary antennas must also be grounded securely to the tower. (These wires either must be bonded to the tower or encased in a metal conduit so that they cannot affect the tower's tuning by the induction of out-of-phase RF in them. If this is not done, some strange effects may be encountered.)

Here is a basic parts list:

- Angle iron to hold drop wires;
- Enough 4-inch copper strap to ground tower across base sides;
- Stranded copper or aluminum wire, 1/8-inch diameter (for drop wires, plus 30 feet);
- Suitable strain-type insulators to secure bottom ends of wire;
- Standoff insulators, number depends on tower height;
- One spring for each dropwire, about four inches long;
- One turnbuckle for each drop wire;
- Selection of bolts, nuts and assorted hardware;
- Wire clamps (one per drop wire);
- Tower leg wire clamps (one per drop wire).

To avoid any noise generated by poor connections, bypass the spring and turnbuckle at the lower end of each drop wire. Install a length of drop wire across each group to the bottom insulator. This can actually be a continuation of the drop wire after it has been hooked to the spring.

Fabricate a shorting stub for each drop wire. Secure a wire clamp to one end of a piece of drop wire long enough to reach from the tower to the nearest drop wire. At the other end, fasten a clamp to attach the wire to the tower.

Attach a length of drop wire to the circular ring wire that goes around the base of the drop wires. Fasten the other end to the feed-through insulator at the ATU. Leave the inside end unconnected.

Once all this has been completed, the site should be cleaned up and all connections rechecked for cleanness and continuity. Turn on tower lights and check operation of other antennas on the tower. If everything is OK, proceed to tune the antenna.

Tuning and adjustment

For the record, measure the base impedance at the feed-through insulator inside the ATU (ATU connection). Use low-power transmitter output. Leave the operating bridge in circuit and record the impedance. Sometimes this impedance is satisfactory, but more often than not, tuning will be required. Be careful to record all data as it is measured.

Select a point about a quarter of the distance down from the top of the tower. Clean the paint off the tower close to one of the drop wires. Clamp a piece of stub wire there and clamp the other end to the closest drop wire. Measure the base impedance. There should be a change – probably lower.

Move the stub about 10 feet higher and remeasure the base impedance. These two impedances should show you which way you need to go to obtain your desired base operating impedance. If you can't determine which way to go, continue making readings every 10 feet or less. There is nothing sacred about a 50Ω base resistance, but it makes matching the transmission line simpler.

When you have reached an acceptable impedance, install tuning stubs on the other drop wires at the same level.

> The folded unipole is not a wonderful gizmo that will make a poor operation into a first-class one.

When this is done, there is usually a small change in operating impedance. This may still be acceptable, or you may want to fine tune it by moving stubs until the desired value is reached. It is best to set the impedance to a positive *j* value at the desired base operating resistance.

Unless you are working with a tall tower, you probably will not encounter second resonance. However, if you should find a desirable base resistance with a negative *j* value, continue moving the stub down the tower and you should return to an inductive reactance and the desired resistance.

If you have a 50Ω-line and your base operating impedance is 50 $+j90\Omega$, you need only insert $-j90\Omega$ to cancel out the reactance. However, there is better control of the antenna tuning if an adjustable reactance, such as a variable coil and a capacitor in series is used, or an adjustable gas-filled or vacuum capacitor can be used if it is not too expensive. If necessary, a simple L network can be used for precise trimming if a high operating resistance is used. (I prefer to place the base current meter at the output of any ATU circuits and measure the current into the base impedance.)

When the new antenna system seems to be working properly, make another 4-radial "partial" proofs using the same measuring points as the original. You should observe a useful increase in radiation.

Note that the folded unipole is not a wonderful gizmo that will make a poor operation into a first-class one. Moreover, every antenna system is different, and in an article of this length, it is not possible to give precise directions for specified antenna electrical lengths and conditions. But in most cases, the folded unipole should produce a noticeable improvement, especially for stations with badly deteriorated ground systems.

For more information on folded unipoles, circle (102) on Reply Card.

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14 ❑ Station Manager
15 ❑ Production Manager
16 ❑ Program Manager
17 ❑ News Director
18 ❑ Other Operations Title

D. Other (please specify): ______

4 Which statement best describes your role in the purchase of equipment, components and accessories?

A ❑ Make final decision to buy specific makes, models, services or programs
B ❑ Specify or make recommendations on makes, models, services or programs
C ❑ Have no part in specifying or buying

5 Which of the following types of equipment will you be evaluating for purchase in the next 12 months? (Check ALL that apply.)

1. Audio Products
A ❑ Audio consoles
B ❑ Audio recorders/players
C ❑ Microphones
D ❑ Digital audio workstations

2. RF Products
E ❑ Transmitters/antenna systems/towers
F ❑ Test & measurement equipment
G ❑ Program transmission systems, STL/fiber
H ❑ Satellite equipment/services

3. Other Products
I ❑ Monitors
J ❑ ENG/EFP equipment
K ❑ Tape/optical storage
L ❑ Cases, consoles, cabinets, racks, wire, cable
M ❑ Automation equipment

4. ❑ None of the above

6 What is the budget for equipment you are evaluating for purchase in the next 12 months?

1 ❑ Less than $10,000
2 ❑ $10,000 - $24,999
3 ❑ $25,000 - $49,999
4 ❑ $50,000 - $99,999
5 ❑ $100,000 - $299,999
6 ❑ $300,000 - $499,999
7 ❑ $500,000 and up

7 If you checked A on question #2, what is the ADI rank of your market?

A ❑ Top 20
B ❑ 21 to 50
C ❑ 51 to 100
D ❑ Over 100

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FCC Update:

FCC standards for AM and FM upgrades

By Harry C. Martin

Following is a review of the FCC's current standards and procedural requirements for upgrading AM and FM stations.

AM upgrades

Change in facilities:

• Must meet interference standards set forth in Sections 73.37 and 73.182, as well as other limitations for the class and frequency applied for.
• Must provide 5mV/m or better daytime signal to entire principal community to be served and, at night, a 5mV/m or nighttime interference-free contour, whichever is greater, to 80% of the principal community.
• Increases in power or changes in frequency, hours of operation or community of license require a $2,590 filing fee. The filing fee for a site change is $650.
• A minimum increase in power of 20% is necessary if no site change is involved.

Change in community of license:

• The requirements with respect to interference protection and principal coverage must be met.
• If the station is the only one licensed to a community, the new community must have a population at least as large as the community of license; the relocated station should represent the new community's first transmission service. If the new community is located within the urbanized area of another large city, the proposal may not be credited with providing a first transmission service, a potentially fatal flaw.

AM expanded band:

• Applicant must have notified the FCC of its intentions and have received word of tentative acceptance and frequency assignment.

Pre-sunrise and post-sunset authorizations:

• Permits operations pre-sunrise and post-sunset with up to 500W, with only co-channel stations being considered the calculation of permissible power.
• Pre-sunrise authority allows commencement at 6:00 a.m. local time or, for stations within the protected nighttime contours of U.S. Class A station, at sunrise at the location of the nearest Class A station to the east.
• Post-sunset authority is permitted for up to two hours after sunset or, for stations operating within the nighttime protected contour of a U.S. Class A station, until sunset at the nearest Class A station to the west.
• The FCC will calculate permissible pre-sunrise or post-sunset parameters upon request.
• Daytime stations also may be granted limited-power nighttime authorizations upon informal application to the commission without regard to principal city coverage requirements.

FM changes

One-step upgrades:

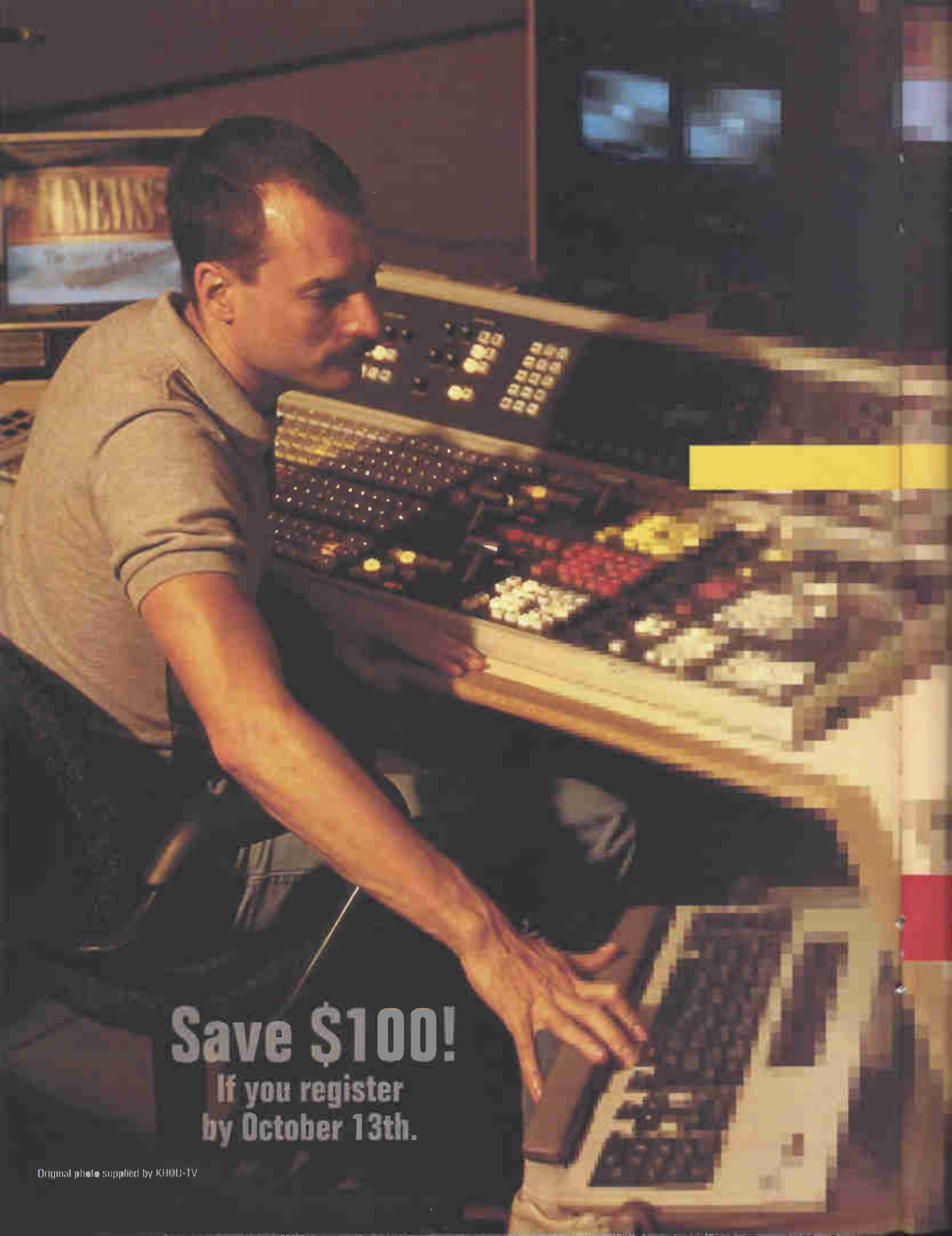
• Requires a filing fee of $650 to accompany the application for construction permit.
• Requires fully spaced transmitter site, although a contour protection showing will be accepted if it is shown that an alternate, fully spaced site is available.
• Must be done on authorized channel or a channel mutually exclusive with the authorized channel.
• One-step upgrade proposals are unacceptable in applications for new stations, except where the frequency is available on a first-come, first-served basis.
• The application achieves cutoff status vis-à-vis conflicting applications and rulemaking proposals as of the date of filing. A one-step upgrade application that is filed before the cutoff date established in a conflicting rulemaking will be considered a counterproposal in the rulemaking proceeding.
• Downgrading to a lower class or changing to a different channel of the same class is permissible if needed to accommodate a site selection incompatible with the applicant's authorized channel.

Rulemaking:

• Petitions for rulemaking are used to propose an allotment, upgrade to a non-adjacent channel, change community of license or accomplish an upgrade that involves changes in other allotments.
• As many as two additional involuntary changes in the table of allotments can be proposed in connection with an upgrade or new allotment proposal, but the FCC will not involuntarily impose a transmitter site move to accommodate a petitioner's allotment plan.
• Community of license changes are not acceptable if they propose the removal of a community's only radio station or if they propose a "move-in" to a metropolitan area.
• If acceptable, from a technical standpoint, rulemaking petitions become the subject of a Notice of Proposed Rule Making (NPRM) within three to five months after filing.
• The NPRM invites counterproposals, i.e., petitions proposing a mutually exclusive, conflicting allocation or allocation scheme. Comments on the original proposal also are invited in the NPRM. Claims of economic injury as a result of the new allotment are not entertained.
• If there are timely filed conflicting proposals, the FCC will decide the case according to criteria that favor the most efficient use of the frequency in terms of coverage of underserved populations or communities.
• A successful rulemaking petitioner must pay a $1,800 rulemaking fee with its application for the new facility.
• Once a requested allocation is made, a Form 301 or Form 302 must be filed. (Form 302 is used where no change in physical facilities is involved.) The filing fees for Form 301 and Form 302 are $650 and $135, respectively.

Dateline: By Dec. 1, radio stations in Alabama and Georgia must file their license renewal applications. Commercial stations in the following states must file their ownership reports on or before Dec. 1: Alabama, Georgia, Colorado, Minnesota, Montana, North Dakota, South Dakota, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

Harry Martin is an attorney with Fletcher, Heald & Hildreth, Rosslyn, VA.



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EAS Update

The network web of EAS

By Paul Montoya

Last issue, we reviewed some of the history of emergency broadcast alerting and how need and technology has caused the evolution into the new Emergency Alerting System (EAS). We will now break down the components of this system and explore how each part is important to the overall operation of this system.

The three key components to a well-functioning EAS in each state are:

1. Detailed coding of messages;
2. A network "web" structure to disseminate information; and
3. Detailed plans as to how the coding and "web" will work within the state and operational areas.

Let's explore how the network web functions.

Why a web is necessary

EBS always operated on a modified "daisy-chain" system. It was a modified system in the sense that an operational area could normally function with one station directly disseminating information to all or most of the stations within a market. This normally worked well but provided no redundancy. The problem that came into play was one in which we relied on a station to deliver a message from a central location (maybe the state capital) to a station on the other side of the state, which then disseminated the information to the stations monitoring its signal. Sometimes these relays required four or five stations in a chain to pass information to the alerted area.

In many states, terrain was often a problem, but more often it was a misinterpretation of what a station was to do with a message passed on to it. With one part of the chain broken and no redundancy, some real problems developed.

The web system answer

The web system addresses these problems on two fronts: It tries to get information to the station needing to broadcast the message as directly as possible, and it provides an alternate or redundant path should the first path fail.

Sometimes, getting the information to the broadcaster in the most direct form means bypassing the upstream broadcast station completely. A good example of this is NOAA Weather Radio. In most populated areas, stations can monitor NOAA Weather Radio directly at their stations on VHF.

Other examples are communities that use UHF repeater frequencies for police and emergency management, statewide satellite broadcast news distribution or broadcast frequency coordination/emergency alerting via RPU frequencies. Many of these already-in-place systems can be used to get information directly from the emergency manager, police dispatch 911 center or weather office to the broadcast station needing to put the information on the air.

This is not only more reliable, but much faster. No longer is there the need to wait for the relaying station to get to a commercial break to relay information. This can take the average message dissemination time from as much as six to nine minutes down to less than 30 seconds.

Other non-broadcast means of disseminating information are used in areas with terrain or physical-size obstacles. Large states like Texas or Alaska can now rely on satellite for information distribution. Many of these areas already have sports and news networks in place. States like Colorado, Utah or Montana that have terrain obstacles can now use microwave or satellite to get signals over their "hills." The FCC has not really put any restriction on how a state might distribute messages.

Redundancy in the web

A level of redundancy is also built into the web system. As an example, should the Weather Service generate an alert, it could go out via NOAA Weather Radio. It could simultaneously be placed on a broadcast RPU channel located on a high building or hilltop. It could also be placed on the statewide microwave system that the state police might use for record clearance. And remember, an upstream broadcast station may also rebroadcast the information.

What all of this means is that if all paths function well, stations could actually receive the message from many different sources. This improves system reliability greatly. Should any one path break down, other paths remain intact.

This will take a well laid-out plan within all states and local operational areas. The web can always grow, but remember to initially install equipment that will allow for monitoring as many sources as you may need, plus future expansion. In smaller communities, the system may require only two inputs, while in larger cities you may want to provide five or more sources.

Input considerations

Hardware configurations are also important in planning your system. Some manufacturers may provide "receivers" internal to the complete unit, while others may just provide audio or data input ports and leave it up to you or a third-party vendor to provide the receivers. The latter may be a better choice, anyway, because we never know what the future might hold for receive sources.

For example, John Hart of Lakewood, CO, has begun the "first public worldwide emergency communication center." He calls it E-COMM. The purpose of this center is to link amateur radio operators worldwide within the Internet. Even more creative distribution systems will likely evolve, and you should be prepared to accept their signals.

With all of this information coming in, how will a station sort this all out and decide what to put on the air? This is an exciting part of the new EAS, and much thought has gone into this coding of information. We'll cover it in the next issue.

Paul Montoya is president of Broadcast Services of Colorado, a contract engineering firm in Lakewood, CO.

COMING IN THE NEXT ISSUE . . .

COVER STORY: *Datacasting*

Today's radio broadcasters are transmitting more than just audio, and the market in this area may soon grow dramatically as new data broadcasting services are launched. The author will take a detailed look at new and proposed methods of data transmission that are delivered over radio stations' broadcast signals. The techniques will provide value-added services to listeners, and lucrative options to broadcasters.

The Signal Chain

The signature sound of a radio station is a combination of its format and its signal chain. The path between the console and the transmitter can make all the difference. Learn how new audio processors, STLs and exciters are improving the levels of control, efficiency and quality available to broadcasters.

Managing Technology: *Using Computers*

Managers can use computers in many ways to help them run a radio station.

Contract Engineering: *Handling Multiple Clients*

Contractors often have to juggle dozens of clients and treat all of their needs in a timely fashion.

RF Engineering: *Proof of Performance*

This measure of a station's quality is sometimes required and always worthwhile.

FCC Update:

EAS alert procedures and other regulatory news.

Plus *BE Radio's* usual roundup of product reviews, industry news, business happenings, new product announcements and more. All coming in the November/December issue of *BE Radio.*


TOM JOYNER
ABC RADIO NETWORKS

Future-proof production studios

By Margaret Bryant

Get out your graph paper, T-square and crystal ball...

Bottom Line: The tools and facilities for making radio are changing dramatically, but the process is not yet complete. Therefore, building new production studios that will remain current into even the near future is a steep challenge. It's not an insurmountable problem, though. With careful planning and a bit of educated guesswork, today's studios can be designed to accommodate practically anything the future has in store.

Recently, while giving a tour of our new facility, I was asked why we still had a room with an 8-track reel-to-reel machine when we had other rooms with digital audio workstations. The answer to that question perfectly illustrates some of the difficulties in transitioning from an analog to a digital world. Whether it is because the station can't afford new digital studios all at once, the existing analog equipment is not yet fully depreciated, or some other reason, stations are having to design new studios incorporating existing analog equipment and planning for future digital equipment. What problems can you anticipate in designing such studios and how do you plan for a future that, theoretically, has no limits?

Equipment considerations

Start planning by drawing up a list of the equipment in the new studio. Presumably, all or most of the items will be analog devices. Some may be existing and some may be new. Describe the function of each item. This will become important later in determining replacement digital devices and configuring the equipment in the room. In the functional description, list not only what the device does, but the frequency of its use and any ergonomic or environmental considerations. Also consider the possibility that the production room will be used as a backup air studio. This will affect the design of the room. Note which devices are existing and which need to be purchased. This helps in: 1) drawing up a purchasing plan, and 2) organizing the move into the studio. Get an overview of the general function of the room. Decide if this functionality is likely to change, and if so, how it will change. Once there is enough information on the expectations of the room and its likely initial configuration, it's time to gather information on potential future changes.

Phasing out analog

The next step in planning for the new studio is to decide what types of analog devices you will be replacing either now or at some future date. Once these analog devices are identified, some thought, and perhaps some guesses, will be made as to what digital devices will be employed in their place. You don't need a crystal ball to see the trends in digital equipment. With a little investigation, realistic planning can take place.

One of the trends is that manufacturers are recognizing that their new digital devices will be directly replacing old analog devices. As a result, the size, shape and function of many new digital products are similar to those of the analog devices they are replacing. If you are replacing the ubiquitous cart machine with a CD player, there are CD players that will fit in the same slot. Or if you replace that same cart machine with some sort of recordable digital storage, there are devices that fit that bill. If you are replacing a reel-to-reel tape machine with a digital audio workstation, there are workstations that roll right into the space formerly occupied by the reel machine. Dozens of digital product manufacturers have devices that are almost exact replacements for analog devices. This dramatically simplifies anticipating the digital future.

Unfortunately, it's not always that easy. Many digital devices require the use of computer CPUs, keyboards, CRT monitors and/or touchscreens. Planning a room and the furniture for these types of devices requires more effort. These replacement technologies have many special requirements. Placement of the computer system parts depends partly on the existing pieces of equipment in the room. The first question involves the audio console. Will you use one during the analog phase of the studio and will you be keeping it during the digital phase? Chances are pretty good that there will be a console or mixer of some type in the analog and digital phases. Even if a new console is installed to handle all digital signals, the mixing function still exists. It is a rather large piece of equipment and will become a bit of a nuisance to plan around.

Installing computer-based equipment

Assume there will be at least one digital device that runs on a computer. Planning a location in the furniture for the CPU is the easy part. When planning the CPU location, make sure you consider the necessary wire runs, limits on wire length, sufficient air circulation and cooling, and mechanical and electrical noise that might be generated. Design a place in the furniture that fits the criteria. While you are at it, design two or more areas, because there is always the possibility of additional devices. (See Figure 1.)

Now on to the harder parts. Does the computer need a keyboard? If it is rarely used, say only for rebooting, you may want to just stick it on top of the CPU unit that is hidden away in some cabinet in the studio furniture. It's out of the way and hopefully is easily accessible. If the keyboard is used regularly, you need to find a location that makes sense. The keyboard should be in front of the user at a height that is comfortable for long-term use. (See "Ergonomics for Desktop Systems," *BE* February 1994). Also, the keyboard should be in front of the CRT monitor.

This is usually where the audio console gets in the way. The CPU was easy; there were many locations in the furniture to select from. So, how do you combine a working keyboard, a monitor and an audio console? Before determining a location for the keyboard and monitor, some thought needs to be given on how the keyboard and monitor will be used in relation to the audio console. If the computer is used in conjunction with the audio console, the monitor/keyboard location needs to be in close proximity to the console without getting in the way of console functions. If the computer is used independently of the console, or if certain computer functions are remoted to the console, then the computer can be placed some distance from the console and the problems of monitor/keyboard location are greatly simplified.

In some situations, the monitor/keyboard combination needs to be near the audio console. Before deciding if the monitor is to the left, right or behind the console, consider that the keyboard and monitor should be close to each other. The user should be able to use the keyboard while looking straight ahead at the monitor, not off to the side. The keyboard can be in a drawer so it is out of the way when not in use and the drawer could also be used to lower the keyboard to the correct working height. Do not forget the standard-sized computer keyboard is wider than a 19-inch rack space, so you will need either a custom drawer or a smaller keyboard.

Ideally, the monitor screen is of sufficient size and in a location that makes information on it easy to view from the user's normal operating position in the studio. Determine the likely size of the screen of the monitor. These days, even the small-screen monitors are physically large and the large-screen monitors are not only expensive, but are absolutely enormous! Plan not only for easy viewing but also for easy repair. Design the location so some variation in monitor size is allowed in case an exact replacement is unavailable in the future. Take into consideration proper ventilation and any electrical noise problems. If speakers are in close prox-

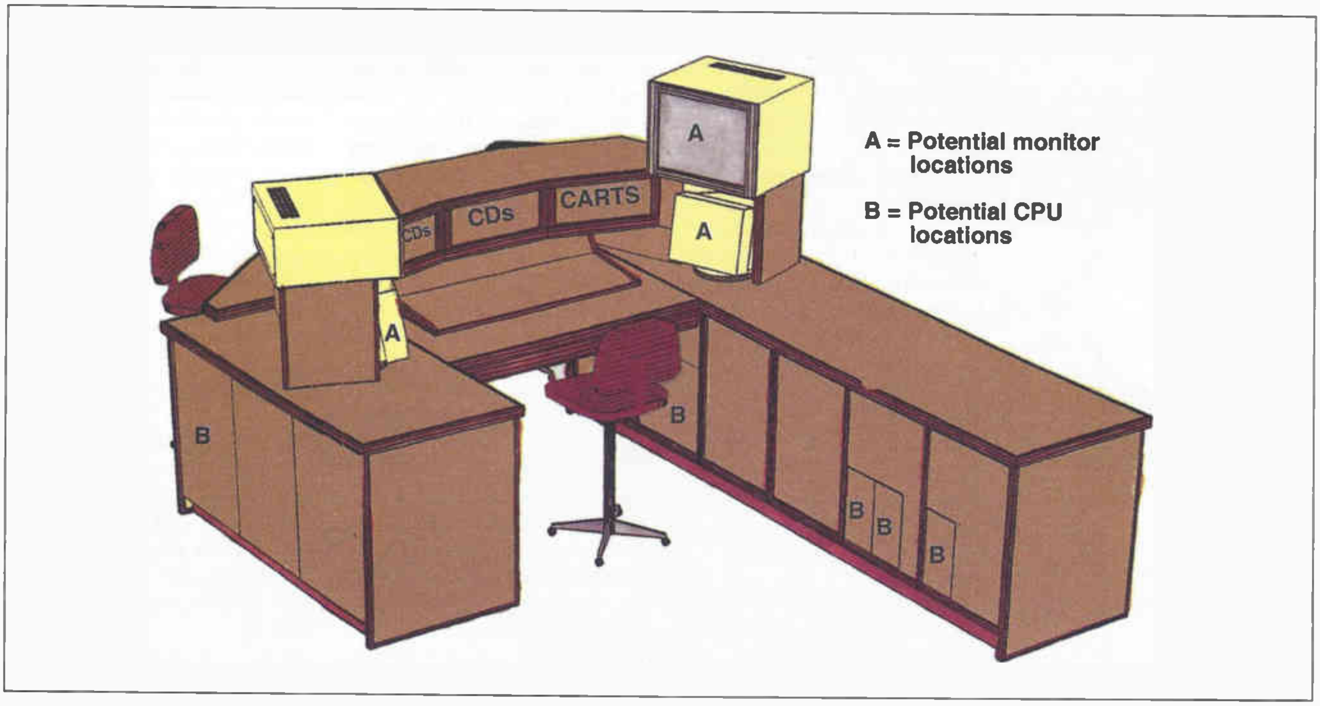

Figure 1. Layout and cabinetry for the analog/digital hybrid air studio. Airflow, noise and operator's reach must be considered for all CPUs and monitors (some of the latter may be touchscreens).

imity, the speakers need to be shielded. If you time the trip into the digital age correctly, flat-screen monitors may be at the point where they are affordable. The front cross-sectional area may be the same, but the depth will be dramatically reduced. Thus, there may be more choices for where to place the monitor.

If the monitor is being used as a touchscreen, the need for a nearby keyboard has been eliminated, but an additional requirement is created for the monitor; the monitor screen must be close enough to touch. This severely limits the possible locations for a monitor. Most studios locate them to the left or right of the user. Neither location is ideal because the user could be right-handed with a screen placed to the user's left and vice versa. Placing the monitor in front of the user is often difficult because the audio console is in the way. Some furniture is designed with the idea that the overbridge over the console will be removed in the future and will be replaced with a cabinet piece to house a monitor. Although it is convenient to view, touching it can be a reach. It also may get in the way of the copy stand or the jock's view of other people in the room.

Pay attention to the ergonomics of the room. If the equipment is not easy to use, the jocks won't use it! In some rooms, the ideal might be to place the touchscreen monitor ona movable arm. The arm can be added at any future date, so no intense planning is required, and it can be adjusted to suit the user.

Preplanning the production studio design

Furniture ideas can come from a number of sources. Many of the established

Continued on page 33

Fast-track facility construction

By Margaret Bryant

Everybody wants a studio built in a hurry. It is possible and can be done well if certain important ideas are kept in mind. First and foremost, you buy time with money. If the project is pushed to fit a short time frame, it will cost more money to build. No one likes to hear this, but it is a fact you can count on.

The second question deals with risk. Murphy doesn't strike more often with a project that is fast tracked, but the systems aren't usually in place to deal with problems promptly and effectively. So, the decision must be made to accept the risk and keep to the short timetable or put in time to prepare effectively for the anticipated problems. Everyone says they'll take the risk until the unexpected happens, which usually means lost air time. If you are not willing to risk losing air time, then give more time for the project.

Never stop planning

Plan as much of the project in advance as possible. Whatever time is available, put it to good use. Continue to plan during the execution. The more you and your staff know about the project and the more contingency planning is done, the better prepared you are to deal with the problems that arise. Know where every piece of equipment goes and where every wire goes. Plan the design, the installation, the documentation, the testing and the move. There is no such thing as too much planning.

Manage your manpower carefully

Have vendors turnkey as much of the project as you can afford. Make sure you select vendors who have a track record for getting the job done in the required amount of time. Many vendors can do an excellent job, but may not deliver in the required time frame. If there is money to turnkey only part of the project, choose the part of the project that is the most complicated. Then hire local contract help to execute the remaining part of the project. Don't expect your staff (if you have one) to devote all their time to the new construction unless you don't care about maintaining the existing facility. Their time, and yours, must be split between the existing studios and the new studios. The better way is to hire local contract help to concentrate on the project. If the project is large and you are not up to the task, or you do not have the time for project management, hire someone locally to manage the project. This may seem to be wasted money, but it is important to have someone who has a grasp of the big picture and can keep the project moving.

While we are talking about staff, remember they are people who have limits. Everyone needs sleep and some time off. No matter how much the project is pressed for time, it is vital to have the staff get adequate sleep. If they are too tired, mistakes get made. Some may be unrecoverable. If necessary, rotate the shifts so the work gets done and the crew gets rest. If it is possible to throw in an afternoon off, all the better. Don't stretch the staff to their limits; the cost of the time saved may be too high.

Have the people on your team specialize. There is time later for everyone to learn the various systems. During the project, far more is accomplished when one person does wiring for the studio, another does wiring for the rack room, another installs equipment and another does final testing. All answer to you or the project coordinator, who is keeping track of how the project is progressing.

Documentation is vital

There may not be time for some things, but documentation should not one of them. Don't skimp on documentation. It is too important to be left out or done in a slipshod manner. Create a standard by which all wiring will be done. See that the staff follows this standard. Create a standard for all numbering and labeling. Last, have a standard form to keep record of the wire runs and see that all of the staff use it properly. Do it right the first time. It is time consuming to go back later and do correct documentation, and more than likely, it will never get done.

Plan the move down to each detail

Choreograph the move and plan the order of tasks that need to be done. Assign tasks to the various members of the crew. For example, a move from an old studio to a new studio might go like this:

- The new wiring and equipment are tested in advance of the move.
- Prepare a checklist for the move.
- Have someone be responsible for the RF change (if there is one).
- Have someone remove the old equipment and move it to the new location.
- While this is happening, have someone else double-check preparations in the new studio.
- The crew that removed the old equipment can reinstall it in the new studio.
- Have someone start a final check of the studio. The check should include the phone, clocks, headphones, air monitors, air lights, levels and all the equipment in the studio.

The most difficult part of a fast-track construction project is keeping the existing facility running well. The last thing the disc jockeys want to hear is how the engineers are working on getting the new studios built and don't have time to fix the broken equipment in the existing studios. Be prepared and find time to maintain the old studios. If you don't, it is guaranteed that the air staff will remember the hell they went through long after the pleasure of the new studio has worn off.

Producing on-line audio

By Dave Harris

A new use for audio on the Internet has developed with the explosive growth of the World Wide Web (WWW). Audio on the net no longer refers to a file that is available for someone to download from some remote computer for some unrelated later use.

On-line audio can now have context. It can be associated with something else: a graphic image, a complex concept that benefits from an aural explanation or the promotion of an audio CD. New uses are being thought of every day. These new uses bring a different set of production challenges.

The use of audio as part of a multiple media experience is made possible by the basic design of the World Wide Web and programs called *browsers*, which are used to search and display the Web content. There are text-only browsers and browsers that display different graphics and sound formats.

The bulk of the graphical browsers in the world are accessing the Web over 14.4kb/s modems. The audio formats, production tools and techniques discussed here are geared to this level of delivery. On a typical 14.4kb/s modem, experience has shown that data throughput ranges from 900-1,300 bytes/sec, usually around 1,100 bytes/sec. (Some phone lines accessing some service providers may yield other rates.)

Coping with narrow bandwidth

This data pipeline limitation defines much of the audio used on the WWW today. In order for audio to be at least minimally convenient on the Web, smaller file size needs to be maintained.

At the CD level of audio quality, 16 bits are used to describe the voltage of each audio sample and 44,100 samples are saved every second. This hogs approximately 5MB of storage space for every track-minute of audio (double for stereo and so on).

The storage "hit" or download time of digital audio is minimized by the reduction of the number of bits used to represent the analog voltage of the audio sample, the reduction of the number of samples taken per second, the use ofdata compression of some type or all three.

File formats

The most popular formats used in on-line audio fall into two categories:

1. Files that need to be downloaded first and;
2. Files that will "stream" (play immediately after being clicked on) through a 14.4kb/s modem connection.

The .au, AIFF and most of the MPEG formats need to be downloaded first then played using "player" software, such as *SoundMachine* and *MPEG CD*. The audio here varies widely from the lo-fi .au to the high-quality AIFF and MPEG. The higher the quality, the larger the memory and transmission requirements are.

RealAudio is a new format for use on Web pages. It is designed to allow the audio to "stream" to your desktop without downloading first. The immediacy provided by ".ra" files is particularly appealing when using audio on the Web. The RealAudio player and encoder are available from the Progressive Networks Web site listed at the end of this article.

Another similar system is *Streamworks* from Xing Technology. Unlike RealAudio, which is currently limited to on-demand playback, Streamworks can provide real-time, continuous programming, and it supports high-speed (ISDN) interconnections. (RealAudio expects to support similar services soon.)

All of the encoding software for the above formats have some capability to take audio files that have various "bit depths" (or resolution levels) and sampling rates, and convert them to some target format. You might take a .wav file that was recorded with 16 bits and sampled at 22,050 samples per second, and using a single application, convert it to a .au (pronounced "dot-a-u") file, which is 8 bits at 8,000 samples per second using µlaw compression (European telephony standard).

Many trade-offs are made in these conversions. The sample rate and bit depth can be converted by the encoding software or as part of the production process prior to encoding. I prefer to do the conversions before encoding, using higher-quality filtering and conversion utilities than those found in the all-in-one encode programs. In this way, the dynamics and character of each audio production can be considered separately. The encoder only needs to do the data compression.

To achieve the best sample rate conversion, high-quality pre-filtering should be used (done in the digital domain if possible) to minimize any aliasing arising from out-of-band (higher than the Nyquist frequency) audio energy. This filtering will tailor the bandwidth to fit the target sample rate. That is, the highest frequency in the audio file should be one-half the final sampling frequency. If your final product will use an 8k sample rate, then the audio should cut off at 4kHz.

Although it is a good idea to keep full-frequency originals of your raw audio, this bandlimiting should be done early in the production so that your editing and mixing decisions are based on the sound of the final product.

Now, what about those bits? Many think that if their end product is going to be 8 bits, it might as well be recorded at 8 bits in the first place. This assumption probably contributes the most to poor-quality on-line sound. The bit conversion should be the *last* step in the production.

Production tips

All manipulations of the audio in the digital domain (editing, level changes, equalization, mixing, etc.) produce changes in the audio, which require more bits to describe than were used in the original file. The extra bits, which high-quality production software adds during processing, are later taken away in order to restore the file format.

The errors in the reconstruction process manifest themselves as noise and are additive throughout a production. It is for this reason that the resolution of the audio in bits should be kept as high as possible (usually 16 bit) during production processing and converted to 8 bit only after all production is completed.

Another thing to keep in mind about 8-bit audio is that low-level sounds, which are easily represented in 16 bits, often cut completely off in an 8-bit word, causing the signal to drop to zero. In other portions of a file, where the audio is low, but not low enough to cut to silence, the shortage of available bits causes the sound to jump up and down between voltage steps, which are much wider than the actual variation in the original audio.

These distortions cannot be eliminated, but they can be minimized by retaining the highest possible audio level through the conversion from 16 bit to 8 bit. One well-known application for bit-depth conversion (or *normalization*) is *L1* from Waves (also available in the *Waveconvert* package). It includes a look-ahead limiter to maximize the signal level during conversion and noise shaping to minimize apparent noise.

Further information on audio formats can be found on the World Wide Web at http://www.cis.ohio-state.edu/hypertext/faq/usenet/audio-fmts/top.html. Progressive Networks information is located at http://www.realaudio.com/. Xing Technologies is at http://www.xingtech.com. Production tools for Macintosh can be found on the DAW-Mac Homepage at http://www.bakalite.com/Daw-Mac.html.

Dave Harris is president of Harris Consulting, Woodacre, CA.

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2 Please check the ONE type of facility or operation that best describes your primary business classification:

A ❑ Radio Station & Network (including education, government and religious)
C ❑ Recording Studio (including education, government, religious, production and research)
D ❑ Consultant
E ❑ Contract Engineer (including maintenance, technical support)
G ❑ Dealer or Distributor
F ❑ Other (please specify): ____________

3 Which of the following best describes your title? (Please check only ONE box.)

A. Company Management:
01 ❑ Chairman of the Board
02 ❑ President
03 ❑ Owner
04 ❑ Partner
05 ❑ Director
06 ❑ Vice President
07 ❑ General Manager
08 ❑ Other Corporate/Financial Official (including corporate sales)

B. Technical Management & Engineering:
19 ❑ Vice President Engineering
09 ❑ Technical Director/Manager
10 ❑ Chief Engineer
11 ❑ Other Engineering or Technical Title

C. Operations & Station Management/ Production & Programming:
12 ❑ Vice President Operations
13 ❑ Operations Manager/Director
14 ❑ Station Manager
15 ❑ Production Manager
16 ❑ Program Manager
17 ❑ News Director
18 ❑ Other Operations Title

O. Other (please specify): ____________

4 Which statement best describes your role in the purchase of equipment, components and accessories?

A ❑ Make final decision to buy specific makes, models, services or programs
B ❑ Specify or make recommendations on makes, models, services or programs
C ❑ Have no part in specifying or buying

5 Which of the following types of equipment will you be evaluating for purchase in the next 12 months? (Check ALL that apply.)

1. Audio Products
A ❑ Audio consoles
B ❑ Audio recorders/players
C ❑ Microphones
D ❑ Digital audio workstations

2. RF Products
E ❑ Transmitters/antenna systems/towers
F ❑ Test & measurement equipment
G ❑ Program transmission systems, STL/fiber
H ❑ Satellite equipment/services

3. Other Products
I ❑ Monitors
J ❑ ENG/EFP equipment
K ❑ Tape/optical storage
L ❑ Cases, consoles, cabinets, racks, wire, cable
M ❑ Automation equipment

4. ❑ **None of the above**

6 What is the budget for equipment you are evaluating for purchase in the next 12 months?

1 ❑ Less than $10,000
2 ❑ $10,000 - $24,999
3 ❑ $25,000 - $49,999
4 ❑ $50,000 - $99,999
5 ❑ $100,000 - $299,999
6 ❑ $300,000 - $499,999
7 ❑ $500,000 and up

7 If you checked A on question #2, what is the ADI rank of your market?

A ❑ Top 20
B ❑ 21 to 50
C ❑ 51 to 100
D ❑ Over 100

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broadcast furniture designer/builders are familiar with the problems of designing for current analog and future digital. They can be a valuable resource. Furniture constructed for multimedia use can also provide some good ideas. While large audio consoles aren't usually in the furniture, there may be some ideas regarding keyboard and monitor placement that might be worth using. Again, the furniture/equipment layout needs to be easy to operate and equipment needs to be arranged in a logical fashion. It is likely the digital replacements can do more than their analog predecessors. Keep this in mind during the design phase. Pay attention to reach distances, sight lines and counter space.

One of 13 broadcast studios in the new ABC Radio Network's headquarters in Dallas. Each studio occupies about 225 square feet, and includes a variety of digital and analog equipment. Flexible planning also allows easy future updates.

Jocks will still need to see clocks, timers, other jocks and copy. They need some elbow room, and the space needs to feel comfortable.

Armed with all this information, it is now time to put pencil to paper and do a rough sketch of the furniture. Start out with a drawing of how the studio will look in its analog form. Pay attention to all the ergonomic considerations. Refer to the earlier description of the function of the items in the room. Make sure the analog design meets as many of the functional requirements as possible. Then mark all the devices that are likely candidates for digital replacement. Decide what form the replacements are likely to take. If they will occupy the same location as their analog counterparts, you are home free. If the replacement involves devices larger than the originals, it is time to explore locations. Take the criteria listed previously and select multiple possible locations. During the selection process, get input from the disc jockeys. They will give insight to problems encountered by the user. This may also be the time to alter the original analog design to better fit the changes for the digital future. Don't be afraid to experiment with the design. The final product may be a compromise between the optimum analog studio and optimum digital studio, but a workable compromise is more cost-effective than starting all over with a digital studio.

Other issues

Some other items to consider in the design of the production room might be wiring and lighting. If wiring changes can be done easily, it may be better to wait and see what the future needs might be. Otherwise, at least a LAN cable or two should be run for future use. It is likely that the venture into the digital world might not only involve the production room, but the on-air studio as well. The two studios will need to be digitally interconnected. Also, remember that commercials are a likely candidate for digital storage and a LAN connection to the traffic department might also be in order.

With regard to lighting, flexibility is the key. In the digital studio, it is likely that CRT monitors will be in use. Glare can be difficult to control unless you have some flexibility in the lighting. Track lighting may be the easiest to install. Putting the lights on a dimmer or several dimmers gives even more control. Also, pay attention to any outside windows that might contribute to glare on the monitor screen.

Don't forget the role of vendors in the planning process. Most of the broadcast equipment vendors can supply valuable information about the equipment being considered for the studio. Perhaps they even know manufacturer's plans for future products. On the other hand, sometimes the broadcaster must educate the vendor. For example, the decision is made to go with a local cabinet maker rather than one of the large broadcast furniture builders. The local vendor will need to be educated on the need for attention to the interior spaces of the furniture. There are now new and different concerns regarding wire chases, routing of power cables, ventilation and noise control. If the overbridge is to be removed at a future date, the cabinet maker needs to design in easy removal. Work with vendors to get the most out of the planning process.

The human factor

The most important issue in changing over to digital is how easily the staff is going to adapt. Some jocks feel more comfortable with redundant systems that are analog. Some won't even touch digital devices, while others can't wait to use the new "toys." Because it is likely that commercial spots are candidates for digital storage, the jock has to be comfortable with the technology and the systems involved. If severe mistakes are made, it could result in lost revenue. The transition time should be planned. Ease in the new devices. In appropriate areas, plan to have analog and digital side by side, so the old system can be phased out and the new one phased in. The transition becomes more complicated but consideration is given to human nature's reluctance to change.

They know more about their job than you do and their input is needed. And when it is time for the change, train them in the use of the new equipment. The more the staff is trained, the more comfortable they are and the more time engineering can spend on other projects.

Margaret Bryant is the director of engineering and technical operations at ABC Radio Networks, Dallas.

Feature:

Using ISDN for remotes

Get ready for dial-up digital audio.

As ISDN becomes widely available, broadcasters have begun to use it in earnest. With appropriate equipment, ISDN allows near CD-quality audio backhaul at affordable rates. Soon, there will be no excuse for noisy, bandlimited remotes or news feeds.

By Theodric Young

Over the past few years, more broadcasters have been using switched digital telecommunications to get their audio from one place to another. Switched digital services have largely replaced satellite communications as a more economical method of point-to-point transmission of high-quality audio. For about the price of a phone call, you can send broadcast-quality audio back from the field.

Unlike satellite feeds, these connections are inherently bidirectional – you can send and receive audio at equally high fidelity on a single switched-digital circuit. This allows high-quality monitoring and program back-feeding at remotes, along with flexible audio transmissions between stations and networks. Bridges offered by telephone companies can allow point-to-multipoint distribution.

Switched-56

The first type of switched digital service available in the United States was Switched-56. This line provides a single, full-duplex, synchronous data channel between two locations on a dial-up basis that operates at a data rate of 56,000 bits per second (56kb/s). The two different types of Switched-56 lines include 2-wire and 4-wire. The type available to you will depend upon the type of central office switching equipment that is used by your local phone company.

A Switched-56 line will not work with a standard analog telephone. You need a special piece of *terminal equipment* at the end of the line. This equipment is known as a CSU/DSU (channel service unit/data service unit). The CSU/DSU handles the dialing and call setup on the Switched-56 line, and translates the data between the telco network's *alternate mark inverted* (AMI) transmission format and a standard hardware interface format, such as V.35 or RS-232.

ISDN

The successor to Switched-56 is the *Integrated Services Digital Network* (ISDN), which is intended to become the standard universal phone service of the future. ISDN is based on a set of standards and recommendations from the International Telephone and Telegraph Consultative Committee (CCITT) for sending voice and data over a single digital telephone network. Although ISDN has been available in Europe and Japan for some time, it has only become widely available in the United States in the past few years. If it is available in your area, ISDN is preferable to Switched-56. An ISDN line usually costs less than a Switched-56 line and can provide more than twice the digital bandwidth.

Like Switched-56, an ISDN line has to be installed by your phone company, and in most cases, it cannot be routed through a PBX. These lines use standard, unshielded twisted pairs (UTP) of copper telephone wires, however, so you probably won't need to have new wires run to or through your building to carry the service.

The standard implementation of ISDN is the *Basic Rate Interface* (BRI) line. BRI includes two full-duplex, synchronous 64kb/s *bearer* signals (B channels) plus a 16kb/s *data signal* (D channel) that is used for call signaling and for sending X.25 packet data. This configuration is often referred to as a 2B+D circuit.

Just as in Switched-56, you need a special piece of terminal equipment to connect to the ISDN line. This is called a *terminal adapter* (TA). It converts a standard data interface into the *two-binary, one quaternary* (2B1Q) format used by the ISDN network. The single, twisted-pair ISDN line that shows up on your doorstep is known as a *U-interface*. You will need a device called an *NT-1* to change this U-interface into a 4-wire *S/T interface*. Many TAs now come with a built-in NT-1, eliminating the need for this extra piece of equipment.

Some TAs allow you to make two simultaneous data calls to different locations on each of the B channels, at either 56 or 64kb/s. Some also allow you to use inverse multiplexing (IMUX) to combine both B channels into a single 128kb/s datastream (more on this later).

Audio codecs

The ISDN (or Switched-56) line is nothing more than a data transmission path. To use this channel for sending audio, you must turn your analog audio signal into a digital bitstream. A device that encodes and decodes audio into data is called a *codec* (short for coder/decoder). A codec is inserted between conventional audio equipment and the terminal equipment for the switched digital network, as shown in Figure 1.

There are many different protocols for encoding digital audio. For example, the stereo audio on a CD uses *linear 16-bit PCM* encoding with a 44.1kHz sample rate, which produces data at a rate of about 1,400kb/s. This is much more data than can be carried by a switched digital circuit. By using a specialized bit-rate reduction (or "data-compression") algorithm, however, this data can be converted by the codec into a lower bit rate, allowing it to be transmitted over available switched digital channels while retaining reasonable fidelity.

The most widely used method of sending audio over switched digital telecommunication lines is a CCITT protocol known as *G.722.* This technique uses statistical models of human speech to digitally compress a 7.5kHz monaural audio signal down to 56 or 64kb/s. The result, although a tremendous improvement over analog phone lines, is still a far cry from CD-quality audio. The fact that this form of digital audio can be sent over Switched-56 lines has made G.722 codecs common in radio stations. (One manufacturer has developed a proprietary 15kHz mono variant of G.722 called *Turbo G.722,* which operates at 112 or 128kb/s.)

Perceptual coding

In the quest for higher-quality digital audio at lower bit rates, a number of digital compression algorithms have been developed that rely on *perceptual coding* techniques. Most of these algorithms make use of the psychoacoustic phenomenon known as *masking* to represent audio with fewer bits.

Using a perceptual coding algorithm, extremely high compression ratios are achievable, allowing high-quality audio to be transmitted or stored at low bit rates. As the bit rate gets lower, however, more audio information has to be discarded. Eventually, some noticeable degradation of the audio will occur. Traditional methods for testing audio equipment are meaningless with this new technology, however. The only proven way to evaluate the quality of these coding algorithms is to conduct extensive subjective listening tests on a variety of different audio sources.

The Motion Picture Expert Group (MPEG), under the direction of the International Standards Organization (ISO), has conducted listening tests on a number of different perceptual coding algorithms in recent years, and eventually adopted a set of digital audio compression standards. MPEG recommended three different compression algorithms, known as Layer 1, Layer 2 and Layer 3. In ascending order, each layer is more complex than the previous one and is designed to sound better at decreasing bit rates. For example, Layer 2 was optimized for 128kb/s per audio channel, while Layer 3 was targeted to still sound good at 64kb/s.

Technically, the MPEG standard only defines the *decoding* algorithm, which

MANUFACTURER	MODEL	ALGORITHMS SUPPORTED	DATA RATES SUPPORTED (kb/s)	INTERNAL IMUX AVAILABLE	INTERNAL TA AVAILABLE
Audio Processing Technology (APT)	DRT128	apt-X100	56 to 128	Yes	Yes
	DSM100	apt-X100	56 to 384	Yes	No
Comrex Corporation	DXP.1 (xmit), DXR.1 (rcv)	Turbo G.722	56 to 128	No	No
	Nexus	Turbo G.722	56 to 128	Yes	Yes
	DX100	apt-X100	56 to 256	Yes	No
	DX200	ISO/MPEG Layer 2, Turbo G.722	56 to 384	Yes	No
Dolby Labs	DP523, DP524	Dolby AC-2, Dolby AC-3	56 to 384	No	No
Intraplex	Series 4400	ISO/MPEG Layer 2, G.722	56 to 128	Yes	Yes
MPR Teltech	LII Blue	ISO/MPEG Layer 2	64 to 384	Yes	No
	Capella	ISO/MPEG Layer 2	56 to 384	No	No
MUSICAM USA (formerly CCS Audio Products)	CDQ PRIMA series	ISO/MPEG Layer 2, G.722	56 to 384	Yes	Yes
	CDQ 2000, 2001	ISO/MPEG Layer 2	56 to 384	No	No
	CDQ1000	ISO/MPEG Layer 2, G.722	56, 64	No	No
	Micro series	G.722	56, 64	No	No
RE America	RE660 (xmit), RE661 (rcv)	ISO/MPEG Layer 2, G.722	56 to 384	Yes	No
	RE662 (xmit), RE663 (rcv)	ISO/MPEG Layer 2, G.722	56 to 384	Yes	Yes
Telos Systems	Zephyr	ISO/MPEG Layer 2, ISO/MPEG Layer 3, G.722,	56 to 128	Yes	Yes

Table 1. Audio codecs available today, with a few of their basic parameters.

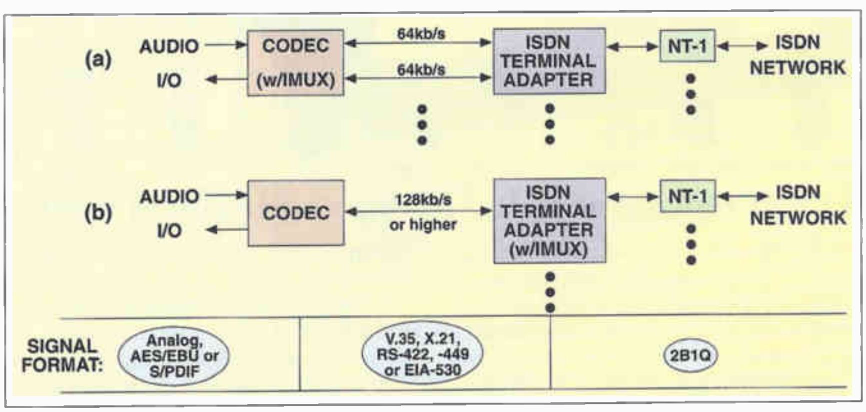


Figure 1. Basic block diagram of inverse-multiplexed audio data transmission via ISDN, showing various signal formats employed. In (a), IMUX is handled by codec at both ends of the circuit, using any IMUX protocol that both codecs share. In (b), a higher-speed data signal is sent to the TA, which applies the standard BONDING protocol. Some TAs do not offer IMUXing, while others can apply it to six or more B channels. Some codecs include a TA (and in some cases, an NT-1) internally.

should be identical in every decoder. The real magic of these algorithms lies in the encoder, and how well they work depends upon how the available bits are allocated. Refinements to the encoding algorithm are being made all the time, and some manufacturers claim that their encoding sounds much better than other systems. A few codecs are equipped with a method of upgrading the internal software to take advantage of new refinements in coding algorithms.

Choosing a codec

Several things need to be considered when choosing from the many audio codecs available. (See Table 1.) For example, some systems house their encoder and decoder in separate units, while others combine both units in one chassis. Some are more *scalable* than others, meaning that they can be operated over a wider range of bit rates. Some can operate in several different modes (mono, stereo, dual mono, joint stereo), while others are more limited. (*Dual mono* operation allows two independent mono audio channels to be coded simultaneously without crosstalk; *joint stereo* exploits the commonality between channels of a stereo signal for additional compression.) All codecs require some processing time to apply their data compression, but some introduce longer throughput delay than others. (Long-delay codecs may require alternate monitoring schemes for live announcers.)

A growing number of codecs can operate at higher bit rates than 128kb/s. For ISDN application, this implies the use of additional IMUXing across multiple BRI circuits. Hardware is available from audio codec manufacturers for IMUXing up to three BRI circuits (i.e., up to six B channels), allowing high-quality transmissions up to 384kb/s. In most cases, the *BONDING* protocol is used for IMUXing. It can be applied either in the TA, the codec or a separate IMUXing box. (See Figure 1.) The term BONDING has become somewhat synonymous with inverse multiplexing, but it is actually an acronym for a specific IMUX algorithm. The acronym is derived from *Bandwidth ON Demand INteroperability Group.* If IMUXing is applied in the codec, a proprietary algorithm may be used.

BONDING is called a "set-and-pray" algorithm, meaning that it establishes its synchronization across multiple B channels only when the call is initially set up. If anything changes during the transmission (e.g., a line drops or synchronization is lost), no recovery is possible without starting over. CCITT has developed a new IMUX protocol known as J.52, which would allow dynamic monitoring of the inverse multiplexing process. To do so, J.52 takes up a small amount of the ISDN bandwidth throughout the transmission (unlike BONDING, which is inactive after call initialization). Given smart enough hardware, J.52 would allow a codec to adjust its output data rate – and a TA to redial and resynchronize – in the event of a line-loss during an IMUXed transmission. But the complexity of J.52 and the acceptable performance of BONDING has kept manufacturers from quickly implementing the new standard, leaving BONDING as the de facto IMUX standard.

Some codecs include built-in ISDN terminal adapters, either with or without NT-1 interfaces. Memory on some such codecs can be used to store call setup information. Several codecs offer ancillary data transmission of up to 9.6kb/s, and/or control inputs and closures, using their compression algorithms' auxiliary packet-data capacity. A few systems provide AES/EBU or S/PDIF digital audio I/O, as well. Other options include Windows software for external PC control of codecs, on-board diagnostics and other display features, and variable audio sampling rates. (For voice or other reduced-bandwidth applications, a lower initial sampling rate like 16 or 24kHz requires less data compression to produce a sufficiently low output bit-rate.)

The configuration you choose from all of these options will depend upon your particular application(s). You may also want to make sure that your codec has the same data interface (V.35, RS-449, X.21, etc.) as your TA or CSU/DSU, although data interface converters are available.

Problems with ISDN

Deployment of ISDN is not yet complete, and in many rural areas the service will not be available for some time. Most areas should have ISDN access by the end of 1996, however, at prices comparable to standard telephone service. But having ISDN service and hardware installed doesn't mean that using it for audio backhaul will be easy. Numerous compatibility issues must be sorted out before your ISDN audio transmission is truly "plug and play."

First, your terminal adapter must be properly configured to your telephone company's specific flavor of ISDN. (Four variations of ISDN service can be encountered in the United States alone.) This should be sorted out when your service is established and your line is issued its *service profile identifier* (SPID), which includes the line's dial-up numbers. Next, your codec must be compatible with the codec in use at the other end. Even when the same algorithm is employed, variations between manufacturers or models can create incompatibilities. Finally, if IMUXing is used, these compatibility problems can be compounded.

Long-distance remotes can be particularly appealing with ISDN because of the relatively low cost of service, but dealing with two different phone companies and a long-distance carrier complicates matters. For this reason, a number of service bureaus offer "packaging" of long-haul ISDN links. These businesses work with radio stations to determine their needs for a remote link, then deal with the various telcos to implement the service. The station pays no fee for the packaging because the service bureaus take a commission on the sale from the telcos they work with (similar to travel agents). Some service bureaus also can provide terminal equipment and codecs on a rental or lease basis.

Multiple codings

While the digital audio data compression used in ISDN transmission is a tremendously enabling technology, it also has a dark side. As digital audio compression technology pervades the broadcast industry, broadcasters need to be aware of the effects of multiple generations of coding on audio programming.

Because the perceptual coding algorithms attempt to use as few bits as possible to represent an audio signal, a fair amount of quantizing noise is added in the encoding process. In general, the algorithms are clever about where they add this noise, trying to add it only in places where you cannot hear it because it is masked by adjacent louder frequencies. But running this audio through the same encoding and decoding process over and over will add more and more noise and artifacts to the original audio. Eventually, perhaps after five or six iterations, this noise will exceed the masking threshold and become audible.

For this reason, it may be wise to avoid digital compression systems unless absolutely necessary. In addition, using more bits for coding audio (i.e., applying a lower data-compression ratio) will introduce less noise, so it is advantageous to use higher bit rates whenever possible. In most cases, less compression also means less throughput delay.

Used sensibly, ISDN and digital audio codecs can provide broadcasters with powerful, flexible and cost-effective ways to transport audio signals, either across the street or around the planet.

Theodric Young is satellite systems engineer for Monitor Radio, Boston and chief engineer at WMBR-FM, Cambridge, MA.

For more information on digital audio codecs, circle (101) on Reply Card. See also "Audio Coders & Decoders," p.49 of the BE Buyers Guide.

Field Report:

Denon DN-995R MiniDisc recorder

By Christopher H. Scherer

It is understood that digital audio has changed our lives. Many types of media are available now that take advantage of the benefits, some of them proprietary and some of them becoming universal. Imagine the ease of DAT tape, with the random access of compact discs, and you imagine MiniDisc.

The MiniDisc uses magneto-optical recording for a robust, recordable and reusable storage system. Using the Adaptive Transform Acoustic Coding (ATRAC) data-reduction scheme, up to 74 minutes can be recorded onto a single disc. The Denon DN-995R is a MiniDisc recorder, built to act and function like a cart machine. With the familiar layout Denon uses on its CD players, jumping in and using the DN-995R should be simple.

The controls

The basic controls are well-marked and easy to use. The PLAY/PAUSE and STDBY/CUE (standby) are lit buttons that can easily be seen. As the name implies, PLAY/PAUSE is a toggle function. The STDBY/CUE is used to cue to the last PAUSE point or the new track selected. Track selection is done with the rotary SELECT knob. The PLAY MODE selector is behind the select knob, allowing for single track or continuous play. The RECord switch lens is red, and when pushed, glows brightly so there is no mistake that you are recording.

The SEARCH buttons allow frame-by-frame cuing of a selection. Time elapsed and remaining is toggled using the DISPlay button, and it is possible to listen to the end of a track using the END MONitor button. The length of the end monitor is adjustable in the machine setup. These last buttons also have secondary functions when labeling individual tracks. The MODE button is used to access the editing functions, such as track or disc labeling, and moving, combining or splitting of tracks.

The large EJECT button is to the right of the disc slot. This is a mechanical eject, and it will be interesting to see the long-term wear of the mechanism; it does feel sturdy when the machine is new. Also, it is possible to lock-out eject during playback or recording to prevent accidental use.

The fluorescent display shows quite a bit of information. The 24-segment peak-level meter is enough to give you a good indication of the audio level. There is also a 13-character matrix display for time and track label information. The 3-digit track number indication could be larger, especially for an on-air application.

Other indications are: Eject Lock, TOC (table of contents), EDIT, CUE, REM (to show elapsed or remaining time indication), VARI and DIGITAL IN.

The controls' positions are similar to other Denon products, giving them a familiar feel. The PLAY/PAUSE and STDBY/CUE buttons are bright enough to easily be seen and recognized, and because they have chip LEDs instead of lamps, the lamps will not need frequent replacement.

> The Denon DN-995R is a MiniDisc recorder, built to act and function like a cart machine.

The ins and outs

The rear panel is filled with connectors. Analog audio in and out is through XLR connectors, as are the AES/EBU connections. Next to the analog XLRs are the level set trim pots. There is a 9-pin D-sub for RS-232C or RS-422A (switchable) connection, and a 25-pin D-sub for parallel remote connection. Two BNC connectors for external synchronization are internally switchable for high or low impedance. There is also a headphone jack (1/4-inch TRS), but without a level control, it is probably better suited for an unbalanced audio out.

Denon also provides the ACD-19 software package to interface a PC running Windows to control the machine functions. This makes the task of labeling tracks less tedious than when you use the front-panel controls.

Some features on the DN-995R really are special. You can access a menu of options by pressing the MODE and STDBY/CUE buttons simultaneously. This menu has all the operational settings, such as SCMS enable/disable, eject lock during playback/recording, cue detect level and so on. There are actually 29 options you can change, and the 30th entry is the software version number.

The selection of analog or digital inputs is in this menu, and it is an option I would prefer to see elsewhere, because it is something that could possibly be changed frequently. However, as the first option choice in the menu, it is easy to locate.

One option I found particularly useful tells the machine what to do after playing a track in the SINGLE play mode. You are given three choices: Stop, Recue or Next. The options all have ideal applications in the air studio, production studio and for live production (news or theater) accordingly.

Stop is similar to replay lock-out. When a track finishes, the machine will not play again until a track is manually selected. Recue does just that, it recues the same track again for play and is perfect for multiple takes with the same music bed. The NEXT option cues the player to the next track in sequence. If the machine was being used for news actualities, the entire actuality list could be kept on one MiniDisc, and automatically recue to the next cut, like a

Features at a glance:

- Small size (three across in a rack)
- Long record times
- Non-proprietary media format
- Versatile connection options
- Parallel remote control
- Tally and cue indications
- Internal and external clock synchronization
- Easy-to-use controls
- PC control in Windows

Christopher H. Scherer, CBRE, is chief engineer at WMMS-FM, Cleveland.

cart. Most of the other options deal with less-frequently modified settings, but allow the machine to be customized to suit almost any need.

Another function of the MODE button is placing CUE points within a track. Cue points could be used for simply marking specific points for alter recall or for triggering external events becausethe machine will provide an open collector or dry closure output. (The dry closure is determined by the tally preset in the software.) This can be used like a cart's secondary tone or the Index 3 on broadcast CDs for cuing or sequencing.

Editing

Although some basic editing can be performed on the DN-995R, don't throw out your splicing block and razor blade just yet. The simplest edit function involves simply moving tracks. The machine automatically renumbers a disc after moving tracks, so track selection progresses numerically.

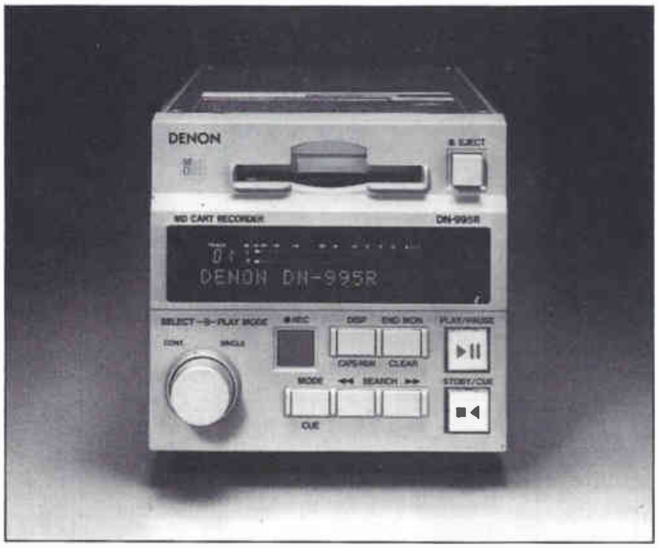
The actual track is not moved physically on the disc, but the User Table of Contents (UTOC) information is modified to reflect the change.

You can split an individual track into two tracks using the DIVIDE function. A single track is divided, and the two new tracks are given the name of the originating track. I would have preferred that it give one of them a modified name for keeping things straight.

Using the COMBINE function allows you to create a single track from two adjacent tracks giving the new track the name of the first one. You can also erase individual tracks or a complete disc.

Using these functions, it would be possible to edit a complete track by dividing it into several sections, then moving the wanted sections together in the proper order and moving the unwanted sections out of the way. You could then combine the wanted pieces back into a single track, and erase the tracks that are unwanted. I tried this using voice tracks for a spot and from a news actuality, and although tedious, it can be done. You can even preview a Combine function by listening to the tracks in the continuous playback mode. By playing the first track, and then letting it play into or cuing up the second track, you can hear how the final edit will sound.

Editing music was a bit more difficult, but not impossible. As you are shifting a divide point, the DN-995R plays the last three seconds of audio so you can hear the edit point. The only problem I discovered was while trying to combine two non-adjacent tracks when the first one was less than 10 seconds long. The machine can seamlessly play two non-adjacent tracks, and does so by relocating the pickup to the second track during the last 10 seconds of playing the first track. If it must play four seconds from one disc location and then continue from another location, it does not have enough time to complete its operation. When you try to combine tracks that are not adjacent physically, the display gives the error message "Can't combine."



The Denon DN-995R MiniDisc cart recorder.

Looking through the window

The DN-995R comes with software that allows you to control it through Windows 3.1. The deck's 9-pin D-sub allows connection to an unused COM port on a PC. The Window's control panel gives you access to any of the machine functions, with point-and-click buttons for accessing the editing and setup functions, and the interface is clean and straightforward. There is a slight delay when a command is given (Play, Cue), that is barely noticeable.

The real advantage of PC control appears when labeling and re-labeling tracks or discs. Because you have a full ASCII keyboard, you can easily enter or change text, instead of turning a select knob. Also, track selection is somewhat simplified since the screen can show you 10 tracks at one time. Simply click on the desired track, then click STBY/CUE. The screen also shows you the full track title.

The Windows interface certainly adds to the function of the machine, and with two DN-995Rs interfaced to the same computer, you can copy tracks from one to the other, supplementing the editing capabilities. To copy, you simply select what tracks you want to copy, which places them in a copy window. You can then change the order in which they will be copied to the target disc. When the execute command is given, the audio is passed between decks at real time via the AES/EBU connection, while the track information is passed via the RS-232/RS-422 port. You can also access all the options that are available on the front panel in the Windows software, with the advantage being that you can see all of them at once. The ACD-19 software can communicate with serial ports 1 through 4 on a PC.

Finally, the operating manual appears as though it was originally written in a language other than English, and then translated by someone who does not speak English as a native language. Although the meanings can be understood, sometimes the sentence structure is confusing. Perhaps Denon could retranslate the manual.

The MiniDisc format has shown some acceptance in the audio industry. Its small size and large (data-reduced) storage capacity will be attractive for the space-conscious. The DN-995R is designed to act like a cart machine, giving it a familiar look and feel, but the long recording time and physical small media size do not make it a direct replacement. Some people would naturally be concerned with the data reduction.

> One useful option tells the machine what to do after playing a track in the SINGLE play mode.

The long record time makes it good for longer program playback such as interviews. If MiniDisc is a format you are interested in trying, you should consider the Denon DN-995R. ■

DAR laboratory testing finished

Digital Audio Radio (DAR) has completed laboratory testing at the National Aeronautics and Space Administration's (NASA) Lewis Research Center in Cleveland.

Tested under the sponsorship of the EIA DAR Subcommittee and the National Radio Systems Committee's (NRSC) Digital Audio Broadcast Subcommittee, collective results were reviewed by proponents and Subcommittee members in August. Further evaluations will take place during the Subcommittees' meetings through the fall.

However, USA Digital, AT&T and the VOA have filed protests with EIA over testing procedures used for IBOC (in-band on-channel) testing. They say that the equipment used to simulate multipath interference was adjusted incorrectly, resulting in poor IBOC performance in multipath rejection tests. Each system will be field tested in several San Francisco stations over the next few months.

RFI interference may become private responsibility

The FCC is investigating the idea of privatizing the handling and resolving of RFI interference problems.

Following in the footsteps of Canada and Great Britain, who already have privatized RFI handling, the Tampa Office of the FCC's Compliance and Information Bureau (CIB) is undertaking a pilot project to determine the feasibility of such a program in the United States.

In July, a meeting was held to begin exploring the possibility of privatization. Moderator Ralph Barlow, FCC engineer-in-chief, said that RFI represents a problem to the public that is large enough that the FCC can't handle it alone. Barlow believes that putting the responsibility in the hands of the private sector will create an opportunity for stations to provide a service and will promote job growth.

Barlow cited the new RFI standards of the telephone industry saying, "You may wish to establish liaison with power companies. Cable companies may wish to contract with you to resolve interference complaints for them. Telephone companies may refer customers to you."

Barlow asked attendees for proposals on the best way to put a program in place that would allow for the privatized resolution of RFI interference to home electronic equipment.

R and R Hall of Fame opens with large radio presence

Labor Day weekend in Cleveland saw the long-awaited opening of the Rock and Roll Hall of Fame and Museum. This event attracted radio and TV coverage from 15 countries and more than 10,000 visitors for the monumental ribbon-cutting ceremony.

The opening was the culmination of more than 10 years of planning and $92 million. The local Society of Broadcast Engineers (Chapter 70, northeast Ohio) extended assistance to the event and Ameritech installed about 600 telephone lines, both POTS and ISDN. The media command center had a temporary 100-line PBX installed and GTE Mobilnet installed a temporary cell-site on a crane for additional coverage.

One of the more visible additions was "Radio Row" at the north end of East 9th Street. Tents were erected to house 43 radio stations and networks to cover the weekend. Of the 32 out-of-town visitors, about 20 used ISDN for audio transmission and backhaul. The SBE helped by arranging Ameritech assistance, and in one case, loaned a station complete emergency broadcast setup. Ameritech installed 20 ISDN and 70 POTS lines for Radio Row.

The Rock Hall also includes a permanent radio studio on the 5th floor sponsored by Radio Shack. This studio houses a Wheatstone A-300 console, three Denon 961 CD players, two Tascam reel-to-reels, a Telos direct telephone interface with Delta Hybrid, a Telos Zephyr ISDN interface, two Technics turntables and Electro-Voice RE-20 microphones.

The first station to operate from the newly built studio was Cleveland's WMMS-FM.

Information and photo provided by Christopher H. Scherer, CBRE, chief engineer at WMMS-FM, Cleveland.

Revised EBS test script allows for 30-second test

The FCC has adopted a revised test script for EBS testing. When used with the new 8-second EBS alerting tone, broadcasters will be able to perform a weekly test in 30 seconds using the following steps:

- Discontinue normal programming.
- Broadcast this statement: "The following is a test of the Emergency Broadcast System."
- Transmit the attenuation signal for eight seconds as specified in Section 11.32 of the EAS rules.
- Broadcast this statement: "This station is testing its Emergency Broadcast System equipment. The EBS will soon be replaced with the Emergency Alert System. The EAS will provide timely emergency warnings. This station serves the (insert EBS/EAS local area name) area. This concludes this Emergency Broadcast System test."
- Resume regular programming.

Broadcasters still need to make sure that all EBS tests from their own stations or stations that they monitor are recorded in the official station log.

Expanded AM-band proposal gets its figures checked

Engineering calculations for deciding who will receive frequency allocations for the expanded AM band (1605-1705kHz) are being rechecked by the FCC's AM engineers.

The allocation plan had already been sent to the commissioners by the AM Branch, and the current checks have sent it back to the staff level. Future proposals by the AM Branch will determine if the plan may have to be completely recalculated.

BUSINESS

MPR Teltech Ltd., Vancouver, BC. has been chosen as the supplier of MPEG audio encoders for Ottawa-based International Datacasting's Audio/Data Satellite Broadcast Systems.

The **Telos Systems'** live remote system, Zephyr, was demonstrated during the grand opening of the Rock and Roll Hall of Fame and Museum. Several broadcasters and syndicators used the Zephyr including: WCBS, New York; WXTR, Chicago; WMMR, Philadelphia; KYYS, Kansas City; WBAB, Long Island; WEFX, Norwalk; WMMS, Cleveland; ROCKLINE; the CBS Radio Network and Westwood One/The Source.

National Public Radio (NPR), Washington, DC, is offering technical services and its state-of-the-art audio production facilities in Washington, New York, Chicago and Los Angeles for hire by domestic and international broadcasters. The studios are equipped to handle call-in programs, live interviews, audio mixing, voice tracking, and domestic and international transmission.

DG Systems, San Francisco, CA, and **ABC Radio Networks** have formed an alliance to create a new digital audio distribution system that will integrate existing satellite and landline communications, server and switching technology, and station traffic and automation systems. The alliance will result in increased flexibility for network radio advertising, improved access to ABC's products and services and streamlined administrative processes for affiliates.

Scientific-Atlanta, Atlanta, GA, has announced that its satellite digital audio products now support MPEG audio compression, as well as Scientific-Atlanta's SEDAT audio compression. The company licensed the MPEG audio technology from **MPR Teltech**, a subsidiary of **BC Telecom**, Vancouver, BC. ABC Radio will receive the first Scientific-Atlanta digital audio receiver systems incorporating MPEG and SEDAT.

Communications Data Services, Inc. of Falls Church, VA, has announced the availability of the Fryer's Site Guide Database on a variety of digital media including 4mm or 8mm tape, floppy diskettes, 1/2-inch 9-track magnetic tape and CD-ROM. The guide is a comprehensive listing of telecommunications facilities for the United States, including Alaska and Hawaii. The database provides latitude/longitude coordinates, height AGL or AMSL, city name for the location, and contact information for owners and managers. For more information, call 800-441-0034 or 703-534-0034.

PEOPLE

Chester A. Massari has been named vice president-general manager of Harris Allied's Broadcast Division, Quincy, IL.

David H. Layer has joined the National Association of Broadcasters as a senior engineer.

Eric Rhoads, a long-time broadcaster and station owner, is publishing a collection of more than 900 photographs chronicling radio's impact on American history. The book, "A Blast From The Past: A Pictorial History of Radio's First 75 Years," explores the metamorphosis of radio from the first broadcast at Pittsburgh's KDKA on Nov. 2, 1920, to the radio talk show phenomenon of today. For more information, call Celia Rocks at 704-322-3111.

New Products

All-solid-state 1MW transmitter
Harris Allied

▶ **DX 1000:** an all-solid-state megawatt medium-wave transmitter featuring improved on-air reliability; the DX 1000 operates five identical 200kW water-cooled power blocks in parallel; each power block uses 239 identical and interchangeable 1.5kW solid-state RF amplifiers, the output from individual power blocks is summed in a 5-way combiner. designed for 'N-1' operation; if a fault occurs, the system will retune for 800kW operation and place the faulted power block into a test mode, allowing on-air maintenance; an industrial-grade programmable logic controller (PLC) is used for main transmitter control.

Circle (150) on Reply Card

Level converter
Henry Engineering

• **Matchbox II:** an updated version of Matchbox, a level converter used to interface semi-pro unbalanced audio equipment with professional equipment that requires balanced audio lines at +4dBm; Matchbox II features user-programmable gain options for compatibility with PowerMac and other digital audio sources, enhanced audio performance, and upgraded gold-plated connectors for reliability.

Circle (151) on Reply Card

Mixing console
Mackie

◀ **SR24•4:** a 24x4x2x1 console featuring high headroom, low-noise mic pre-amps with phantom power; the SR24•4 integrates features from the 8•Bus and the compact series to provide features such as 3-band EQ with swept mids and smooth custom faders; console also includes channel mutes and soloing, six independent balanced AUX sends with masters, sweepable MID (100Hz-8kHz) tape assign to monitor or L/R mix switch, and double busing to feed eight tracks at once.

Circle (152) on Reply Card

Microphone mixer
Audio-Technica

▶ **SmartMixer:** a smarter, quieter and more versatile version of SmartMixer, a 4-channel automatic microphone mixer; new features include: transformerless input design to further minimize noise, switchable mic/line inputs and outputs, an added master gain control, switchable phantom power on individual channel, rms/peak meter functions and a manual mode switch that allows the AT-MX341a to function like a conventional mixer; each channel has its own priority pre-select switch and if all priority switches are off, the SmartMixer opens one mic at a time, switching to the next only when the controlling channel becomes silent; when a single channel is set to the "on" priority, that microphone has the ability to override all other microphones; when all channels are set to the "on" priority, any number of microphones may come on simultaneously.

Circle (153) on Reply Card

Stereo encoder
Orban

▲ 8208 digital stereo encoder: a compact, stand-alone unit that accepts either analog or AES/EBU digital inputs; all the encoding is accomplished in the digital domain by a dedicated DSP chip; the digital input automatically synchronizes to any sampling rate from 32kHz to 48kHz; the 8208 responds to status bits in the AES/EBU datastream that may be used to turn de-emphasis on or off; both analog and digital inputs are electronically balanced and floating on XLR-type connectors with levels adjustable by recessed front-panel trimpots; rear-panel BNC connectors are provided for two subcarrier inputs that are summed into the 8208's two composite outputs.

Circle (156) on Reply Card

Headsets
Audio-Technica

▼ ATH-M40 and ATH-D40: two models of closed-back, dynamic precision studiophones; the ATH-M40 features a flat, extended frequency response; the ATH-D40 provides a bass-enhanced frequency response that is ideal for use with drums, bass and other low-frequency sound sources; features include high SPL capabilities and comfortable circumaural earpieces that can be rotated 180° for 1-ear monitoring; both models use 40mm drivers with neodymium magnets and copper-clad aluminum wire voice coils; each pair is equipped with an 11-foot cable terminated in a standard 1/4-inch connector; the ATH-M40 features a frequency response of 5Hz to 28kHz, a sensitivity of 100dB and an impedance of 60Ω; the ATH-D40 offers a frequency response of 20Hz to 28kHz, a sensitivity of 102dB and an impedance of 66Ω; both models feature a maximum input power of 1,600mW at 1kHz.

Circle (155) on Reply Card

Fiber-optic distribution system
BEC Technologies Inc.

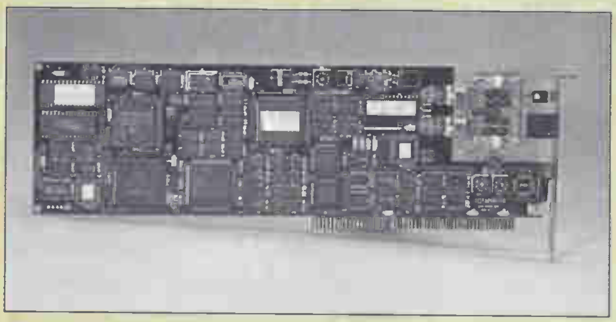
• Σnet: a fiber-optic distribution system that is fully compatible with BEC's ProLine series of digital audio-signal distribution products; the series is comprised of the AD2 stereo analog input module and the DA2 stereo analog output module, both of which communicate in 20-bit digital; the modules offer a 2-channel alternative that acts as a single stereo point-to-point link or can be used to add or drop two channels at a time onto a full 64-channel audio local area network (A-LAN); the modules also provide two additional data channels for control and monitoring by tying other manufacturer's equipment into the network.

Circle (154) on Reply Card

Compact disc player
Tascam

• CD-301MKII: a second-generation 3U rack-mountable CD player that features an advanced 1-bit delta-sigma D/A conversion system, an industrial-grade midship-mounted transport mechanism, balanced and unbalanced outputs, and SP/DIF digital output; other features include an auto cue function with two sensitivity levels, remote fader start capability, a single play function, and timer on/off switch; the unit's outputs are both XLR +4dBm balanced and RCA -10dBv unbalanced pin jacks; this unit can play 8cm or 12cm compact discs.

Circle (157) on Reply Card



Digital telecom interface card

Industrial Computer Source

◀ **Model COMMPORTER/56:** a high-speed digital telecommunications interface card for ISA and EISA bus computers that is nearly five times faster than a 24.4kbps V.42bis analog modem; COMMPORTER/56 operates as a combined channel service unit (CSU) and data service unit (DSU) and provides connectivity to standard 4-wire, switched-56, telephone circuits offered by local exchange and interchange carriers; full-duplex data rates of 56kb/s (switched circuit) and 64kb/s (dedicated circuit) are supported; plug-and-play compatible with a variety of operating systems such as MS-DOS, Windows, Unix, etc., and most data communications software such as PROCOMM or Crosstalk.

Circle (159) on Reply Card

Audio mixing consoles

Soundtracs

• **Topaz Mini:** provides four mono and four stereo inputs plus two stereo effects returns into a stereo output; suited for keyboard mixing, stereo recording and conferences.

• **Topaz Macro:** provides 10 mono and two stereo inputs plus two stereo effects returns into a stereo input; ideal for fixed installation, larger keyboard configuration mixing and MIDI-based recording studios.

▶ **Topaz Maxi:** available in two sizes, 24-4-2 and 32-4-2; the 24-channel version has 20 mono and two stereo inputs and the 32-channel version has 28 mono and two stereo inputs; a unique switching arrangement allows conversion from a 4-group output console to an 8-group output console by adapting four of the eight auxiliaries; suited for sound reinforcement applications or 4- and 8-track recording.

Circle (158) on Reply Card

Hard-disk recording system

Soundscape

• **SSHDR1:** an 8-track disk recording system (expandable to 128 tracks) that uses an IBM-PC as its front-end with all numerical computation taking place in the 2-rack space unit; using standard IDE drives, the unit performs all standard DAW functions, as well as having 64 bands of fully parametric EQ, full chase lock to MTC, full expandability and crystal semiconductor 64x oversampling sigma-delta converters for excellent sound quality; available in three versions: the standard model with RCA analog and digital I/O (SP/DIF), the SSHDR1Pro with RCA and XLR analog and digital I/O (AES/EBU), and the new SSHDR1R with removable drive cartridges.

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Graphics software

Otari

• **Radar View:** graphics software package that allows Otari's Radar hard-disk multitrack recorder to monitor complex recording sessions from one source; the Radar View visual interface displays the instantaneous status of all functions provided by Radar's comprehensive RE-8 session controller; all information is displayed simultaneously on one window; the software includes 24 input/output meters, large SMPTE time-code display, audio display of all 24 tracks with multi-level zoom capability and digital audio routing status for internal AES/EBU, SP/DIF and optional ADATLink ports.

Circle (162) on Reply Card

CD changer

Denon Electronics

▲ **DN1400F:** a 200-CD changer that employs two separate transports to quickly access any CD; a CD in one tray can be loaded and cued while a CD in the second tray is playing for uninterrupted playback; the unit also allows simultaneous playback from the two transports for monitoring/cuing or for independent playback; the unit occupies 19-inch rack space and stores up to 200 CDs, 100 per tray.

Circle (167) on Reply Card

Compact DA

Radio Design Labs

▲ RU-BDA3: an ultracompact DA that occupies 1/3-rack space; the unit provides a front-panel XLR input and input connections on the rear panel full-sized barrier block; inputs can be strapped to provide phantom power through the standard XLR input connector; when rack-mounted, a line level signal can be hardwired into the unit inside the rack; both the front-panel input XLR connector and the rear-panel input terminals are active at all times and gain trim is provided on a front-panel control accommodating a range of line-level signals; outputs are driven through XLR connectors on the front-panel and are 150Ω balanced to drive short or long balanced lines; a 24VDC power supply input is provided on full-size barrier block connections on the rear panel.

Circle (164) on Reply Card

Composite audio processor

MicroCon Systems Ltd.

• **FM FlexiMod**: a flexible FM signal management system based on the DBE-1000 composite processor; system can be configured in a wide variety of operating modes including broadbrand and high-frequency limiting applications with either an internally generated and phase-locked stereo pilot or pilot reuse from the stereo generator; the proprietary processing engine is a hybrid limiter-clipper with extremely low second harmonic distortion products; the FM FlexiMod combines high-speed limiting and ultraclean, low-distortion clipping.

Circle (165) on Reply Card

Software

TimeLine

• **Studioframe** version 6.20: a software package that adds significant productivity, user interface, and speed enhancements to the Studioframe system; the Studioframe waveform re-drawing is significantly faster regardless of the zoom-view level used; the newly enhanced function operates on any individual track or on all tracks simultaneously; using customizable menus and accelerator keys, an advanced custom interface allows Studioframe users to redesign the edit control interface to suit their individual styles.

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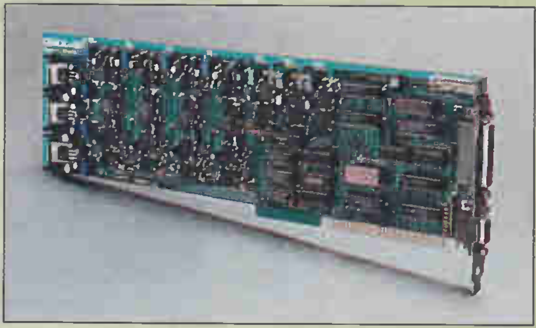
New Products continued



Matrix switcher system
Jasoni Electronics

• **Model 2000:** a matrix switcher system designed for use with analog reel-to-reel tape machines for dubbing from reel tapes to analog tape cart machines or digital hard discs (can also be used with any stereo analog sources); the 1-rack size unit is five inches deep and has XLR connectors for I/O connections; eight output selections allow the highest quality transfer from source to dub.

Circle (161) on Reply Card

RPU receiver
Marti Electronics

• **SR-10:** a frequency-agile RPU receiver; the unit features full remote control capability and six preset channels that can be scanned; an LCD display is used to show all 158 channels in the 450MHz and 455MHz RPU bands.

Circle (163) on Reply Card

Graphic addition to DCS
Computer Concepts

• **CartRack:** a graphic addition to DCS that puts an announcer's carts on the screen; each on-air talent can set up and assemble an individual rack of carts and get instant access to each sound effect or snippet of audio as many times as needed.

Circle (167) on Reply Card

Audio switcher
Electric Works Corporation

▲ **DMX-4:** a software-programmable stereo 4-channel audio switcher that mounts directly into a full-length 16-bit slot on any IBM PC-compatible computer; four unbalanced stereo inputs under the software control of programmable DAC devices terminate in one balanced stereo audio output; in addition to the stereo switching, mixing and fading controls, the DMX-4 also includes a summed mono balanced audio output and has provision for software selectable external level controls for each source; connections for eight incoming logic closures are included and the DMX-4 can generate up to eight outgoing logic closures through software; a buss jack allows limited interconnect ability with other DMX-4 cards on the same motherboard.

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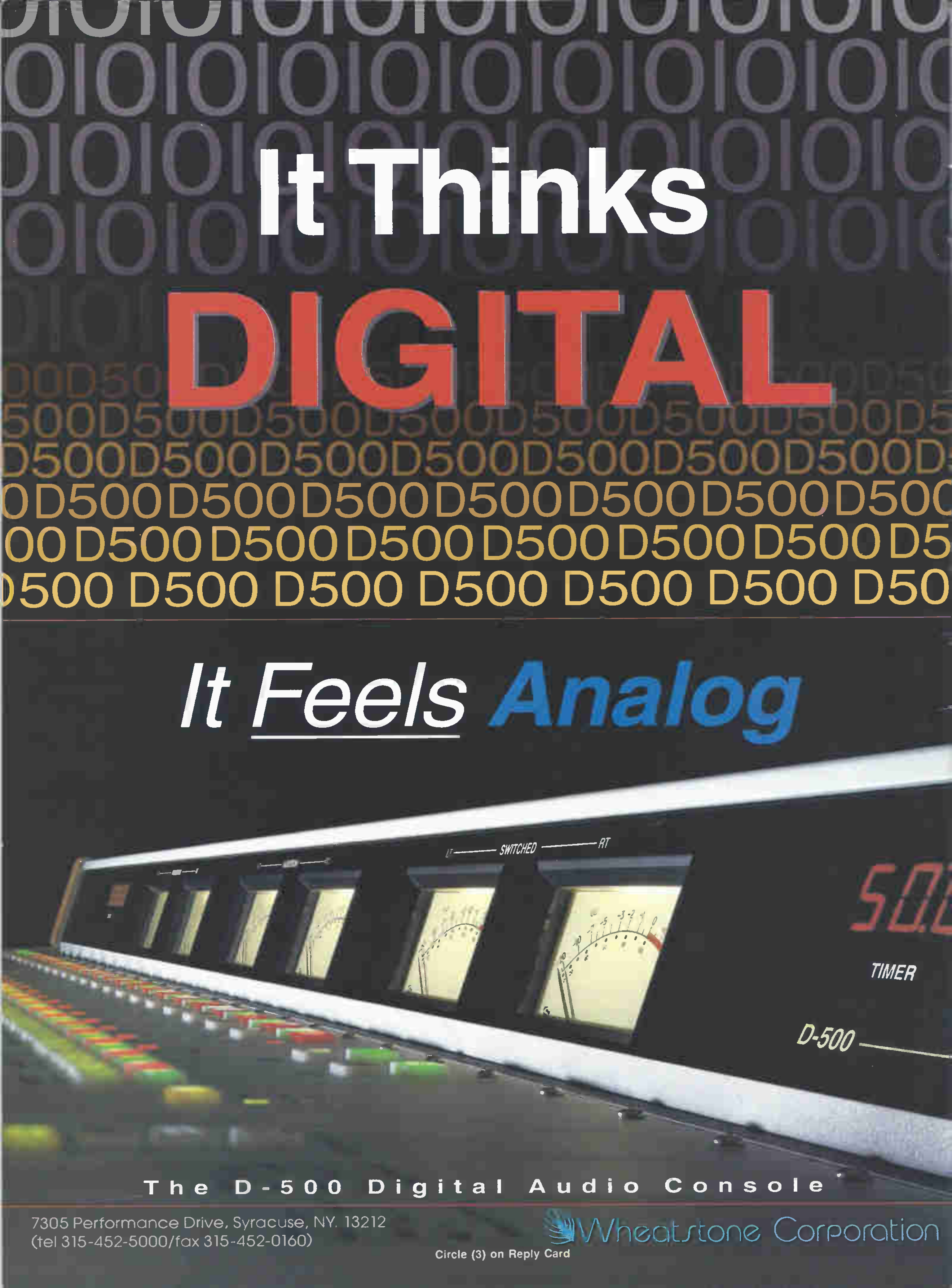
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