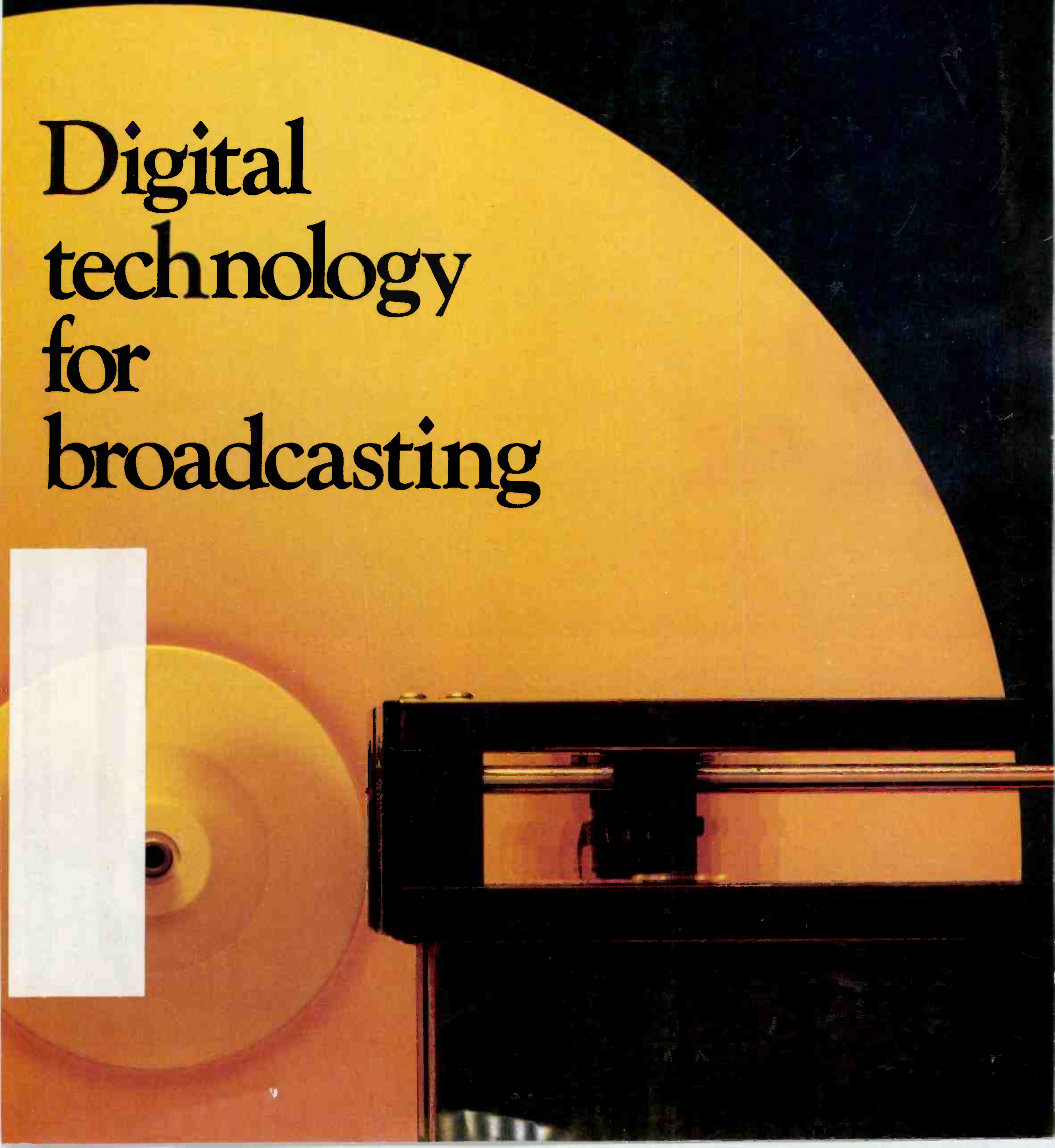
# BROADCAST ENGINEERING®

AN INTERTEC PUBLICATION

February 1988/$3

# Digital technology for broadcasting



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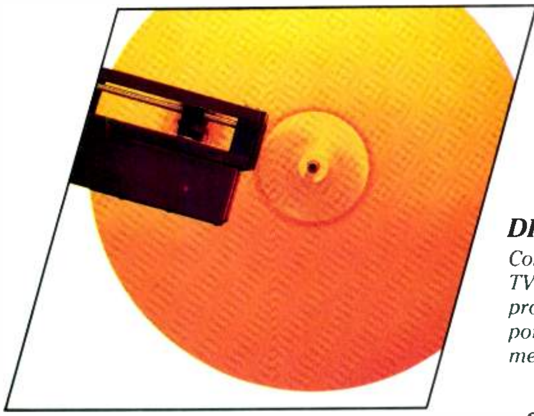
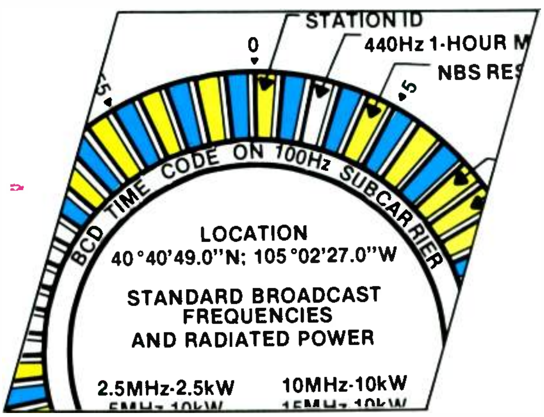
# Contents

February 1988 • Volume 30 • Number 2



Page 26

Page 46




Page 108

**BROADCAST engineering**

*DIGITAL TECHNOLOGY FOR BROADCASTING:*

*Computer-based equipment has reshaped the face of radio and TV broadcasting. New technology has given our industry new products that solve old problems and open the doors to new opportunities. Our examination of new directions for digital equipment in broadcasting includes the following articles:*



*HIGH-DEFINITION TV SPECIAL REPORT:*

*HDTV represents new possibilities to some and a significant threat to others. This technology now is emerging from the lab and beginning to affect the business and technical plans of broadcasters, post-production facilities and the film community. We examine these aspects of HDTV in the following special report:*



OTHER FEATURES:



## ON THE COVER

Two primary forces drive development in digital-based equipment: speed and memory. Our cover this month illustrates both. Shown is a hard disk drive prior to final assembly. The needs of broadcasters for additional memory space and rapid access time in computer-based equipment are growing daily. (Photo courtesy of Oktel, Santa Clara, CA.)

## DEPARTMENTS

# PROBLEM SOLVERS

## How to get perfect camera setups in three minutes—with a single camera or up to 42 cameras. That's right, 42.

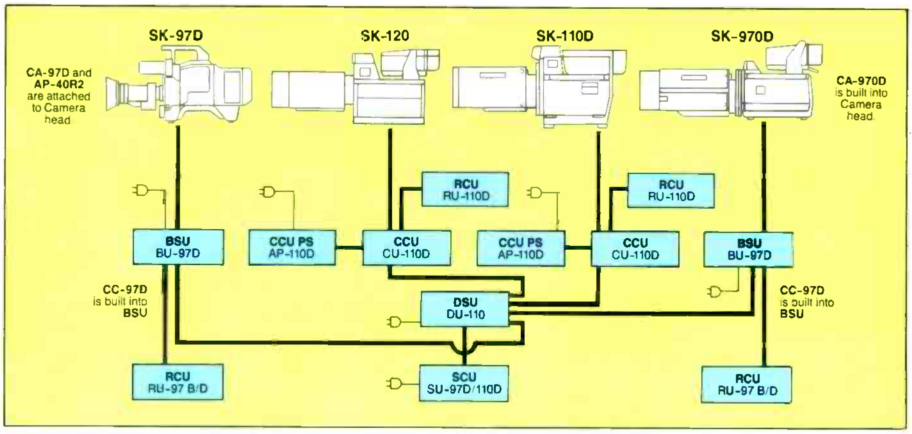
Camera setup problems always seem to happen when there's absolutely no time to waste.

That's why Hitachi's setup solution is quick and easy. Our microcomputer Zero Control automatic setup of all three channels is built into every Hitachi SK-970D and SK-97D camera. Zero Control totally eliminates manual adjustment of the G channel.

Now, imagine yourself as the engineer with this setup problem.

You're setting up three cameras to shoot an hour of drama. It has already taken 40 minutes to adjust the G channels and get the color and registration right. The talent is yawning. The crew is telling jokes. The director is having a fit. Then one of the cameras fails. You bring in another camera and start adjusting G channels again. But you find yourself wishing TV was still black and white.

Stop sweating over G-reference setup. With Hitachi Zero Method automatic setup, no adjustments are required. Just fire up, press the auto setup button and within minutes you're ready to shoot. It's that simple.




*How Hitachi's SU-97D Auto Setup Control achieves simultaneous setups on four different camera models. System can expand to set up and control 42 cameras.*

Even better, Hitachi's SU-97D Auto Setup Control Panel can simultaneously and automatically set up as many as 42 cameras. Not only does the SU-97D achieve identical perfect setups on SK-970D and SK-97D cameras, it can also control auto setup of Hitachi SK-110D and SK-120 cameras (see chart).

Another Hitachi exclusive—you can record complete setup and camera adjustment data on a floppy disk, and use the disk to check camera status against the original setup values. Or, for instant automatic checking of registration and color balance, you can use Hitachi's "Quick Check" switch.

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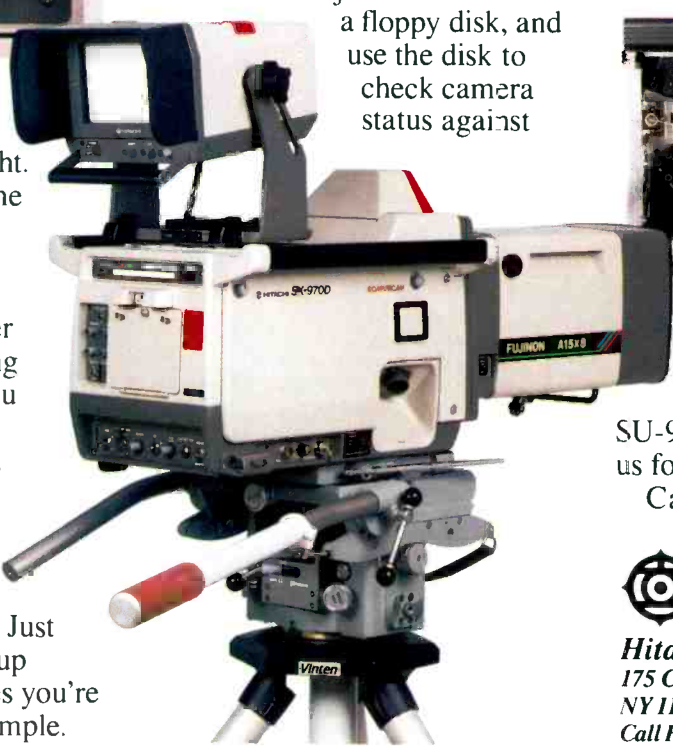
The world's toughest customers—major networks and major independent producers—are our best customers for SK-970D's, SK-97D's and SU-97D's. Isn't it time you called us for a demonstration?

Call now.


*Rear panel on Hitachi's SK-970D camera. Complete controls for automatic setup and camera operation.*




*Easy access to plug-in modules for quick service.*

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## SMPTE elects engineering VP

Stanley N. Baron, managing director in the technical division of NBC, has been elected engineering vice president of the Society of Motion Picture and Television Engineers (SMPTE) for a 2-year term.

Beginning last month, Baron assumed responsibility for the supervision and coordination of the work of the nine technical committees of the society. He succeeds Richard G. Streeter, CBS, who had held the office since 1984.

At NBC in New York City, Baron evaluates emerging technology and directs the installation of new equipment in the NBC Television Network. He has been involved in the design and development of digital TV systems for more than 21 years.

For the SMPTE, Baron has had a key role in the development of standards for digital video. He has been a member of the SMPTE Working Group on Digital Video Standards since 1977, serving as chairman of the group from 1984 to 1986. He is currently co-chairman of the SMPTE Standards Committee and Society Engineering Director for Television. He is a Fellow of the SMPTE and active in the engineering work of the European Broadcasting Union.

## NAB department makes changes

Changes in the NAB Science and Technology Department are part of the adjustments related to the formation of the Broadcast Technology Center (BTC), which will focus on the realization of a high-definition TV system for U.S. broadcasters, in addition to other broadcasting research.

Thomas B. Keller, who has headed the department since 1981, is the chief scientist. He is located at the Broadcast Technology Center. The NAB also is searching for a director of the center.

Michael C. Rau, an engineer in the Science and Technology Department, is vice president and acting head of the department.

## 1988 SBE call for papers

Abstracts are being accepted for proposed engineering papers for the 1988 **Broadcast Engineering** conference of the SBE national convention. The conference is being organized again this year by John Battison.

If you are interested in preparing a technical paper for presentation at the conference, submit an abstract outlining the scope of the paper, and its importance to the industry, to John Battison no later than March 31.

The SBE will again publish a *Proceedings* of the conference, which will be distributed at the convention. Authors should be prepared to submit a camera-ready manuscript by June 30. Send your correspondence to: John Battison, conference chairman, 890 Clubview Boulevard North, Columbus, OH 43085.


**BROADCAST ENGINEERING**

*Editorial and advertising correspondence should be addressed to: P.O. Box 12901, Overland Park, KS 66212-9981 (a suburb of Kansas City, MO); (913) 888-4664. Telex: 42-4156 Intertec OLPK. Circulation correspondence should be sent to the above address, under P.O. Box 12937. RAPIDFAX: 913-888-7243.*





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

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**Advertising offices listed on page 150.**



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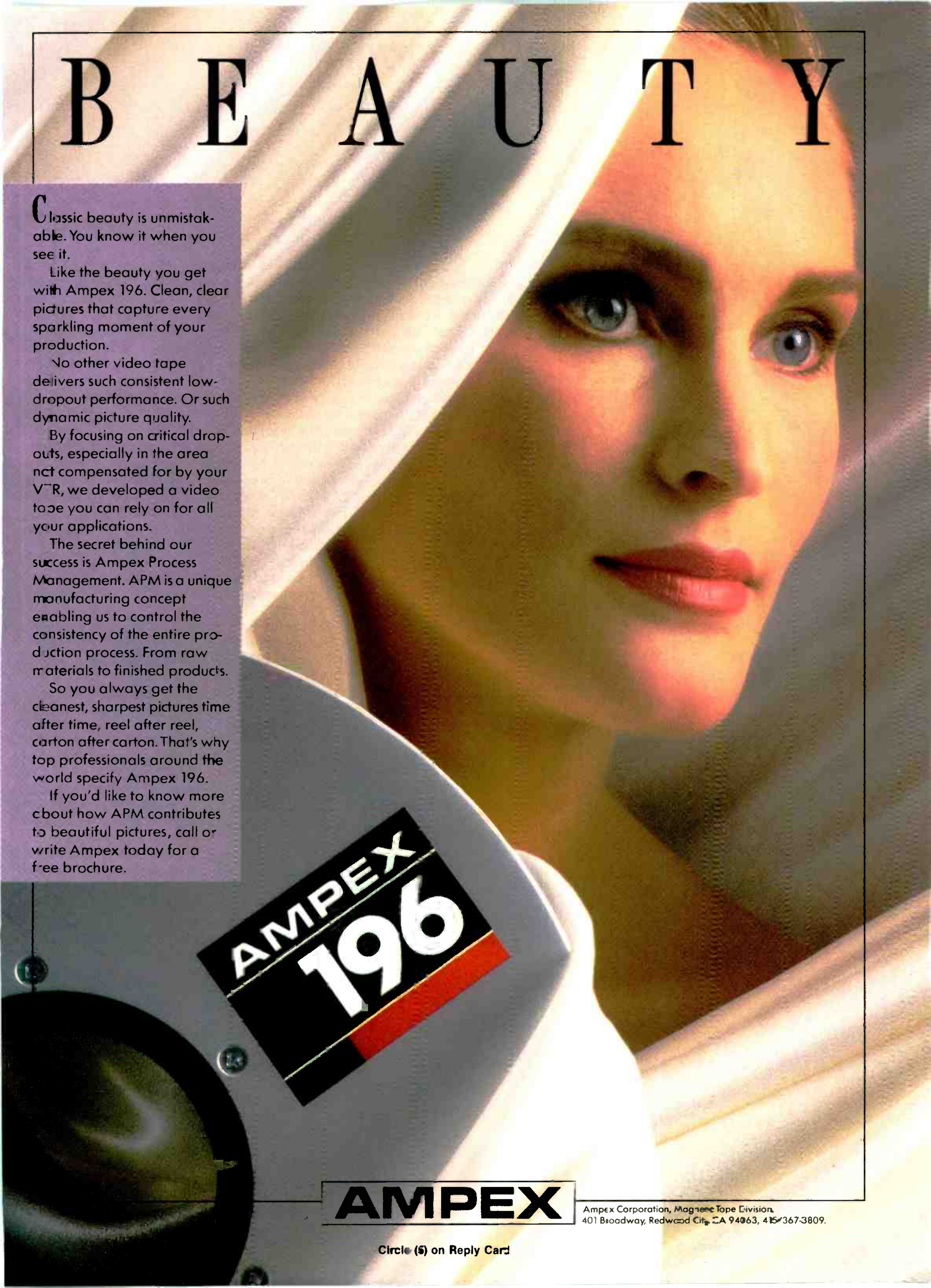


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# The road to success

The Society of Broadcast Engineers has been in existence for more than 20 years. And, like someone entering the prime of life, SBE is emerging as a force in the broadcast industry. The national focus for the organization has, for the past two years, been the SBE national convention. The staff of this magazine, which served as sponsor of the engineering seminar portion of the '86 and '87 conventions, has been impressed with the professionalism of the show's organizers and the people it has attracted.

The SBE national convention has—in just two years—emerged as an important event to attend for technical managers and engineers. The exhibits have increased dramatically, and the technical sessions are top quality. The 1987 engineering seminar featured 25 hours of instruction in every area of radio and TV broadcast technology, drawing some of the top speakers in the industry. A printed "Proceedings" of the conference included 26 of the papers presented at the convention, numbering more than 270 pages. The SBE national convention has become a key event for the fall.

Now, as the show matures, further improvements are on the horizon. The society has launched an ambitious 3-year plan for the national convention that covers all aspects of show planning and execution. Following are some key elements of the 3-year plan:

- **Broadcast Engineering** has committed to sponsor the technical seminars, with John Battison as conference chairman. Battison's track record for formulating a hands-on program is well-known in broadcast circles.
- Eddie Barker Associates has been retained to organize and coordinate all exhibit-related activities. Barker is a veteran show organizer, having been involved in numerous shows over the years, most notably RTNDA.
- Convention sites have been selected for the next three years, allowing exhibitors and attendees to plan their participation well in advance. The 1988 show will be Sept. 22-25 in Denver. Kansas City, MO, will be the site of the 1989 show, Oct. 5-8. The 1990 show is scheduled for Oct. 4-7 in St. Louis.

SBE also has taken an unprecedented step in inviting other organizations to participate in the society's annual national conventions. This cooperative approach begins with this year's show in Denver. The Rocky Mountain Film and Video Expo and the regional ITVA (International Television Association) will hold their annual conventions in conjunction with SBE's. Also, the Society of Cable and Television Engineers has been invited to participate in the show.

The concept of combining events is beneficial for attendees as well as exhibitors. Most people in the business would agree that there are too many trade conventions for the professional audio/video industry. We applaud any effort to reduce the number of events by combining shows if it makes sense.

The Denver gathering will offer attendees additional exhibits and seminars on a variety of topics. Cooperation is the name of the game, and in the process, everybody wins.

The SBE National Convention and **Broadcast Engineering** Conference has become the focus of the society's activity on the national level and an important force in reshaping the profession of broadcast engineering. Much has been done. And more is on the way.

We hope to see you in Denver Sept. 22-25. See for yourself how the SBE has grown on its road to success.

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# Focus is on tower lighting and painting

By Harry C. Martin

A survey by the FCC's Field Operations Bureau has revealed that many communications towers are not in compliance with FCC painting and lighting requirements. Of the 289 towers inspected, approximately 13% had some sort of lighting problem. The FAA had been notified about less than half of them. On approximately 27% of the towers inspected, the paint was so faded, peeled or otherwise deteriorated that visibility of the tower was severely diminished.

The commission, in a recent public notice, reminded licensees and tower owners of the importance of proper lighting and painting to air safety. The agency intends to continue to scrutinize towers and to take appropriate action—including assessment of fines—where towers are not properly lighted or painted.

Typical forfeiture amounts for various violations are listed here:

- All tower lights out and FAA not notified within 30 minutes as required—$2,000.
- Majority of tower lights out and/or loss of top flashing beacon and FAA not notified within 30 minutes—$1,000.
- Tower lights not observed at least once each 24 hours—$500.
- Temporary warning lights not present and operational during construction—$1,000.
- Tower not properly painted—$750.

### Obscenity and indecency policy

In November, the commission reaffirmed its enforcement policy against obscene or indecent programming.

Obscene material does not receive First Amendment protection and is prohibited at all times. The Supreme Court defines obscenity by the following criteria:

- An average person, applying contemporary community standards, must find that the material, as a whole, appeals to the prurient interest;
- The material must depict or describe, in a patently offensive way as measured by contemporary community standards, sexual or excretory conduct; and
- The material, taken as a whole, must lack serious literary, artistic, political or scientific value.

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

It also is a criminal offense to broadcast obscene programming.

The commission also made it clear that it will apply a broader definition of indecency than the "seven dirty words" standard previously followed. There will be a return to the definition affirmed by the Supreme Court in 1978 in "FCC vs. Pacifica Foundation," i.e., "language or material that depicts or describes, in terms patently offensive as measured by contemporary community standards for the broadcast medium, sexual or excretory activities or organs."

Indecent programming may be broadcast legally only between the hours of midnight and 6 a.m. Prior to midnight, there is a reasonable risk that children may be in the audience. The focus of the commission's enforcement efforts will be the investigation of complaints regarding indecent programming broadcast prior to midnight.

### Equipment authorization procedures

The commission is proposing a significant change in its authorization procedures for broadcast equipment. Under the proposal, transmitting equipment for most facilities authorized under Parts 73 and 74 no longer would be subject to registration. Because equipment marketed for use in the broadcast services has a satisfactory record of compliance with FCC technical standards, the commission believes a further relaxation of equipment authorization procedures is warranted.

Since 1984 most broadcast and broadcast-related equipment has been subject to a "notification" requirement. Under this procedure, the commission grants an equipment authorization based on the manufacturer's or importer's statement that the equipment has been tested and complies with appropriate emission regulations. The equipment then appears on an FCC authorization list and is considered suitable for the uses for which notification was made.

Under the current proposal, manufacturers, importers and other parties responsible for marketing a radio frequency device are not required to file any material with the commission. Rather, such parties would be required only to retain in their own files sufficient measurements and other data demonstrating compliance with the rules.

The proposal places special attention on equipment used in the newer broadcast services, such as LPTV. Continuation of notification requirements still may be necessary in such services because of the lack of experience with some of the equipment now being manufactured.

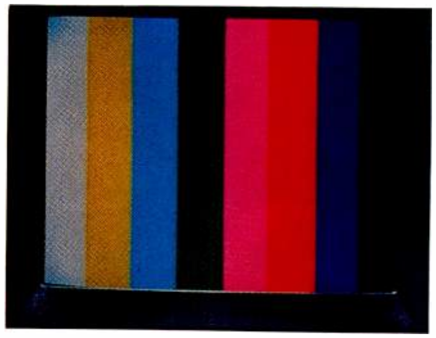
Expansion of the verification procedure to cover most broadcast equipment may require additional paperwork for broadcasters. Currently, an applicant for a broadcast authorization is required only to list the authorization number for the equipment being proposed for use, or to indicate that the equipment is type-accepted. Because the commission would no longer maintain lists of type-accepted equipment for many uses, it would be up to individual broadcasters to verify and demonstrate that the equipment they are using is in compliance with applicable emission regulations.

In most cases, this could be done by simply referencing the manufacturer's verification data. Presumably, manufacturers would issue certificates of rule compliance to all customers so they could make the requisite showings in their FCC applications.

### Must-carry rules rejected

On Dec. 11, the U.S. Court of Appeals in Washington, DC, struck down must-carry rules imposed by the commission. The rules had required cable systems to carry the signals of broadcast stations in their areas. In a unanimous option, the court declared that the rules violate cable operators' First Amendment rights and held that they are not necessary to advance a substantial government interest. The court struck down the commission's original must-carry rules in 1985, also on constitutional grounds.

The decision leaves the door open to the possibility that yet another set of must-carry requirements will be enacted by the commission or Congress. It also spurs debate on the issue of how programmers should be compensated for the broadcast material cable systems carry.



# Prepare for graphics hardware repair

**By Rick Lehtinen, TV technical editor**

As a result of the popularity of computer graphics, broadcast engineers eventually will have opportunities to repair these systems. Before you can make the repairs, however, you must understand what the modules do and how they interconnect.

The heart of a graphics system is a computer, either a proprietary or an existing product with custom cards to make video (see Figure 1). Some systems use two computers—one for operator interface and design station work, and the second working in the background, drawing frames and controlling the recording machine.

### Input/output

Operators can enter input data from a keyboard, but artists are not always numbers people. They work with art tools, simulated by a sketch tablet and stylus or a mouse. These tablets seldom are made by the vendor of the graphics system, so if you need repair assistance, go directly to the tablet manufacturer.

Video from the system is made with digital-to-analog converters (DACS), by changing a stream of digital bits to an analog video output signal. Adequate documentation on the converters is essential. Too much gain in one channel is easy to fix if you know what to adjust and where to connect an oscilloscope.

The graphic video must be timed to the switcher for use in production. A sync generator solves the problem of timing. In freestanding systems feeding only a tape machine, the generator provides stable sync for recordings. For integrated systems, the generator locks to outside equipment with advance or delay timing adjustments.

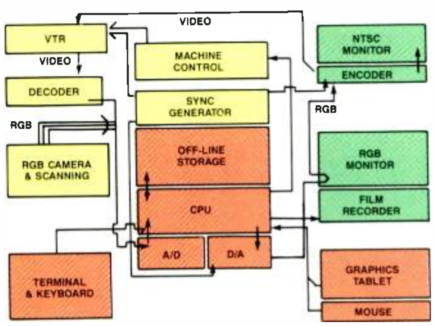



*Figure 1. Modules forming a graphics system.*

The generator also produces drive pulses for the encoder, cameras and related hardware.

The sync generator should be a separate unit so that if it fails, it can be replaced or repaired without shutting down the entire system. Graphics people know about graphics system design, and sync generator people know about sync generator design. Companies that know both fields well commonly keep the two products separated.

### Storage

Graphics systems need off-line storage as a filing system to hold pictures that are not needed right away, so that they do not use system memory. Storage also provides a backup for work that is valuable or hard to recreate. Finally, it gives a method to transport images to other systems or to provide some security for proprietary images.

Storage systems include removable hard disks, floppy disks or streaming tape media. An axiom of bookkeeping systems—that the interval between backups should not exceed the amount of work one cares to do over—applies in computer graphics, but even more so. An accountant can reconstruct accounts receivable from invoices. An artist has no paperwork to fall back on. Just matching a color can mean hours of repeat work.

### Interface

Communication with the computer can be through prompts and icons on the monitor screen and points on the graphics tablet. Most systems also have a terminal and keyboard for entry of alphanumeric text, file names, passwords and system-level communications with the computer. Operation menus may appear on the terminal or the monitor used for painting. Instructions regarding choice and mixing of color must be displayed in color, so every system uses some icons or palettes on the color monitor.

The computer output is usually in red, green and blue (RGB) channels, sometimes with a fourth for sync (RGBS). Some put sync on green (SOG), and others forget about it. The RGB signals must be changed into the format used in the plant. For NTSC systems, an encoder converts RGB components to composite video. For component systems, a transcoder converts between RGB, Y/R–Y/B–Y, YIQ and others.

Hand-drawn images take time. A more efficient method to put images into the computer is by using a camera and analog-to-digital digitizing hardware. Later, the artist retouches images as necessary. Logos and trademarks often are difficult to recreate, but a camera and copy stand near the operator's console simplify the process.

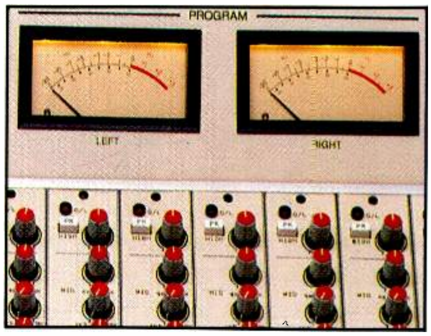
Using a studio camera for scanning or retiring an ENG camera to the art department is tempting, but neither is really cost-effective. A better solution is a new camera from the top of the industrial range. The artist gets clean, crisp images with auto-centering and color balance, and the engineer won't be in a constant state of tweak for registration and shading. Although less expensive than a broadcast unit, such a camera should perform well on a copy stand. In adding the camera, plan on analog-to-digital (A/D) conversion cards and, perhaps, software updates.

If an image is already in a video format, then NTSC-to-RGB decoding enters the system. Like the sync generator, a decoder is probably best left to decoding experts.

A likely source for graphics is a VTR, probably the one used to record animation. Computer control of the VTR is convenient for scanning images from tape, but automatic machine control becomes essential for animation and its many single-frame edits. Choices include a serial interface card in the computer and a 9-pin cable connected to the VTR or an external controller for machine tending.

Photographic copies of graphics are useful in cataloguing the image inventory as well as creating art materials for print or projection. Plan on a video printer or film recorder for this function.

Graphics system components will vary. However, if you compare what we have discussed here to the equipment needing service, it will help you to understand your system and its operation and to increase your effectiveness in servicing graphics products.




## Bring your DA back with phaser rocking

**By John Battison, P.E.**

A technique often employed to return a wandering directional antenna system to its licensed parameters is *phaser rocking*. Carried to its ultimate conclusion, phaser rocking involves the stationing of personnel equipped with field measuring sets and mobile radio equipment at each of the points to be monitored. The process is not something to be undertaken lightly or without making the proper preparations.

Because phaser rocking must be done carefully if it is to be useful, it also is time-consuming. After each change is made in a phaser setting, the fields measured at the monitor points are reported by radio to the engineer performing the adjustment. These values then are recorded in the appropriate columns against the specific adjustments.

If an operating bridge is available, it should be connected at the common point to ensure that abnormal departures from the licensed common-point impedance, hence current, do not occur. Normally, small variations in the common-point impedance will be noted and can be recorded as the phaser controls are rocked. But unless any wide variations are noticed, which would indicate severe misadjustment of the phaser, these readings are not too important at this time. Of course, if a new set of phaser control settings is obtained, it will be necessary to measure and correct the common-point impedance as required.

### Careful adjustments

A good way to proceed with phaser control rocking is to vary the controls systematically in turn, commencing with the magnitude control for tower No. 1 and advancing it about three quarters of a turn clockwise, depending on the gear ratio. All phase-monitor readings are then recorded along with the reported monitor-point readings. The actual change in phaser settings will depend on individual preference and the conditions.

The No. 1 tower magnitude control is then retarded one and one-half turns counterclockwise from its last setting, so that it is actually three quarters of a turn counterclockwise from the original setting. Again, all phase monitor-point readings are recorded. This magnitude control is now returned to its original setting. All readings should be the same as they were prior to the first movement of this control.

Next, the phase control of tower No. 1 is moved in a similar manner, as are all the other controls in turn. When the exercise has been completed, the results can be tabulated. Analysis of the data should show that specific adjustments to certain towers cause changes in the desired direction in monitor-point and phase-monitor readings. It usually is possible to determine from the tabulated data the direction in which the phaser controls should be moved to obtain the desired results.

It is absolutely essential to record the phaser settings before any knob is turned and to keep an accurate and concise record of every adjustment you make. If you don't, you are liable to end up with an array that is completely out of adjustment.

### Transverse radials

In the adjustment of a directional antenna, an unwanted null or lobe may sometimes appear. It frequently happens when the monitor points have failed to show incorrect adjustment of the antenna, that is, the monitor points are within FCC limits. Unfortunately, however, when a skeleton proof of radials is run, it is sometimes found that the inverse fields along these radials are higher than you would expect from the monitor-point values. Or, the monitoring points could be a great deal lower than the licensed monitor-point values. This also would be a cause for suspicion.

If an unwanted lobe or null is suspected, run a transverse or cross radial. This frequently will show the unwanted effect. The technique of making a transverse radial is a little different from running a regular radial.

### Example

In the case of a transverse radial, it is a good idea to select an arc or radius of a suitable value, perhaps two miles. Draw this arc with a radius covering the entire suspected area. In one case, we had four radials with an arc at a radius of about 1.9 miles crossing all four. Good measuring points were picked at intervals of approximately one-tenth of a mile or less along this arc, and a series of measurements were made.

These measurements were plotted on linear paper with the azimuth plotted in degrees along the abscissa, and the field strength in millivolts along the ordinate. The licensed pattern called for a null at 277°. To our surprise, we found the null to be at 287°!

The transverse radial could be run as a straight line in any desired direction. However, the distance from the antenna would then vary from each point, and a third variable would be introduced into the problems. Use of a transverse radial is not common in normal directional antenna work. However, it is a tool that can be extremely useful at times.

### Weeds be gone

The antenna field should be kept clear of all brushy vegetation, and grass and weeds should be kept cut to a low level. Within the area around the tower base, crushed rock—and only crushed rock—should be used as a ground cover. The area must be kept clear of weeds and vegetation. Apply weed killer to the area at regular intervals. Allowing tall brush to grow around the tower bases is a sure way to encourage varying DA meter readings.

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

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# About waveguide components

By Elmer Smalling III

The most common waveguide devices used in satellite communications include isolators, directional couplers, circulators, power splitters and dc blocks. Many of these passive devices appear to be simple lengths of waveguide, so it is worth investigating each of them and understanding how they are used in a system. Some systems employ coaxial cable as transmission line rather than waveguide, but the same information applies, because the coax devices are waveguide elements fitted with coax-to-waveguide adapters.

### Isolators

Isolators are transmission-line sections that have been inserted with the magnetic substance *ferrite*. The ferrite absorbs power that is reflected from the antenna but passes power going toward the antenna. Ferrite isolators are based on the *Faraday effect*, which describes radio wave transmission and attenuation in a magnetic field. An isolator includes a small permanent magnet that is mounted on the waveguide section next to the ferrite element. Depending upon the position and polarity of the permanent magnet, the ferrite element absorbs the phase-shifted reflected waves, while appearing almost transparent to incident (forward) waves.

Reflected power can damage transmission components as well as the front end of a satellite receiver. For this reason, isolators are employed in all earth-station systems to protect other elements of the system.

### Directional couplers

Directional couplers pass a signal in one direction with little attenuation (0.5dB to 3dB), while exhibiting 20dB to 40dB attenuation in the opposite direction. These devices usually are constructed of stripline circuitry and mounted in housings not much larger than waveguide.

The basic directional coupler consists of a straight-through section of transmission line with an adjacent loop section closely coupled and terminated to ground or to the outer conductor or case. The reflected signal is 180° out of phase with the incident or forward signal. Measuring the voltage on the probe loop with the loop terminated at one end, then reversing the termination and measurement, achieves a voltage ratio. This ratio is called the *voltage standing-wave ratio* and indicates how well the transmission line couples the signal from the transmitter to the antenna.

A poorly matched antenna or transmission line may show maximum power on the transmitter output meter when, in reality, only a small percentage of the signal is being delivered to the antenna. In the case of a mismatch, power is reflected back down the line or dissipated in the isolator.

The voltage standing-wave ratio (VSWR) may be calculated with the formula:

$$VSWR = (V_{out} - V_{ref\ 1})/(V_{out} + V_{ref\ 1})$$

Maximum SWR limits are usually included as part of transmitter specifications. Earth stations should include a permanently mounted directional coupler, so the VSWR can be checked as a part of routine maintenance.

### Circulators

A waveguide circulator has multiple ports feeding from a central unit that includes an internal ferrite phase shifter. The circulator allows for multiple use of one port by the other ports. Like the isolator, the circulator employs a permanent magnet to change the characteristics of the ferrite at the hub of the unit and, therefore, the phase of the incoming and outgoing signals.

Under normal operating conditions, one port (output) of the circulator is connected to the antenna, while the remaining ports (inputs) are connected to transmitters or receivers using that antenna. Because of the characteristics of the ferrite noted under isolators, the circulator offers little attenuation to the input port signals in one direction while offering high resistance (attenuation $\geq$20dB) to signals reflected from the output or antenna port.

### Power splitters

Waveguide devices that divide an input signal between two or more output ports are called *power splitters*. It is standard practice to feed multiple receivers or test and monitoring devices from one transmission line using splitters. Splitter designs have two basic parameters: input/output impedance (normally 50Ω) and port loss. As the number of outputs increases, the port loss increases until a usable lower limit is reached. For each 2-way split a loss of 3dB from the input to each output occurs. A 4-output device will have a port loss of about 6dB. If higher input/output losses are desired to limit signal levels to a particular output, attenuation can be integrated into each output port.

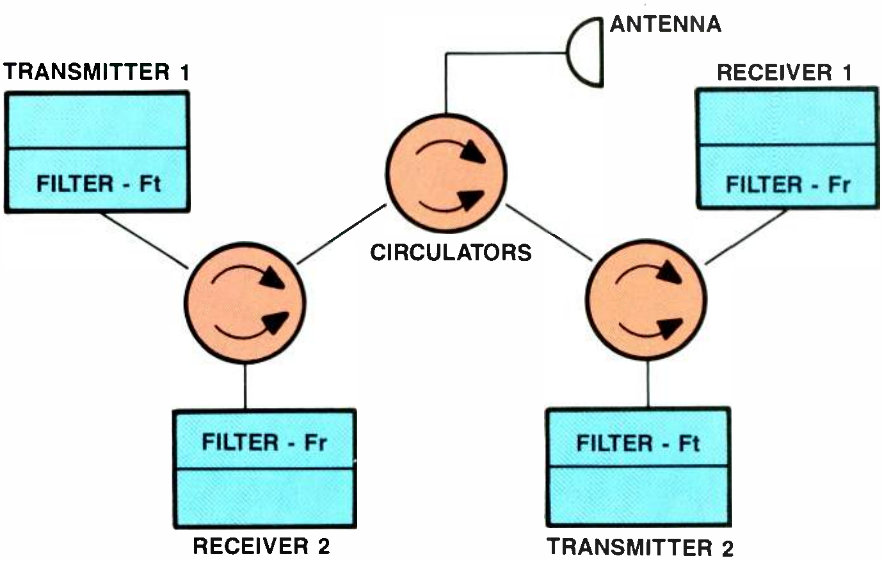


*Figure 1. A system with three circulators allows two receiver/transmitters per antenna.*

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

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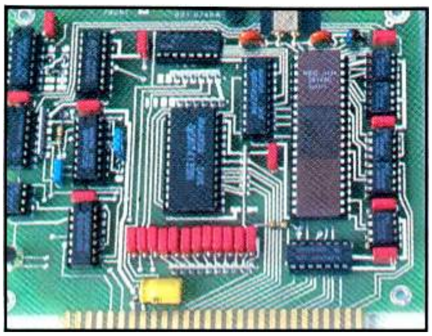

# Inside digital circuits

By Gerry Kaufhold II

A digital equipment designer usually will strive to minimize the number of parts used to implement a circuit. For this reason, most digital decoder circuits work with true binary or hexadecimal datastreams, because fewer gates and digital IC packages are needed if data is represented in binary form.

### Decoding thumbwheel switches

One practical application in which you are likely to see the need to convert decimal digits into binary digits occurs whenever thumbwheel switches are used to control a device.

For example, the remote channel select thumbwheel switches used on your station's satellite receiver will present choices for up to 99 channels, by using each of the digits 0 through 9 twice. The receiver circuit may bring in the 10 wires from the remote thumbwheel switch through an input/output printed circuit module. The information from the decimal-coded thumbwheel switches is buffered through an interface circuit, then decoded into binary.

The numbers 0 through 99 (decimal) can be expressed with only seven binary bits, so a smaller edge-connector can be used to interconnect the input/output module to the tuner circuit if the information from the decimal thumbwheel switches is converted into binary. A smaller connector will cost less, and the system will be more reliable if the number of interconnection points is minimized.

If the thumbwheel switches are decoded into binary right at the switch, then fewer wires need to be run from the studio back to the satellite control room. You can see how the decision to convert decimal information into the binary is based on common-sense business logic, in addition to basic engineering.

### Doing the decoding

The circuitry for converting inputs from two decimal thumbwheel switches into their binary equivalent is called a *decimal-to-binary converter.* Recall from last month's column that four bits of digital data can represent up to 16 possible unique logic states. In order to represent the 10 logic states of the decimal system, four is also the minimum number of bits that must be used.

The technique of using four bits to represent only 10 unique states is called *binary coded decimal* (BCD) notation. Even though you could use four bits to represent up to 16 unique combinations, the BCD notation "wastes" the logic states represented by the hexadecimal digits A, B, C, D, E and F.

The 74184 and 74185 TTL-integrated circuit packages are examples of devices that convert BCD into binary numbers.

### Decoding using ROM

One technique used for converting BCD to binary uses *read-only memory* (ROM). The BCD inputs are used to select memory locations inside the ROM chip. The ROM is programmed so that the true binary equivalent of the BCD number is stored at the address defined by the BCD data. Almost half of the addresses in the ROM are wasted using this method, but the conversion is fast because no active operations must be performed inside the chip.

When the output of the converter circuit is activated by its output enable line, the binary signal is used in place of the BCD data at the input of the converter.

### Shift, subtract and shift

Another decoding scheme that does not waste storage addresses in ROM, and therefore costs less, performs several active steps in the conversion. Flip-flops are used as shift registers, and a simple 4-bit subtract circuit is gated on and off by the data of the BCD number being converted.

Because the least significant bit (LSB) of a binary number is either a logic one or a logic zero, and has the same value as the LSB of a BCD number, it can simply be passed through from the input of the converter to the output.

Odd BCD or odd binary numbers will have a one for the LSB. The LSB of an even BCD or even binary number will be zero. The rest of the BCD number is examined in groups of four bits each. Any 4-bit group that has its leftmost bit set has a binary 3 subtracted from it.

As soon as all the groups have been adjusted, the process is repeated by shifting the LSB to the right. The remaining bits of the BCD number once again are adjusted in groups of four, until all bits of the BCD number have been shifted and adjusted, and the leftmost bit is a zero.

The converted BCD-to-binary number is made up of the bits that have been shifted out of the converter, plus the final three bits left in the converter shift register.

This active process of shifting right, grouping into 4-bit elements and subtracting binary 3 can be implemented into an integrated circuit with less complexity than you might guess. The shifting is accomplished by a shift register based on flip-flops, and the decision to subtract is controlled using the fourth bit of each 4-bit group.

### Mathematical conversion

In a purely mathematic sense, the circuits just presented convert numbers from the decimal numbering system into equivalent numbers of the binary numbering system.

If you are given a decimal number that you want to convert into a straight binary number, the easiest way is to use a calculator that has decimal-to-binary or decimal-to-hexadecimal functions. If your calculator works only with decimal numbers, the best way to convert from decimal to binary is by using an intermediate step:

Convert the decimal number into its hexademical equivalent, then convert the hexadecimal number into binary using the rules presented in last month's column. For example:

- To convert a decimal number into hexadecimal, start by dividing the decimal number by the lowest hexadecimal value (from the table in last month's column) that will work.
- To illustrate the point, if the decimal number is 5,000, dividing 5,000 by 4,096 yields 1, with a remainder of 904.
- Divide 904 by 256 to get 3, with a remainder of 136.
- Divide 136 by 16 to get 8, with a remainder of 8.

Now you have converted the decimal number 5,000 into the 4-digit hexadecimal number of 1,388 hex. By referring to the figure from last month's column, and converting each hexadecimal number into its binary equivalent, you'll get the binary number 0001 0011 1000 1000 = 1,388 hex = 5,000 decimal.

Kaufhold is an independent consultant based in Tempe, AZ.

*THE NEW OPTIMOD®-AM 9100B*

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Today, after hundreds of hours of discussion and study, the standard finally exists that will allow receiver manufacturers to increase and flatten their frequency response without risk of increased interference. But for them to do this, broadcasters must implement the standard: a "modified 75μs" pre-emphasis specification brightens up the sound on older radios while minimizing interference to adjacent stations, while a sharp-cutoff 10kHz low-pass filter specification protects the second adjacencies by limiting occupied bandwidth.

Receiver manufacturers have stated their willingness to replace their current AM receiver designs (with their telephone-quality fidelity) with AM receivers having full 10kHz frequency response—but *only* if and when the NRSC standard is fully adopted by broadcasters. For the NRSC standards to be successful, broadcasters must change over ***quickly***. If the new high-fidelity receivers generate complaints of interference caused by stations not complying with the new standard, the receiver manufacturers will revert back to the present low fidelity 3kHz designs! *Everyone* will lose.

Orban was the first to propose and implement AM pre-emphasis and low-pass filtering, and we were heavily involved in the Committee work and research. We strongly endorse the new NRSC standard. It's good engineering ***and*** good business, and we are making it easy for all OPTIMOD-AM owners to comply.

**Introducing the *new* Model 9100B:**

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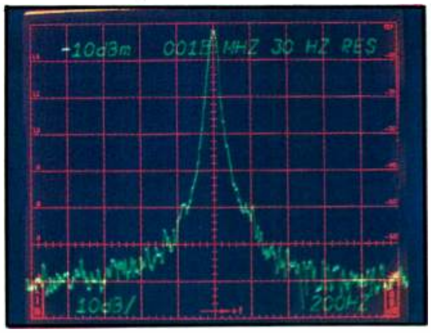
Part 2

# Troubleshooting



## Maintaining computer storage devices

**By Allan Hughes**

Floppy disk drives, the mechanical marvels of most computer systems, do require periodic maintenance. Because a drive usually is ignored until a problem arises, it is subject to both mechanical wear and possible circuit degradation throughout its life.

Although you can test drives in most computer systems using a software program, you're limited because the drive has to be working properly to load the program.

Most drive-test programs available today are designed only to tell you if the drive needs servicing. The actual servicing is not performed with the software program.

### Levels of service

With the drive removed from the system, two distinct levels of service are necessary—head alignment and drive functional (read/write) testing. Head alignment refers to the five most common adjustments on every drive: radial alignment, azimuth adjust, motor speed, index and track 0 sensor position.

Functional testing determines whether the drive reads and writes properly with a minimum of errors. A drive can be perfectly aligned and adjusted and yet not be capable of reading and writing data when installed in the system. Conversely, a drive may have excellent system performance and yet be so far out of alignment that other disks cannot be interchanged with it.

Selecting the right test equipment is straightforward once you have identified the level of service you wish to achieve. Head alignment can be performed easily with a simple drive exerciser, analog alignment diskette and a dual-channel oscilloscope. Functional testing is best performed by a disk-drive tester. It has many test capabilities not available using system diagnostics, such as measurement of window margins, asymmetry and step rates. All testers on the market duplicate the functions of an exerciser for head alignment.

### Head alignment

The block diagram in Figure 1 illustrates the test setup to perform a head alignment on a 5¼-inch floppy disk drive. With the possible exception of the dc power-supply voltages, all sizes of drives use this same setup.

Typical oscilloscope waveforms from an analog alignment diskette are shown in Figures 2 and 3. The actual adjustment procedures and specifications vary from drive to drive and can be found in the drive maintenance manual.

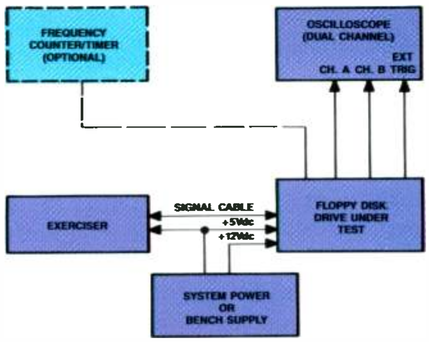



*Figure 1. Connection of a floppy disk drive to an exerciser and oscilloscope for head alignment.*

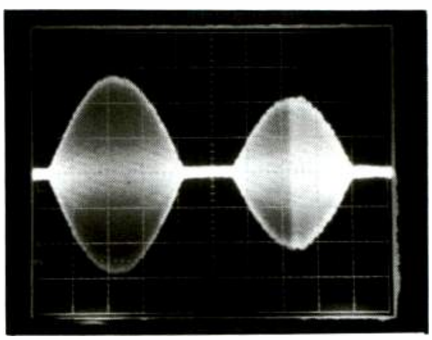


*Figure 2. The "cat's eye" pattern seen on the oscilloscope during radial alignment.*

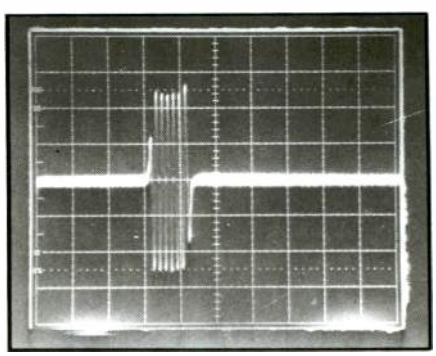


*Figure 3. A scope trace showing the time from index to burst with the scope triggered on the leading edge of the index pulse.*

Figure 2 shows the *cat's eye* radial alignment pattern, in which the ratio of lobe amplitude determines the adjustment needed. Here the lobe rate is approximately 75%. Perfect alignment is 100%, or both lobes equal.

Figure 3 shows the time from index to burst, with the scope triggered on the leading edge of the index pulse.

### Exerciser vs. tester

There is much confusion about the use of the terms *exerciser* and *tester*. Fundamentally, exercisers do not process or analyze the *read* data coming from the disk drive. Although they may or may not be microprocessor-based, their primary function is to allow a service technician to select a track or head, start/stop the drive motor, and complete other exerciser functions for the purpose of head alignment and/or troubleshooting. Most exercisers also are capable of writing simple 1F or 2F (unformatted) data on a blank diskette to verify the operation of the drive-write circuitry.

Testers, also called analyzers, are microprocessor-based instruments that can format and read an entire diskette and report errors as they are found. Most can test multiple drives automatically and show the results with a hard-copy printout. In addition to their read/write capabilities, testers can perform read (window) margin checks and other parametric testing to determine whether the drive meets manufacturer's specs.

Most testers can measure head alignment without an oscilloscope, either by duplicating the analog functions of a scope or by using a digital alignment diskette. The advantages are a greatly simplified setup and the capability for recording on a printer the results of all tests.

Although few broadcast facilities would have the need to purchase a floppy disk-drive exerciser (prices range from $200 to $500) or a tester ($1,000 to $8,500), it is reassuring to know that drives can be accurately checked and reliably repaired. As with hard disk drives, the key is finding a computer maintenance shop with the right test equipment—and people who know how to use it.


Hughes is president of AVA Instrumentation, Ben Lomond, CA.

Part 3

# Management for engineers

## Time management

By Brad Dick, radio technical editor

A popular management theory states that 80% of what you achieve is accomplished in 20% of your time. The experiences of many management experts support this ratio. After completing the time audit outlined in the last two columns, you may be able to provide first-hand confirmation of this theory.

If, like many engineering managers, you are working 40 to 50 hours a week, then according to this ratio, only eight to 10 hours of that may be quality work time. (How would you like to admit that to your boss?) The solution to improved productivity lies not in working harder, but in working smarter. Armed with the results of your time audit, you are in a good position to do just that.

### Four mistakes

The majority of a manager's time often is spent resolving crises instead of preventing them. When was the last time you planned a thorough preventive maintenance program? The key here is to plan for such events, then work to see that problems don't develop.

The second most common mistake is letting frequent interruptions destroy planning incentives and momentum. Close the office door, and don't answer the telephone. Don't be afraid of seeking time away from the office hassle to plan for effectiveness.

A third mistake managers make is spending too much time on unimportant objectives. It is crucial to work on things that matter. Unfortunately, it is common to find managers spending time in activities they consider fun, rather than on tasks that produce results.

Do you have a favorite task that you prefer to complete, although it could be delegated to another person? I know several engineers who take it upon themselves to take weekly transmitter readings, even though they have fully qualified staffs capable of performing this task. Why do they do it? Because they enjoy it. Another engineer insists on sorting and distributing all the station mail. Tasks such as these could be handled by others, freeing the manager for more important jobs.

Another mistake is spending your most productive time on tasks that don't require the most creativity. When are you personally the most productive—in the mornings or afternoons? If you are at your best in the morning, then don't waste that time reading the mail. Instead, tackle a complex or important project. Use your creative energies on tasks that matter. Later, as your energy wanes, you can read the mail or work on less strenuous or less critical tasks. Some typical barriers to effective time usage are listed in Table 1.

- TELEPHONE INTERRUPTIONS
- SPENDING TIME ON LOW-PRIORITY ACTIVITIES
- EXECUTIVE HOBBIES
- OFFICE TRADITIONS
- UNSCHEDULED VISITORS
- LACK OF PROPER COMMUNICATION
- INABILITY TO SAY "NO"
- CRISIS MANAGEMENT

*Table 1. Typical barriers to effective time management.*

- SCHEDULE AROUND KEY EVENTS
- PLAN EARLY-DAY ACTIONS
- ALLOW FOR GROUP-RELATED ACTIVITIES
- MATCH WORK TO YOUR ENERGY LEVEL
- SET ASIDE ENOUGH TIME FOR EACH TASK
- AVOID "EXECUTIVE HOBBIES"
- CONFIRM YOUR APPOINTMENTS
- WATCH YOUR TIME

*Table 2. These guidelines can help you to manage your time better, improving your overall job effectiveness.*

### Solutions

The time audit has shown you how you are spending your time. You are now aware of some common time robbers and know that a typical manager is effective only about 20% of the time. So what can you do to improve your productivity?

First, identify the major objectives of your job. What are the most important tasks that must be completed to reach these objectives? When you've identified them, write them down. These are the tasks on which you should be spending your time.

Second, block out committed time over which you have no control. This might include scheduled meetings and conferences. After all, it doesn't make sense to plan on completing a budget report on a day when you will be out of town or tied up in all-day meetings. You now have a calendar on which to base your efforts.

Third, using the calendar, set deadlines for completion of the major tasks you have identified. Estimate the amount of time needed to meet these deadlines, and working backward, determine when you must begin each project. Be sure to allow for unforeseen circumstances. Remember, Murphy's law is always at work. Some projects may take weeks or months to complete. Others, such as a budget report, may take only a few hours or days. The important thing is to recognize that these projects now have deadlines that must be met.

Using the calendar and task list, spot the important deadlines that must be met within the week or month. Consider all items that have to be completed within the week as main events. These are the tasks on which you should be concentrating your short-term efforts. Finally, using the guidelines listed in Table 2, organize your day in an effective manner, blocking out the necessary and appropriate time slots as you see fit.

It might sound complex, but it isn't. Time management is actually a simple and logical process, but it does take determination and honesty. Once you've mastered it, you're sure to agree that the results are worth the effort.

By Jerry Whitaker,
editorial director

# Digital technology

**Once a novelty, computer-based equipment is becoming the mainstay of broadcasting.**

Think back to 10 years ago. You could look through this and other trade magazines and see products offered that trumpeted in their advertising terms such as "computer-controlled" or "microprocessor-based." It was a big deal back then. And it signaled a major change in the way broadcast products were designed, built, operated and maintained.

The digital revolution that began approximately 10 years ago in the radio and TV industry hasn't slowed. However, we have become accustomed to the march of progress that the digital world has given us. Each trade convention brings with it new products, usually built around or controlled by a computer of some kind. We have grown to appreciate and to depend on computers to provide equipment with greater flexibility, features, reliability and performance than were possible with any previous technology—and all at steadily decreasing prices.

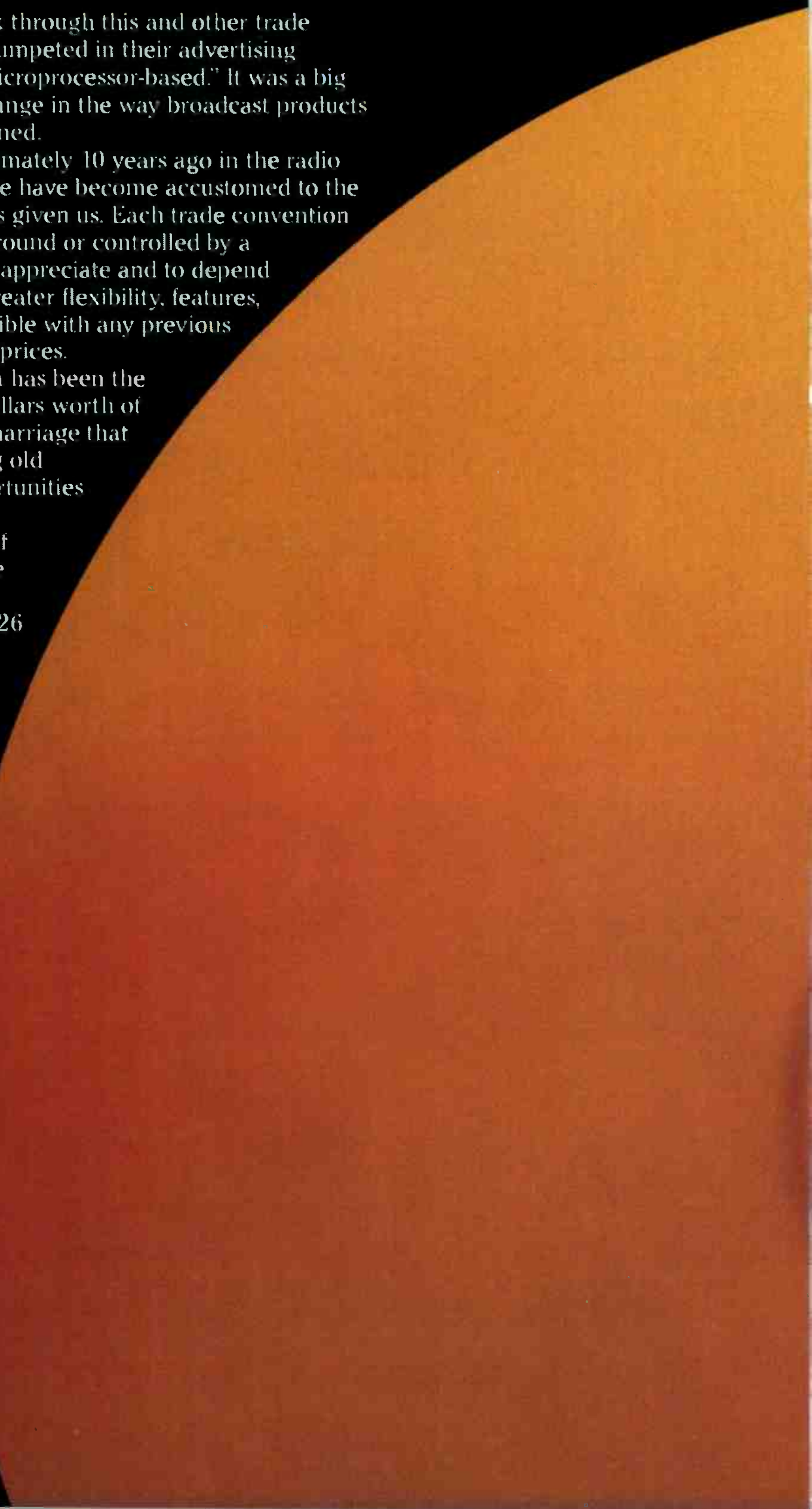
Digital technology in the broadcast arena has been the recipient of millions, perhaps billions, of dollars worth of research by the computer industry. It is a marriage that has given broadcasters new ways of solving old problems, and it has opened doors to opportunities that nobody dreamed about a decade ago.

This month, we examine two key areas of digital technology for broadcasting: storage media and user interface.



The broadcast industry has reached a point of sophistication with digital hardware. We can anticipate upcoming developments, and we welcome them from hardware manufacturers. The days when computer-based gear was distrusted or even feared are, thankfully, behind us.

Digital technology for broadcasting has provided the means for radio and TV stations to offer more to their audiences, in less time, and for less money.



*A key frontier in the design of digital audio and video products is storage capacity. Improvements continue to be made in magnetic disk recorders, shown here, and in alternative optical and solid-state systems. (Photo courtesy of Oktel.)*

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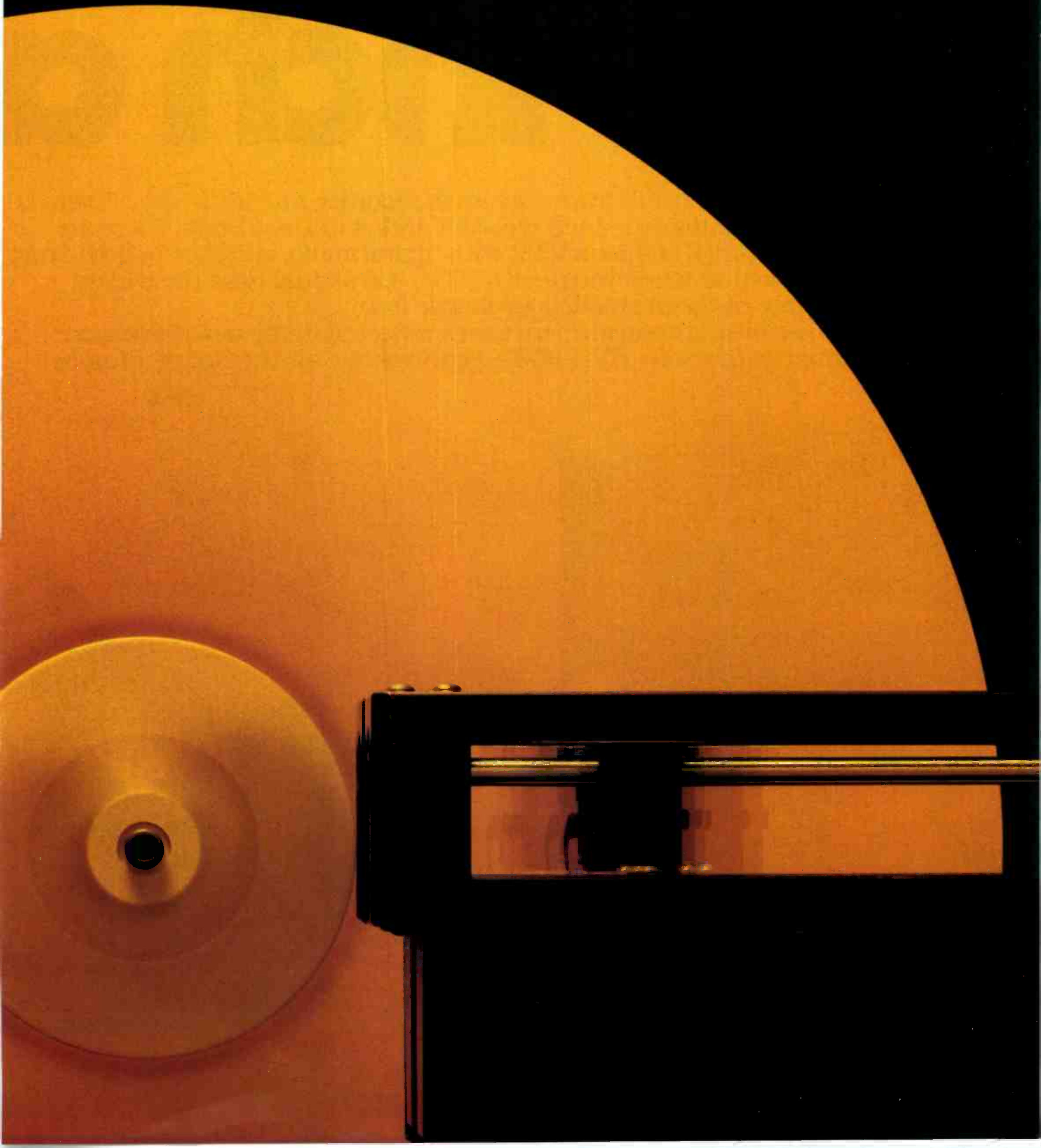

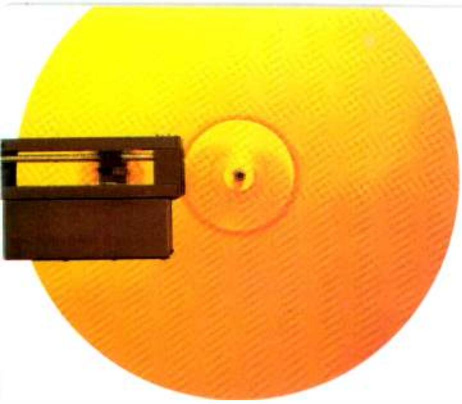

# Disk recording technology

By Jerry Whitaker, editorial director

**Advancements in hard disk drives have provided new creative tools for TV and radio broadcasters.**

Data is data. Right? Well, when you're talking about data that represents video or audio signals, the similarities stop at the ones and zeros. The recording and reproduction of data for common computer applications is not *time-dependent.* It is true that the access time for a storage device has a significant effect on the execution time of any program. However, the only problem for the computer operator is a few wasted seconds or tenths of a second.

**Editor's note:** The author wishes to thank the following individuals for providing input for this article:
- Mark Pinkel, Abekas Video Systems
- Kevin Dauphinee, Digital Audio Research
- Mark Terry, New England Digital

When you start recording video or audio, however, a tenth of a second is a big deal. A disk-based recorder must be capable of keeping up with the sampled input, then reproducing the signal in *real time.*

A video waveform presents the greatest challenge to designers of disk recorder hardware and software. Video is extremely structured. A given amount of data is needed every field, every frame, every second. If you can't get the required amount of data, you don't have a machine. It's that simple.

*From the outside, hard disk recorders appear as just so much black magic. A closer examination, however, reveals the basic principles upon which these units operate. Improvements in design and manufacture of disk drives promise more benefits to broadcasters. (Photo courtesy of Oktel.)*

### Winchester disk

A Winchester disk drive is a historic name commonly used to describe a class of hard-drive systems. The exact origin of the name is a bit unclear, but most accept the term to represent a wide variety of hard disk storage units, in which the head floats over the medium on a thin film of air.

The design of a Winchester disk is elegant in its simplicity. There are few moving parts to wear out or lose their designed tolerances. In nearly all disk drives, one read/write head is associated with each side of each platter. (See Figure 1.) Each head is connected to an arm that is mechanically linked to the other read/write head arms to form a single mobile assembly. This assembly is moved across the disk by the *head actuator,* a special solenoid or motor.

Unlike floppy disk drives, hard disk platters constantly spin, at least while powered up. The mass of a large hard disk platter assembly can take significant time to achieve its designed rotational speed of about 3,600rpm. Start-up time for a hard disk from a cold stop can range from 10s to 30s.

Most newer read/write head actuators use a *voice coil* assembly that provides fast and reliable operation. The voice coil approach is a substantial improvement compared with the jerking action of mechanical band positioner designs previously used. The voice coil mechanism operates in a fashion similar to a loudspeaker voice coil, hence its name.

A voice coil head actuator operates in a

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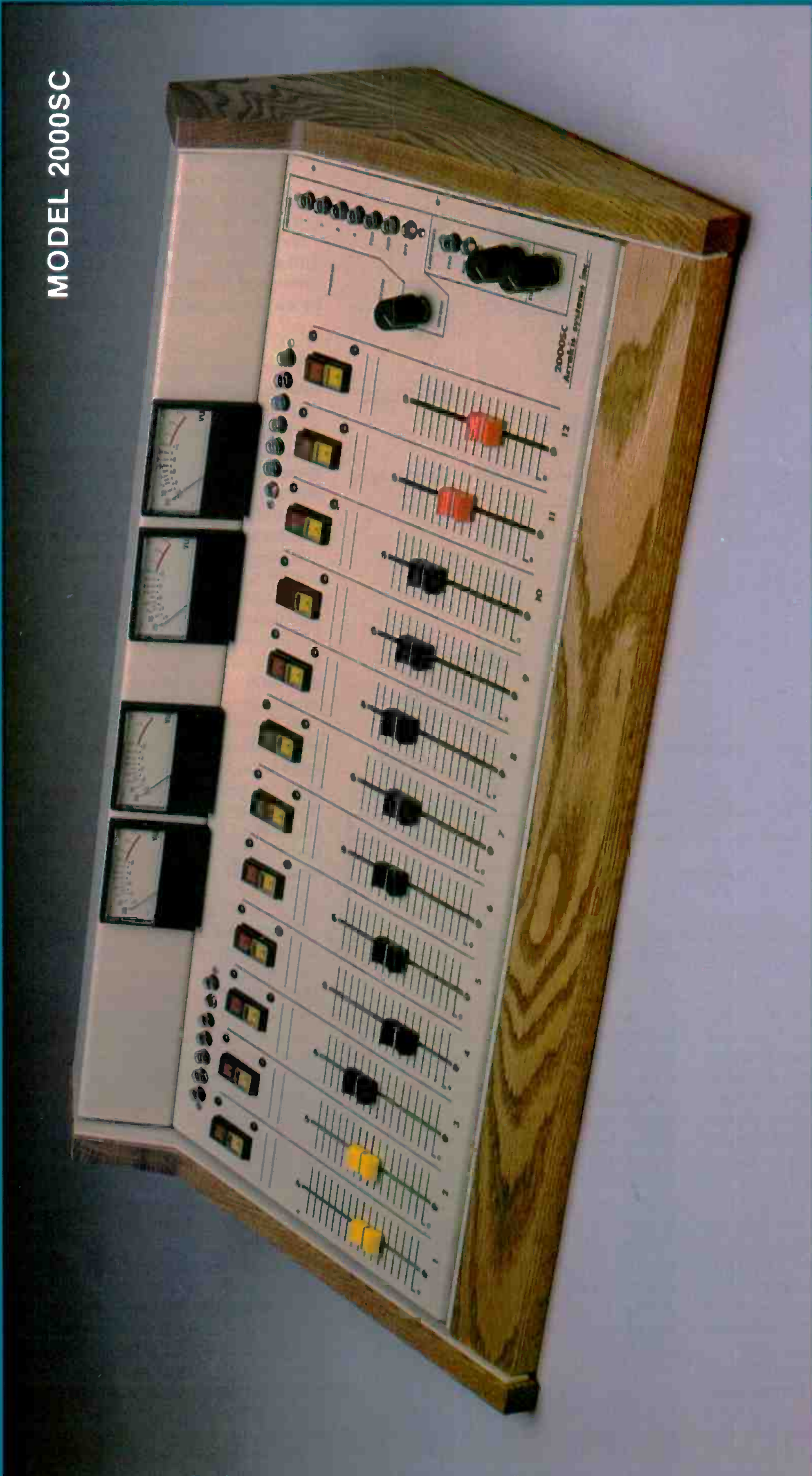

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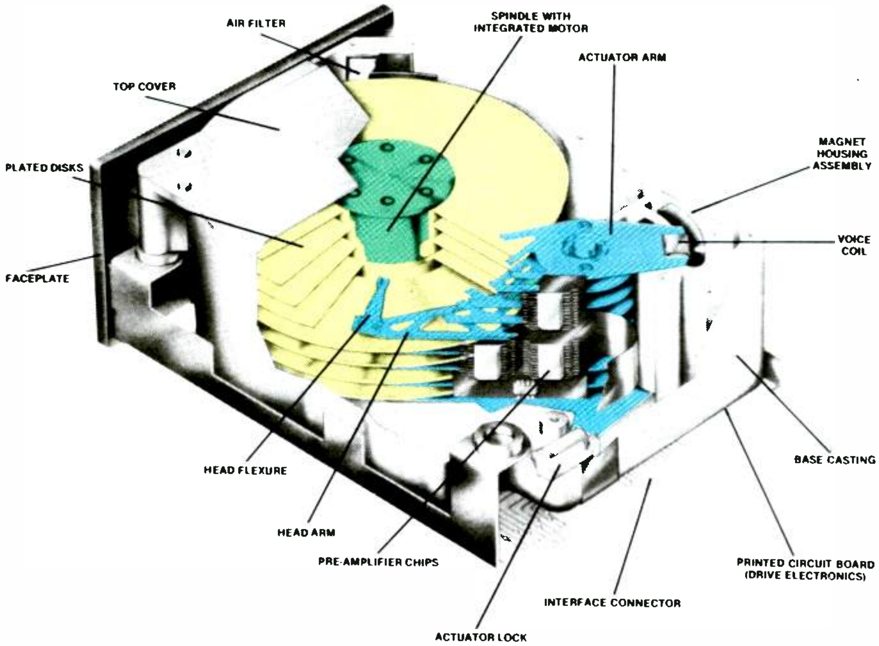


***Figure 1.** Construction of a typical hard disk drive. Note that each disk is locked together by an integrated spindle motor. (Illustration courtesy of Maxtor.)*

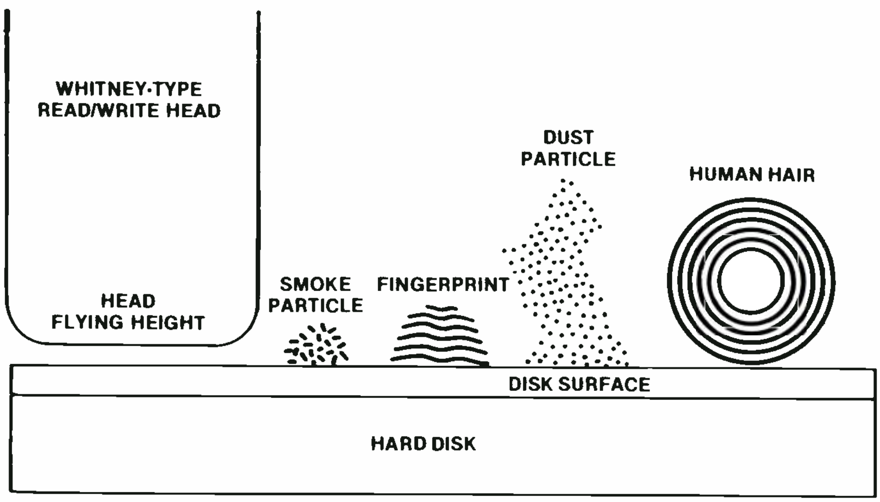


***Figure 2.** A dramatic illustration of why hard disk drives are evacuated and sealed. Many commonly occurring contaminants can destroy data or even the disk drive itself. (Source: reference 6.)*

closed-loop environment. The disk controller always knows where the head is by reading data from a special, dedicated platter in the disk pack. This platter, the *servo surface*, includes a special pattern that identifies each disk location. The voice coil pulls the head mechanism against the force of a spring, and because the current is varied through the coil, each part of the disk can be accessed.

The platters in a hard drive generally are constructed of thin, rigid aluminum disks covered with a magnetic material, such as ferric oxide compound, coated over the aluminum substrate and held in place by a binding material. The process is not unlike that used to produce magnetic tape.

Improvements in the medium itself have provided users with greater storage capabilities. Thin-film magnetic coatings have been applied to platters to yield disks with greater packing density. Data tracks can be placed closer together on thin-film disks, meaning that the drive's read/write heads do not need to move as far between random bytes. This improves, to a small extent, the *data access time* of the drive.

An additional benefit of thin-film technology is the durability it gives to the disks themselves. Thin-film disk packs are less vulnerable to some forms of head crashes that usually are fatal to an oxide-coated disk. When a head crashes on an oxide-coated platter, it actually plows a small channel in the soft oxide coating, destroying data as it goes. When the harder thin-film media is used, however, the head may merely bounce off the disk, preserving the recorded data. The benefits to users are obvious.

### Data format

When the drive reads or writes data, the head actuator must stop its lateral motion across the disk. Each time the platter completes one revolution, the head traces a full circle across its surface, defined as a *data track*. Each head traces out a separate track simultaneously across its associated platter.

The combination of all tracks traced out during one revolution at any given position on the disk is defined as a *cylinder*. This description comes from the shape that is traced by the heads from the bottom to the top of the disk pack.

Most hard disk drives divide each track into short arcs, or *sectors*, usually 17. The division of sectors on a disk is determined by the formatting of the system.

### Construction

The construction and assembly of a hard disk drive is a delicate process. A typical drive must position the head in relation to the platter with an accuracy of 20$\mu$m or less while the platter spins at 3,600rpm, and these tolerances must be maintained for the life of the product. The intricacy of the assembly process of a hard disk is, in fact, comparable to that of an integrated circuit.

Basically no maintenance is required for a hard disk-storage system. The units are assembled in a clean environment and evacuated to protect the media from contamination. Barring a break in the vacuum envelope of the recorder, the only contamination threat involves a head crash, which usually is catastrophic anyway.

To increase the security of the data recorded on a hard disk, better drives offer a *park and lock* feature that withdraws the read/write head from the active data portions of the disk when the drive motor is shut down. This minimizes the possibility of damage to active data during transportation of the drive.

### Disk features

Winchester drives come in a wide variety of options and capabilities. The 5¼-inch hard disk drives available today can be supplied with at least eight platters installed, and two heads per platter (front and back). Disk units can be supplied with a wide variety of configurations, storage capabilities and data-access times.

Disk drives provide data output in one of two modes: parallel or serial. Parallel drives permit faster writing and reading speeds because the entire byte of data (all eight bits in an 8-bit system) are available simultaneously. Parallel disk units are more complicated and, not surprisingly, more expensive.

For recording video and high-sample-rate audio, parallel data systems are used. By definition, an 8-bit disk drive will use a minimum of four platters with heads on each side of the platters. In actual practice, more data channels are included in the system to handle housekeeping functions, such as servo tracks and operating-system program storage.

The bandwidth requirements for a video-disc recorder are enormous. And high-

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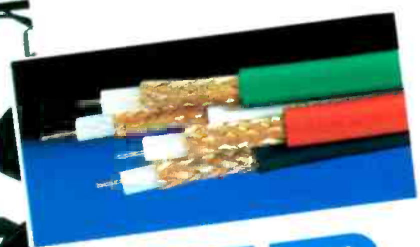

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quality audio is not exactly a piece of cake either. For top-quality recording and reproduction, providing adequate bandwidth requires mass storage capabilities. Table 1 compares the storage capabilities and approximate costs of various media. In the world of mass storage, there are no free lunches.

Advancements continue to be made in packing densities for hard disk units. Each year brings new improvements in disk technology, driven primarily by the computer industry's growing needs for mass storage and rapid random access.

### Error correction

Although digital recording is, theoretically, error-free, much discussion has been focused on *error correction* for various digital recording formats. In point of fact, there is no such thing as error correction. More correctly, it is "error concealment."

Error correction, however, is primarily a concern only with media that is exposed to the operating environment. Dust, dirt and other contaminants can make portions of any magnetic media unreadable, as illustrated in Figure 2. It is the function of error correction to allow reconstruction of the lost data so that the fault is not apparent to the user.

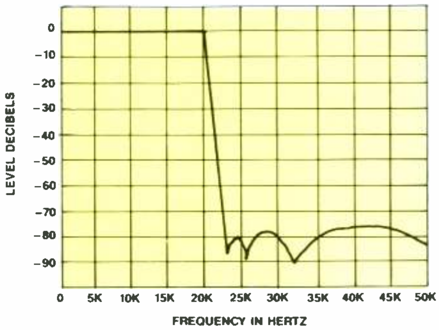


***Figure 3.*** *A typical frequency-response plot of an 11th-order elliptical anti-aliasing filter used in a digital audio recorder. (Source: reference 1).*

The types of media most susceptible to errors caused by media contamination are reel-to-reel or cassette/cartridge tape and floppy disks. High-quality hard disk drives are evacuated and hermetically sealed to prevent contamination from affecting the storage media. As a result, error-correction schemes are rarely required for a hard disk-based system. The result is a system that is simpler to implement in hardware and software.

Even with the best hard disk media, however, some contamination can occur during the manufacturing process. The solution to this problem is implemented during assembly of the disk-based recording system. A software routine examines all storage addresses on a hard disk unit prior to shipment to look for media errors. After those bad addresses are identified, the test fixture burns a PROM that will reside in the host data-management computer. The PROM identifies all of the addresses to which data should not be written or read. The result is that no errors are generated in the recording and reproduction processes. With no errors to correct, there is no need for error correction.

This is not to say, however, that error correction could not be, or has not been, implemented in disk recorders for audio or video. Error-correction codes have been developed by the computer industry to permit reconstruction of lost data from the remaining data, provided the errors are not profound. Codes used in equipment today are virtually media-independent. For example, the Reed-Solomon code can be found implemented in systems using Winchester disks, compact discs and magnetic tape.

With the continual push in the computer industry to pack greater amounts of data onto a given medium, the importance of error-correction codes increases. With higher packing density, minute media imperfections can result in large data losses. Higher packing densities require higher-quality media and, in some applications,




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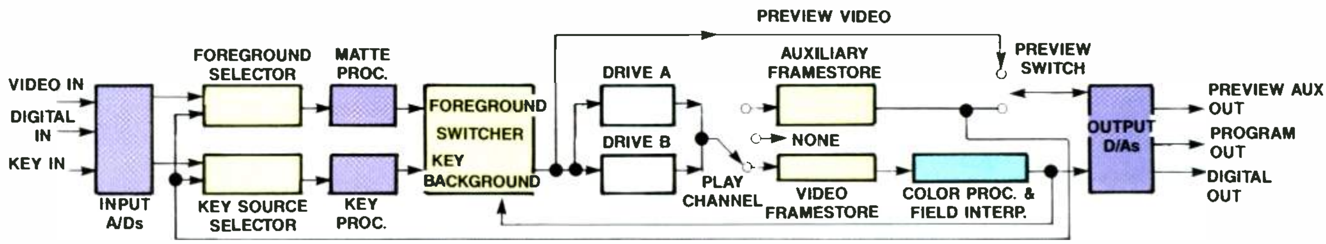


*Figure 4. Block diagram of a digital videodisc recorder offering additional user-selected functions. In this implementation, one Winchester disk drive provides for 50s of record time. The addition of a second drive increases recording capability to 100s and allows simultaneous record and playback.*

| MEDIA | STORAGE CAPABILITY | COST |
|---|---|---|
| 5¼-INCH FLOPPY | 360kb | $1.50 |
| 5¼-INCH FLOPPY | 1.2Mb | 3.50 |
| 3½-INCH CARTRIDGE | 750kb | 1.50 |
| 3½-INCH CARTRIDGE | 1.5Mb | 3.00 |
| BERNOULI DISK | 20Mb | 100 |
| OPTICAL DRAW DISK (12-INCH) | 2,500Mb (double-sided) | 450 |
| WINCHESTER REMOVABLE | 20Mb | 100 |
| WINCHESTER DISK DRIVE | 320Mb | 2,000 |

***Table 1.** Comparison of the storage capabilities of various media, and the approximate cost of the media. Note that the cost of a 320Mb Winchester drive applies to the hardware. (Source: reference 1.)*

more powerful error-correction schemes.

### How many bits?

The resolution to which an analog audio or video signal is coded during the analog-to-digital conversion process involves a number of critical trade-offs. Additional bits mean greater dynamic range, which translates into the primary system specifications of concern to users. Additional bits also mean a more complicated—and more expensive—machine.

Each additional bit in the data word doubles the resolution of the recorded analog signal. An 8-bit system can have a theoretical dynamic range of 49.76dB. A 16-bit system's theoretical dynamic range is 97.76dB. A shorthand formula for determining the theoretical dynamic range of a digital system is as follows:

Dynamic range (in decibels) = $(6 \times N) + 1.76$, where N represents the number of bits in the system.

In the world of video recording onto hard disk units, eight bits has become the current practical standard, sampled at four times the subcarrier frequency (4fsc). The dynamic range possible in actual practice in an 8-bit system is a function of what type of signal is being recorded.

A component signal can exhibit greater apparent dynamic range with a given number of bits than a composite signal because it does not have to go below blanking. With a composite waveform, additional dynamic range is required for accurate sampling of

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| CV-2240 | 3CX10,000U7 | 54–88 | 10 kW† |
| CV-2250 | 3CX10,000U7 | 170–227 | 10 kW† |
| CV-2400 | 8874 | 420–450 | 300/1250 W* |
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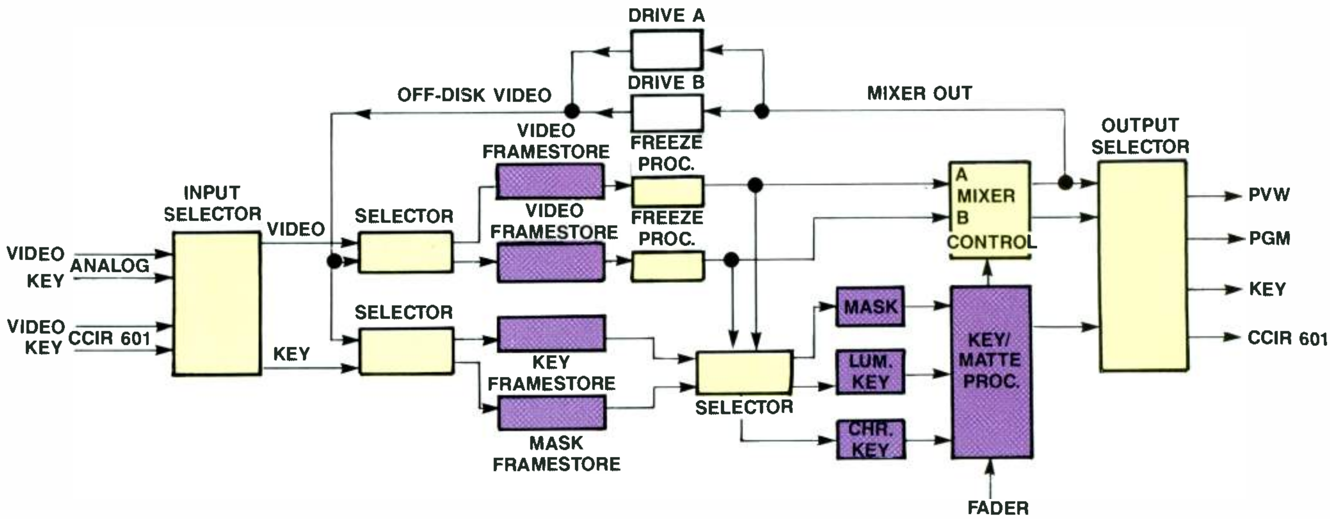


*Figure 5. A videodisc recorder designed for recording to CCIR 601 standards (component video). The luminance signal is recorded on one Winchester drive, and the chrominance signal is recorded on the other drive. Simultaneous record and playback is possible with the addition of sufficient drives.*

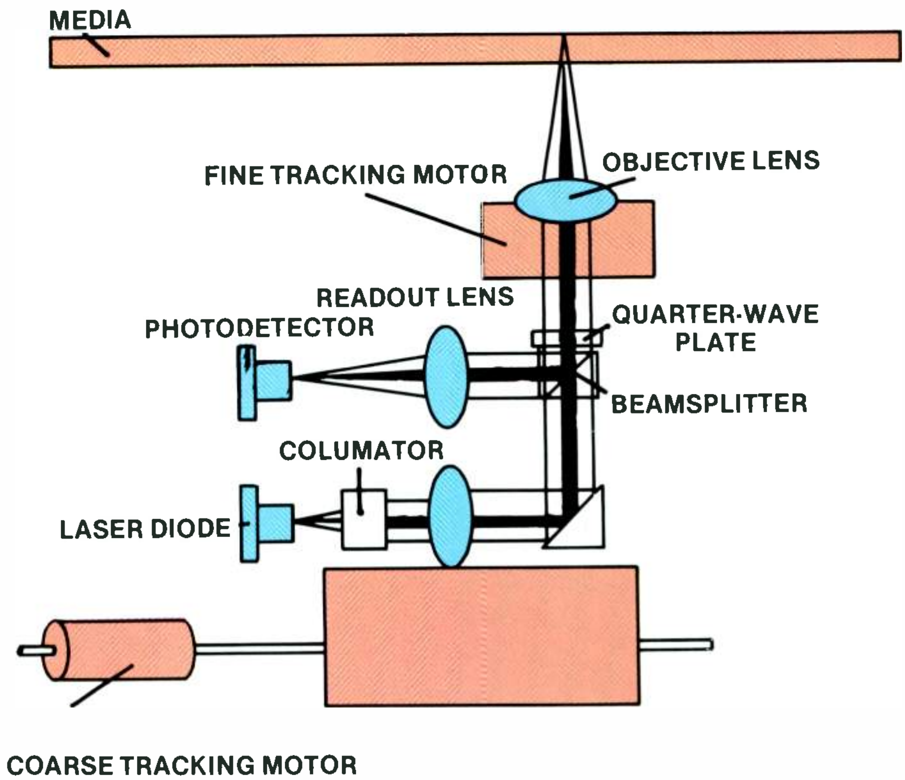


*Figure 6. Major components of a WORM disk drive. The fine tracking motor is positioned to permit reading several tracks without movement of the coarse tracking system. (Source: reference 4.)*

the input video. Adding bits basically buys improvements in signal-to-noise and differential gain and phase performance.

In audio recording using hard disk systems, a number of variations can be found. The current practical limitation is 16 bits, although higher-bit-rate systems have been produced. Because the bandwidth requirements of audio are small compared with that of a video signal, disk-based audio recorders offer users much longer recording times and, in some cases, user-selectable sampling rates. Systems are available that allow the user to trade off recording time for audio bandwidth.

For example, one system might provide 26 minutes of stereo recording time on a group of Winchester drives with a sampling rate of 50kHz. At the option of the user, however, the sampling rate may be switched to 100kHz, but at the penalty of only 13 minutes of stereo recording time available from the system. It may be important to the user to have the wider bandwidth when recording synthesized sounds that exhibit extended high-frequency information.

The bandwidth (frequency response) of a digital audio or video system is limited by the sampling rate of the A/D converter and its associated filters. The *Nyquist* criteria states that any sampled continuous waveform can be reproduced faithfully if the sampling rate is at least twice the highest frequency present in the sampled waveform. For the disk-based audio-recording system described previously, the sampling rate of 50kHz would provide frequency response out to 25kHz. At the 100kHz sampling rate, response would extend, in theory, to 50kHz.

Video sampling at 4fsc (14.32MHz) should, under the Nyquist theorem, provide a video bandwidth to 7.16MHz. It does not, however, in actual implementation because of the limitations of filter design and the complicated video signal that must be sampled. In a representative videodisc recorder, bandwidth in the composite mode extends to 4.2MHz ±0.25dB, well within the requirements and capabilities of the overall NTSC video system.

Anti-aliasing filters are used in A/D converters to prevent sampling of input signals that are higher than the frequency limits set by the Nyquist theorem. Figure 3 shows a representative filter used in the A/D stage of an audio recorder. The filter is designed to exhibit zero loss at 20kHz and 86dB loss at 22.5kHz. Not surprisingly, the design of anti-aliasing filters is a difficult proposition.

Distortion in a digital system is the result of inaccuracies on the quantization process of the A/D converter. It is directly related to the bit resolution. The greater the number of bits used to define the input signal, the more faithful the digital representation will be. For video systems, distortion components show up as errors in differential gain and phase.

Hard disks are byte-organized devices. Data buffers, which serve to smooth the data flow from the disk, can be used to process the output data to provide special functions or effects. The data also may be modified in place by providing access to an audio or video signal processor.

### Unique features

Because disk-based video and audio recording systems are relatively new to the


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broadcast marketplace, the lack of any baseline determinations as to what such a system should do, or how the control surface should look, has given designers the freedom to implement non-traditional approaches. There are many ways to present operational data to the user and many ways for the user to control the operation of the system.

Implementation of a disk-based recorder in hardware varies greatly depending on the manufacturer. Figure 4 shows a basic block diagram of a composite videodisc recorder. Note that the system is designed to perform more functions than simply record and playback, including digital keying and matting, variable play speed and sequence editing. Because disk technology is new to the broadcast market, it has provided manufacturers an opportunity to define the functions such a system should offer.

Recording a component video signal requires more hardware and memory space than a composite system. Figure 5 shows an implementation of such a system. In this design, two disk drives are used and electrically locked together in record and playback modes. One drive stores luminance data, and the other stores chrominance. The component (in this case, CCIR 601) system requires twice the storage capacity of the comparable composite video recorder shown in Figure 4.

Disk-based recording systems offer the user virtually infinite layering capabilities. Because sealed hard disk units do not use error-correction schemes, the full benefits of digital recording can be realized. In any practical digital video or audio reel-to-reel or cassette/cartridge recorder, there is a finite limit to the number of generations that can be recorded of any section of program before media-induced errors become visible or audible. The major drawback to a hard disk system is its limited storage capabilities.

Within the time frame of the recording limit of a disk-based system, access to a program segment is fast, sometimes instantaneous. To improve access time, the methods by which data is written to the disk must be managed carefully. For example, if one segment of a program spot on a video recorder is stored on cylinder No. 1, and the next segment is stored on cylinder No. 330, only one field access time is available to move from one point to the other if the recording is to be played back in real time.

### Access time

The factors determining the net data-transfer rate of a disk drive are numerous and complex. Software designers must use ingenuity when designing for random access. One approach involves allocation of temporary storage positions on disk or in RAM for duplicate portions of data to accommodate the access times that are required for the video or audio recorder. These operations are performed automatically without intervention by the operator.

The mechanical design of the hard disk system and components has a major effect on the time it takes for a disk drive to go from one data address to another. For real-time recording and reproduction of audio or video, the heads must be at a given address at a specific time.

Some of the mystery and misunderstanding that occur when broadcasters shop for a disk-based recording system is that users look at their PC disk drives and say, "Well, this Winchester disk only cost me $250." Then they look at a disk-based video or audio recorder and see that the drives cost much more. That extra cost goes into the electrical design and mechanical hardware needed to provide a system that will meet the necessary specifications for access time and other critical parameters.

Most disk drives have a servo system that allows the head to lock onto the proper

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storage address. With any system, however, there is some delay in the actual movement of the head carriage. If a command is given for the head to move to track 10, the head generally will not land directly on track 10, but will overshoot slightly. When the system corrects for the overshoot, the head may overshoot slightly in the other direction. Rapid settling of the head into a specific track is a function of the weight of the head and carriage and the power and reaction time of the head-moving mechanism.

The effective data-transfer time of a drive is determined by the time it takes for the heads to seek a new sector and includes the *latency* time (a period of one revolution of the medium), track-to-track access time and full sweep time (the maximum *seek time* for a new track).

The disk-controller hardware and software play key roles in improving access time. Important elements include the capability of the controller to transfer a track of corrected data at a single pass and to minimize the gap in data transfer at track boundaries by *spiraling*.

Spiraling represents the degree to which data can be transferred without interruption. Several modes of spiraling can be identified. The most rapid mode occurs when the *sector seek* at a track boundary is sufficiently fast to permit continuous data transfer across the boundary without incurring a track latency delay. This is possible for multihead drives when the heads can be switched electrically within cylinders.

Under normal circumstances, however, when a seek to an adjacent cylinder is initiated, the access time caused by head movement (typically 2ms to 10ms) will incur a latency (typically 16ms). *Skew sectoring* is a technique by which the first sector in each cylinder is offset to anticipate this delay and can be used to advantage in disk systems with many tracks of low capacity.

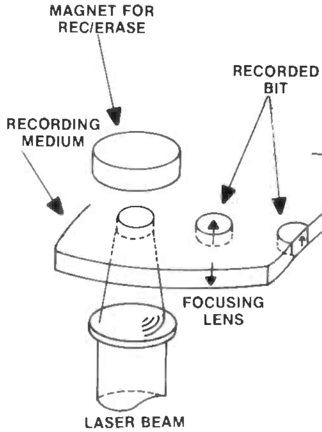


***Figure 7.*** *The data storage principle for the magneto-optic disk recorder. In magneto-optic recording, the medium is formed on a transparent substrate, and a laser beam usually is focused through the substrate to accomplish the required localized heating of the medium. (Source: reference 3.)*

### Interchanging media

One drawback to disk recorders is the difficulty of interchanging media. In the computer industry, disk packs are available that permit moving files from one machine to another, or from one facility to another. However, the costs for such systems are high. Furthermore, removal of the disk pack from a protected environment opens the door to possible damage and subsequent data errors.

Because of the inherent problems in exchanging disks, some form of digital off-line storage is used. Several variations of hardware and formats are available for both video and audio recorders, most centering on streaming linear magnetic tape. There is, however, a time penalty in streaming tape off-line storage. Most systems cannot run real time. Again, the cost of the off-line system is a major concern. Off-line storage

*Continued on page 42*

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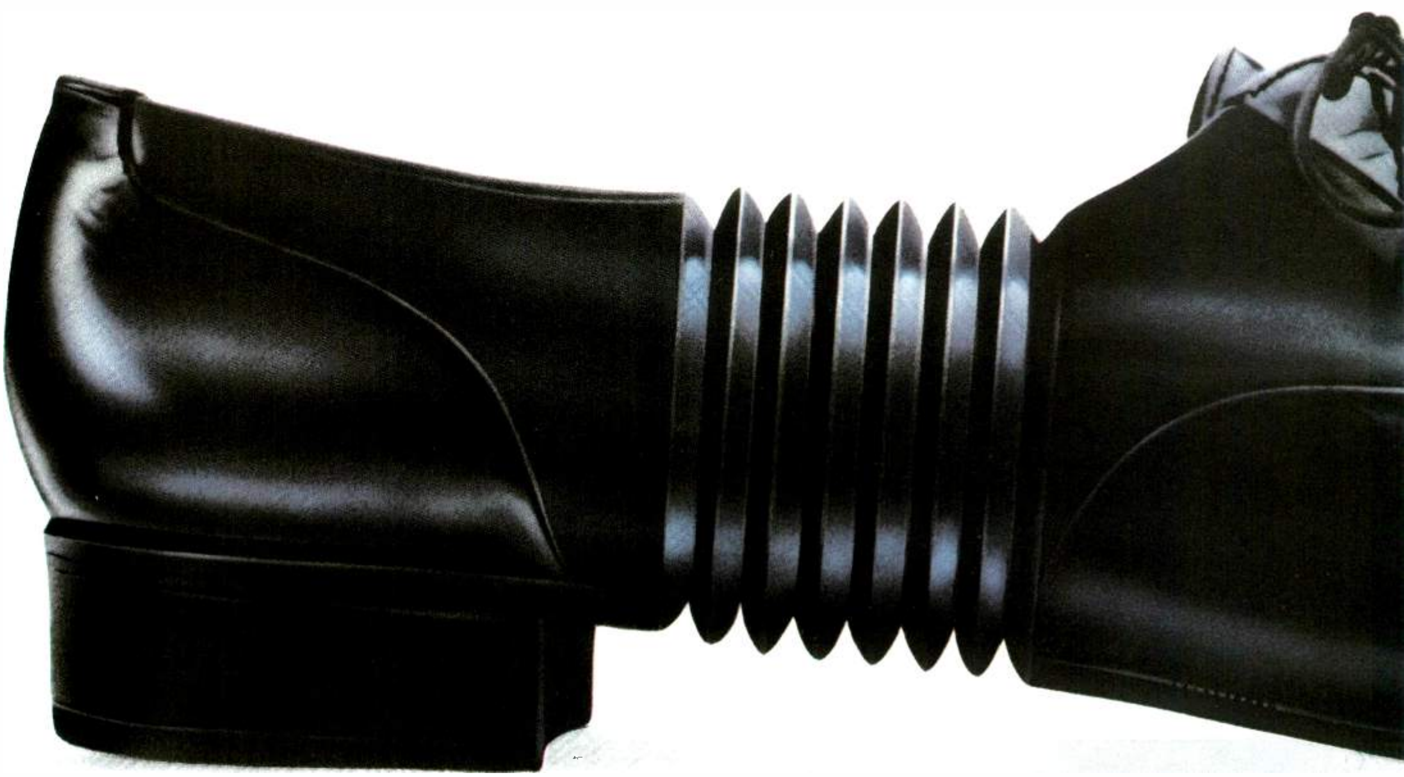

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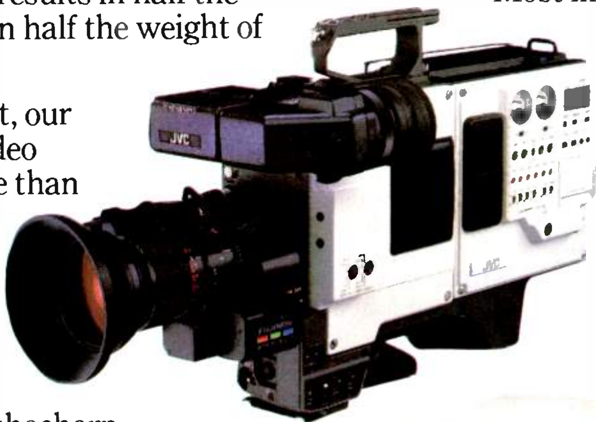

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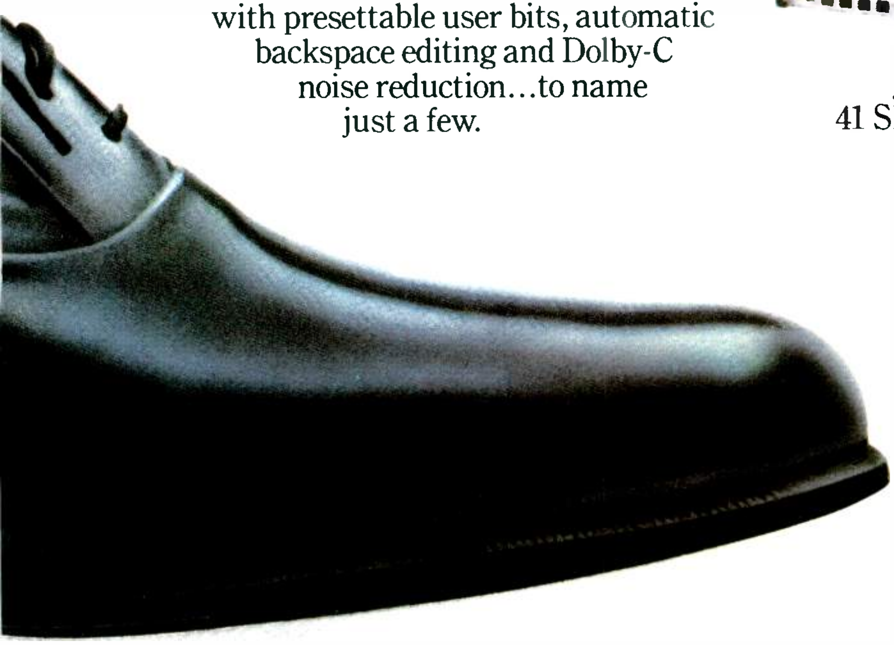


JVC®

**ALWAYS A STEP AHEAD...**
**TO KEEP YOU A STEP AHEAD.**

Circle (25) on Reply Card

*Continued from page 38*
using optical disks holds promise for future systems.

### Optical disk drives

The use of an optical storage medium is attractive to the broadcaster because it permits exchange of programming between facilities. Most optical drives offer error specifications that compete well with Winchester drives. Most *WORM* (write once, read many) optical drives currently available, however, offer low data-transfer rates and data-access times that are significantly longer than those of their magnetic counterparts.

For audio or video applications, the data-transfer rate and seek time are critical performance factors. High transfer rates provide the excess data needed for buffer memory during seek periods when no data can be read. At the current state of development, magnetic drives hold the performance edge in the primary specifications of interest for real-time recording and playback.

Improvements will continue to be made in the key specifications for optical disks. At present, several broadcast equipment manufacturers have introduced products based on WORM drives that provide non-real-time storage of images and sounds.

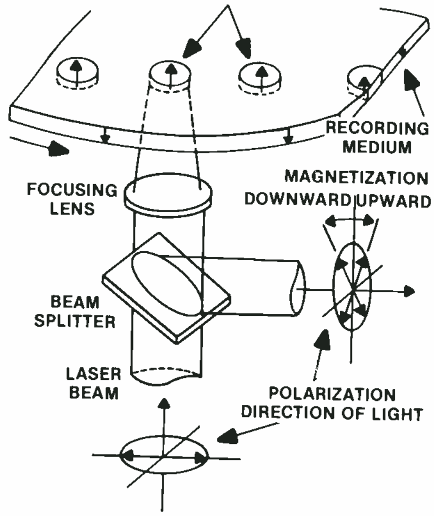



***Figure 8.*** *The data-retrieval process for a magneto-optic disk recorder. Note that the magnetically coded information on the disk is read through the use of an optical process. (Source: reference 3.)*

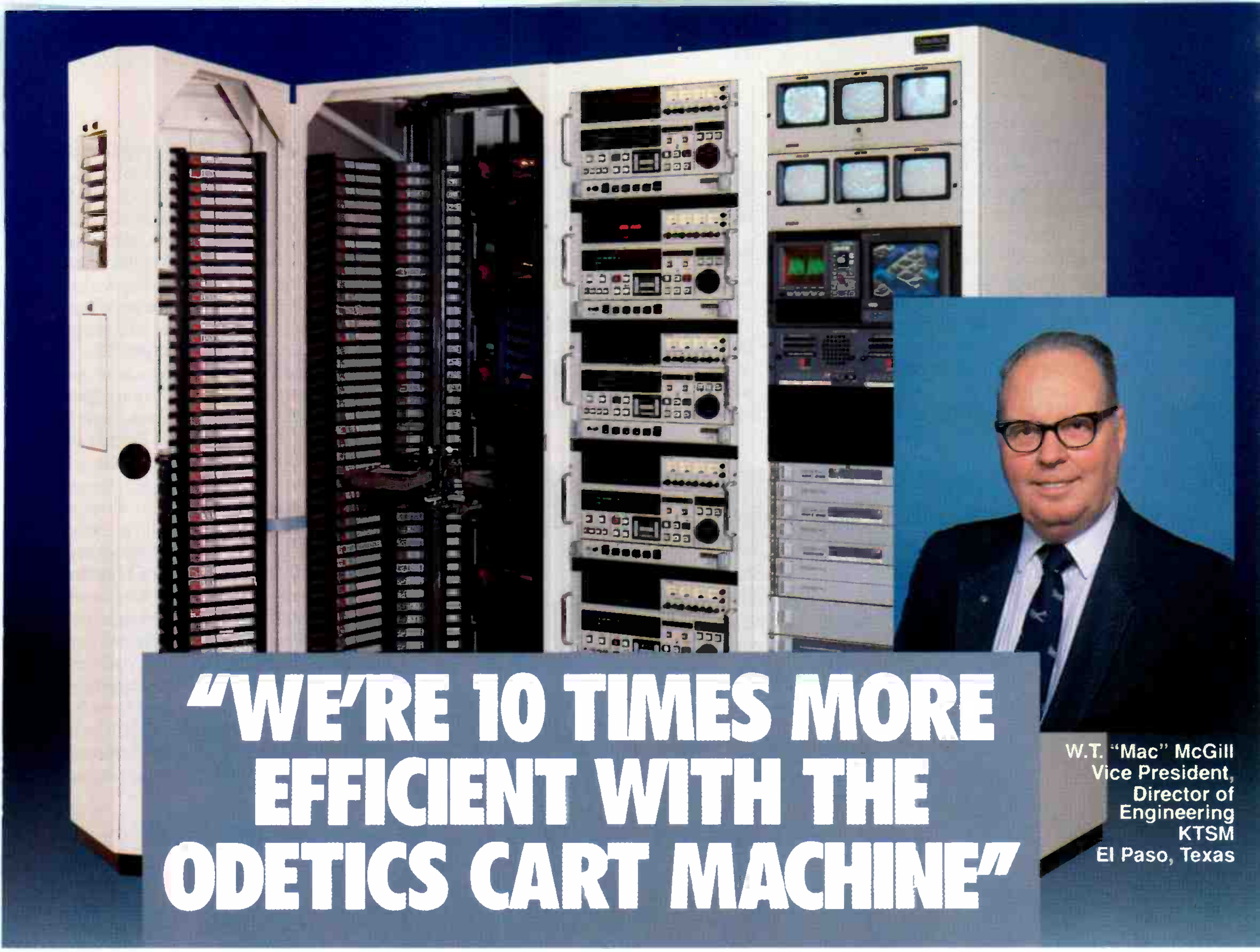
During the recording process for a WORM disk, a laser is used to etch a hole in a thin metal film near the surface of the disk. Surface tension on the film itself causes the hole to enlarge to its final form. Figure 6 shows a simplified diagram of a WORM drive. The system uses an integrated focusing scheme for reading data from the disk. A coarse positioning mechanism and *fine tracking* motor work together to allow direct access to a number of tracks on the disk without the need for additional movement of the coarse tracking assembly.

### Magneto-optic disks

Most applications in broadcasting require the ability to record more than once on a given medium. WORM drives, by definition, do not permit this feature. Erasable optical disks are currently under development to fulfill this need. Erasable disks rely on an optically bistable medium that will shift between two states of reflectivity under the joint influence of a laser and a magnetic field.

An erasable videodisc recorder has been demonstrated by NHK (the Japanese broadcasting company) using a magneto-optic disk as the storage medium. A recording time of 10 minutes has been achieved, with an access time of less than 0.5s.

To understand the operation of a magneto-optic disk, we must first examine conventional magnetic disk recording. The recording density in a Winchester-type disk recorder is determined primarily by the track width and the gap length of the magnetic head. Current technology permits practical recording density on a magnetic




After years of working with manually operated cart machines, the engineering staff at KTSM is breathing a sigh of relief. Now they rely on The Odetics Cart Machine.

Mac McGill says that The Cart Machine has been responsible for a dramatic reduction in errors — spots airing at the wrong time or not at all.

*"With our old cart machines, between the time the traffic department's logs were printed and the airing of the carts, we could count on numerous errors every week," he explains. "Now the logs are automatically downloaded to the Cart Machine from the traffic computer. From there, The Cart Machine handles just about everything else. As a result, we've seen a significant reduction in lost spots."*

The Odetics Cart Machine can automatically manage, record and play-to-air all forms of spots and programs — including events as short as one second.

An average day's play list at KTSM consists of 380 to 400 individual cart events, including repeats. Mac cite's the Cart Machine's extraordinary storage capacity — which includes a 65,000 cart database and 1,600 event look-ahead feature.

*"The Cart Machine requires a minimum amount of space, yet it has a library of 280 cassettes. That allows us to store almost an entire day's worth of events."*

The Odetics Cart Machine can automatically preplan spot play lists hours, or even days, in advance of airing. In fact, every weekend KTSM operates with four days of play lists loaded into their Cart Machine.

And, now that KTSM is broadcasting 24 hours a day, six days a week, The Cart Machine lets them broadcast with just one operator during the early morning hours.

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disk of about $2Mb/cm^2$, with a recording capacity of about 1Gb/spindle for comparatively large magnetic disk drives.

A magneto-optic system can offer a significant improvement compared with the storage capacity of a Winchester because of the unique way data is stored and retrieved from the disk. Figure 7 shows the method used to record information onto a magneto-optic disk. A modulated laser beam is focused on the recording medium, which causes local heating. In the presence of an external magnetic field, the direction of magnetization of the irradiated area is reversed. Upon cooling of the media to room temperature, the area retains the magnetic direction of the external field.

The readout principle is illustrated in Figure 8. When a linearly polarized light is reflected by the magnetic medium, there is a slight rotation of the polarization plane. This effect is called *Kerr rotation*. The direction of rotation depends on the orientation of the magnetization of the medium. To read a magneto-optic disk, a continuous laser beam is focused on the recording medium. The direction of the polarization plane of reflected light changes corresponding to the recorded bits. When the light passes through the polarizing prism, the direction of the polarization plane is converted into a change in light intensity, which is decoded by a photodetector.

To erase the medium, a laser is focused on the disk in the presence of a magnetic field in the opposite direction. The erase process is essentially the same as the recording operation except for a difference in direction of the external magnetic field.

The key to high packing density of the magneto-optic system is the size of the read/write laser beam. Typical recording density obtained with a laser diode operating in the wavelength of $0.8\mu m$ range is about $50Mb/cm^2$. This provides a recording capacity of about 2Gb per 12-inch disk.

At the current state of development, the NHK system uses a 3:1:0 component coding scheme, which includes error-correction coding and pulse code modulated audio signals. The reproduced picture quality is described as equal to or better than a ½-inch helical scan VTR. The number of dubbing times possible before signal degradation is limited, to approximately three.

### The future

What does the future hold for media storage? Optical storage of various types is emerging and will continue to be used in broadcast applications, first for functions that do not require real time video or audio playback. Streaming tape technology also will improve, and new off-line storage methods based on video technology will become practical.

One concern with any new storage technology is volatility in the marketplace. In an area of rapidly developing technology, the lifetime of a product can be less than a year. Broadcasters do not want to purchase a product that may be made obsolete by a new development before the unit is paid for. Broadcasters demand consistency in the hardware they buy.

Established technologies generally provide the best return on investment for the end-user.


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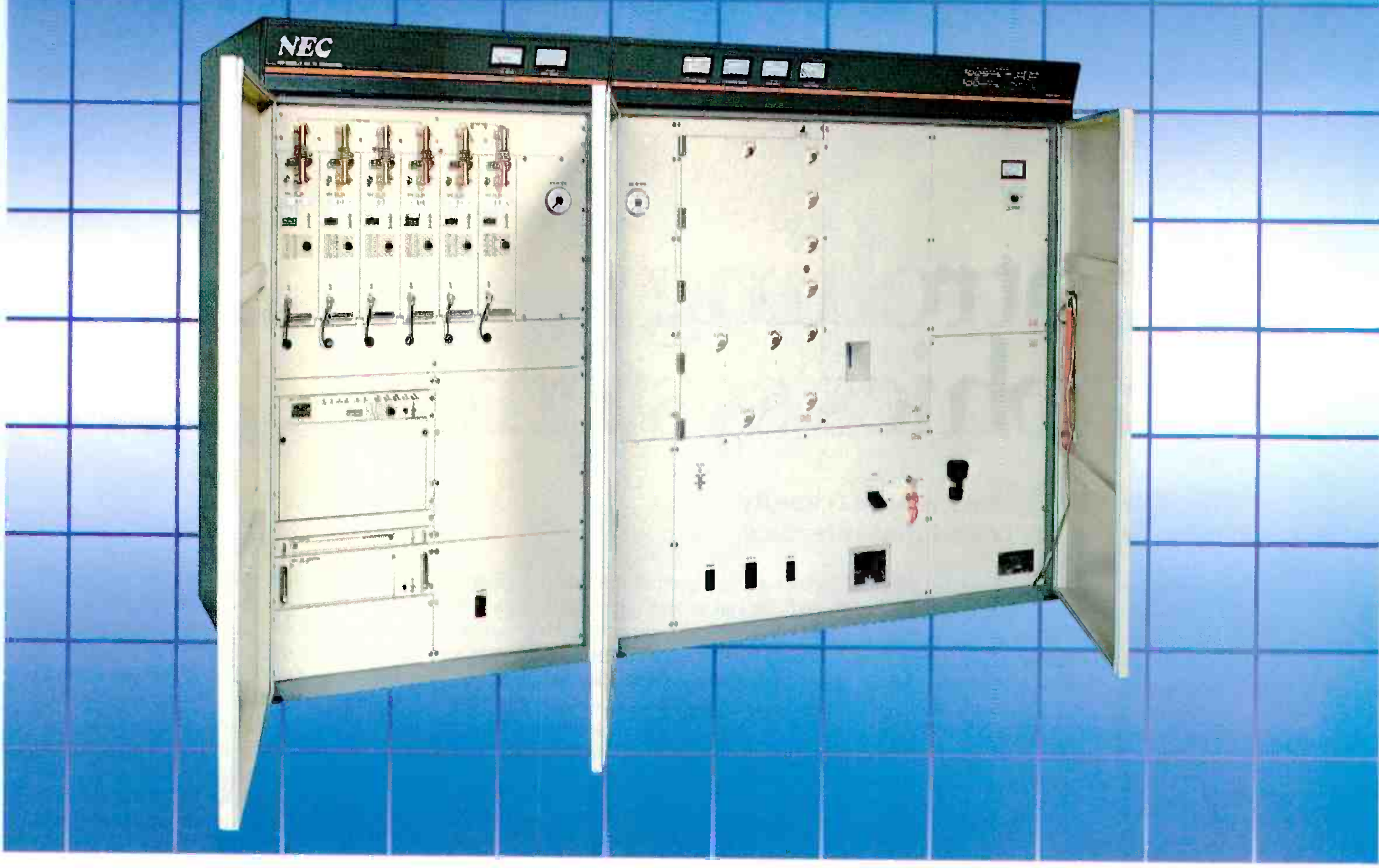


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NEC

# Controlling graphics systems

**By Carl Bentz, technical and special projects editor**

**The difference between user-friendly and user-*fiendly* is an input interface.**

If computers had remained in offices, relegated to word processing, accounting or engineering calculations, things might have stayed simple. However, when computers moved into video production and broadcast control environments, they introduced a new series of numbered Excedrin headaches to equipment designers.

The problem was not in making the computer do the desired operations—drawing pictures and generating video type. According to equipment designers, that part was easy. The difficulty was in getting a system to do its tricks for someone who was not a computer addict. To use a high-tech phrase, the "control surface" of a computer-driven system is one of the most difficult aspects of the design process.

*The work-station monitor display includes a menu for operator convenience.*

### Let your fingers do the talking

The capabilities of most microprocessor devices with 8-bit and wider bit-structure architectures have barely been touched by the available software. Functions may seem limited to specific logical processes, but when new releases of software hit the processors, those functions seem to have undergone changes to increase the speed dramatically. Perhaps the programmer provided single-keystroke function selections or another shortcut. Whatever the change, the goal was to make the program easier to use.

Microprocessors do not inherently understand words entered into a keyboard. They must be taught the meaning of every instruction in the programming language. The language may be a *low-level* type, requiring the user to have an intimate knowledge of the internal operation of the microprocessor and its support circuitry. Each step of the program accomplishes only a small portion of the desired action. For example, the program might include a sequence such as:

```
      LDX m1
      LDA m2
      CPX m3
      BEQ THERE
      STA m1
      TXA
THERE ADC m4
      STA m2
      ...
```

These steps seem to have little meaning, but if you look closely at each, you can see how assembly language programming is accomplished.

- LDX m1: load the X-register with the value found in memory location m1.
- LDA m2: load the accumulator with the value in location m2.
- CPX m3: compare the contents of the X

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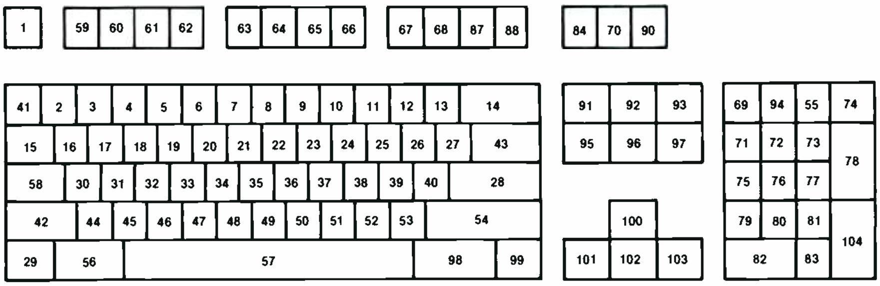


***Figure 1.*** *Many software packages allow key functions to be altered on an IBM keyboard.*



register with the contents of memory cell m3.

- BEQ THERE: if the X and m3 values are equal, branch (a change in program flow based on a logical comparison) to a different point in the program. If they are not equal, continue with the next step.
- STA ml: store the value in the accumulator in ml.
- TXA: transfer the contents of the X-register to the accumulator.
- THERE ADC m4: logically add the value of the accumulator with the value in m4, keeping the carry bit, if the new value overflows the bit width of the accumulator. (This step also is the destination of the branch instruction, as indicated by the label THERE.)
- STA m2: store the new value of the accumulator in location m2.

When assembly language programmers complete a project, they use an *assembler* (specific to the microprocessor being used) to translate the instructions into "hex," or hexadecimal numbers (represented as 0-9, A-F). Once the numbers are stored in the computer memory and instructions are issued to run the program, each step is accomplished at speed of electrons.

Programmers who truly understand the microprocessor can write in microcode, tucking the correct hex numbers directly into memory without the assembler translation. Most people prefer the route of a *high-level* language. BASIC, C and PASCAL are three common, high-level forms.

With high-level languages, the programmer works with recognizable words and symbols. POKE places a value into a memory location. PEEK pulls a value from a location. Logical operations include AND, OR, NOT AND, EXCLUSIVE OR, GREATER THAN, EQUAL TO, and so on. A PRINT or WRITE command sends information to an output device (the CRT or a line printer), and INPUT, INKEY and GET are instructions to accept information from an input device (such as disk, tape, modem or keyboard). Inside the language environment these English instructions are stored as *tokens.*

When the program is executed, the computer must translate the tokens into usable form. Most computer systems have a BASIC *interpreter.* When the operator types RUN and RETURN (or ENTER), the microprocessor, aided by the interpreter, begins to PARSE or read the instructions. Each time it reads a POKE token, it goes to a translation library where POKE is a shorthand label to express a number of machine language steps. Because each instruction must be interpreted, BASIC is a slow-operating language.

Interpreters also are available for C, PASCAL and others. However, utility programs called *compilers* are more common. Compilers read a source program and translate it to an object or machine language form. For execution, the compiled form of the program is used. If changes become necessary, the source program must be recompiled to a new

*Continued on page 52*

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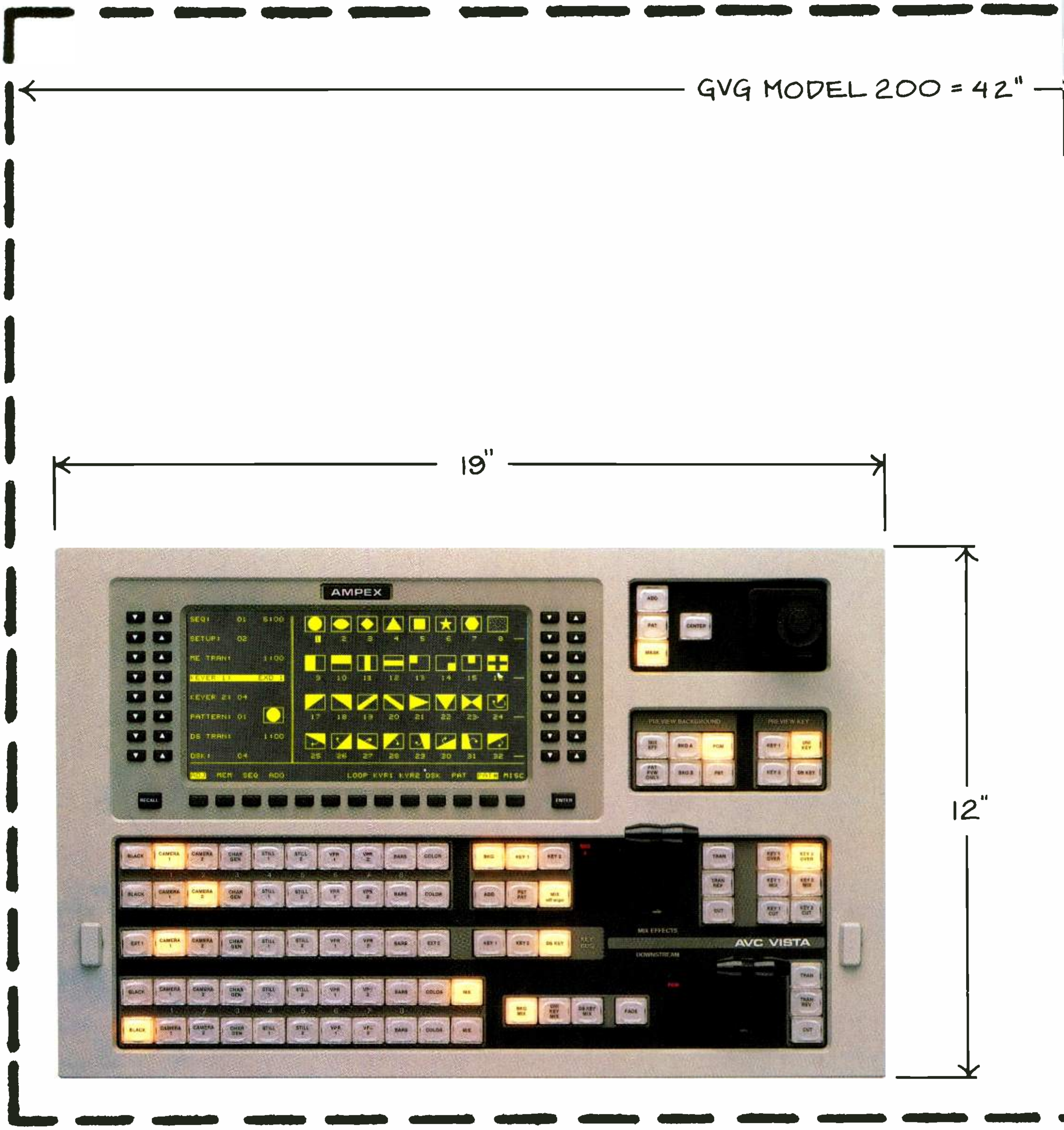


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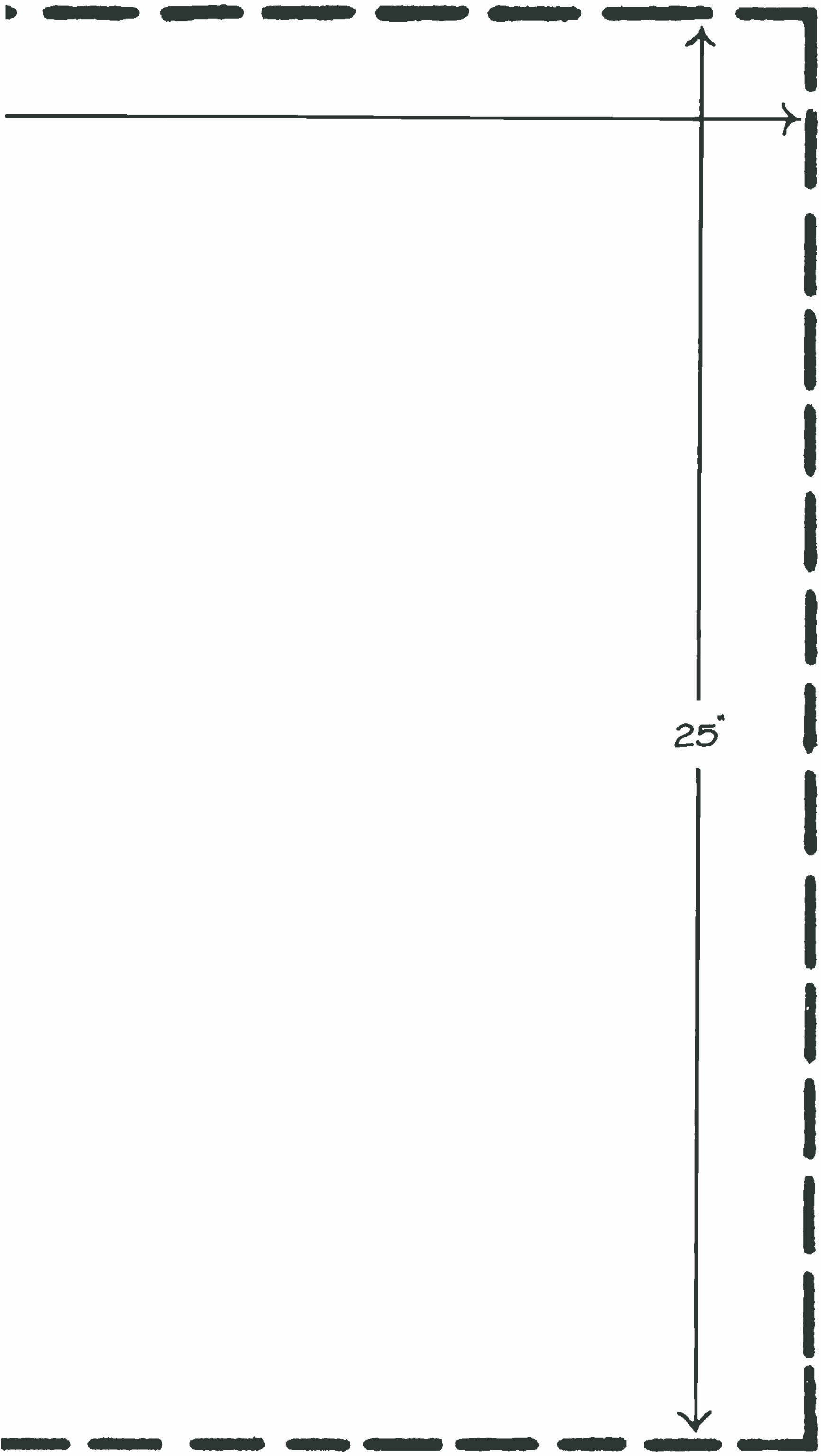


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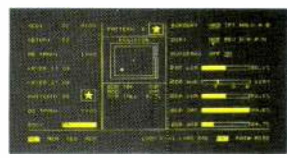

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*Continued from page 48*
object program.

### Keyboards vs. control panels

To the computer purist, using the keyboard is the most direct method of talking with the microprocessor. Compared with early methods of placing instructions and data into the system memory through a set of toggle switches, a keyboard is absolute simplicity. The keyboard, however, is a *peripheral device.* That means that *some method must be provided to interpret signals from the keyboard to the microprocessor.* The method usually is called a *device driver* and is a resident segment of the operating software. The term resident means it loads into memory automatically when the computer is turned on and remains there unless specifically removed (or the computer is turned off).

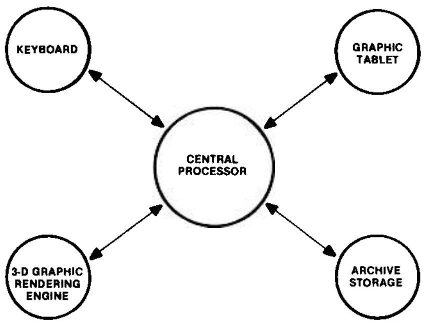



***Figure 2.*** *This diagram illustrates the concept of distributed intelligence.*

The keyboard driver assigns specific functions to each switch (see Figure 1). When the "A" key is pressed, the digital representation of the letter A is sent along to the microprocessor. Other functions assigned include SHIFT-A, CONTROL-A and, with some keyboards, ALTERNATE-A. The software driver may allow the user to program the keys. A single key might initiate a series of program steps.

In a computer-controlled editing system, CONTROL-R could mean to start a videotape recorder with an additional number key to determine which VTR is to be used. CONTROL-C3 can initiate a search-for-cue operation, then back up for the preferred preroll time, then drop into standby condition.

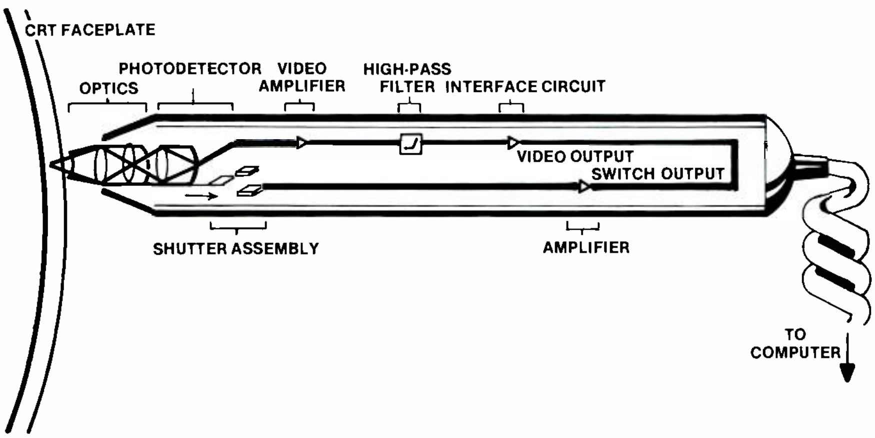



***Figure 3.*** *Inside the light pen.*

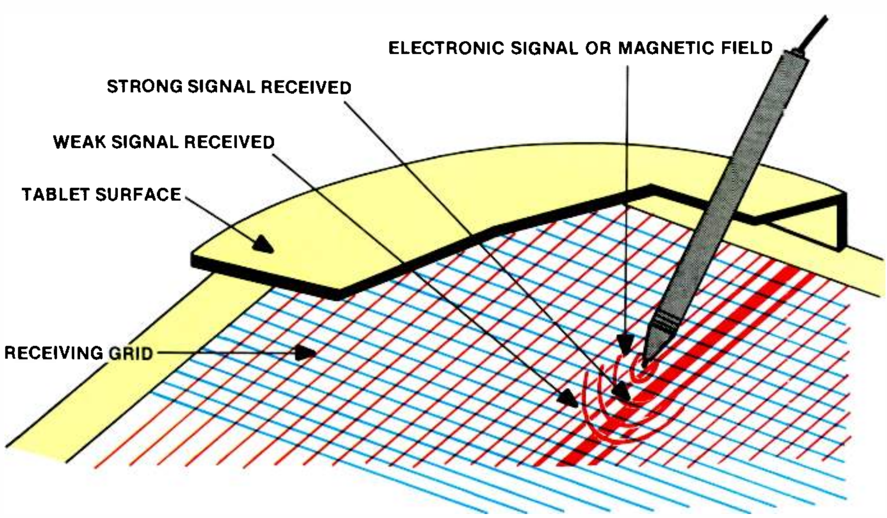



***Figure 4.*** *Conceptual drawing of an electronic graphics tablet.*

Many of the current videographic art systems, production titlers, editing control systems and special effects units can be operated effectively from a typical personal computer keyboard. Such a control approach may present problems, however. If a large number of instructions exist, the operator must either remember each of the instructions or use a keyboard template to indicate the functions.

If only one operator uses the system, it will take only a short time to achieve proficiency on the system. However, if there are multiple users of the system, not everyone will have time to learn all of the functions, and their ability to use the system effectively will be minimized.

A standard computer keyboard is perhaps the most flexible of all inputs, particularly if the computer is used for several functions. Some manufacturers and some equipment operators prefer dedicated control panels compared with a generic keyboard. Such a control panel may consist of a number of defined function keys, each initiating a fixed action. The editor control surface, for example, may have one button marked RECORD. The operator presses that button followed by a number (n) to initiate the recording on VTR-n.

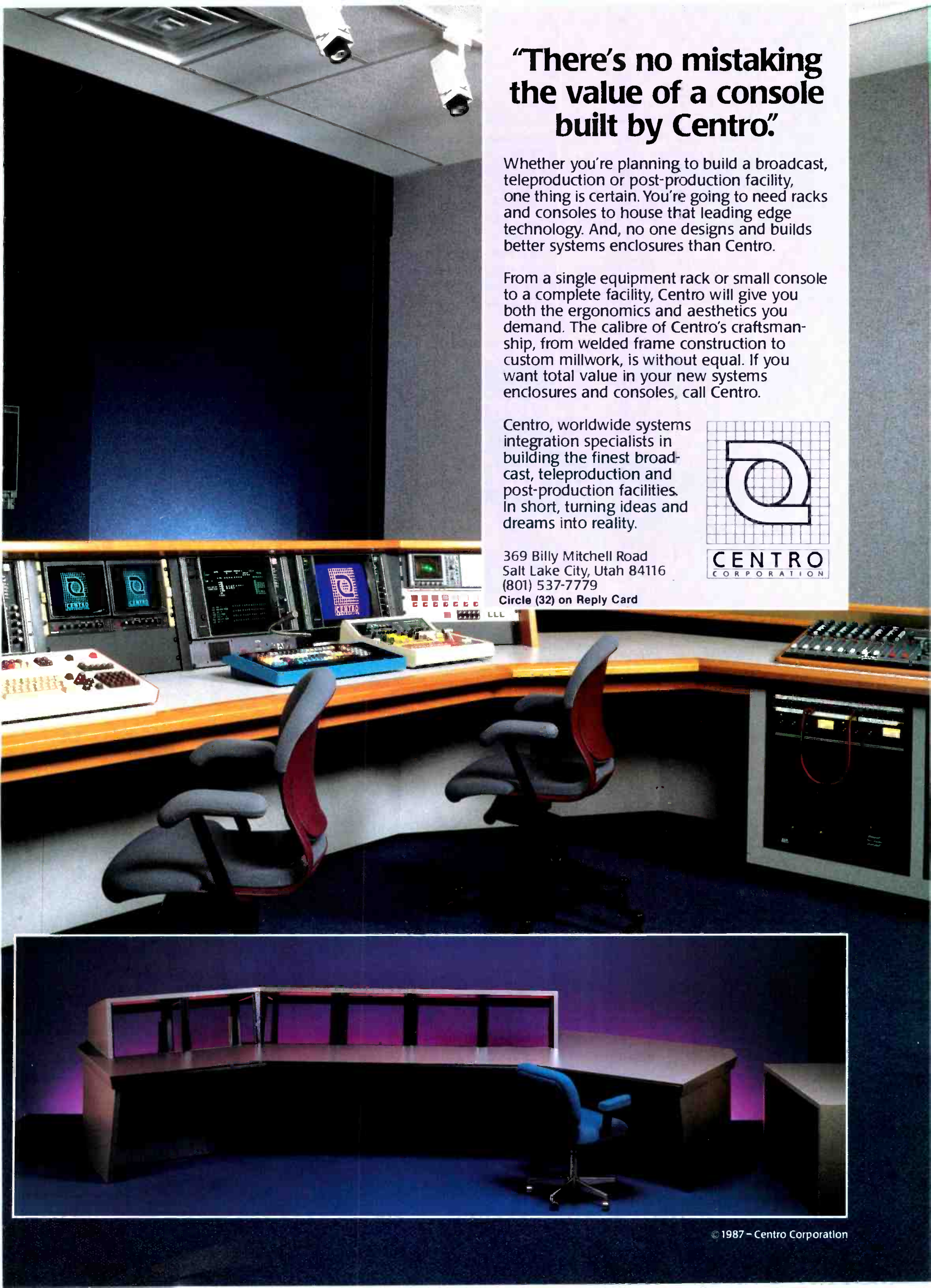
For a given system, there may be no need for 88 to 104 programmable keys, but certainly some *soft keys* enhance flexibility. Soft keys describe control buttons that may be programmed or assigned to a series of steps. Assignments can be made in multiple layers of programmability.

On the effects system, a soft key might be set to call up a series of manipulations, such as a zoom from full screen to an infinitely small dot. The manipulation might move a point from center screen along a catenary trajectory toward the upper left corner of the screen. In another layer, the same key might initiate other effects calculations.

A third keyboard approach is to combine a typical alphanumeric character set with a variety of dedicated functions and other soft keys. For editing controllers with edit decision list (EDL) software, the advantages of alphanumerics are obvious for event entries, although there are keyboard drivers that define dedicated keys for list generation.

For a graphics/titling computer, the alphanumeric keyboard makes complete sense. The graphics art/paint system probably is more efficient with the keyboard as well. Both products can use dedicated keys and soft keys for some functions.

On the graphics system, however, creativity is the goal. It is impractical to expect an artist to operate a computer-aided design (CAD) system, defining lines by entering end-point X–Y coordinates. Even engineers who become adept at the CAD keyboard find that other devices can be more efficient in communicating with the main computer system.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An artist expects a few keys to call certain functions but, likewise, expects that most of the art functions are accessible by some simpler method—an on-screen menu.

As the complexity of the system increases, a single microprocessor is unable to handle all of the computation. If peripheral devices contain their own microprocessors, it is said that the system uses *distributed intelligence*. See Figure 2.

The "central processor" and its software operating system theoretically become managers of a group of department heads. One is assigned to deal with the keyboard; another interprets requests for video effects manipulations. The effects processor may provide instructions for another subsystem (or engine) to handle high-speed calculations of 3-dimensional effects movements.

For 3-D rendering, paint systems commonly use multiple microprocessors to perform at MIPS and MOPS (millions of instructions or operations per second) rates. Some auxiliary microprocessors may use a *RISC* (reduced instruction set computer) or *ASIC* (application specific integrated circuit) format. Speed of processing is improved if a microprocessor, which does not need to deal with certain machine code instructions, is relieved of those instructions in its microcode set.

A 3-D rendering engine also may be capable of dividing its processes into segments or *bit slices*, allowing a process called *pipelining* to occur. In simple von Neumann computers, a single instruction must be concluded before the next is initiated. Pipelining, on the other hand, allows portions of the next step to begin before the previous one is completed.

### Beyond keys

For art or graphics purposes, it is desirable to be able to place a cursor on the screen at any point and perform a function at that point. Such functions might include: place a red dot, create a circle, begin drawing a line or pick up the color that exists in that picture element (pixel) of the image to use elsewhere in the picture.

Control of a cursor for such functions can be accomplished with several devices, including light pens, mice, trackballs and drawing/graphic pads. Varieties of each type of device exist, each requiring driver software.

In essence, drawing peripherals operate through references to X and Y axes. The least axis-oriented is the light pen (see Figure 3). Inside the pen, an optical system concentrates light from the CRT screen onto a photo sensor. One or more switches on the pen control the operation (according to driver software). As the pen is held to the face of the

*Continued on page 58*

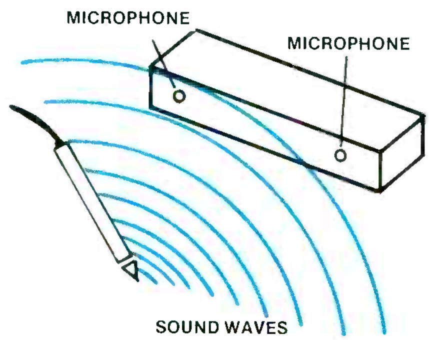


***Figure 5.*** *Conceptual drawing of an acoustical graphics tablet.*

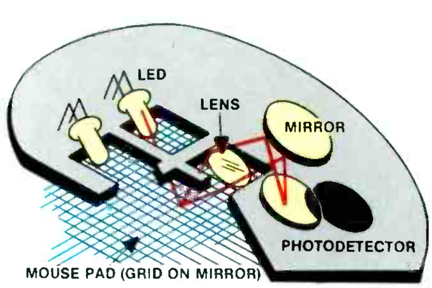


***Figure 6.*** *Construction of an optical mouse.*

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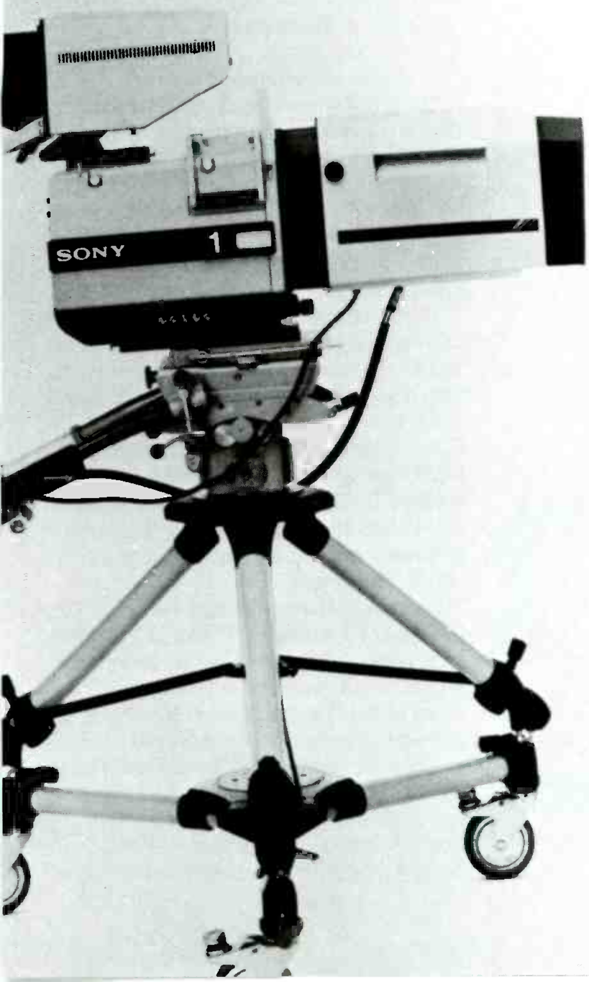


# Bang.

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Continued from page 54
monitor screen, light generated by the scanning electron beam activates the photo sensor and circuitry, placing a dot on the screen during the next downward scan of the beam.

The light pen has two drawbacks. The resolution achievable in drawing may be limited. An aperture in the optical path of the pen reduces the number of scan lines seen by the photo-sensitive device. However, the thickness of the glass faceplate of the CRT can reduce the effectiveness of such an aperture and drawing accuracy.

The second undesirable feature of light pens also relates to the monitor. Normally, the CRT screen is vertically oriented in front of the operator. To use the pen, the operator extends an arm to hold the device against the faceplate. Even for short periods of time, the resulting fatigue affects operator productivity. In contrast, to produce quickly drawn illustrations of football, basketball or other sports events, a CRT mounted into the tabletop, with its screen oriented horizontally, allows the operator (and perhaps commentator) to quickly sketch the pattern of play.

As control devices, light pens are effective for *point-and-shoot* operations. The programmer creates a menu of the possible control actions on the screen. The system operator holds the pen against the screen with the desired action block and presses the control button to initiate the action. Such systems must expend extensive memory to provide the screen displays and to decode beam-pen coincidence situations for the control activity.

### Styli—pens sans ink

The most widely used input device for paint systems is the *graphic pad.* Most tablets are magnetic or resistive in design, although some use an acoustical approach to locate the drawing device on the drawing surface. A recent entry into the market is capacitive in nature.

The magnetic tablets contain a gridwork of wires beneath the drawing surface (see Figure 4). Resolution of the pad is determined by the number of X–Y wires forming the embedded network. The stylus produces a magnetic or electric field that is sensed by the gridwork. The tablet controller microprocessor continuously scans the X–Y lines for evidence of a signal. If a signal is found, an algorithm compares the output of several consecutive X and Y lines for the strongest signal response. On screen, the point of crossing for the two lines carrying the greatest signal becomes the center of the drawing cursor.

The tablet and stylus most closely resemble an artist's brush or pencil. Control switches in the stylus are provided to plot a point, initiate a line, set the center of a circle and so on. Resolutions of 200 points per inch or more allow a high degree of control and drawing accuracy.

A pressure sensor integral to the point of the stylus increases flexibility of the device. As the artist presses harder against the surface with the pen, the line created on the screen can be made wider, a color can be made more intense or a different brush stroke can be developed.

The resistive touch-pad drawing tablet uses a sandwich of resistive materials with minuscule air gaps. Contact wires connect to the top and bottom edges of one surface. On the second layer, the wires connect on the right and left edges. With no pressure on the pad, no current flows. When pressure is exerted, and the surfaces are brought into contact, a small current flows from the bottom connection through the bottom layer, through the point of contact between layers, through the top layer and back to the driver circuit.

Through the two sets of contact wires two currents are produced, which are interpreted as X and Y coordinates of the point of pressure. In operation, the resistive touch-pad is quite similar to a joystick, which determines direction of the handle through pressure-induced resistive current paths.

The acoustical approach to the tablet and stylus is less common (see Figure 5). The stylus transmits an omnidirectional, high-frequency sound signal. Along one side of the drawing area, two microphones pick up the sound. Through an algorithm that compares the strength of the sound, the controlling microprocessor locates the stylus position through triangulation.

Although electronic tablets are more common, the acoustical version offers an advantage over the others. The magnetic or resistive forms require the presence of the tablet surface and its buried wire or resistive material matrix. The acoustical stylus does not need a specific surface. The microphone unit on any tabletop allows any area to be used for drawing.

All stylus types lend themselves to point-and-shoot menu function selections. One control button can activate a menu overlay on the screen. While observing the screen, the operator moves the cursor into the preferred area and presses another button for the menu option. An alternate system dedicates physical areas of the drawing surface to on-screen menu responses.

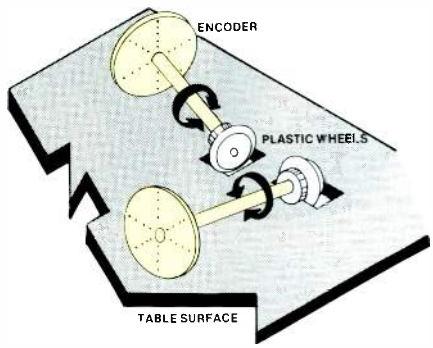



*Figure 7. Construction of a wheel mouse.*

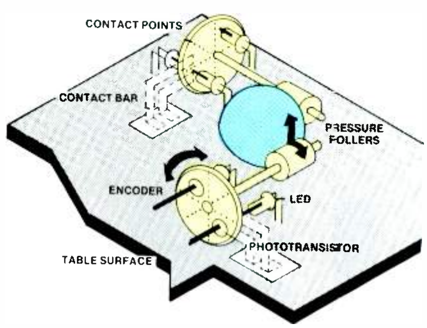



*Figure 8. Concepts for opto-mechanical or mechanical mice. Instead of LED- and phototransistor-sensing, contact bars (indicated by dotted lines) read contact points on the encoder wheel.*

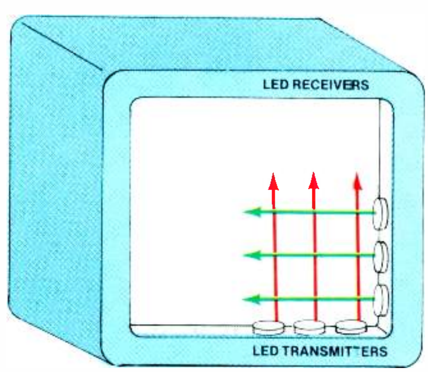



*Figure 9. Conceptual drawing of an LED touch-screen device.*

### The user-friendly mouse

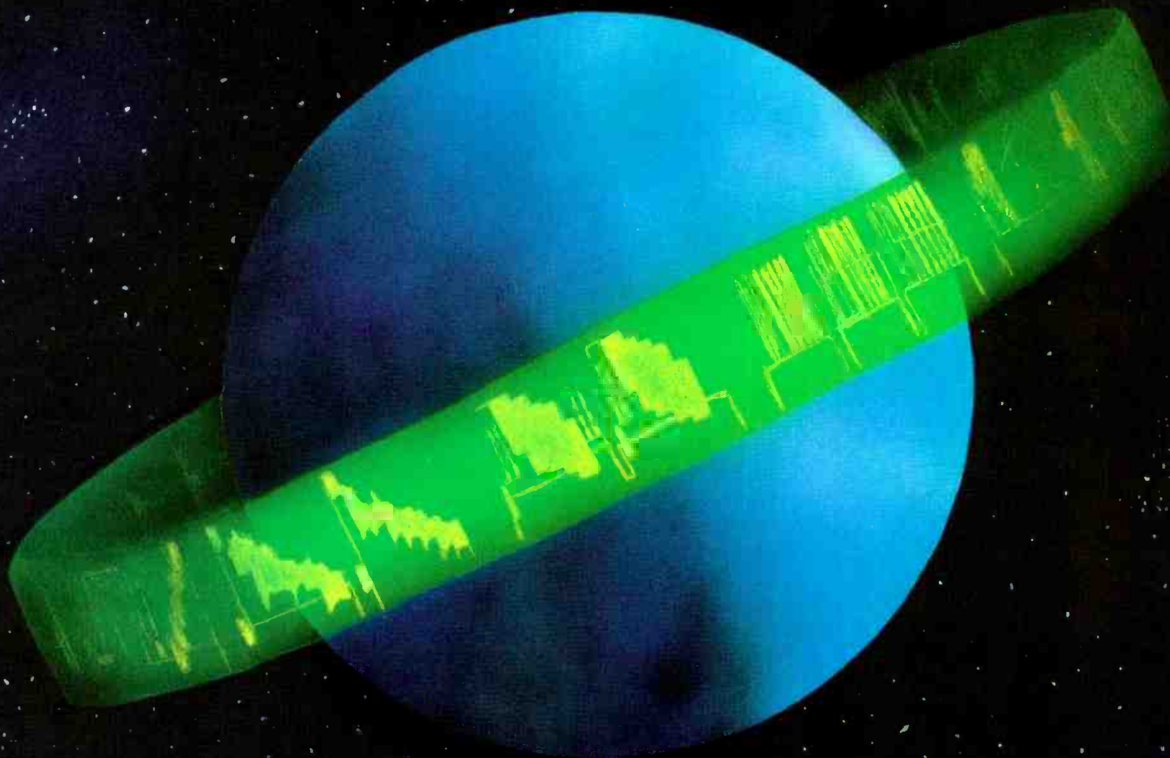
The popularity of the mouse as a drawing device is understandable because of the cost. Compared to drawing tables, it is an inexpensive device in any of its forms. Mice may be constructed along several designs, but all work on the principle of indicating positions relative to the previous location. Tablet-stylus systems produce "absolute" positions.

The strictly optical mouse uses visible red and invisible infrared LEDs and phototransistors to read the relative position of the unit with respect to a special gridwork of blue and black lines on a required mouse pad. See Figure 6. Blue lines absorb the red light, while black lines interrupt the infrared beam. Each break of the light beam represents an increment of distance. Direction and distance are determined by counting the number of breaks and colors.

The design of a mechanical mouse may be ball-type or 2-wheel (see Figure 7). In the ball type, pressure rollers contact the ball at right angles. Small encoding disks are connected to the rollers. The encoding is accomplished by counting a number of points and the direction of their passing into X and Y directions and distances.

A 2-wheel mouse is designed to place the two pressure rollers in contact with the drawing surface instead of a ball. The two rollers

# *Everything that Goes Around...*



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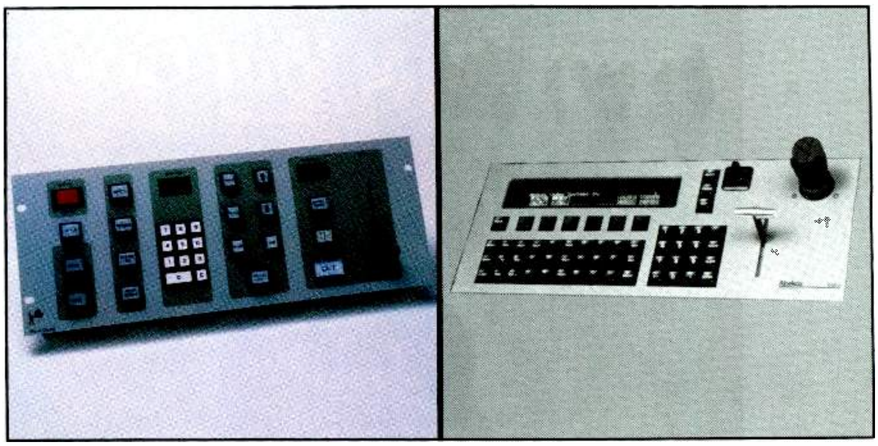

*Control panels may involve defined function keys or programmable soft keys.*

are oriented at right angles to one another to represent X and Y directions. Again, the rollers drive encoder disks to signal activity to the mouse driver software.

In the opto-mechanical mouse device, the motion of the ball is translated through pressure rollers to disks that are photo-etched (see Figure 8). Point-source LEDs on one side of the disk and phototransistors on the other produce a series of pulses to signal the driver of the change in direction and distance from the last position.

All mice include switches to control functions from the device itself. The mechanical mice have an advantage in that they can operate on any surface. However, dirt can be picked up by the ball, resulting in improper contact with the pressure rollers. When dirt becomes too thick, accuracy is affected. In contrast, the optical mouse does not exhibit a problem with dirt or any mechanical failure, but it does require a special mouse pad for operation.

For those who abhor mice, the trackball device offers the resolution of the mechanical mouse but requires no surface for operation. By turning the mouse on its back (actually a different suspension of the ball also is necessary), the trackball requires only enough space for the housing that contains it. Control buttons, located around the ball, activate special functions.

Trackballs offer the advantage of integration into a control surface, similar to a joystick, so that they are not lost amid a jumble of scripts, paper sketches, schedules and other debris on the control surface.

Like the pen-based units, the mouse-type devices may be used to pick menu functions shown on the screen. Software senses the location of the cursor within a menu box, while a click of a control button signals the computer to select the function represented by the outlined screen area.

### Getting in touch

The last of the non-keyboard input devices, the touch screen, is most effective as a function controller rather than an art development device. (See Figure 9.) Two approaches to touch screens are found. One method places a series of LEDs along one side and the top of the CRT screen. A series of photosensors is along the opposite edges. The grid of light beams is broken as the operator touches the surface of the CRT.

The resolution of an LED-based touch screen usually is somewhat limited. Typically, not more than about 32 points across the screen in either direction are individually addressed. The method is effective for menu selections to control equipment in editing, but as with light pens, extended pointing causes operator fatigue unless the screen is oriented in a horizontal plane.

A transparent, pressure-sensitive layer, similar to that of the resistive drawing tablet, can be placed over the display CRT faceplate. Through sensing of resistance variations, the point of contact is determined, and the driver circuitry takes predetermined action.

Operator fatigue has been mentioned as a disadvantage of this type of control. Another is a matter of dirt and body oils from the operator's fingers. Critiques of touch-screen systems often suggest that a bottle of glass cleaner or a solution formulated for the resistive material is kept at the work station, along with a supply of towels.

### Personal preferences

If the need for control of your computer-based system is not necessarily one of high resolution, obviously any of the devices discussed enable point-and-shoot functions with appropriate driver software. When increased resolution is needed, the tablet/stylus systems or mice are more satisfactory. The choice of system is open to operator preference.

Beyond the advantages and disadvantages noted for each of the devices, one caveat should be mentioned. Any specific device requires a way to interface to the primary computer in the system. Before you specify a particular brand and model, make sure that the correct driver software is available for the computer you intend to use.

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# HDTV: where it is, where it's going

By Jerry Whitaker, editorial director

**In the world of high-definition television, you can't tell the players without a scorecard.**

The economic, political and technical implications of HDTV have caused a frenzy of activity in post-production and broadcast circles, both in the United States and abroad. To paraphrase Winston Churchill, never have so many talked about so much for so long.

There seem to be increasing numbers of technical and business managers in the world of professional video who have come to believe that high-definition television is real and here to stay. Some have been motivated to analyze the potential for HDTV by the promise of new opportunities. Many more have been motivated by fear. HDTV represents a significant long-term threat to over-the-air television, and the only way broadcasters can protect their investments for tomorrow is by becoming involved in HDTV planning today.

### HDTV scorecard

Within the past six months there has been no lack of activity in the area of high-definition television. In fact, the speed with which the technology is moving is almost frightening. To bring you up to date on where HDTV work stands now, here's a thumbnail sketch of what's new:

• A blue-ribbon committee of industry representatives has been established under the auspices of the FCC to discuss where HDTV fits into terrestrial broadcasting. At the opening session of the Committee on Advanced Television Systems, FCC chairman Dennis Patrick characterized HDTV as something that will "dramatically alter the face of television."

The membership of the blue-ribbon panel reads like the "who's who" of broadcasting. The committee includes Laurence Tisch, head of CBS, Thomas Murphy, chairman of Capital Cities/ABC, and Robert Wright, president and chief executive officer of NBC.

On the technical side, Joseph Flaherty, vice president and general manager of CBS Engineering and Development, is heading up the major subcommittee charged with examining the various approaches to production and transmission of HDTV signals. Six working groups have been formed to provide input to Flaherty's subcommittee.

• The NAB has embarked on an ambitious effort, along with other industry leaders, to develop and implement an HDTV terrestrial broadcast service for the United States within the next five years. The association has established an HDTV project office, which will be a part of the new NAB Technology Center, to conduct and coordinate much of the industry's work in developing a broadcast HDTV system.

• The NAB, PBS and the Advanced Television Systems Committee (ATSC) have conducted over-the-air tests of HDTV encoding systems incorporating simultaneous use of VHF and UHF TV bands. A second phase of the project involves spectrum field tests comparing UHF and SHF (12GHz) bands for suitability for terrestrial broadcasting of HDTV. CBS will participate in those tests.

NCTA is conducting similar tests of cable transmission characteristics affecting HDTV signals.

• The Japan Broadcasting Corporation (NHK) has announced plans to begin HDTV service in 1990 to Japan by direct broadcast satellite using the MUSE transmission system. Consumer receivers designed to decode the signals are now being developed, along with VCRs and disk players.

• Battle lines are being drawn at the FCC for an expected fight over spectrum. As many broadcast industry leaders see it, the critical issue in the HDTV question is the availability of spectrum. The NAB and others have petitioned the FCC to delay proposed re-allocation of UHF spectrum to the land-mobile industry. Broadcasters want the UHF TV spectrum in question reserved for transmission of future HDTV signals.

• Researchers are working with great speed to see who can develop the best "narrowband" HDTV system. This work has brought a new twist, that of "degrees" of high definition. The HDTV signal in its pure form is shown in Table 1. You will notice, however, that the bandwidth of 30MHz is far beyond anything that can be reasonably transmitted. Enter the HDTV encoder/converter players.

1. *MUSE*, probably the best-known system and the one with a number of on-air trials under its belt. It is considered, by and large, transparent to high-definition video. The only problem is it was designed for FM satellite broadcast and requires a bandwidth of 9MHz. Sure, that's better than 30MHz, but still too wide to be transmitted by conventional

| | HDTV | NTSC |
|---|---|---|
| LINES MAKING UP PICTURE | 1,125 | 525 |
| ASPECT RATIO (PICTURE HEIGHT: WIDTH) | 16:9 | 12:9 |
| MONOCHROME (B&W) BANDWIDTH | 30MHz | 4.2MHz |
| COLOR BANDWIDTH | 30MHz | 1.5MHz |

***Table 1.*** *A comparison of HDTV and NTSC specifications.*

terrestrial television. A converter is required to display the MUSE signal on an NTSC receiver.

2. *Narrow-MUSE* and its sisters, *MUSE-6* and *MUSE 6+3*, are HDTV encoding systems that permit high-definition signals to be transmitted within the bandwidth restrictions of a 6MHz TV channel. There is, predictably, a reduction in picture quality over standard MUSE.

   Narrow-MUSE also requires a converter to operate on a standard receiver, although the two are reported to be "compatible."
3. *Advanced Compatible Television* (ACTV), an encoding scheme developed by the David Sarnoff Research Center for NBC. The system uses time-compression and expansion-processing techniques to transmit four signal components in a single 6MHz channel. Special ACTV receivers would decode the enhanced-definition signals, while standard (NTSC) receivers would display a normal picture.
4. *The Glenn system*, developed by Dr. William Glenn of the New York Institute of Technology and shown at the NAB convention in Dallas last year in a closed-circuit demonstration. The concept involves supplementing a TV station's 6MHz on-air signal with a 3MHz augmentation channel from the UHF band. The extra signal would contain additional picture detail that, when recombined at the receiver, would produce an HDTV signal.
5. High-definition NTSC is another 2-channel approach proposed by North American Philips. Like the Glenn system, this scheme relies on a separate transmission channel for picture details that will yield an enhanced-definition image with a wide aspect ratio when decoded on a special receiver.
6. *HDMAC-60*, another Philips development for high-definition multiplexed analog component (MAC) television with a 60Hz field rate. HDMAC-60 is intended as a way of transmitting via satellite the same amount of information as the Philips high-definition NTSC system.
7. *The Del Ray system*, a 1-channel solution under development by Richard Iredale of the Del Ray Group (Marina Del Ray, CA). At this point, the project basically exists only in software, but Iredale is confident that the hardware can be built to send "true HDTV" within a 6MHz channel.

So, there is no shortage of activity on the HDTV question. And there also is no shortage of disagreement over which way to proceed on high definition.

### View from the top

To gain a perspective on how the broadcast industry may be moving on HDTV, I talked with the engineering chiefs of the three major networks. Their views carry a lot of weight with TV stations, manufacturers and the FCC. As you will see, the three are far from a consensus on where we go from here.

*Continued on page 73*


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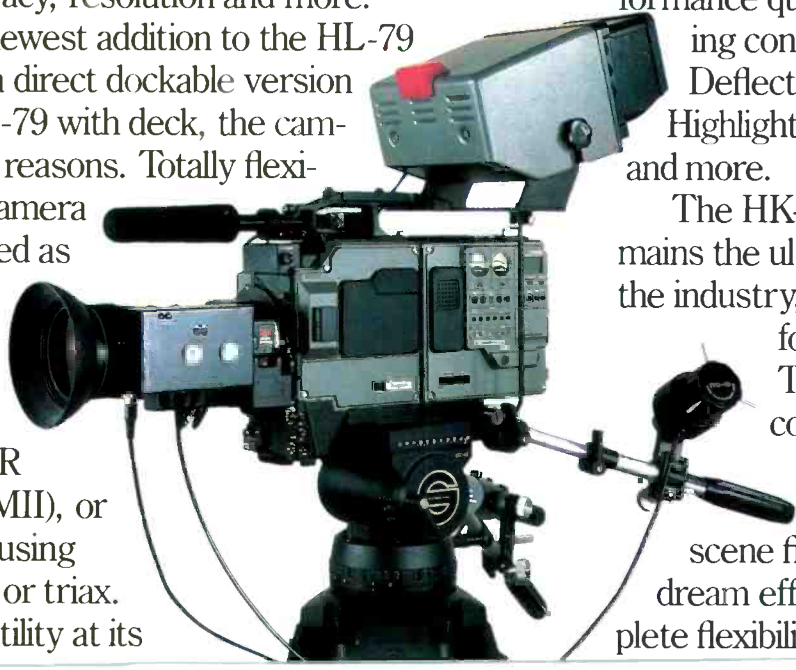

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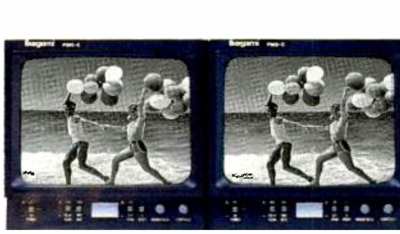
Ikegami monitors are available in 3-Series Monochrome, 5-Series Low Cost Monochrome, 9-Series Color (In-line Gun), 10-Series Color (Delta Gun), 15-Series Color (Auto Setup) and 16-Series Color (Low Cost Professional) Models. What distinguishes Ikegami monitors from others is a commitment to research and development, and continued market analysis to meet the broadcasters' needs. The results speak for themselves. Today, Ikegami is proud of its reputation not only for the finest cameras, but the finest monitors. It's a reputation that we strive to maintain.

Consider the latest advancement in monitor technology: Auto Setup. Originally pioneered for Ikegami cameras and now available in the Ikegami 15-Series Broadcast Color Monitors.

With an optional Auto Setup Probe, the 15-Series is menu driven with data shown on the CRT. An optional Remocon Box provides for remote control operation. The CRT features a Fine Dot Pitch Shadow Mask for superior resolution, an In-line Self Converging Electron Gun, Controlled Phosphors and a Black Matrix. The 15-Series is available in 14″ and 20″ and uses a Digital Control System (DCS) to simplify monitor set up. When using the Auto Setup Probe, the following functions can be automatically set, at a reference level, and stored in less than 50 seconds: contrast, brightness, chrome, hue, RGB background and GB gain. Auto Setup is another Ikegami breakthrough.


TM 20-15RH Auto Setup Monitor with Probe.

The Ikegami 16-Series Low Cost Monitors feature an In-line Self Converging Electron Gun, a Black Matrix CRT, a Comb Filter/Trap, and front panel selectable A/B Video and RGB video outputs. Specifically designed for a wide range of production and broadcast applications, the 16-Series is available in 14″ and 20″ at surprisingly low costs, making the series extremely competitive. The introduction of the 15-Series and 16-Series monitor comes as



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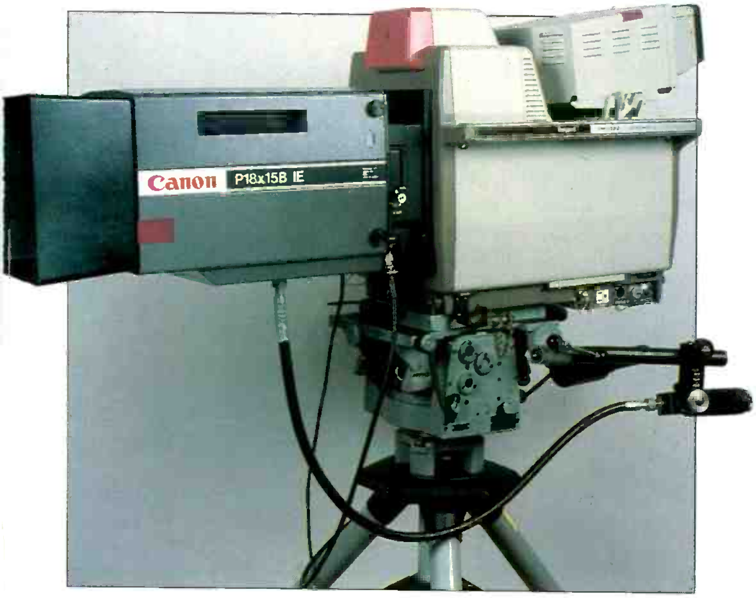
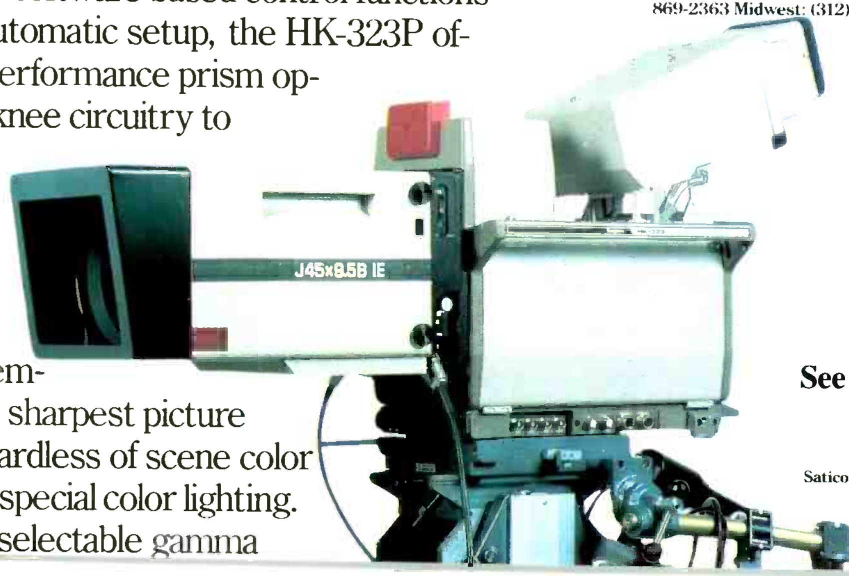



available as the companion camera.

For field/studio operation, the HK-323 with 1″ or ⅔″ tubes, recently introduced by Ikegami, have quickly gained acceptance with the networks as the market leaders in this segment of fully automatic micro-processor controlled, lighter weight broadcast cameras. The HK-323 is available with the optional hand-held companion, the HK-323P, which operates off the same base station. Featuring a built-in micro-processor for various software based control functions and fully automatic setup, the HK-323P offers high performance prism optics, auto-knee circuitry to handle high contrast, and scene files with extensive memory for the sharpest picture quality regardless of scene color content or special color lighting. This, plus selectable gamma values; 0.45, 0.4, 0.35, two motorized servo filter wheels each with four positions and a back-up memory system for total system flexibility. The HK-323P is now available with dockable Beta and MII VCRs.

What distinguishes Ikegami cameras from the competition, aside from its full line, is its total commitment to design and manufacture the very best cameras possible. It's what makes an Ikegami camera the absolute leader in its class.

For further information contact your Regional Ikegami Office.

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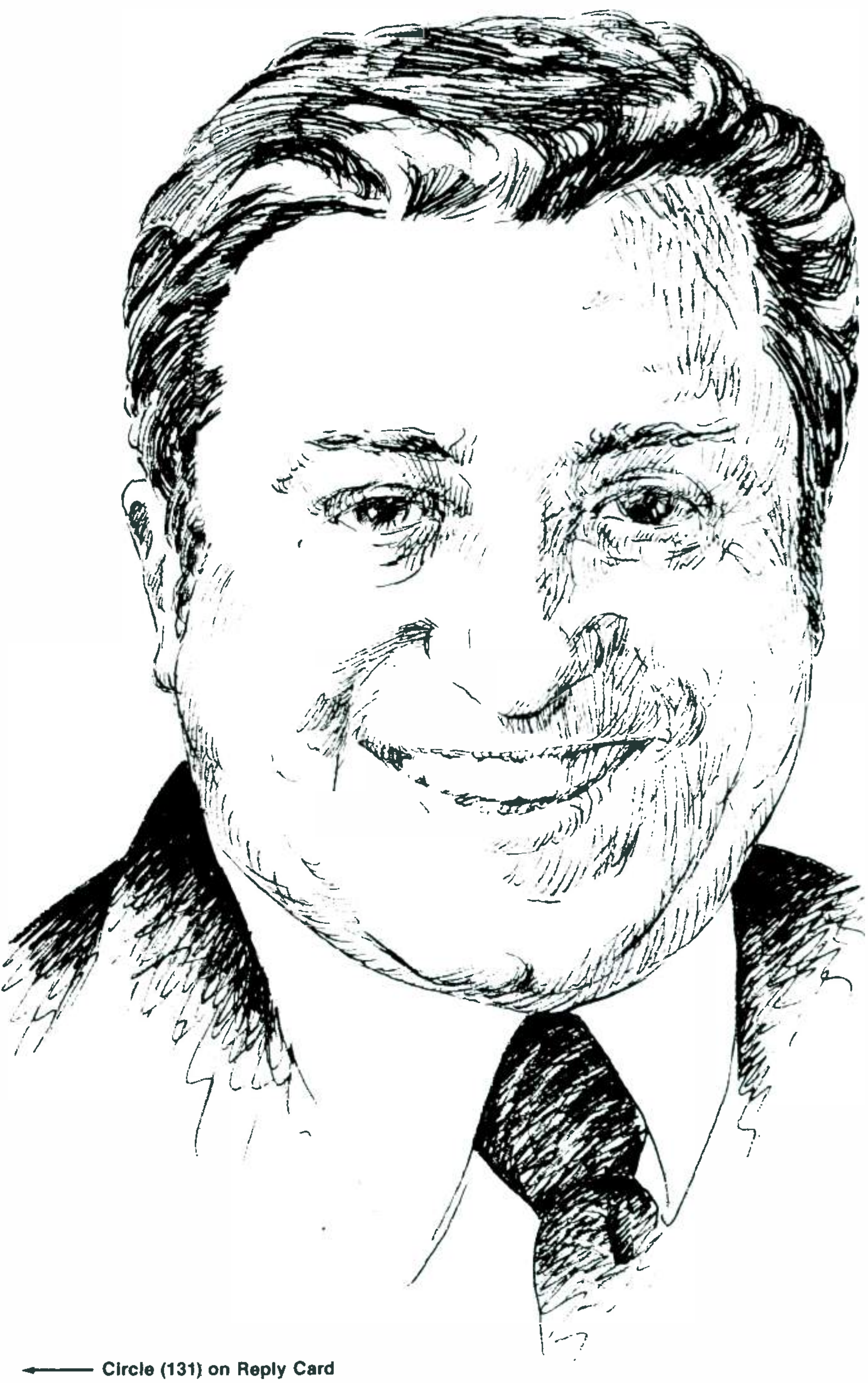
*Continued from page 64*

**Julius Barnathan, President, Broadcast Operations and Engineering, ABC**



**Q: Does HDTV have any viability in over-the-air television?**

A: Does it have any viability anywhere is what I'm trying to figure out. You know, I'm a marketing man. And I am from Missouri, I must admit, because I believe in asking not what I think is needed, but what does the consumer think is needed? That consumer sees two ends of the problem. One end is the receiving end, and one end is the manufacturing end.

I don't see anyone in Hollywood busting the doors down saying, I've got to change from 35mm film. I haven't had one person come out. They all talk about it, but I haven't seen anybody saying they've got to have something different. So, there is the one customer.

The other customer is the people at home, who are lucky when they get a signal that doesn't have a ghost in it.

Now, they're out to have a production standard, and that's fine. But I say, why do you need a production standard until you determine how you're going to transmit HDTV? Now, how much bandwidth is it going to use in transmission? They say, well, about 9MHz. I ask where do we get the 9MHz from?

Then, I turn around and say, this is wonderful. Let's assume we do get 9. Assume we get the 6 we have now and 3 more from the commission. Or, we get 6 that we have now, and 6 more from the commission (the AM-FM approach). We operate them both, and then some day we switch over to the other, or we always have the one and one-half system.

Now, remember, more than 50% of us are now on cable. And the cable companies don't understand it, but should know it, that more than 50% of their audience is from the networks. So, we are intimately tied together.

So, now here we are three years from today. By that time maybe we're up to 65% cable penetration. We're now transmitting 9MHz. What do we tell the cable companies? All the broadcasters on the air get

9MHz, move everybody out. Is that what's going to happen? The cable guys will say, wait a minute, I'll take your old signal.

These are the kinds of problems that nobody faces when they talk about high-definition standards and such. The difficulties of doing it aside, even if you could do it, how do you broadcast it? This is one of the concerns I have.

This may happen. We may be able to do it over the air. We may find that fiber optics will allow us to do all of this. I don't know the answer to that.

I think the so-called 1125/60 production standard is premature. And regardless, whatever is used for transmission has to be compatible with 525, at 525 quality. Now, that's basic. So, when they talk about MUSE, MUSE is no good for us because it isn't compatible.

And what do we do? Go to Congress and show them 9MHz? It's ludicrous. Who cares? What can you do with it?

It's like going to shop for a car. I'll take you to the dealer and show you a Rolls Royce. It's a wonderful car, go buy it.

"How much is it?"

"$100,000."

"How much?"

"$100,000."

---

***I think the so-called 1125/60 production standard is premature. And regardless, whatever is used for transmission has to be compatible with 525, at 525 quality.***

---

"I don't have $100,000. How about $10,000?"

Now that's the problem.

You know, I'm in a losing position here. I say this and people say, he's against progress. That's it.

I think inventions should come from a real need. The Japanese found saturation of the current 525 system and said, we need a new market. But I say why create a new market? It's not a new market. It's not a change from black-and-white to color.

If you say, why don't we change the aspect ratio, well, we might consider that. But let's find out what the viewer wants. And how many people are going to be able to afford and put into a house a television set that's going to be 4½-feet diagonal? That's a tremendous-sized screen.

**Q: Is DBS a long-term threat to networks?**

A: No, not to networks. To stations, yes. The network could turn around and go right on it.

DBS is just like anything else in this world. You can talk technology, but technology is not the thing. Software, product, is the rea-

# Our bold new technology has created a shotgun 55% lighter, 55% hotter, and 28% shorter,* yet with 100% of the sound you need!


These two new Audio-Technica studio condenser microphones represent a small revolution in shotgun design…inside and out. Meet the Model AT4071 (just 15½" long) and the AT4073 (a mere 9"). They may look like other shotguns (although somewhat shorter than most), but the resemblance stops as soon as you plug them in.

### New Coaxial Tube Design

First, both 40-Series microphones perform far "longer" than their actual size. In effect, the ingenious coaxial interference tubes perform as though the microphones were half again as long. Our unique tube design goes far beyond the normal phase cancellation that occurs in a simple resistance-damped tube. There is actually a tube-within-a-tube, creating a separate, acoustically longer path for the lowest frequencies. Low frequency directivity (normally a simple function of tube length) is maintained, yet the microphone size is reduced to a far more practical length.

### The Result: Far More Versatile

This shorter length for a given acceptance angle is a practical benefit in the studio and the field. It's easier to avoid shadows and to stay well out of the frame. Cancellation from the back is also impressive, making exact mike placement less critical. And their very light weight (far less than the others) will be appreciated by every user. As a bonus, the nested internal construction makes the 40-Series shotguns unusually resistant to accidental damage.

### Clean Transformerless Output

Listen carefully to the 40-Series sound. The transformerless output insures fast, distortion-free response to transients. You'll hear crisp, natural dynamics over an extended frequency range, even under high SPL conditions. Output is extremely high, making the 40-Series hotter than any other shotgun available. A built-in high-pass filter is included, of course.

### Quiet in Every Way

The low noise of these new microphones is impressive. Self-noise is almost immeasurable at about 12dB for the AT4071, and just 14dB for the shorter AT4073. Equally important, the rejection of wind and handling noise is outstanding. Coupled with excellent sensitivity, the 40-Series design allows you to take full advantage of the finest digital and analog studio electronics.

### Compatible and Competitively Priced

Finally, both can be powered from any 12-48V phantom power supply. They come complete with foam windscreen, stand clamp, and case. Yet, with all their advances and performance superiorities, the new A-T 40-Series microphones are priced competitively with the best known shotguns.

The significant performance advances of these new 40-Series microphones demand a trial in your most difficult environment. Heft them. Hear them. Compare them in every way. This bold new technology has raised the standards for shotgun performance!

*Model AT4071 compared with Sennheiser MKH816P48-U. For complete shotgun comparison, call or write.

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## Film: still alive and well

What does the film industry think about HDTV? Well, it depends on who you talk to. Program producers are thrilled at the prospects of reducing production costs and cutting production time, but they also are concerned about the drawbacks, real and perceived, of high-definition video.

By and large, program producers never buy anything unless they absolutely must. Hollywood loves to rent. And in the film business, you can rent just about anything you want, except high-definition video equipment. The first drawback of HDTV is the initial capital outlay of equipment.

The second is the lack of portability, compared to a 35mm film camera. TV cameras, no matter how advanced, require an umbilical cord to a camera control unit, connected to, at minimum, a monitor and video recorder.

The third drawback is the editing equipment needed to transform "dailies" shot on video into a finished program for delivery to the networks or syndication. Video editing systems and their associated HDTV VTRs and switcher are expensive and require a level of technical training that many film editors do not have.

On the plus side, videotape is cheaper than 35mm film and is reusable. Special effects and titles are much easier and faster to produce and modify using video techniques, rather than film. Plus, the finished program is in a video format that is easier to convert to a broadcast format (NTSC or something else), with fewer artifacts, than 24fps film.

### Coleman on HDTV

Still, nagging questions remain. One involves the actual quality of HDTV, as compared to 35mm film. One person to speak out on this question is Leonard Coleman, a vice president at Kodak and former SMPTE president. Coleman, in an interview released to the trade press at the fall SMPTE convention in Los Angeles, urged caution with regard to high-definition video production. (It must be noted that Kodak is, of course, a major supplier of film.) He said that HDTV pictures are not as good as 35mm film and are not likely to reach parity until significant advances are made in CCD imaging technology. Coleman placed the time frame for such work at about 10 years.

"Our scientists believe it would require a CCD solid-state array with a potential for capturing 54 million bits of information per frame 30 times a second. That's about 25 times more information-packing capability than today's 500x720 pixel sensors provide. We are at least 10 years away from being able to deliver that technology on an affordable basis."

Coleman said that it is certainly possible to develop such a device, if someone wants to pay for the research to do it. In the meantime, he said, film technology also will be moving forward.

". . . Tremendous advances (have been made) in film technology. Now people are shooting with . . . high-speed film which . . . provides the cinematographer with good exposure latitude and has greatly reduced the amount of light and air-conditioning needed on a typical set. At the same time, the cinematographer has more depth of field, and there is more room to maneuver and do subtle lighting for artistic effect.

"The result is that film shows shot on sound stages now tend to have a location look and the overall texture of the film which tells viewers that this story is a fantasy. At the same time, advances in film-to-video transfer technology have just about eliminated the financial edge that video producers had."

But how much improvement can still be made in film technology? Coleman said it is impossible to predict, but that film technology has a lot of life left in it.

"Today, some 84% of the prime-time evening shows on the CBS, NBC and ABC television networks are produced on film. The fact is you can upgrade film technology by simply inventing a new emulsion and loading it into an existing camera. When you invent new technology for video, you generally have to throw away the old system. The result is that film technology usually advances at a more rapid pace."

In Coleman's view, the issue of cost savings attributed to HDTV production methods is subject to some debate.

"The comparisons I have seen make some assumptions which aren't necessarily realistic. For example, most of the film produced for television today is transferred directly from negative to tape for post-production. I assume that the same would also be true in an HDTV environment. In that case, cost comparisons therefore come down to comparing the price of renting film cameras and paying for the film, processing and the film-to-video transfer, to costs for amortizing and maintaining an HDTV system and buying tape."

Cost savings in crew expenses and reductions in production shooting time have been suggested as benefits of HDTV work. However, Coleman isn't convinced.

"Some proponents of HDTV believe you can work with a smaller crew and produce TV programs faster. In fact, you do have an operator, an assistant and a crab dolly grip on each film camera, while in video one person does all of these jobs. However, that's inherent to the cultures of shooting film and tape, rather than to the technologies. And you can generally see the differences in production values. Also, video tends to have more people behind the scenes. . . . I don't see how HDTV could cost less than a conventional video production. It is almost certain to cost more."

Still, Coleman said he has hopes for the 1,125-line, 60Hz HDTV system. He describes it as promising.

"I wouldn't be at all disappointed to see a VCR that makes it possible to view videos on HDTV. That would allow the audience to see films more like they were made to be seen. I don't think some broadcasters are all that happy about this prospect. However, there is no quick fix. . . . Before we get on the bandwagon for NHK's HDTV system, let's see what path it is taking, and where it is headed."

son anything is going to succeed.

If you took the Super Bowl and all of the major events that Ted Turner talks about trying to secure, and said the only way you could get them now is high-definition television, there would be screams, but there would also be mad rushes to get HDTV sets. Product is what does it. There's no question about it.

Having worked at ABC for 35 years, I can say that the only thing that got ABC out of the doldrums and got it viewed was programming.

I'll tell you what. I'll play in 525 the World Series and let somebody else run something different in high-definition television, side by side. I guarantee you I know which one I'm going to get, and who's going to watch what.

***You can talk technology, but technology is not the thing. Software, product, is the reason anything is going to succeed.***

**Q: What about the ATSC efforts to preserve additional spectrum?**

A: It's a chicken-and-egg situation. If you are going to provide for this kind of technology, which at this moment says 9MHz, you've got to say, wait a minute! If we need 9 to broadcast it, then cable needs 9 to relay it. But, at the same time, if it's going to be 9, it's got to be compatible, and until you make those determinations you must reserve the frequency, because there's no other way to do it that means anything. I think 12GHz is a dream.

***We're always talking about HDTV in the lab. I haven't seen HDTV in a reality situation.***

There are still a lot of unanswered questions. Like, can you send a UHF and VHF signal together? Can you create a receiver that will reliably decode it?

We're always talking about HDTV in the lab. I haven't seen HDTV in a reality situation.

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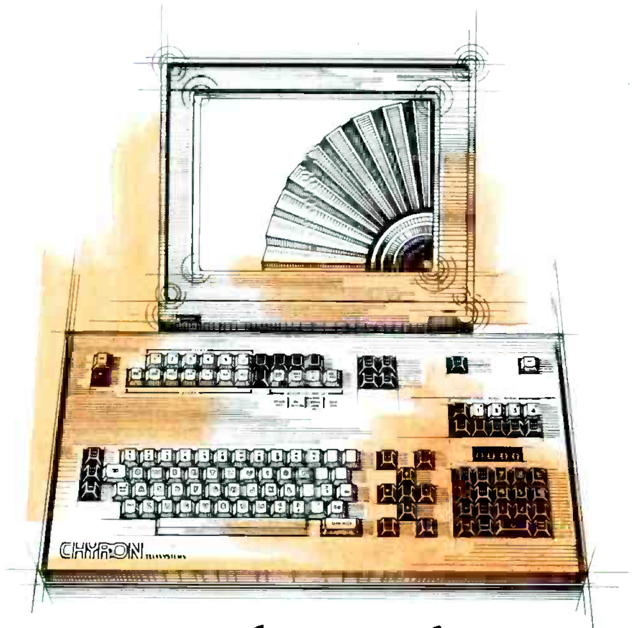


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## Joseph Flaherty, Vice President and General Manager, Engineering and Development, CBS

**Q: Where does high-definition television fit into the network picture?**

A: When we began our studies of HDTV, the first priority was to reduce prime-time production costs by moving from 35mm film to videotape. I think it is important to realize that we have always recorded, as have the other networks, virtually all of our prime-time programs in high definition for the past 30 years. It's called 35mm film. It doesn't have the best motion portrayal (the wagon wheels go backward), but it is high definition.

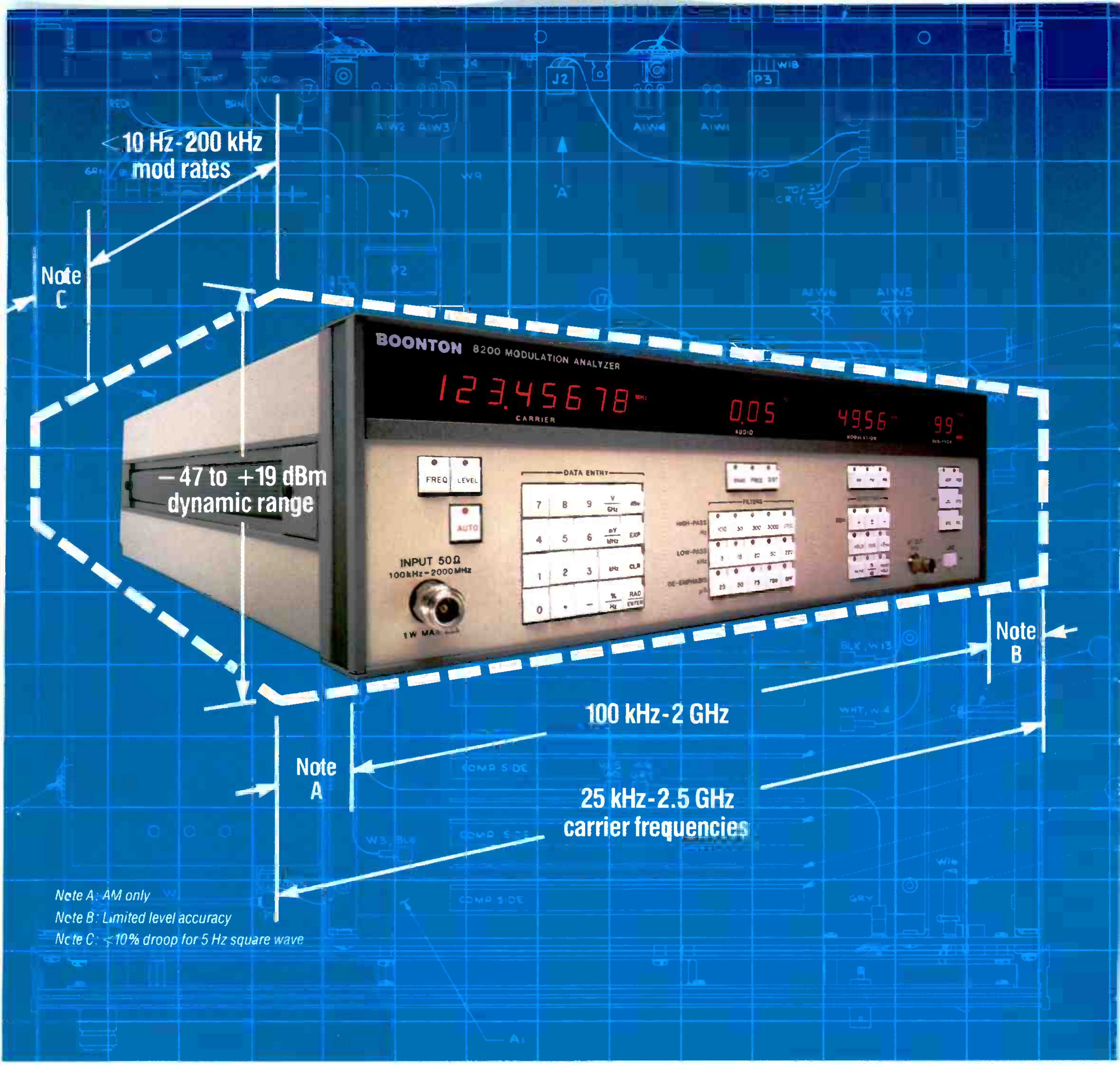
That wasn't just a casual decision. The decision was taken by producers because the residual value of the program is so important, and the cost of production is so high. Today, the cost of producing a prime-time program is more than a million dollars an hour (per episode). So, as we move from film to videotape, we need some system that is equivalent to 35mm quality to maintain the residual value. That is how we began our investigation of high definition. We saw it as an important production tool.

We are already beginning to see commercials being produced in high definition. That is an important milestone.

The next critical step is delivering HDTV to consumers. Now, while that is important and is certainly the direction for the future, just remember that in the 30 or so years we have been producing programming in high-definition 35mm film, we have never delivered one frame of it to the consumer. People tend to overlook that. We don't have to begin broadcasting high definition tomorrow. We do, however, have to begin making programs with it pretty soon.

The way the industry moves on HDTV transmission will be based on three parameters. In the end, it is going to be a triangular decision involving the perceived quality on small and large screens, the economics involved and the spectrum requirements of the system. Technology itself is not even part of the decision, but it underlies each element.

*Continued on page 82*

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*Continued from page 78*

Obviously, any system that is less than the full bandwidth of the production system involves compromises and generates artifacts. The question is, how many of those are acceptable how much of the time, how much does it cost, and what does the viewer perceive of it? Then you can make your choice.

***We are already beginning to see commercials being produced in high definition. That is an important milestone.***

The decision will not be as long or as complicated as many people think. It really doesn't make any difference about the details of the system, but it does make a difference regarding the bandwidth.

**Q: Where do you think HDTV fits into the home?**

A: Well, I think we should look back from the consumer side. I don't think that there is a great pressing rush to implement HDTV transmissions immediately. There was a need when production started because that provided a very definite saving in cost, improvement in quality and shortening of production time.

And time is important in production. Not only is time money, but the length of the pipeline for producing a program, from on-stage photography to on-air transmission, is shorter on videotape. That time gap can be the difference between fixing a show and having it canceled.

You must remember that a producer is working on his series every week. If he is in 18th position, he wants to be in 15th. If he's in 10th, he'd like to be in fifth. And if he's in 30th, he'd better get somewhere. So, the scripts, the actors, the performances and the characters are being worked on every week. The faster you can get those "fixes" on the air, the more timely the program can be and the better chance the show has of surviving.

Getting HDTV on the air is going to take time. There is going to be an economic impact on both sides, broadcasters and consumers. Receivers aren't all going to be sold the first year. The ramp-up period will probably require eight to 10 years to reach the turnover point, as color was. The difference

***In the end, it's going to be a triangular decision involving the perceived quality on small and large screens, the economics involved and the spectrum requirements***

between now and the NTSC days when we changed to color is that while there were arguments over various systems and how they would work, it was known that whatever system was chosen would have a monopoly into the home. Broadcasting was the only way to get there. Today, that's not the case.

There probably won't be just one transmission standard. There isn't today. What's recorded on your VCR isn't NTSC. It is a different signal that can be transcoded into pseudo-NTSC that your receiver will accept.

I think you will see receivers become more and more *monitors*, as you see in the component-type systems, with a series of input ports. And those ports will receive different media. They will compete in quality, as well as in programs. Until now, the competition has only been in programming. The technology was roughly the same. If anything, broadcast quality was better. Now, that's under challenge.

I think the technology will be in place for this transition. The question is whether the broadcast industry and the government will rise to the occasion and do whatever is necessary to compete. Competitive system parity, not only in the beginning, but with enough headroom to maintain competitive parity, is the challenge at hand for terrestrial broadcasters.

***Getting HDTV on the air is going to take time. There is going to be an economic impact on both sides, broadcasters and consumers.***

Systems that don't have the spectrum constraints of broadcasting can play the "I can do anything you can do better" game. It's hard to predict what the public will think of that, but the American consumer is a technology-sophisticated group. They perceived the difference in quality offered by compact discs, for example, and have gone for it in a big way. People are willing to spend money for improvements in quality they can perceive.

**Q: To cover our options, should we then set spectrum aside, even if we don't have a clear idea of the type of transmissions that will be used for HDTV?**

A: No, not set it aside. I think the industry, under the auspices of the ATSC, will be able to determine within the next couple of years which way we should go. We will have to pick a system, know how much spectrum it will take, and set it aside. Whatever system is chosen will have to provide for sufficient headroom to maintain competitive parity with other available delivery systems.

**Q: Does that mean at least 9MHz?**

A: Well, I don't know. There are a lot of people who think it can be done in less. And

I think all those systems should be finished and tested. There are some very clever engineers working on this problem.

***People are willing to spend money for improvements in quality they can perceive.***

Certainly the high-definition receiver of the future will be a smart terminal, and there is a lot of signal processing that can be done.

**Q: A few years ago there was a lot of talk about DBS. Today, however, we don't hear much about it, except from HBO. Where does DBS fit into the HDTV delivery equation?**

A: I think all of the current and future delivery systems have to be recognized as very significant competitors. It appears that, for economic and programming reasons, DBS did not get off the ground with 525 lines and a 3-by-4 aspect ratio. In other words, a few more channels of the same thing that was available on cable did not, apparently, make it.

***The question is whether the broadcast industry and the government will rise to the occasion and do whatever is necessary to compete.***

Whether high definition, considering the increased resolution, wider aspect ratio and digital sound, will be enough of a differentiation to launch such a system is hard to tell. But certainly, if HDTV doesn't do it, nothing else is on the horizon that could.

It seems to me that with the head start that cable has in market penetration, with the penetration of VCRs and higher-quality units coming along, DBS has to make it with high definition or not at all. Probably the next two to five years will tell that story.

Theoretically, from a technical viewpoint, it is an appealing way to deliver a signal to a large segment of audience. However, it is expensive and there is no audience out there yet. And it has a double ramp-up. DBS requires an antenna ramp-up and a high-definition receiver ramp-up.

*Continued on page 88*


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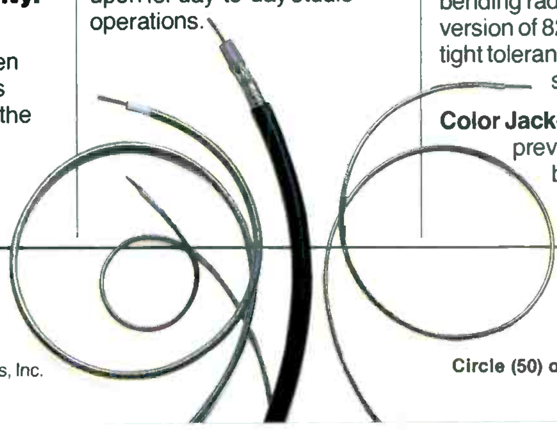

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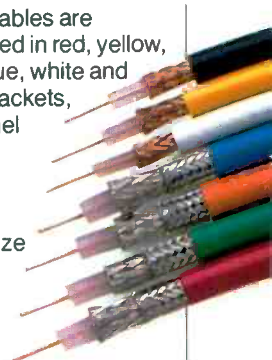

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*Continued from page 84*

# NBC

**Michael Sherlock, Executive Vice President, Operations and Technical Services, NBC-TV**

**Q: Where does HDTV fit into the network picture?**

A: I think all the networks see high-definition television as something that must be dealt with. And in dealing with it, you have to first look at what reality is. Reality at this point, we think, is that there is certainly equipment out there to make product. There is other product out there—35mm film—that is potential product for high-definition television.

**Q: The Advanced Television Systems Committee's VHF-UHF combo system has been demonstrated. Do you see it as viable?**

A: I would never say it is not, because if I did I would be defying my own rules and regulations. I think it is absolutely necessary that we pursue every avenue of spectrum use so that, in the long-term future, broadcasters can participate in delivery of top-quality pictures to the home.

Ultimately, I do think that additional spectrum will be required. And, therefore, we should fight very, very hard to keep that spectrum available. As a matter of public policy, it is important that we keep it available. I support the work being done by the ATSC, and I support the work being done by the NAB. I just think that in the short run, we need something that doesn't require two channels.

I fear that trying to make those channels available and trying to accomplish the engineering task of combining channels or getting more transmission sites is so long-term that, as a broadcaster, you'd never be competitive with the timing of Japanese manufacturers through VCRs.

Then you get to the point that, OK, if there is already that particular incubator, is anybody going to capitalize on it? It appears to me the reality is, yes. I believe the Japanese are going to capitalize on the promise of HDTV delivery to consumers.

How are they going to capitalize on that? Well, certainly in combination with available software it seems reasonable for them

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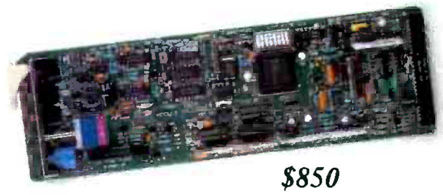

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**Circle (52) on Reply Card**

to produce hardware, both for internal Japanese consumption and then (most likely external to Japan consumption) VCR material and VCR recorders, and maybe video players.

Well, if that's going to happen and be in competition for the home entertainment audience, broadcasters really have to face the situation.

And we at NBC did take a look at that reality years ago and said that if there is going to be a better service, broadcasters need to participate in that better service and be competitive. Therefore, NBC, and at the time, RCA consumer electronics and RCA labs, said "OK, how do we attack this problem? And how do we strategically position ourselves to participate on a level playing field with others?"

The company set aside time, money and resources to develop something that would be compatible with what we have now, and wouldn't throw us totally into a new business in a disruptive way. We wanted to accomplish the same thing that we envisioned the Japanese being able to accomplish with a wide screen and enhanced picture. The end result was Advanced Compatible Television, which we announced last Oct. 1.

> ***"It defies my logic as a broadcaster to put MUSE and ACTV on the same level."***

**Q: I've heard high-definition television likened to a freight train. Broadcasters must either hop on board or get out of the way. What do you think?**

A: That's pretty good. I would buy the first part of what you just said. Getting out of the way, however, is abhorrent to me, because I know we don't have to. And what baffles me at this point is that, from a broadcaster's point of view, there would be any doubt that a solution to high-definition television, such as ACTV, has to be the way to go. Not just that, yes, it's nice and it looks good, and you can fit it through 6MHz.

I think for the moderate term, broadcasters have to insist that a 6MHz compatible solution be the one. And so far as I know, ACTV is the only solution.

If somebody showed me, for instance, something that was even better that could work through a 6MHz system, NBC would certainly want to be working with that, testing it along with ACTV. But the principle of a compatible 6MHz single-channel solution with a wide-screen enhanced picture is to me an absolute imperative as a broadcaster.

To even think of how it compares to MUSE is the epitome of "apples and oranges." I can't use MUSE, so why do I compare it to ACTV? And I'll tell you that ACTV will hold up every bit as good as MUSE, and will look every bit as good as MUSE.

It defies my logic as a broadcaster to put MUSE and ACTV on the same level.


18GHz
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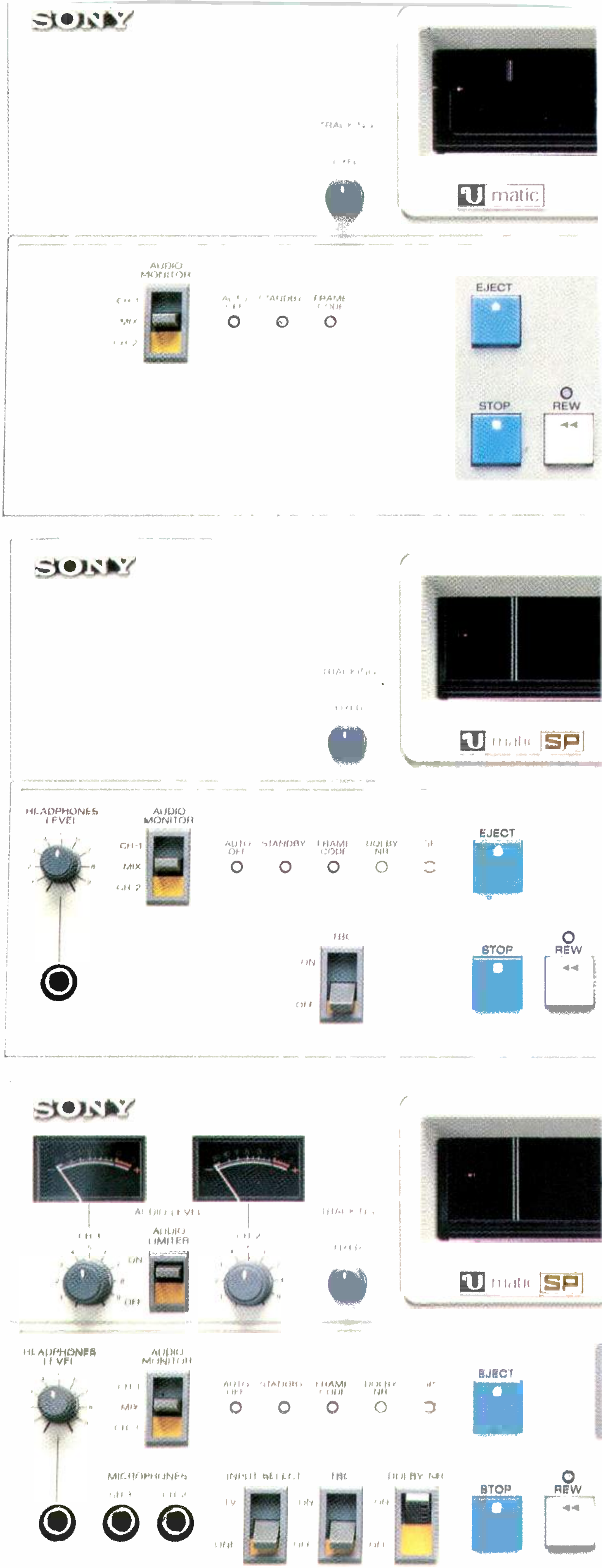


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In fact, with an RS-232C computer interface, you can preset your players and recorders to start and stop on certain frames or rewind and playback at certain times. So you can conveniently automate programming, insert commercials, or set up point-of-purchase displays.

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With U-matic, moving up to a new standard in video could be as simple as opening a box and plugging it in.

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# HDTV: the European view

By Howard T. Head,
*BE* European correspondent

**The subject of HDTV in Europe has become an interesting mix of technology, politics and economics.**

The imminent introduction of high-definition television (HDTV) to the European scene confronts the European broadcasting administrations with an exquisite technological and commercial dilemma. Stripped to its essentials, Europe must choose, and may in fact already have chosen, a field rate for HDTV. All else consists of minor details. Technology is readily available to support any of the choices.

The European community has three options. The present TV field rate in all of Europe, West and East alike, is 50Hz. In much of the rest of the world, especially North America and Japan, it is 60Hz. No other known broadcast system uses any other field rate. And so, Europe's choices are: 50Hz, 60Hz or a brand new field rate.

Serious interest in HDTV dates back to about 1974, when the Japanese gave their first successful demonstrations. By 1980, the United States, which has the same TV standards as Japan, started to follow the Japanese work. About that time the European countries also began to look into the matter, when they appreciated the urgency of narrowing the Japanese lead in the field.

Head is based in Madrid, Spain.

### Standardization work

The first full-scale attempt at international HDTV standardization was made by the International Radio Consultative Committee (CCIR), in May 1986 at Dubrovnik, Yugoslavia. Japan (which has taken the lead in HDTV development) and the United States pushed for a 60Hz production standard. The Japanese already had a working system. The 50Hz countries, caught with their pants down, demurred, asking for time to perfect and demonstrate a non-60Hz—presumably 50Hz—system.

The Dubrovnik meeting concerned itself mainly with a production standard. TV material can, of course, be produced in one standard and readily converted to another for transmission, thanks to modern standards converters. Indeed, we already employ one form of standards conversion every time 24-frame motion-picture film is transmitted at either 50Hz or 60Hz. But a single, universal standard would avoid the bother and the degradation of the conversion process.

The origins of the 50Hz and 60Hz field rates go back to the early days of television, when it was convenient for one reason or another to lock to the frequency of the primary power supply. This way, a vertical frequency reference was readily available. Also, any hum bars arising from power supplies and other circuitry were stationary and, therefore, much less visible.

All of today's standard systems use 2:1 vertical interlace, with a frame rate of half the field frequency. Flicker is intolerable at rates of 24Hz (motion pictures), 25Hz or 30Hz. The movies get around it by means of the *flicker shutter*, and TV by using interlace. Interlace does give rise to an interline "twinkle," but the average viewer has to sit close and look hard to see it.

But if the Europeans stick with the 50Hz

*Continued on page 98*

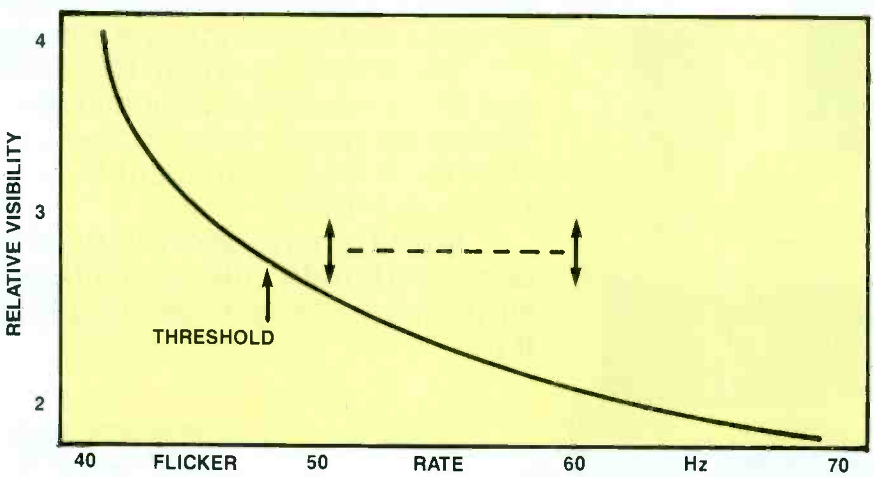


***Figure 1.** Relative flicker visibility as the field rate is increased.*


**\ Clean Sweep**

For every one of their new cameras, :TV Television Network, Ltd., host roadcasters for the '88 Winter Olym-ics, selected Fujinon — more than 8 lenses in all. In the strongest domi-ation of the games, all the action aptured by CTV cameras — from the videst panoramas to the longest, tight-st close ups on the slopes — will be hrough Fujinon lenses.

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Fujinon's brand new 13kg A34X10ESM will be on 10 new CTV cameras. No larger than the lens it re-places (the A30X11ESM), its coverage is wider and longer. From 10mm to 340mm with an F1.6 that's flat to 229mm. Naturally, it has a built-in 2X extender.

In the handheld competition, Fuji-non wins hands down with 28 new CTV cameras equipped with the A14X9ERM, 7 cam-eras with the A8.5X5.5ERM ultrawide zoom, and five cameras with the A18X8.5ERM. All three compact, light-weight, weatherized lenses have built-in extenders.

Long the industry's fa-vorite ENG lens, the A14X9ERM zooms from 9mm to 126mm while the maximum aperture is F1.7 out to 103mm. For events demanding wider and longer coverage, the 18X provides 8.5mm to 153mm range with an F1.7 aperture constant from 8.5mm to 116mm (F2.3 at 153mm). And for wide angle abilities, nothing beats the A8.5X5.5ERM. It's an F1.7 that zooms from 5.5mm to 47mm. And even with its 1.7X extender in posi-tion, it provides a familiar 9.4mm wide angle.

In addition to the CTV cameras, most of the production companies supporting the coverage will be bringing Fujinon equipped cam-eras. And, naturally, Fujinon will be on hand to provide field support. After all, one reason Fujinon len-ses are so widely used is Fujinon serv-ice — it's as good as gold, too.

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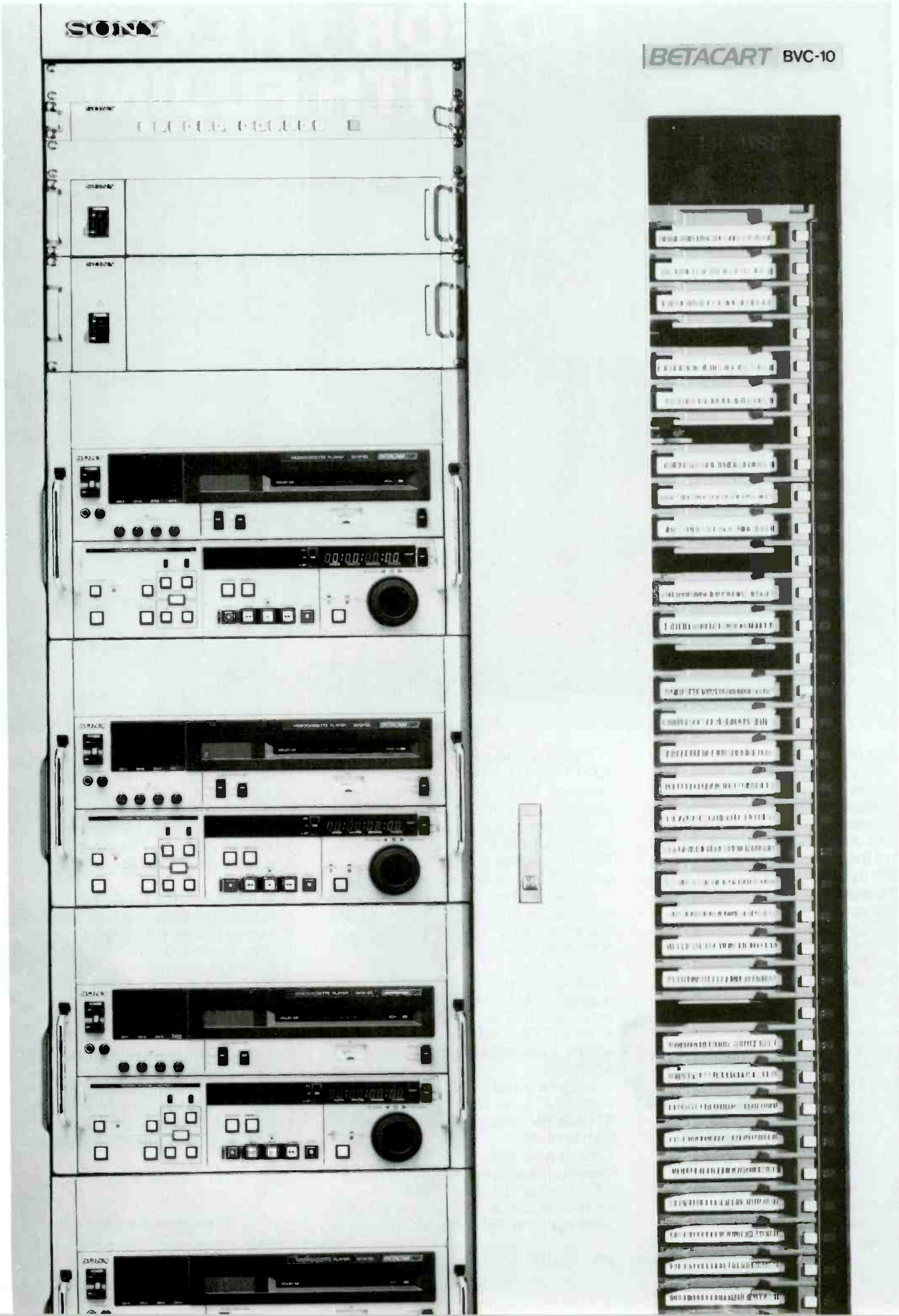
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*Continued from page 94*
rate, then they may also be stuck with flicker. Flicker is visible in European TV pictures today; it gets worse with picture brightness, it gets worse with picture size and it is worse in peripheral vision. But 50Hz is here, and of the 500 million TV sets in the world today, more than half work only at 50Hz. You've got to have an awfully good reason to change that!

Even 60Hz interlaced is no prize, but it is a lot better than 50Hz, largely because of the so-called Weber-Fechner law, summarized in Figure 1. By one of those accidents of nature, flicker, for average scene brightness, is quite bothersome at about 48Hz (twice the motion-picture frame rate), is tolerable at 50Hz and is only slightly visible at 60Hz. Some researchers have reported visible flicker at rates up to 80Hz for bright pictures at close viewing distances, where there is added use of peripheral vision.

However, the 60Hz performance is good enough that no 60Hz administration is going to abandon it, in the absence of some really good reasons. In the abstract, 80Hz, which also has been proposed for HDTV movie production, might be a better TV production choice. This would require standards conversion to either a 50Hz or 60Hz TV rate, but after all, 24Hz motion pictures have to be converted even today.

### The battle lines

The HDTV standardization problem is by no means simply a matter of North America/Japan vs. Europe. Worldwide, the situation is shown in Table 1. Of the 500 million receivers now in use worldwide, a minimum of roughly half would feel the effect of any new frame rate. Still, nothing can change the fact that 50Hz pictures flicker.

There is a way, however, to circumvent the 50Hz flicker problem, and it was demonstrated at the August 1987 Berlin Fair by the "Group of 29," a group of (you guessed it) 29 European enterprises, working together within the *Eureka 95* HDTV program. This work originally was headed by NV Philips (Holland), and included Robert Bosch (West Germany), Thomson S.A. (France) and the Thorn/EMI PLC (Britain). The group was later joined by 25 other companies from Germany, the United Kingdom, France, Italy, Belgium, Sweden and Switzerland, among them Grundig, British Telecom, Telettra and Swedish Telecom.

In the Berlin demonstration, an HDTV picture was transmitted at 50Hz, in field standards compatible with existing 50Hz receivers. New HDTV receivers, however, take this same signal and, using frame storage and screen replenishment, display the picture (now HDTV) on the screen at a higher, flicker-free rate. The same technique can, of course, be used for 60Hz HDTV.

Any production standard of either 50Hz or 60Hz must be transcoded to the other field rate before transmission if the material is to be receivable on existing TV sets. This

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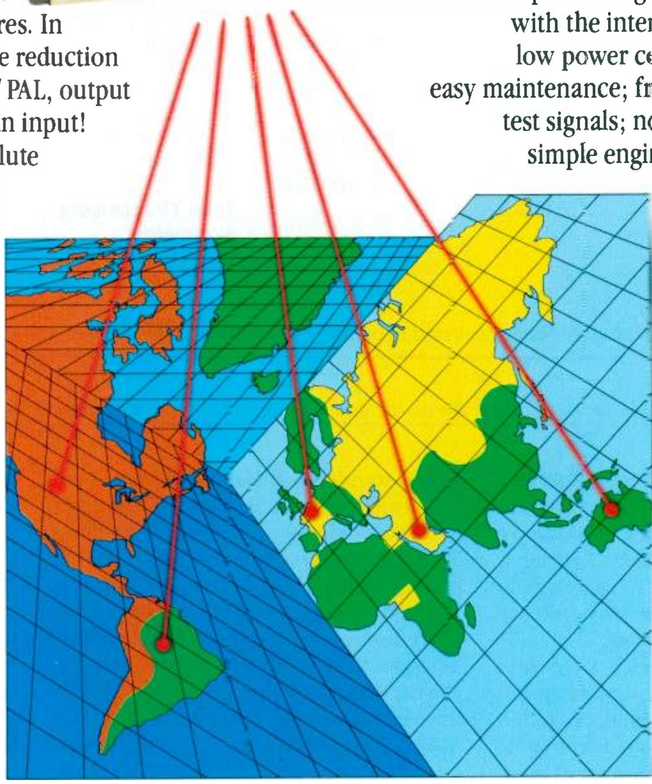

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| NUMBERS OF RECEIVERS | | | | | |
|---|---|---|---|---|---|
| **COUNTRY** | **50Hz** | **60Hz** | **COUNTRY** | **50Hz** | **60Hz** |
| **North America** | | | **Australia** | 6,800,000 | |
| United States | | 163,000,000 | **New Zealand** | 1,100,000 | |
| Canada | | 17,000,000 | | | |
| Mexico | | 9,000,000 | **Africa** | | |
| | | | Algeria | 1,600,000 | |
| **Central America** | | 1,500,000 | Egypt | 2,300,000 | |
| | | | Morocco | 1,200,000 | |
| **Caribbean** | | | South Africa | 2,500,000 | |
| Cuba | | 1,700,000 | | | |
| Others | | 1,500,000 | **Europe (west)** | | |
| | | | Austria | 3,500,000 | |
| **South America** | | | Belgium | 3,000,000 | |
| Argentina | 6,800,000 | | Denmark | 2,200,000 | |
| Brazil | | 35,000,000 | Finland | 2,000,000 | |
| Chile | | 3,000,000 | France | 20,000,000 | |
| Colombia | | 2,100,000 | Germany (West) | 25,500,000 | |
| Peru | | 1,500,000 | Greece | 2,000,000 | |
| Venezuela | | 3,300,000 | Ireland | 1,000,000 | |
| Others | | 1,900,000 | Italy | 16,000,000 | |
| | | | Netherlands | 5,100,000 | |
| **Asia** | | | Norway | 1,500,000 | |
| China | 11,000,000 | | Portugal | 1,700,000 | |
| (People's Rep.) | | | Spain | 11,400,000 | |
| China | | 7,000,000 | Sweden | 3,700,000 | |
| (Rep. of) | | | Switzerland | 2,400,000 | |
| Hong Kong | 1,500,000 | | United Kingdom | 21,500,000 | |
| India | 2,500,000 | | | | |
| Indonesia | 5,500,000 | | **Europe (East)** | | |
| Iran | 2,400,000 | | Bulgaria | 2,300,000 | |
| Saudi Arabia | 4,200,000 | | Czechoslovakia | 5,000,000 | |
| Turkey | 5,700,000 | | Germany (East) | 6,800,000 | |
| Japan | | 35,000,000 | Hungary | 3,300,000 | |
| Korea (South) | | 9,000,000 | Poland | 10,000,000 | |
| Malaysia | 1,700,000 | | Rumania | 4,500,000 | |
| Pakistan | 1,300,000 | | U.S.S.R. | 98,000,000 | |
| Philippines | | 3,000,000 | Yugoslavia | 4,500,000 | |
| Thailand | 3,500,000 | | Others | 400,000 | |
| Vietnam | | 2,600,000 | | | |
| Others | 5,700,000 | | **Total *TV* receivers** | | |
| | | | **worldwide:** | at 50Hz: | 324,600,000 |
| | | | | at 60Hz: | 297,100,000 |
| | | | | | 621,700,000 |

(The only countries listed separately are those having at least 1,000,000 receivers.)

***Table 1.*** *The field rates in use in various parts of the world, and the number of receivers estimated to exist in those locations.*

problem will exist no matter what field rate may be chosen, because of the large number of receivers now in use, all of which are either 50Hz or 60Hz. Standards conversion is available, of course, but at a sacrifice in picture quality, which is worse in picture areas having the most motion.

Problems associated with field rate include not only the intrinsic flicker, but also a "beat" with studio lighting of a different frequency, especially when gas-discharge rather than incandescent lighting is used.

The areas of general agreement on HDTV standards in Europe include a picture aspect ratio of 16:9 (today's standard is 4:3 everywhere), with some reservations. There also is agreement on Y–U–V (component rather than composite) transmission using one of the MAC packets when a 50Hz field rate is used. However, there is no agreement on which MAC packet, although the participants in the "Group of 29" Berlin meeting seem to have agreed on the D2-MAC packet parameters. Some people want interlace, some don't. The Japanese MUSE scheme (a MAC technique that uses heavy bandwidth compression) is a 60Hz system and, therefore, is incompatible with the 50Hz family of MAC packets.

### Standards conversion

HDTV standards conversion work is proceeding actively in both the 50Hz and 60Hz camps. Most efforts are concentrating on the problem of converting pictures with motion, because pictures with little or no motion already can be easily converted with negligible degradation. The Japanese are determined to show that standards conversion is no limitation to the adoption of a 60Hz rate, and they have demonstrated

high performance in both 60/50Hz conversion and 60Hz/24-frame film conversion. The British are working on the problem with equal zeal, just in case, and also have put on some impressive demonstrations. In both cases, selective motion-adaptive algorithms are implemented to smooth the jerkiness visible today in converting rapid motion.

Everyone in Europe is thinking of DBS and MAC, with a simple converter to transform MAC into PAL (Western Europe) or SECAM (Eastern bloc and France) for viewing on existing receivers, but still of course with no change in field rate, which is built into the receivers. MAC, devised primarily for 50Hz satellite broadcasting, doesn't necessarily imply HDTV, but it can, so there may be a degree of compatibility.

A number of new terrestrial (conventional) transmitters are being built in Europe, but they will use present-day transmission formats only, although some thought has been given to terrestrial HDTV. This would require adding extra broadcast spectrum space to accommodate the wideband Japanese MUSE, or other schemes that also need extra channel space to piggyback a separate HDTV component.

### Programming

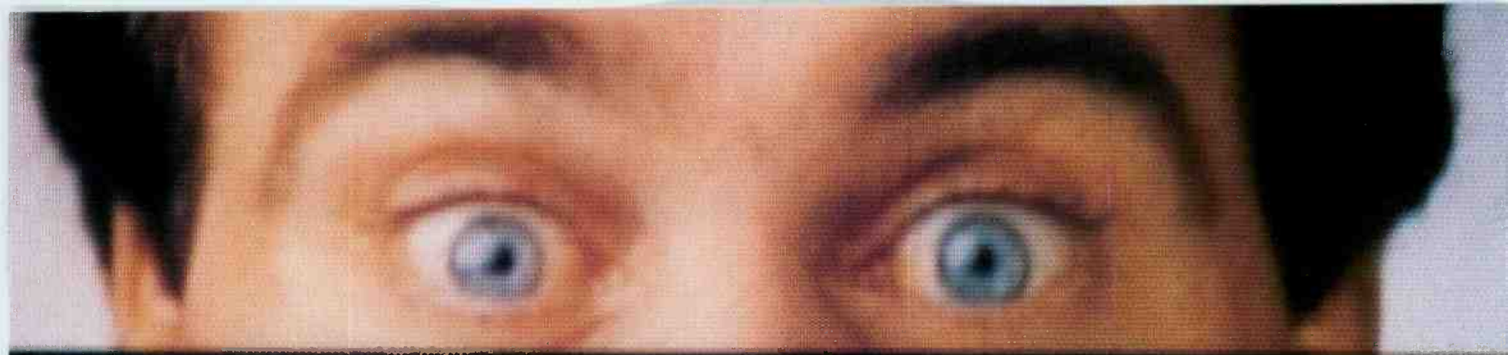
It may be the programs themselves that play a dominant role in the ultimate acceptance of a common production standard. The vast bulk of mass-appeal programs already available, or being produced now, come from the United States. These are either on film at 24fps or on tape at 30fps.

A large quantity of film, as well as 50Hz tape, also is available from other countries. This makes it seem likely that much of the early programming shown on HDTV will be wide-screen movies. It is hoped that these movies will use or be copied from 35mm or 70mm (not 16mm) release prints. Unless these happen to have been made in 25- or 30-frame versions, which is highly unlikely, they'll have to go through standards conversion from one to the other field rate anyway.

Original material in true HDTV will be produced first by the countries in which HDTV is likely to first catch on, probably Japan and the United States. The great bulk of this material will probably be produced in 60Hz.

Another type of programming that will weigh heavily in the development and public acceptance of HDTV is sports, even more popular in Europe than the United States. Sports presentation is an area in which a wide screen has a lot of appeal. Soccer, to take one example, is popular worldwide and crosses TV standards lines. Also, sports fans are a breed apart, the sort who would spend money for the larger, wider screen and increased detail of HDTV.

Among the aims and claims for HDTV has been the use of video techniques directly for movie production, bypassing the use of film in part or completely. Production and editing are said to be enhanced, in addition to the economic con-



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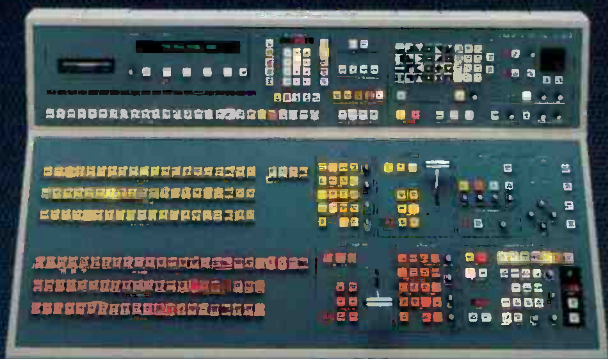

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siderations. As a matter of fact, one of the stated goals of HDTV is the achievement of quality comparable to that of 35mm film production.

However, estimates of the requirements for this level of quality, even taking into account the reduced highlight brightness of the movie screen (and, therefore, less apparent flicker), lead to the use of something like 80fps progressive (non-interlaced) scanning and 2,000 lines of resolution. These values undoubtedly would produce high-quality pictures, but when they are considered for TV transmission, the bandwidth requirements become formidable, even for satellite or cable TV distribution.

Furthermore, there is good question as to whether the typical home viewer could make full use of this much detail. (Town's Law, which states that there is a limit to improving the quality of an already nearly perfect picture, takes over somewhere short of this degree of quality.) So if a movie is shot in HDTV to compete with 35mm film quality, it has to be cut down one way or another to be used on home TV sets. This brings us back to production and transmission standards at 50Hz and 60Hz.

### Political considerations

The commercial implications of HDTV are inextricably intertwined with the technology. Even more in Europe than elsewhere, commercial considerations dominate the thinking. The 60Hz HDTV system is basically a Japanese system. The United States came in late and jumped on the Japanese coattails, aided greatly by the fact that the TV standards are identical in the two countries (CCIR System "M"). But the Europeans don't want to have to buy any Japanese or U.S. equipment, don't want to pay any Japanese or U.S. royalties and don't want to swallow their NIH (not invented here) pride.

But if the Europeans don't go along with a 60Hz production standard, then they've got to adapt in some way to the use of a 60Hz HDTV standard by all present-day 60Hz countries. Japan and the United States aren't going to use an HDTV rate other than 60Hz. There's no reason to do so. If they do, they will lose any initial audience that would be provided by existing receivers watching (in non-HDTV) the first HDTV transmissions.

If high definition is to succeed, it must give the audience something other than increased resolution and a wide-screen picture. If the only thing HDTV is going to deliver is the same old stuff, except with twice the vertical and horizontal resolution, it isn't going to fly.

An official from the BBC wondered during a technical session in 1986 at Brighton why FM radio hadn't caught on in Britain, notwithstanding the manifestly improved audio quality. This observer was tempted to get up and tell him that we had the same problem in the United States until somebody had a bright idea: Put something on that people wanted to hear. The same principle applies to HDTV.

What the European viewers mainly want is more program choice in their own language. This may come through "private TV," which means different things to different people. "Private TV" will be all-satellite in West Germany and all-terrestrial in Spain; it is here now in Britain, France and Italy, and poised in Germany, Luxembourg and Scandinavia. And the differences extend far beyond the mere technical means of delivery.

But in every European country, "private TV" is encumbered by the bureaucratic mindset and the hand of government itself, with social, economic and political restrictions overlaid almost everywhere.

Politicians want favored treatment. Commercial restrictions range from essentially none to "no advertising at all." Commercial broadcasters near common-language borders resent the competition from "across the border." Broadcasting is a "public service" (which is no better defined in any European country than in the United States) that private broadcasters have an obligation to provide. "Entertainment" must not shoulder "culture" out of the way.

And this is the backdrop for HDTV in Europe, with plenty of clear implications for the United States. The main difference is that HDTV will cost a lot of public money in Europe, but mostly private money in the United States.

HDTV is an expensive exercise, and we don't know if it is what people want. But, one way or another, it will come to Europe. You can bet on it.

[BE]

## It can't happen here. Right?

The possibility of the European broadcasting community moving to a field rate other than 50Hz, and thereby rendering obsolete the installed base of TV receivers, is remote, but not without precedence. Britain did it some years ago, scuttling the original 405-line standard that got England off to the first regular TV broadcasts in 1936, in favor of today's 625 lines. The BBC simply shut off 405-line broadcasts after a period of transmitting both signals. If you wanted to see a TV picture, you went out and bought yourself a new telly.

Ordinarily, a reasonable person would think that the only real choices are 50Hz and 60Hz. But if you think that "it can't happen here," that no government body could be so stupid as to adopt a non-compatible field rate that would render obsolete a quarter of a billion existing receivers, then you're too young to remember the adoption of the first commercial color-TV standard in the United States. It used a 24Hz frame rate, and the color was field-sequential. The pictures were beautiful, they just couldn't be seen on existing receivers. Even on their own receivers, they flickered.

The FCC action in adopting incompatible color-TV standards raised an outcry that went all the way to the U.S. Supreme Court. The Supreme Court upheld the commission's choice by the slimmest of margins, with Justice William O. Douglas voting, *dubitante*, to let the commission's folly stand. What Douglas' vote said was, in effect, "The court shouldn't meddle in an agency's administrative decisions, but this one is so stupid that I'm tempted."

The U.S. public was saved by three occurrences. First, the viewers' own good sense kept them from buying many incompatible color receivers. Second, war had broken out in Korea, and copper shortages forced TV production cutbacks. And, finally, a mammoth campaign led to the formation of NTSC II, the second (color) National Television System Committee. NTSC II was spearheaded by RCA and supported by brilliant minds such as Barney Loughlin of Hazeltine, who, among his many other accomplishments, conceived and implemented the *constant luminance* principle, in which the color subcarrier vanishes for areas of zero chrominance.

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# Time synchronization for broadcasters

**Edited by Brad Dick, radio technical editor**

**There is more to accurate time code than the familiar WWV tick tock.**

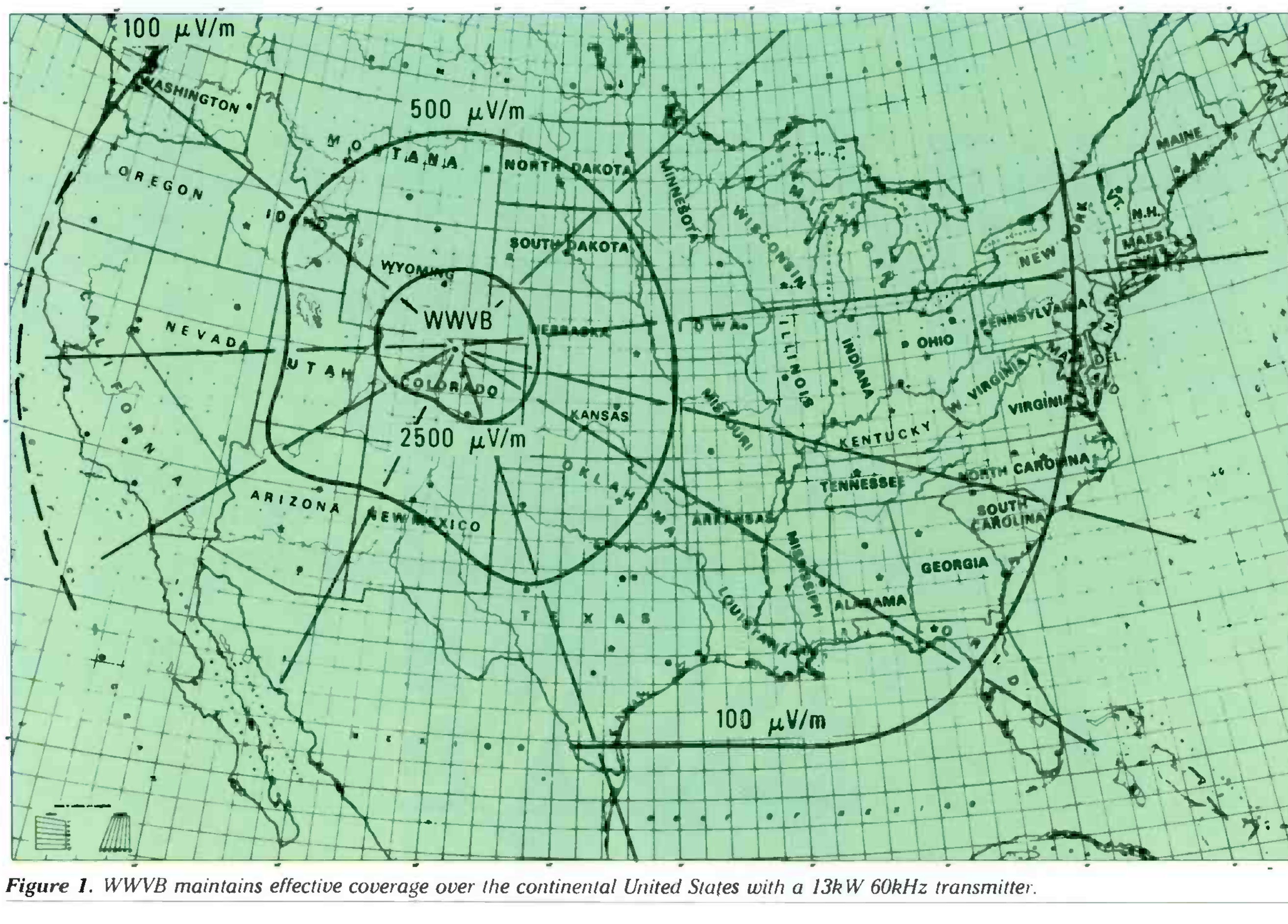
A broadcaster's greatest concern is staying on the air. The second is staying on time. In broadcasting, it is either time for a commercial or time for a program. Time is a precious commodity for which there is no replacement. If a 60-second commercial is lost, the time slot it was supposed to occupy also is lost. That minute cannot be recovered. For broadcasters, the need to maintain an accurate time reference is paramount.

**National Bureau of Standards**

The major source for correct time within the United States is the National Bureau of Standards (NBS). The NBS is responsible for generating, maintaining and distributing the standards of time and frequency. The most familiar source for accurate time and frequency information is station WWV, which is operated by the NBS.

WWV first began broadcasting time and frequency information in March 1923, from Washington, DC. Although the early experiment with providing time information was successful, expansion was slow to come. Over the past 65 years, however, the NBS has seen significant growth as shown in Table 1.

During this time period, the sophistication level required by the time and frequency division of NBS also has increased. Today, this group provides time




Figures courtesy of National Bureau of Standards

***Figure 1.*** *WWVB maintains effective coverage over the continental United States with a 13kW 60kHz transmitter.*

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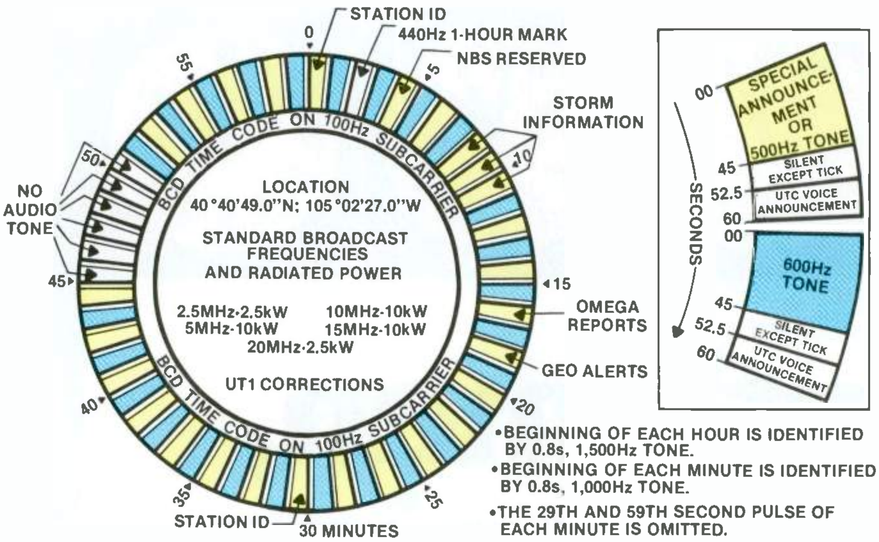


***Figure 2.*** *The broadcast format of WWV.*

and frequency information available on broadcast frequencies from 60kHz to 468MHz, with accuracies in the parts per billions.

## Broadcast stations

Today, precision time and frequency information is broadcast by the NBS on LF, MF, HF and UHF frequencies. In addition to the familiar WWV, NBS stations WWVH and WWVB and the GOES satellite system also provide time- and frequency-related information. The most familiar products are the voice and BCD time-code transmissions.

Stations WWV and WWVB are located in Fort Collins, CO. WWVH is located in Kauai, HI. The station's operating frequencies and power levels are summarized in Table 2. Because of changes in ionospheric conditions, all frequencies are not always available at any given location. Therefore, each frequency carries the same program.

WWVH broadcasts on 5MHz, 10MHz and 15MHz with phased, vertical ½-wave dipole arrays, producing a cardioid pattern in a westerly direction. The 2.5MHz antenna for WWVH and all antennas for WWV are ½-wave dipoles with an omnidirectional pattern.

Station WWVB operates at 60kHz and transmits a standard frequency and standard time signals, time intervals and UT1 corrections in BCD time code. Because of its low frequency, voice announcements are not possible. The station operates with a power of 13kW and a 122m top-loaded vertical antenna. The station's measured field intensity across the United States is shown in Figure 1. The combination of power and low-frequency operation means that reliable reception generally is possible within 1,800 miles of the station.

The WWVB station ID is transmitted by advancing its carrier phase 45° at 10 minutes after the hour and returning to normal operation at 15 minutes after the hour. The sound of the transmitted BCD time code helps make the station easily recognizable.

All NBS stations operate according to highly accurate standards. The frequencies transmitted are accurate to within one part per 100 billion at all times. Deviations normally are limited to less than one part per 1,000 billion. The day-to-day frequency deviation of WWVB is typically within five parts in 1,000 billion. However, because of changes in MF and HF propagation media, causing Doppler effect or diurnal shifts, the resulting fluctuations in the received carrier frequency of WWV and WWVH may be much greater. The propagation effects on transmissions from WWVB are relatively minor. Therefore, frequency comparisons with this signal to better than one part in 100 billion are possible.

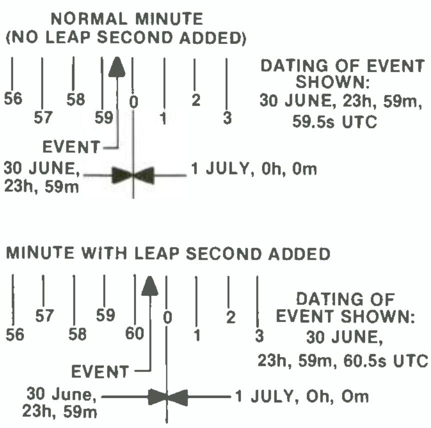


***Figure 3.*** *Dating of the events in the vicinity of a leap second.*

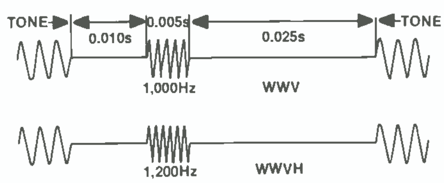


***Figure 4.*** *WWV and WWVH seconds pulse format.*

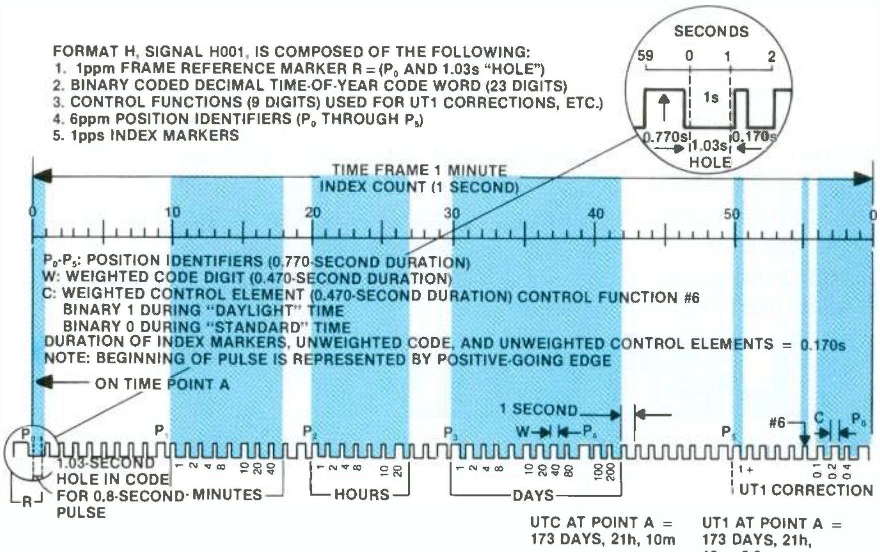


***Figure 5.*** *The WWV/WWVH time-code format is carried on a 100Hz subcarrier.*

## Broadcast services

Broadcast services provided by WWV and WWVH include:

- Time announcements
- Standard time intervals
- Standard frequencies
- Geophysical alerts
- Marine storm warnings
- Omega Navigation System

status reports
- UT1 time corrections
- BCD time code

The program clock in Figure 2 shows the various WWV services and when they occur within the clock hour. The services provided by WWVH are generally the same, but similar products may occur at different places within the clock hour.

### Voice announcements

Voice announcements are made from WWV and WWVH once each minute. To avoid confusion, a man's voice is used on WWV, and a woman's voice is used on WWVH. For you trivia fans, the man voicing the WWV announcements is Don Elliott, and the woman's voice on WWVH is that of Jane Barbe, both of whom are from Atlanta.

The WWV time announcement occurs 7.5s before the minute. The WWVH time announcement occurs 15s before the minute. Although the announcements occur at different times, the tone markers are transmitted simultaneously by both stations. Because of propagation effects, the tones may not be received at the same time.

### Time scales

The time announcements are made in coordinated universal time (UTC). This format is coordinated through international agreements by the Bureau International De L'Heure (international time bureau, BIH) so that time signals broadcast from the many stations around the world, such as WWV, will be in close agreement.

The specific hour and minute mentioned is actually the time near Greenwich, England. This time is considered generally equivalent to the more well-known Greenwich mean time (GMT). UTC time differs from your local time zone only by an integral number of hours.

The UTC time scale was developed as a compromise time scale internationally in an attempt to satisfy the needs for both astronomical time based on the rotation of the earth and for the more stable atomic time based on the definition of the second in terms of the cesium atom's resonance frequency. Basically, the compromise was to keep the *rate* of the compromise UTC scale at some constant value with respect to the cesium reference frequency and then to introduce occasional time or frequency (prior to 1972) steps into UTC to keep its time within some specified tolerance with respect to the earth-based astronomical time scales, UT1 or UT2. As UTC has evolved over the years, the magnitude of the allowable time and frequency steps has been changed from time to time by international agreement.

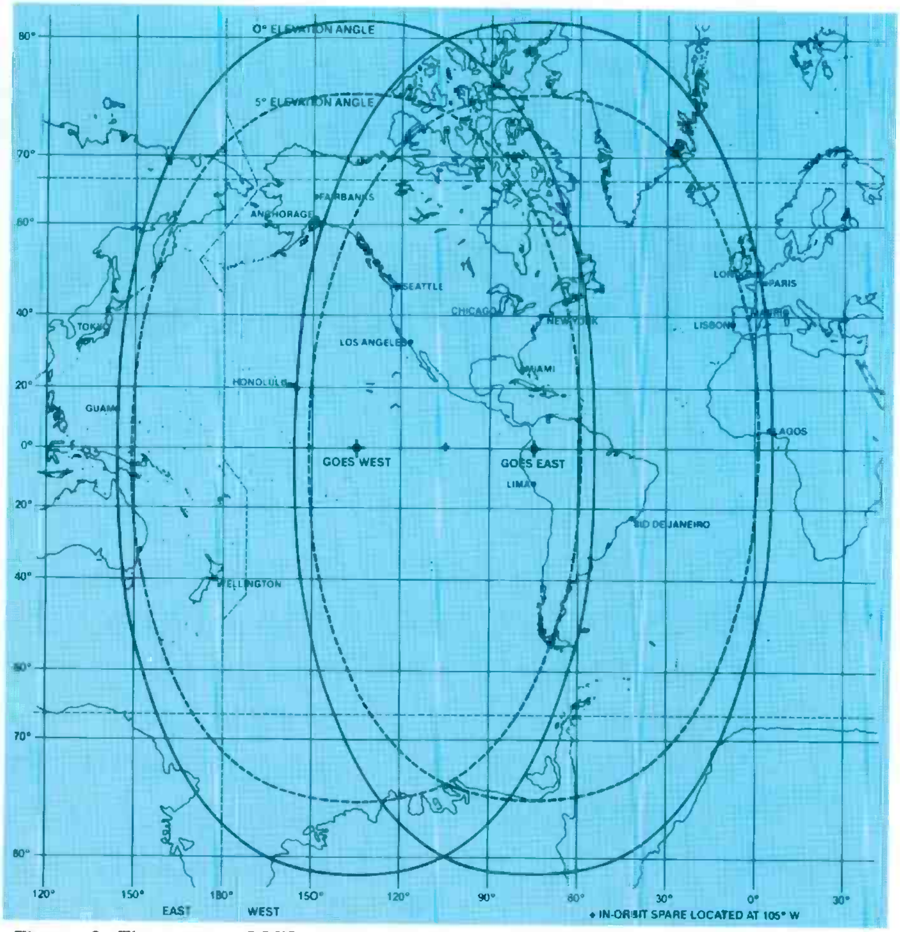


*Figure 6. The western GOES satellite operates on 468.8250MHz, and the eastern satellite operates on 468.8375MHz. The footprint of each satellite is shown here.*

Before 1972, most standard-frequency radio broadcasts were based on a version of UTC. The rate of the UTC clock was controlled by atomic oscillators so it would be as uniform as possible, but it was offset in value so that the time markers would approximate UT2. The atomic oscillators were adjusted at the beginning of each year in an attempt to match the forthcoming earth rotations rate, UT2. This annual change was set by the BIH.

For instance, between 1965 and 1966, the relative frequency of standards stations such as WWV was lowered by a small amount, $-150 \times 10^{-10}$Hz. This meant that all of the WWV frequencies were lower by this amount than their nominal values for the entire year.

Unfortunately, because the earth's rotational velocity could not be predicted accurately, UTC slowly got out of step with earth time. This created a problem for navigators, who require solar time, UT0. They needed to supply a correction to UTC, but it was difficult to know the amount of correction required.

### Leap second

The solution, adopted in 1972, was to return to the nominal values of the frequency standards as determined by the definition of the second in terms of cesium and to eliminate the annual changes in rate. However, without a correction, the clocks gradually would get out of step with the day. Similar to leap year, in which a day is added to the calendar, the leap second was developed.

Leap seconds are added to or subtracted from the UTC clock as needed. A particular minute can contain 61 or 59 seconds, instead of the conventional 60 seconds, resulting from incorporating either a positive or negative leap second. Figure 3 shows how a leap second is added to UTC.

By international agreement, UTC is maintained within 9/10 of a second of the navigator's time scale, UT1. Because the earth's rotation is not uniform, the exact point at which a leap second is needed cannot be predicted. By convention, leap seconds usually occur on June 30 or Dec. 31.

As a concession to the navigators, a simple audible code is now included in broadcasts such as WWV that provides the current time difference between UT1

*Continued on page 114*

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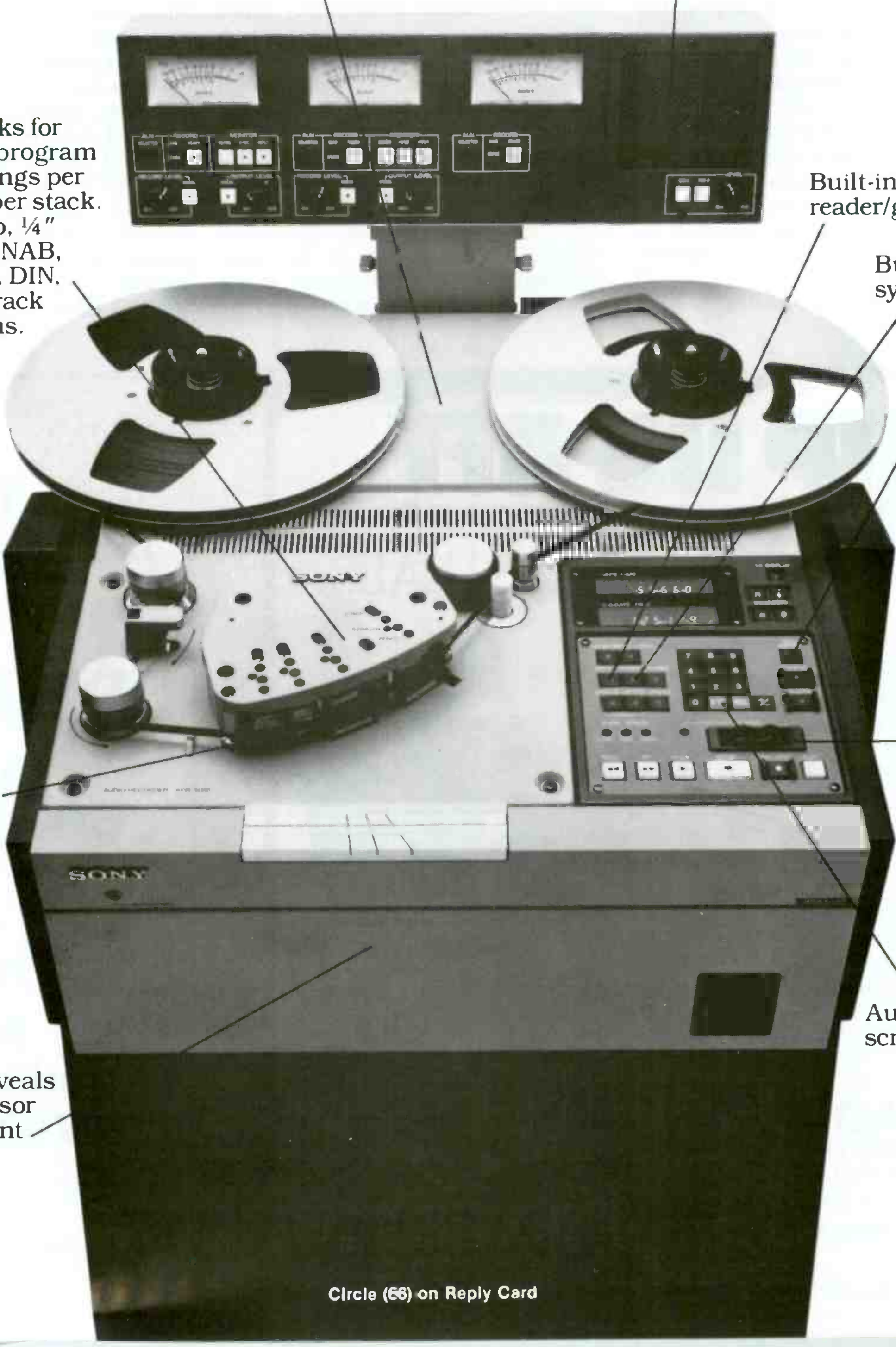


*Continued from page 111*
and UTC in tenths of one second.

### Time pulses

The most frequent sounds heard on WWV and WWVH are the pulses marking the seconds of each minute. The first pulse of every hour is an 800ms pulse of 1.5kHz. The first pulse of every minute is an 800ms pulse of 1kHz on WWV and 1.2kHz on WWVH. Figure 4 illustrates the seconds pulse format for both stations. The 29th and 59th seconds' pulses are omitted. The remaining seconds' pulses are brief audio bursts resembling the ticking of a clock.

Each second's pulse is preceded by 10ms of silence and followed by 25ms of silence to avoid interference. Without this spacing, it might be difficult for receiving equipment to detect the pulses.

In alternate minutes during most of each hour, 500Hz or 600Hz audio tones are broadcast. A 440Hz tone, the musical note A above middle C, is broadcast once each hour. In addition to being a musical standard, the 440Hz tone often is used to provide an hourly marker for chart recorders or other automated devices. Refer to Figure 2.

WWV and WWVH transmit other types of information, including geophysical alerts of solar activity, geomagnetic information, solar information and marine storm warnings. Other conditions broadcast include: solar flares, polar cap absorption and reports of stratospheric warmings in the high-latitude regions of the winter hemisphere.

### BCD time code

For many broadcast applications, the BCD time code is the most valuable product. The BCD time code is transmitted continuously on a 100Hz subcarrier for both WWV and WWVH. The subcarrier is synchronous with the time-code pulses so that 10ms resolution is attained. The time code provides a standard timing base for scientific observations made simultaneously at different locations. A typical application might involve the satellite transmission of data, in which the data and time code are recorded simultaneously.

The time-code format presents UTC information in serial fashion at the rate of one pulse per second. Groups of pulses can be decoded to ascertain the current minute, hour and day of the year. Although the 100Hz subcarrier is not considered one of the standard audio frequencies, the code does contain the 100Hz frequency, which may be used as a standard with the same accuracy as the audio frequencies.

The BCD time code is a modified version of the IRIG-H (Inter Range Instrumentation Group) format. The binary-to-decimal weighting scheme is 1-2-4-8, with the least significant binary digit always transmitted first. Table 3 summarizes the binary coding and decimal equivalents for the transmission scheme.

In the WWV/WWVH format, all tones are suppressed during the seconds pulse transmission. This means that the 100Hz subcarrier frequency also is suppressed, which has the effect of deleting the first 30ms portion of each binary pulse in the time code.

Thus, compared to IRIG-H, a binary 0 contains only 17 (rather than 20) cycles of 100Hz, equaling 170ms duration. A binary 1 contains 47 (rather than 50) cycles of 100Hz, equaling 460ms duration. The leading edge of every pulse coincides with a positive-going zero crossing of the 100Hz subcarrier, but it occurs 30ms after the beginning of the second. The time-code format for WWV/WWVH is shown in Figure 5.



Within a time frame of one minute, enough pulses are transmitted to convey in BCD language the current minute, hour and day of the year. Two BCD groups are needed to express the hour because the time is based on 24 hours per day. Three groups are needed to express the day of the year (001 through 366). The seconds can be determined by counting pulses within the frame.

### Satellite time

NBS also provides accurate time and frequency information via two geostationary operational environmental satellites (GOES). The time code is referenced to the NBS time scale and provides UTC. Although the time code originally was designed as a means of dating environmental data collected by the GOES satellites, it also can be used as a general-purpose time reference for many other applications. The time code is available to the entire Western Hemisphere from two satellites operating on a nearly full-time basis. The satellites' footprints are shown in Figure 6. The basic satellite transmission specifications are shown in Table 4.

The time code is contained within the interrogation channel and is used to communicate with the remote sensors. The interrogation messages and time code are prepared and sent to the GOES satellites from Wallops Island, VA. To generate the time code, the NBS maintains atomic clocks at this site.

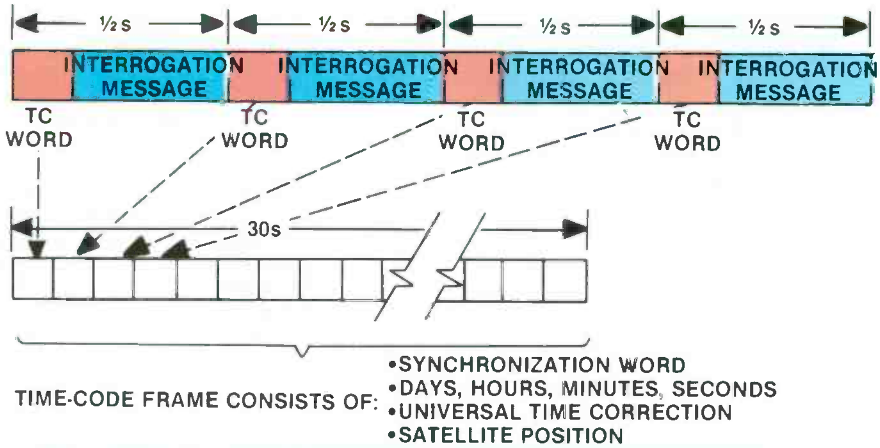



*Figure 7. A complete interrogation message consists of four bits of BCD time code, a maximum length sequence of 15 bits for synchronization and a 31-bit remote data sensor address.*

### Message format

The interrogation message format is shown in Figure 7. Each interrogation message is one-half second in length, consisting of 50 bits. A data rate of 100b/s is used for transmission. A complete interrogation message consists of four bits of BCD time code followed by a maximum length sequence of 15 bits for message synchronization. The message ends with a 31-bit address for a particular remote weather data sensor. This process takes one-half second. Therefore, 60 interrogation messages are required to send the 60 BCD time-code words con-



stituting a complete time-code frame.

The complete time-code frame is transmitted every 30 seconds, beginning on the half-minute. The time code, shown in Figure 8, begins with a 40-bit sync word. The frame provides the following: the year (two digits), day of year; hour; minute; second; UT1 correction; and the satellite's position in latitude, longitude and height above the earth's surface. The position information is updated every four minutes.

In addition, there are indicators in the code for upcoming leap seconds and daylight-saving time changes, current time-code accuracy information and system status data.

The path delay from the uplink in Wallops Island to the satellite and back to earth is approximately 260,000$\mu$s. Because of this delay, all time signals transmitted to the satellite are advanced by this amount. In the uncorrected mode, therefore, the signals arrive at the earth's surface nearly on time (within 16ms). If the mean path delay is accounted for in the timing process, the accuracy increases to $\pm 1$ to 2ms. In the fully corrected mode, both the mean path delay and the earth's cyclic delay variation are taken into account. This mode results in an accuracy of $\pm 100\mu$s.

Because the GOES time code is tranmitted outside the spectrum reserved exclusively for time and frequency broadcasts, it cannot be considered an NBS service in the same sense that the radio broadcast methods are services. The land mobile services and the GOES interrogation channels use the same frequency allocations (468.8250MHz and 468.8375MHz). The result is that the time code may suffer interference from land mobile transmission. This is particularly true in urban areas where there is a high density of land mobile traffic and for the GOES/west signal, which exactly coincides with one of the land mobile channels.

| | |
|---|---|
| **March 1923** | First scheduled broadcasts of WWV, Washington, DC |
| **April 1933** | WWV gets first 20kW transmitter, Beltsville, MD |
| **January 1943** | WWV relocates to Greenbelt, MD |
| **November 1948** | WWVH commences broadcasts, Maui, HI |
| **January 1950** | WWV adds voice announcements |
| **July 1956** | WWVB (KK2XEI) begins 60kHz broadcasts, Boulder, CO |
| **April 1960** | WWVL begins 20kHz experimental broadcasts, Sunset, CO |
| **July 1963** | WWVB begins high-power broadcasts, Ft. Collins, CO |
| **August 1963** | WWVL begins high-power broadcasts, Ft. Collins, CO |
| **July 1964** | WWVH adds voice announcements |
| **December 1966** | WWV relocates to Ft. Collins, CO |
| **July 1971** | WWVH relocates to Kauai, HI |

***Table 1.*** *History of the NBS time and frequency dissemination services.*

| FREQ., MHz | RADIATED POWER, kW | |
|---|---|---|
| | WWV | WWVH |
| 2.5 | 2.5 | 5.0 |
| 5.0 | 10.0 | 10.0 |
| 10.0 | 10.0 | 10.0 |
| 15.0 | 10.0 | 10.0 |
| 20.0 | 2.5 | – |

***Table 2.*** *Operating frequency and powers of stations WWV and WWVH.*

| | |
|---|---|
| **June 1972** | First "leap second" in history added to UTC time scale |
| **July 1972** | WWVL transmissions curtailed |
| **January 1974** | Voice announcements changed from Greenwich Mean Time to Coordinated Universal Time (WWV and WWVH) |
| **March 1975** | Frequency calibration using network color TV becomes a nationwide service |
| **August 1975** | Line-10 time comparisons using TV synchronization pulses become a nationwide service |
| **February 1977** | 20MHz and 25MHz broadcasts from WWV and 20MHz broadcasts from WWVH discontinued |
| **May 1977** | GOES satellite time code officially initiated |
| **December 1978** | 20MHz broadcasts from WWV reinstated |

| | BINARY GROUP | | | | DECIMAL EQUIVALENT |
|---|---|---|---|---|---|
| WEIGHT: | 1 | 2 | 4 | 8 | |
| | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 2 |
| | 1 | 1 | 0 | 0 | 3 |
| | 0 | 0 | 1 | 0 | 4 |
| | 1 | 0 | 1 | 0 | 5 |
| | 0 | 1 | 1 | 0 | 6 |
| | 1 | 1 | 1 | 0 | 7 |
| | 0 | 0 | 0 | 1 | 8 |
| | 1 | 0 | 0 | 1 | 9 |

***Table 3.*** *The WWV/WWVH BCD time code uses the 1-2-4-8 weighting scheme shown here.*

### Atomic clocks

The frequencies, tones and time of day for many NBS services are based on cesium beam frequency sources—atomic clocks. The frequencies of commercial versions of these oscillators are controlled to be within one part in 1,000 billion with respect to the NBS primary frequency standard. The primary standard, a specially designed laboratory cesium beam device, is 100 times more stable.

Atomic oscillators are based on resonances in atoms, which occur at microwave frequencies, generally in the range of 1GHz to 100GHz. The first step in constructing an atomic clock is separating the atoms according to what is called *upper* or *lower state*.

Atoms change from the upper to the lower energy state upon emission of a well-defined amount of energy. Correspondingly, an atom changes from the lower to the upper state upon absorbing an equal amount of energy at the atom's resonant frequency. Separation of these atoms is called *state selection*.

### State selection

In spatial state selection, shown in Figure 9, the atoms produced by heating a metal are passed through a vacuum chamber into a strong magnetic field. The field causes the atoms to separate into two beams, one containing the upper-state atoms and one containing the lower-state atoms.

After the atoms have been separated in the first magnetic field, it is possible to arrange the machine's geometry so that only the upper-state atoms are selected to proceed into the microwave cavity region. Other atoms are effectively removed from the beam.

Once the atoms have been state selected, atomic resonance must be detected. Typically, the state-selected atomic beam is passed through a microwave cavity. When the cavity is excited at the proper microwave frequency, many of the

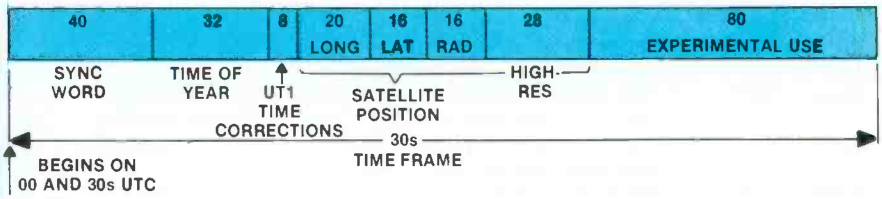



*Figure 8. A time-code frame contains a synchronization word, time-of-year word, UT1 correction and the satellite's position.*

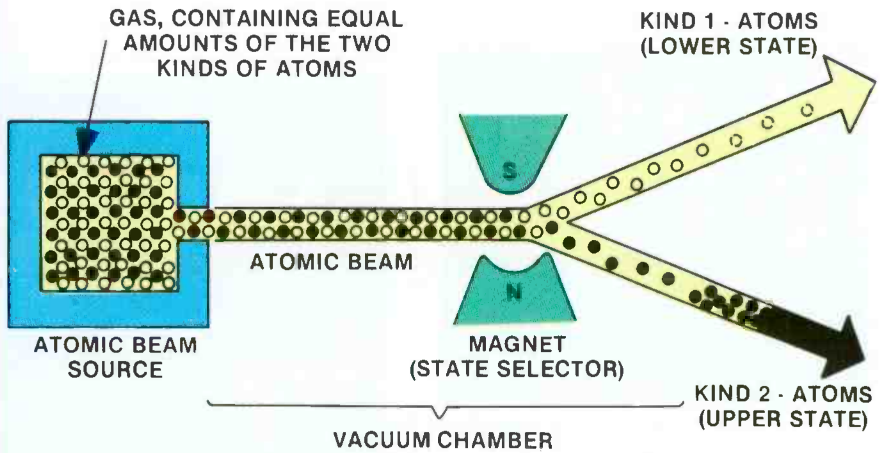



*Figure 9. Spatial state selection sorts the atomic beam source gas atoms from those in the upper state and those in the lower state.*

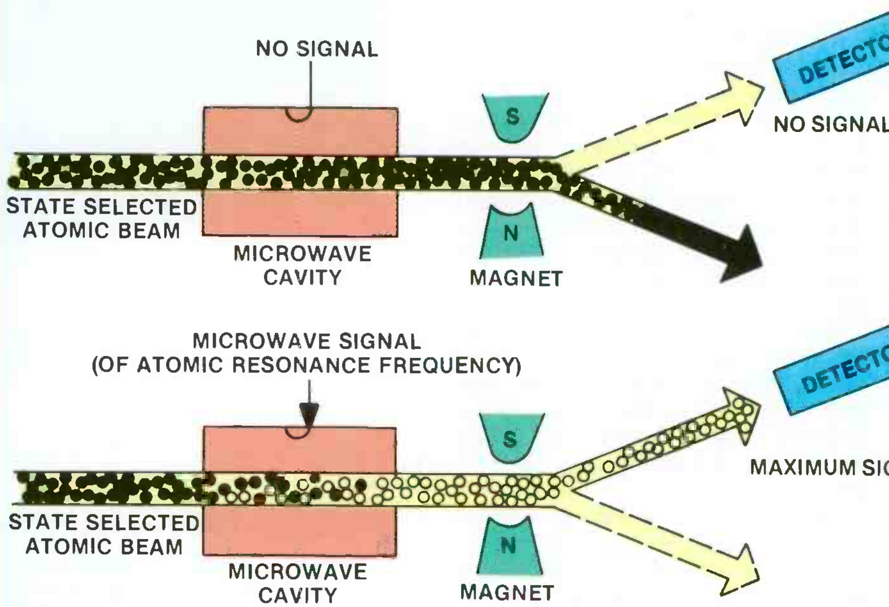



*Figure 10. In atom detection, the atoms leaving the microwave cavity pass through a magnet where they are sorted into two states. An atom detector is used to indicate the number of atoms in the upper (or lower) state.*

upper-state atoms are caused to change to the lower state. The key is to adjust the microwave frequency until the number of atoms in the lower state reaches maximum. This corresponds to the center of the atomic resonance. Some method is needed to detect this resonance condition.

### Detection

Three methods typically are used to detect the RF-produced changes in the atomic beam. One method, shown in Figure 10, is by atom detection. As the atoms leave the microwave cavity, they are passed through another magnetic field that again deflects them in two dif-

| | |
|---|---|
| FREQUENCY: | 468.8250MHz (Western GOES) 468.8375MHz (Eastern GOES) |
| POLARIZATION: | RIGHT-HAND CIRCULAR |
| MODULATION: | CPSK (±60°) |
| DATA RATE: | 100 BPS |
| SATELLITE LOCATION:* | 135° W (Western GOES) 75° W (Eastern GOES) |
| SIGNAL STRENGTH AT EARTH'S SURFACE (OUTPUT FROM ISOTROPIC ANTENNA): | −139 dBm |
| CODING: | MANCHESTER |
| BANDWIDTH: | 400Hz |

*Other satellite locations may be used occasionally when operations must be switched to in-orbit spare satellites.

***Table 4.*** *Basic receive specifications for the GOES satellites.*

ferent directions, depending on which energy state they are in. An atom detector is situated so that only the lower-state atoms follow the proper path to hit the detector. In effect, the detector simply "counts" the number of atoms that have changed from the upper to lower state in the microwave cavity.

Atomic resonance also can be optically detected, as shown in Figure 11. A photodetector is used to measure the relative amount of light passing through the atomic beam. When the light is applied, some of the atoms are removed from one of the states, which is registered on the photodetector. When the microwave energy is applied, some of the atoms resonate at the proper (light) frequency, which is detected. This technique is expected to be used in the next-generation NBS primary laboratory standard.

The third detection scheme involves a process familiar to many engineers. As the atoms are energized within the microwave cavity, some atoms add energy to the cavity, and if the atoms are initially in the lower state, they subtract energy. A detector connected to the cavity monitors this internal change in energy level.

### Basic clock

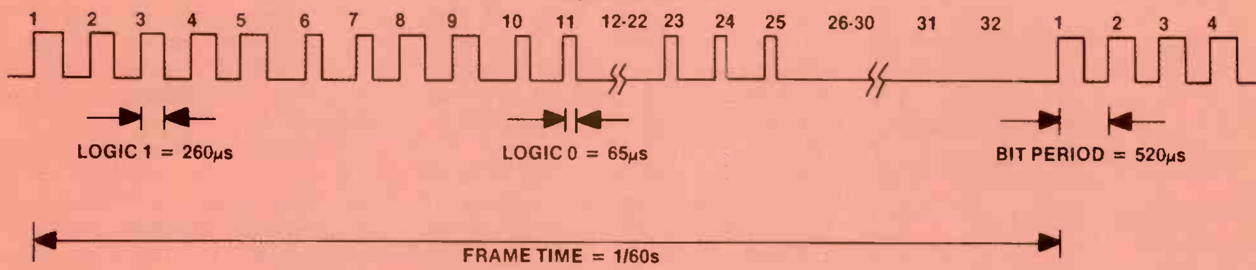
Atomic-based oscillators are not subject to drifting as are crystal-based oscillators. The atomic resonance frequency is defined by the atom itself. Although there are factors that can cause such oscillators to change frequency, atomic resonators with Q values of $10^8$ may have accuracies of one part in $10^8$ or higher.

One of the more common types of atomic frequency standards is based on cesium, which has an atomic resonance of 9,192,631,770Hz. Cesium frequency standards are used where high reproducibility and long-term stability are required. The clock's frequency stability may reach a few parts in $10^{14}$, with sampling times of one hour to several days. For most applications, cesium frequency standards do not even need to be calibrated.

A simplified block diagram of a cesium-beam clock is shown in Figure 12. This clock uses spatial state selection and atom-detection processes. An oven heats cesium metal to 100°C, producing cesium gas. The gas then flows to a vacuum chamber with an atmospheric

# Master clock systems

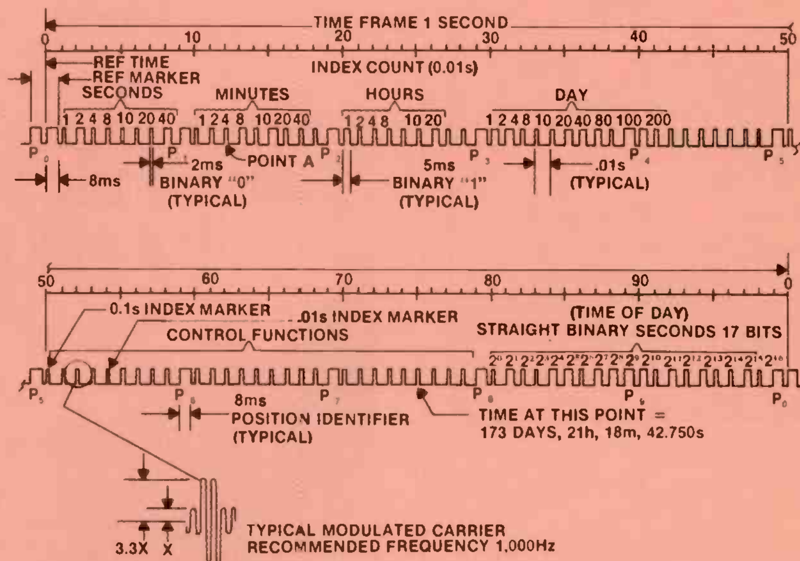
By Rick Dielman




*A typical 24-bit serial time code, which is repeated 60 frames per second.*

When you select a master clock system, keep in mind several important parameters. If your station already has a clock system, any new master clock must be capable of driving the current slaves (unless they also are to be replaced). Most master clocks provide optional circuits that drive the various types of remote displays, but check to be sure.

Typical remote displays include digital, impulse and synchronized-wire clocks. Because each display requires a different type of synchronization signal, several driver circuits may be needed. It also is important to be sure that any master clock system has sufficient battery backup power. Digital slaves often go blank when power fails, but will display the correct time again when power returns.




*IRIG B time code relies on a modulated carrier operating at 1kHz.*

### Displays

Some digital displays rely on serial time code for timing information. In this series of clocks, for example, a 24-bit serial time code is repeated at the rate of 60 frames per second. The clock receives primary power from an ac outlet, so it will blank out if power is lost. Once power is restored, however, it again will display the correct time. Other digital displays rely on IRIG-B, which is 1kHz serial time code.

Two types of analog clocks typically seen in broadcast stations are the synchronized-wire and the impulse type. The synchronized-wire type is driven by a synchronous motor from the 60Hz primary power line. This type of clock uses a supervisory signal to correct the clock to the proper time. Upon command from the master clock at approximately 38 minutes after the hour, the minute and second hands are corrected as needed. At 12-hour intervals, the hour hand is set as needed. The clock's hour, minute and second hands are reset by a small clutch assembly within the clock. If you have this type of display, be sure your master clock can provide the necessary reset pulse.

Impulse clocks typically operate on 12Vdc or 24Vdc and depend upon alternating polarity pulses from the master clock for power. Impulse clocks are connected in parallel. Therefore, if one clock gets out of time, it must be reset manually. However, once all clocks read the same time, the master clock can fast-advance the seconds and minutes hands to the correct time.

It also is important to account for the current demand from the clocks. As the number of clocks increases, so too does the amount of current needed from the master clock—and the battery backup system.

### Time source

Stations WWV and WWVH are sometimes thought of as good sources of time code for master clock systems. Unfortunately, the MF and HF signals from these stations are less reliable than the LF signal for WWVB. For this reason, broadcast applications typically rely on either WWVB or the GOES satellite system as a time source. For locations within 1,800 miles of Fort Collins, CO, the LF signal from WWVB is probably the best choice.

If your location cannot adequately receive WWVB, the second choice might be GOES. The two GOES satellites provide the same UTC time code as the National Bureau of Standards' other stations, and the signal is highly reliable. See the main story for additional information on the GOES system. One drawback to receiving time code from the satellite is the typically higher receiver and antenna cost.

### Set and forget

Using NBS signals for time code provides the broadcaster with many advantages. All clocks within the station display not only the same time, but also the correct time. The constant updating of the master clock by the NBS time source ensures that the correct time, usually to within milliseconds, is available throughout the station.

A second advantage of the NBS signals is the automatic updating for standard and daylight-savings time. No longer is it necessary for a member of the engineering staff to reset all the station clocks every spring and fall.

Master clocks may not have the glamour of fancy test instruments, but they are crucial to the effective operation of a station. The new generation of master clocks offers unprecedented accuracy, along with plug-in-and-forget-it convenience.

Dielman is sales manager for Kinemetrics/True Time, Santa Rosa, CA.

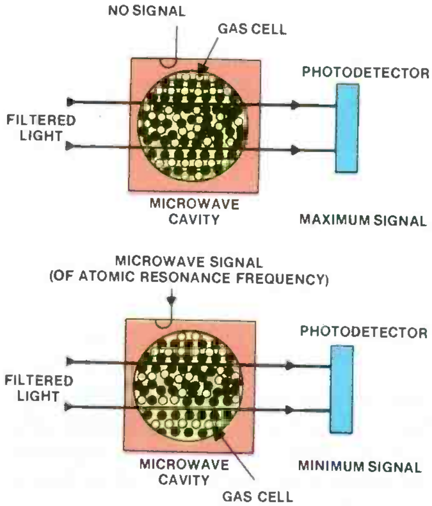



*Figure 11. A photodetector measures the change in light intensity as atoms change states. The change represents a measure of the number of atoms in one of the states.*

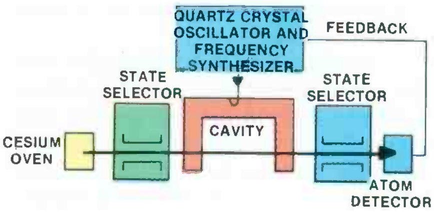



*Figure 12. Simplified block diagram of a cesium beam oscillator.*

pressure of less than $10^{-9}$. From the chamber, the gas flows through the state-selecting magnet and on to the microwave cavity where the RF signal is applied.

After passing through another state selector, the RF-excited atomic beam reaches the atom detector. In this clock, the detector is a tungsten wire heated to approximately 900°C by electrical current. Because the detector contains a small dc bias voltage, when the cesium atoms strike the wire they become charged or ionized. The resulting stream of electrically charged atoms produces a current, which is amplified, detected and used as a feedback signal for the microwave oscillator.

Receiving accurate time code is no longer difficult or terribly expensive. Reliable equipment is available from a number of sources, and installation is usually straightforward. Information on time-code equipment and clock systems is available in the "**Broadcast Engineering** 1988 Annual Spec Book/Buyer's Guide."

**Editor's note:** The material in this article was adapted from two NBS publications: Special Publication 432, "NBS Time and Frequency Dissemination Services" and Special Publication 559, "Time and Frequency Users' Manual." Copies of both manuals are available from the Time and Frequency Division, NBS, 325 Broadway, Boulder, CO 80303.

# News Special Report

## Europe enters the new era of DBS

By Howard Head,
*BE* European correspondent

Mark the date: Friday, Nov. 20, 1987. In the late evening hours, from its space station at Kourou, French Guyana, a European Ariane rocket brought European broadcasting into the space age with the launch of the West German satellite TV SAT-1. It is a true high-power direct broadcast satellite (DBS), one on which industry and development teams of the old continent have pinned many of their immediate hopes.

TV SAT-1 is in geostationary orbit at 19° west, at 22,300 miles altitude. It weighs 2,620 pounds and carries five TWT amplifiers, each with a power of 200W. (Present communication satellites have an average of 50W from each amplifier.) It has a design life of nine years, but will be backed up within a couple of years by a reserve satellite, TV SAT-2.

Operation is in the Ku-band (12GHz). A carefully crafted "footprint" covers West Germany with an EIRP on the beam axis of about 60dBW. The power budget aims at a receiving dish diameter of 60cm (two feet).

Ariane already is preparing for the launch early this year of a twin French satellite, TDF-1, identical to TV SAT-1 except for the footprint. Europe thus will become a full-fledged member of the club of countries that look on satellite television as the TV system of the future.

Japan began true direct satellite broadcasting in 1984 with the launch of BS-2a, followed in 1986 by BS-2b. These are medium-power (58dBW) satellites in the Ku-band. Australia, with vast, thinly populated areas, has low-power (48dBW) DBS in the Ku-band.

TV SAT-1 is the largest satellite launched to date by Ariane. Not only will the new satellite make four new TV channels and eight high-fidelity audio channels available to hundreds of millions of Europeans, but it also will provide a proving ground for the new D2-MAC packet transmission standards. These standards are intended to provide, among other things, the underpinning transmission technology for high-definition television.

The total cost of TV SAT-1 is approximately $40 million, financed entirely from public funds. The two German public TV networks (ARD and ZDF) each will use one channel. The other two channels will be commercialized for the use of German "private television."

True direct broadcast satellites differ from the usual telecommunication satellites mainly in that the former transmit with higher power, permitting reception with antennas of smaller size—in this case, parabolic antennas that are 60cm in diameter. An estimated 10,000 TVROs are in use in Europe today, but most have diameters of 10 feet or more.

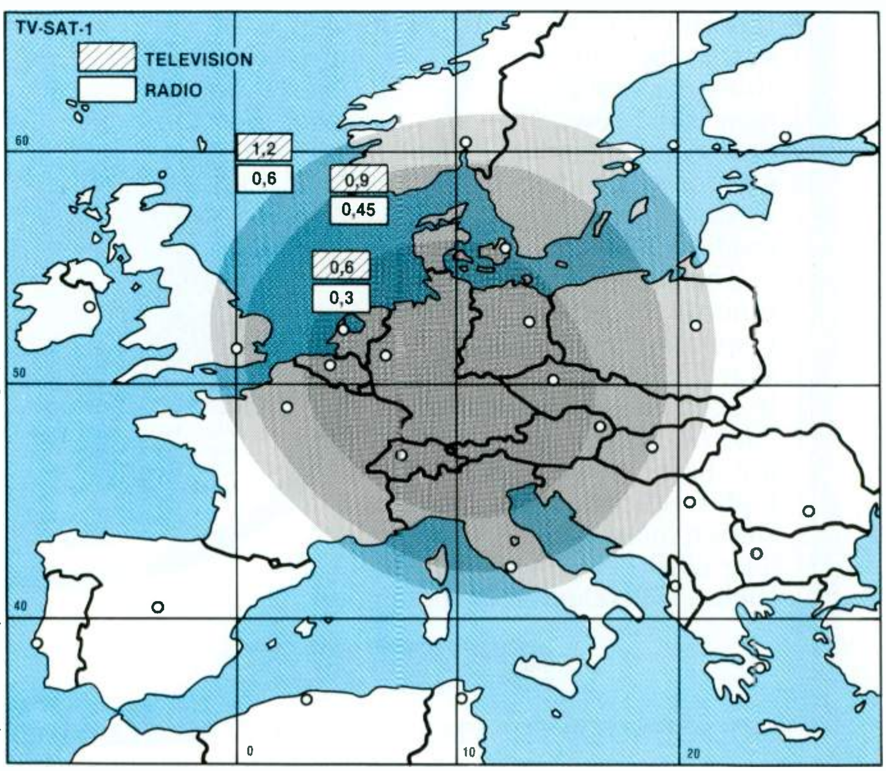
Some Japanese companies have demonstrated small, flat receiving antennas, but these are still in the experimental stages. No one has figured out a way to get around the need for a specific antenna capture area.

Cable television is an obvious natural ally of DBS. West Germany, with a population of 60 million, 25.7 million homes and 6.8 million TV homes, will rely to a great extent on cable distribution of the decoded satellite signals. Although the country is not heavily cabled (as are Belgium, Netherlands, and to some extent, Switzerland), the West German government has undertaken a feverish campaign to cable the country by the end of the year. The government is relying on the satellite transmissions to provide "private television."

France, which already has over-the-air broadcast "private television," has no plans to spend public funds for broadband cabling. The satellite programs in West Germany and France will be "pay TV." Whether customers use individual receiving antennas or the cable, they will pay for a decoder or a connection and maintenance charge.

### MAC standards

One of the big innovations of TV SAT-1 is the use of the unified European D2-MAC (multiplexed analog component) transmission standards, which will be progressively substituted for present systems such as SECAM (used in France) and PAL (used in




Graphics courtesy of the Austrian Broadcasting System

***Figure 1.*** *Footprints of TV SAT-1, the West German DBS launched in November 1987.*

WHAT HAS 5 VTR'S,
2 ROBOTS,
3 ROTARY LIBRARIES,
1,184 CASSETTES,
A COMPUTER,
THE ABILITY TO PLAY
15-SECOND SPOTS
BACK TO BACK
CONTINUOUSLY,
IS AVAILABLE NOW,

AND IS SURE TO TURN
THE BROADCAST INDUSTRY
UPSIDE DOWN?

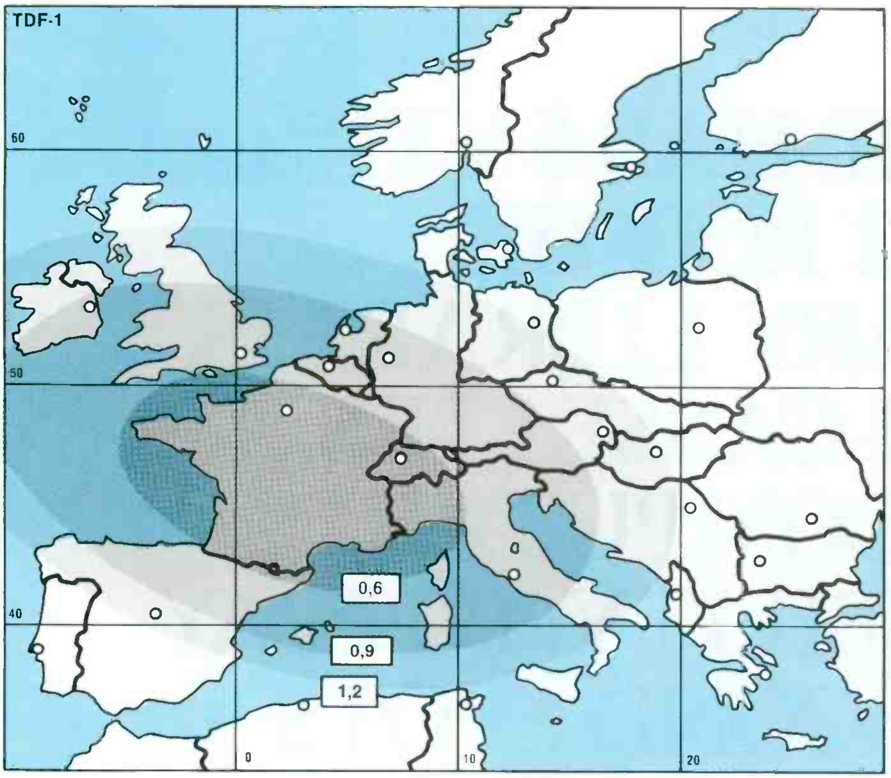



*Figure 2. Footprints of TDF-1, a French satellite scheduled for launch early this year.*

the rest of Western Europe).

The D2-MAC system also provides highly flexible treatment of the sound. Thus, TV SAT-1 has the capability for transmitting multilingual programs, two digital channels in stereo and eight channels in hi-fi.

Low-power DBS exists in Europe today. Presently, there are 73 notified operational civilian satellites in the Western world. Their principal function is the transmission of telecommunications services (such as telephone and data), but they also relay TV signals.

The satellite TV programs that can be picked up at this moment in Europe (a total of 19, including a couple of U.S. channels) arrive by means of Intelsat (International Organization of Telecommunications Satellites), Eutelsat (European Organization of Telecommunications Satellites), Telecom 1 (France) and Gorizon (U.S.S.R.). The Soviet satellite transmits at UHF.

And so the rush is on. Luxembourg, Great Britain, Italy and the Nordic countries all have DBS satellites under construction or in the planning. New launches will continue throughout 1988. All of these projects are under government control, which means that DBS will work—or else!

# ANSWER:

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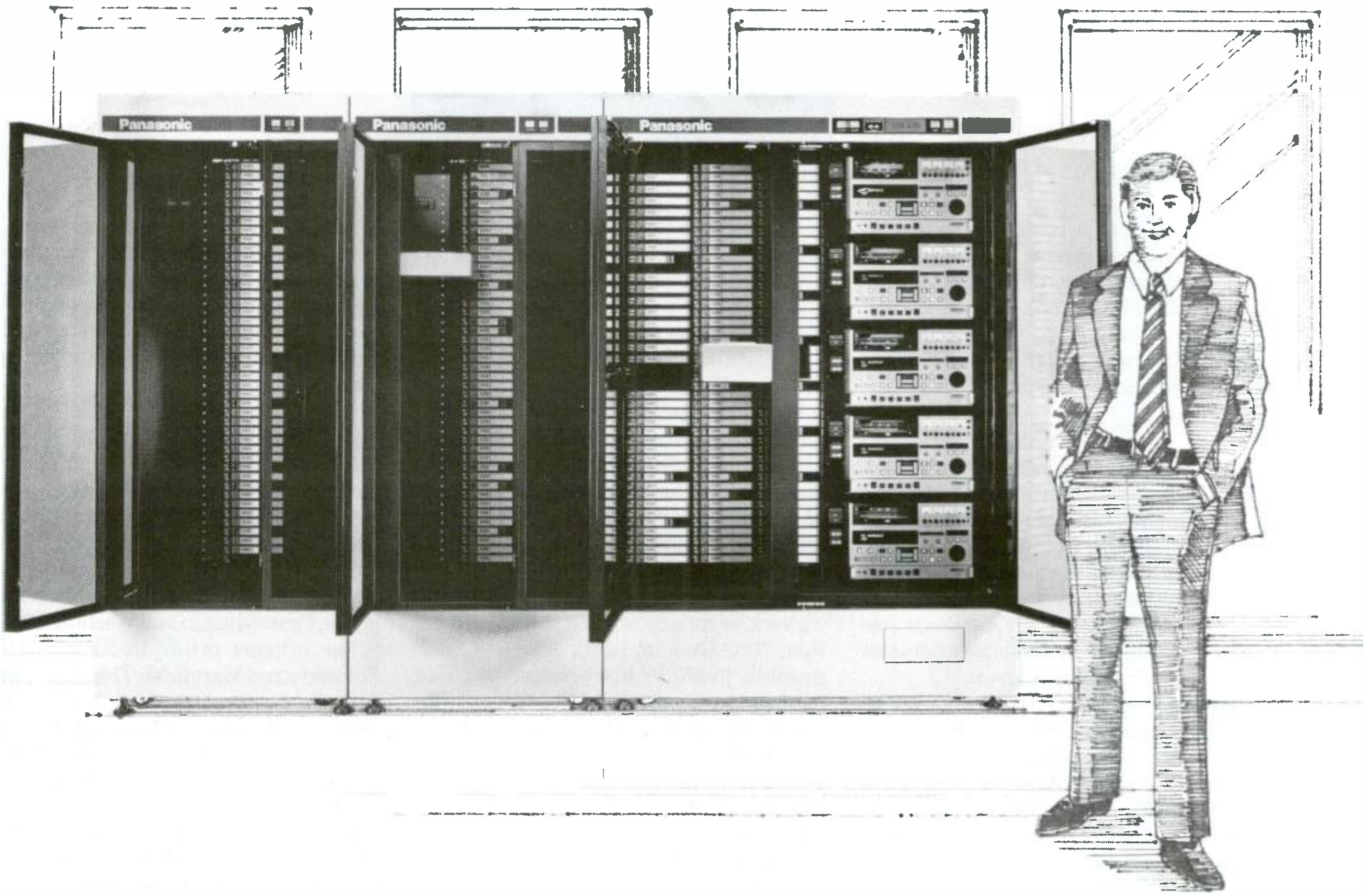


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# Deadlines coming up for scholarships

**By Bob Van Buhler**

The educational arm of the Society of Broadcast Engineers is the Harold E. Ennes Foundation, which coordinates and administers national SBE scholarship funds and activities, including the long-established Ennes scholarship and the Alpha Epsilon Rho (AERho) scholarships.

### Scholarships

At the semiannual Ennes Foundation meeting, the foundation board voted unanimously to increase the ceiling on the AERho scholarship from $1,000 to $2,000. AERho, an established national college broadcasting fraternity that has been working with the society for several years, has provided quality scholarship candidates interested in broadcast careers.

AERho president, David Guerra of the University of Arkansas, Little Rock, AR, attended the Ennes Foundation meeting and the SBE convention. In 1987, the Ennes Foundation awarded a total of $2,500 for AERho and Harold Ennes scholarships. The Ennes awards to AERho members in 1986 included three $500 scholarships. Ennes scholarships since 1980 total $5,600. Scholarship deadlines are Feb. 15 for the AERho grants and March 15 for the Ennes Foundation grants.

The national office recently mailed a questionnaire to chapters asking for information about local and regional scholarships. Chapter chairmen should respond promptly, because the Ennes Foundation may be able to offer assistance even at the local level.

### New foundation director

SBE director and past president Jim Wulliman has retired from his position as vice president of engineering for the WTMJ stations, Milwaukee. WTMJ's loss is SBE's gain, because Wulliman becomes executive director for the Ennes Foundation. He also will continue as the SBE certification chairman. He is relocating to Green Valley, AZ, and will direct the foundation's activities from there.

Roger Johnson, who was a member of the Ennes Foundation by virtue of his position as the immediate past president (IPP), has been asked to remain on the foundation board now that Richard Rudman assumes the position of IPP. Johnson's contributions to the Ennes project have been substantial, and the board voted unanimously to ask him to continue to serve.

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

### Certification exams

The next regular certification examinations are scheduled for June 10-20. Examination study guides are available from the national office for $4.95, including postage and handling. If you ask someone who has taken the exams, you may find that the guides are highly recommended.

To purchase any of the study guides, send a check or money order to SBE Certification, 7002 Graham Road, Suite 118, Indianapolis, IN 46220. Phone orders by credit card also are accepted at 317-842-0836. The deadline for applications is April 15. Application forms and additional information are available from your local chapter or the national office.

Certification tests are administered locally by chapter-approved proctors. Prior SBE membership is not a requirement, but see the application form for details. An added feature of the examination process is computer-generated tests. Now no two examinations are the same. The certification computer system sorts questions and draws each examination separately and randomly from a large database of questions. Each test is carefully constructed to represent an accurate assessment of the working knowledge and experience of candidates, from broadcast technologist to senior broadcast engineer.

You must now be certified to hold national office. As a result of the 1987 bylaws referendum, conducted as a part of the annual SBE election, nominees for the offices and board of directors must have earned certification at some level.

Certification also may soon be an international proposition. According to certification chairman Wulliman, inquiries have been received from groups in the Republic of the Philippines wishing to participate in the certification program. This opens the possibility of establishing chapters in the island nation.

### Sustaining membership

SBE welcomes the support of six new sustaining members: Howe Technologies, Cortana, Jefferson-Pilot Communications, American Family Broadcast Group, KGO-TV and BTS (Broadcast Television Systems). The Professional Directory gained a new member with the participation of Dataworld.

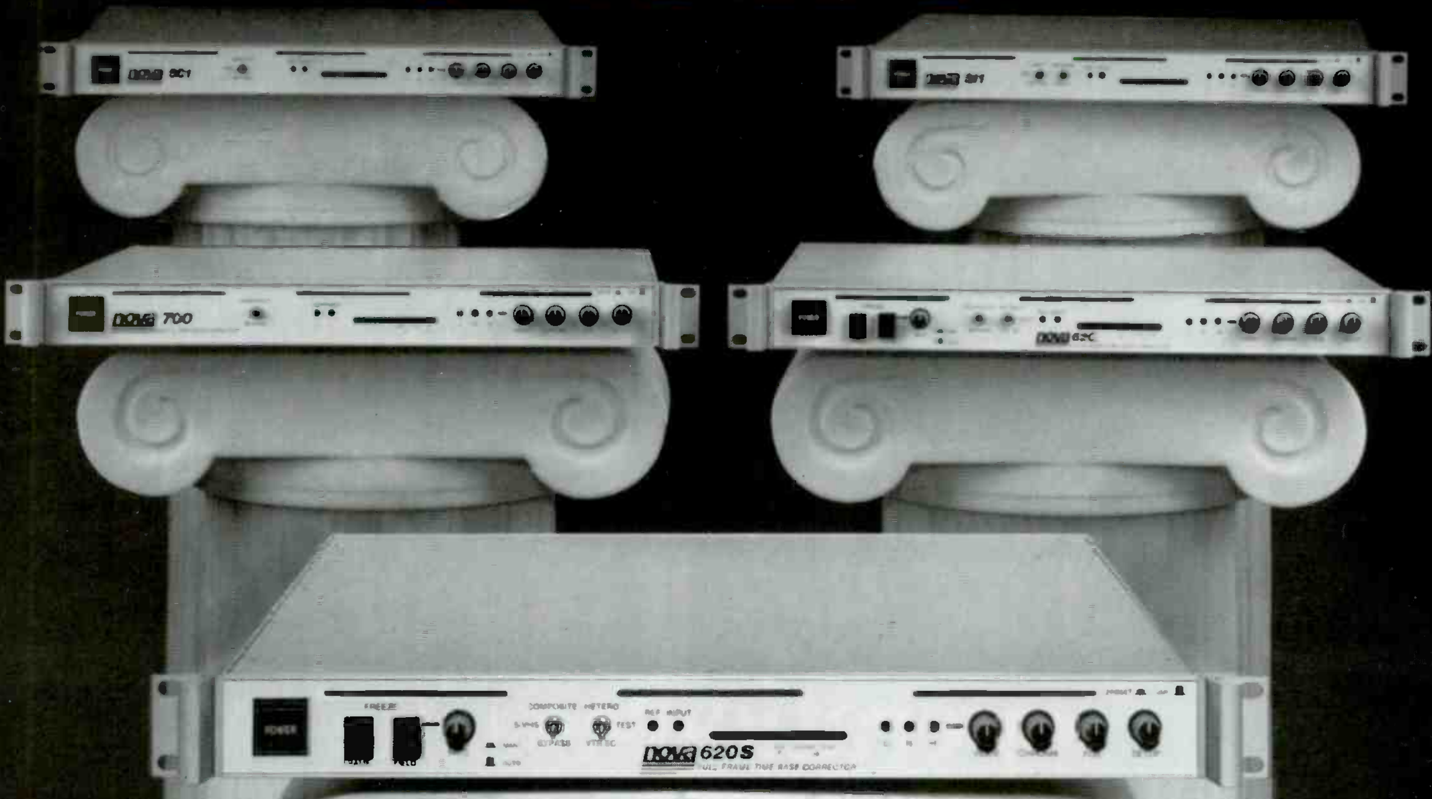
### New board of directors

A look at the newly elected board of directors reveals a wide-ranging representation. Currently serving the society are two directors each from Arizona, California and Wisconsin and one member each from Florida, Minnesota, New York, Oklahoma, Pennsylvania and Washington, DC.

The officers reside in Kansas, Ohio, Colorado and Maryland. The other candidates in the recent election were from Texas, California and Missouri. Directors elected two years ago resided in Illinois, Florida, Oklahoma, California and Washington state.

The conclusion to be drawn from this bit of trivia is that national service patterns in the society tend to represent the concentration and cross-section of the membership, with all areas eventually represented. Chapters recently formed in the Southern states will no doubt produce quality nominees for national service as well.

# GOOD BREEDING SHOWS.

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# Wouldn't it be great if somebody built a fully integrated station automation system that could handle all on-air operations, with off-the-shelf hardware, and backed by a ten-year warranty?

# Designing a time-code reader

By John McGaughey

The University of Georgia Center for Continuing Education maintains several broadcast and teleconference facilities. These include a satellite uplink, video and audio control rooms, time-code editing suite, dubbing facilities and an FM radio station. To keep everyone on time, a system to transmit accurate time of day to all of the facilities was needed. Several commercial products were examined but rejected because of the high cost. Instead, the center decided to use its existing time-code generator in the *drop frame* mode to transmit time of day to all of the broadcast facilities.

An examination of commercial time-code readers made it obvious that many of their features were unnecessary for this application. For instance, the reader did not need to recover code at other than normal speeds and directions. Likewise, user bits, error correction and frames display were not needed. So, instead of paying for unused circuitry, the center designed its own basic time-code reader. Its design goal was a unit with a 1-inch-high LED display, which used standard available parts and cost less than $100.

McGaughey is an engineer with the Georgia Center for Continuing Education, the University of Georgia, Athens, GA.

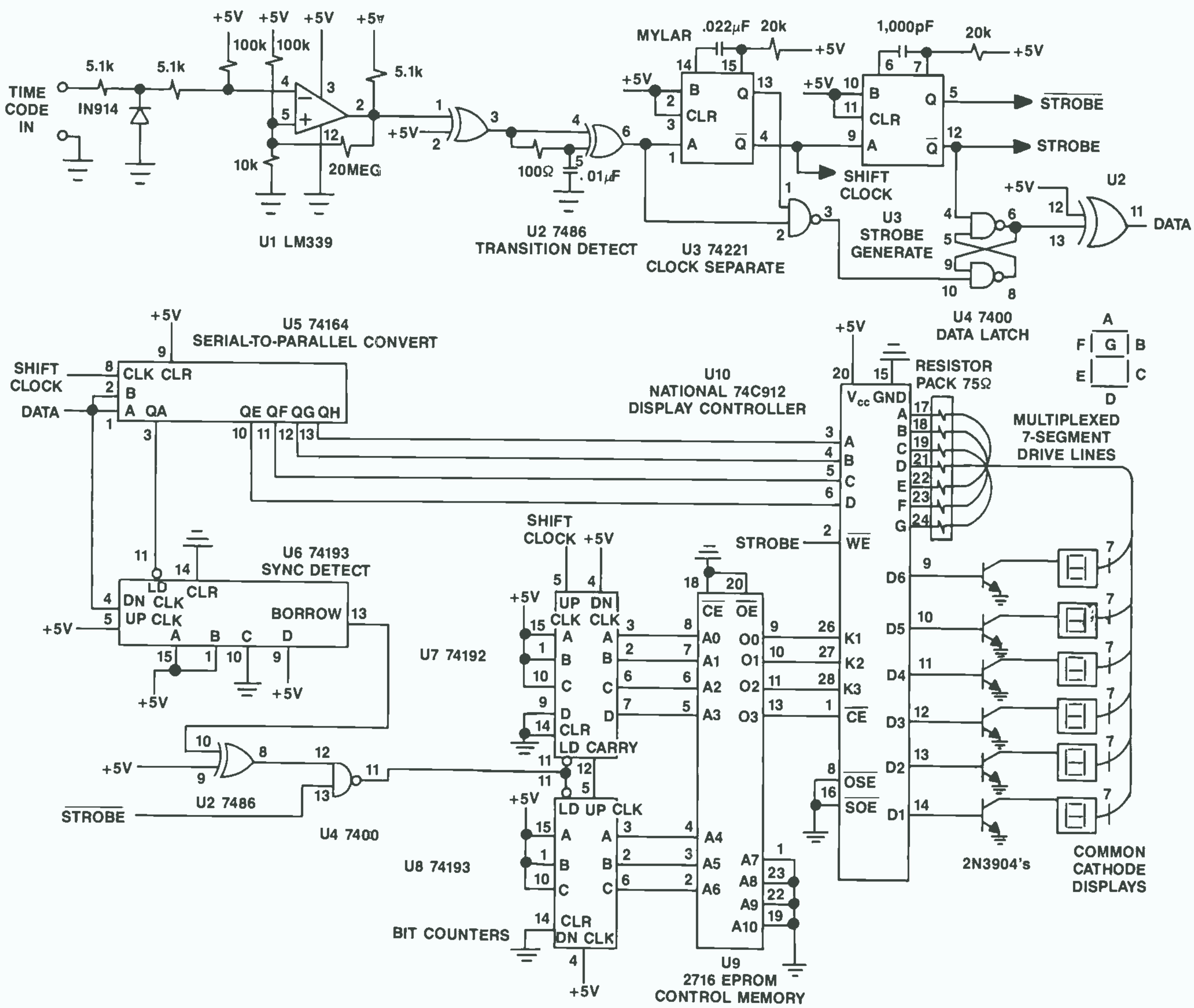



*Figure 1. The time-code reader can be constructed for approximately $100.*

| ADDRESS (HEXADECIMAL) | CONTENTS (HEXADECIMAL) | DIGIT ACTIVE |
|---|---|---|
| 23 | 00 | UNITS OF SECONDS |
| 31 | 01 | TENS OF SECONDS |
| 39 | 02 | UNITS OF MINUTES |
| 47 | 03 | TENS OF MINUTES |
| 55 | 04 | UNITS OF HOURS |
| 63 | 05 | TENS OF HOURS |
| ALL OTHERS | FF | NONE |

***Table 1.*** *Program code for memory IC U9, a 2716 EPROM.*

A time-code reader integrated circuit was found, but its cost alone exceeded the design goal, and it was available only in a surface-mount version, which is difficult to use. Also, it was made in Europe; it was not in keeping with the decision to use standard parts.

**The circuit**

The design described here requires only 10 commonly found integrated circuits costing less than $20. The final complete-unit cost was $110 because of the need for a large LED display.

Figure 1 shows the reader system schematic. Integrated circuit U1 is a comparator, which converts time code to TTL-compatible levels. U2 is an exclusive OR gate used with an RC delay to form a transition detector. It produces a narrow positive pulse for each transition on the input.

U3 is a clock extraction one-shot that ignores data transitions. Its timing period is 75% of one bit time, or about 315ms. U3 section 2 and U4 recover the data information.

U5 is a shift register used as a serial-to-parallel converter. It presents complete 4-bit digits to display controller U10. U6 is a presettable downcounter that looks for 12 consecutive date "ones" that form a synchronization pattern. When it detects this code, pin 13 goes low. This loads a number into a modulo 80-bit counter comprising U7 and U8. This forces their count into synchronization with the incoming time-code frame.

The bit counter outputs drive U9, an EPROM used as a control memory. At the proper times during a time-code frame, it produces a low at pin 13 that enables the display controller to accept a digit. At the same time U9 produces a 3-bit code telling the display controller where the digit belongs in the display.

Table 1 shows the simple program required in the memory. A 2716 EPROM was chosen instead of a lower-density bipolar PROM, because the center had the necessary programming equipment, and it is inexpensive and widely available. U10, the display controller, handles the 6-digit multiplexed display made from common cathode 7-segment displays.

At this point, all areas in the station have readers for less than the cost of one comparable commercial unit.

## Adaptive delta modulation

**Edited by Brad Dick, radio technical editor**

The requirements for a digital audio broadcast system are quite different from those for a recording medium. One of the primary differences lies in the cost of the playback circuitry. In a broadcast application, the cost of the individual receiver/decoders becomes a major design consideration. For the broadcast application to be successful, the decoders must be cost-effective. The digital audio encoding system described here is based on situations in which few encoders and many low-cost decoders are needed.

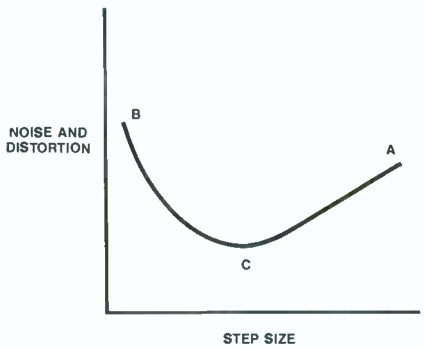



*Figure 1. Adaptive delta modulation requires that the step size vary in accordance with the demands of the input signal. Point C indicates the optimum step size for a particular signal.*

### Digital audio encoding

One method of providing high-quality audio relies on an analog-to-digital conversion process. One common conversion process is pulse code modulation (PCM). Although PCM systems can provide excellent quality, they also suffer from several disadvantages. One problem is that achieving a dynamic range of 80dB or more requires circuitry with an output precise to approximately 0.01%. Such precision is costly.

Another problem lies in preserving bandwidth efficiency. Efficient use of bandwidth requires elaborate (and expensive) filters to reject frequencies above the Nyquist limit. And finally, PCM systems require error-correction and concealment techniques.

The system described here maintains a wide dynamic range by making the A/D and D/A conversion adaptive, hence the name *adaptive delta modulation* (ADM). The available signal-to-noise ratio is further improved by using variable pre-emphasis and de-emphasis. Transient distortion is reduced by using advance information about the signal's characteristics. Finally, control signals are transmitted to the decoder independently, eliminating the need for sophisticated signal analysis in the receiver, thereby reducing the receiver cost.

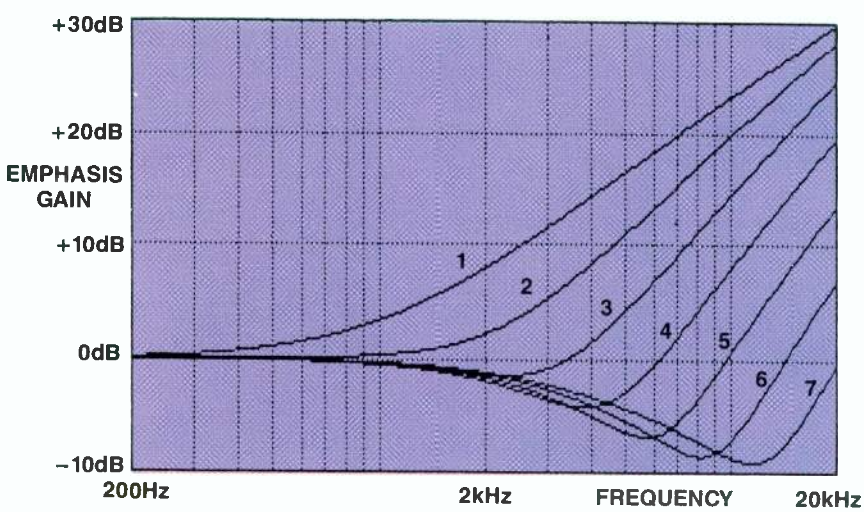



*Figure 2. A family of pre-emphasis curves is used in the ADM encoder. The curve selected at any particular instant depends upon the input signal spectra.*

### Delta modulation

The system design relies on delta modulation techniques. In a delta modulator, a reference waveform, formed by integrating the output bitstream, is subtracted from the sampled input waveform. If the difference is a positive quantity, the output bit at the next sampling instant will be a 1; if the difference is negative, the bit will be a 0. The reference waveform, therefore, moves positively or negatively by one increment (known as a *step size*).

The process tends to reduce or even reverse the polarity of the difference between the two steps. Thus, the modulator becomes a negative feedback system, delivering whatever stream of bits is required to allow the reference waveform to follow the input. The quantizing error or noise level is dependent on the step size. Delta modulation is a special case of differential PCM, with only one bit per sample and a bit rate equal to the sampling frequency.

For broadcast, this process offers several advantages compared with traditional PCM systems. Delta modulation requires no precision components and can be manufactured economically. Because all bits have equal weight, isolated bit errors have only a minor audible effect. When combined with companding, differential coding is preferable to non-differential coding because it more closely matches the properties of human hearing.

### Adaptive delta modulation

In adaptive delta modulation, the digital datastream contains information not about the absolute audio signal value, but on the change in signal value, from sample to sample. In a codec handling a single sine wave, output noise and distortion is a function of step size. As shown by Figure 1, if the step size is too large, excessive quantizing noise is produced. If the step size is too small, and the system is in slope overload, high noise and distortion is produced. For each short time segment of audio, there is an optimum step size. One task of the ADM encoder is to determine the optimum step size.

Adding a fixed-value high-frequency emphasis in conjunction with ADM is effective when the predominant spectral components are low or middle frequencies. However, with high-frequency signals, the boost leads to increased step size and, therefore, increases the broadband noise, whose low-frequency components are not reduced by subsequent de-emphasis.

A better method requires that the pre-emphasis be adjusted according to the spectral content of the applied signal. In a practical system then, a family of curves is used, such as those shown in Figure 2. The complementary action of the pre-emphasis and de-emphasis helps provide the desired subjective noise reduction.

In audio signal processing, the original audio spectrum is contaminated by modulation products. In some cases, the products may be highly objectionable. In complementary noise-reduction processing, the introduction of modulation sidebands in the encoder should be accompanied by a subtraction of the same sidebands in the decoder.

### Control signals

Unfortunately, in a practical noise-reduction system, the encoder and decoder may not track perfectly because of component tolerances and/or channel errors. Therefore, the modulation products generated will not be completely canceled. If all of the modulation products are not canceled, the remaining ones must be inaudible. One method is masking.

Fast-responding control signals modulate the carrier, producing wider sidebands than when a slow-responding signal modulates the carrier. A system with slow-responding control signals produces sidebands nearer the carrier that are more easily masked by the original audio. Hence, the slower the control signal, the less audible the effects of mistracking or the greater the mistracking that can be tolerated.

### System diagram

With that explanation of Dolby ADM, let's examine a practical implementation. A Sony DP85 digital audio encoder is shown in Figure 3. Each audio input channel is filtered by a 9th-order 18kHz low-pass filter. In addition, there are two cascaded notch filters that, together, provide 40dB of rejection at the horizontal-line frequency.

The use of such precision input filters in the encoder is required by the PCM technology used in the delay module. The notch filters are necessary only in video-related applications, because even a small amount of audio leakage at the horizontal-rate frequency could upset the PCM process.

Although any adequate-quality delay could be used in the basic ADM process, this particular implementation relies on a well-established Sony CX20018 IC. The circuit samples two channels of audio at 44k samples/second/channel, producing a serial bitstream at 1.408Mb/s. The multiplexed datastream is then clocked through RAM for the required number of clock cycles, producing the desired 10.8ms delay.

To return the signal to analog form, the multiplexed datastream is converted into two demultiplexed channels of audio at a rate of 44k samples/second/channel. Audio is then reconstructed using a current-output integrating circuit. The audio then passes through several phase-corrected 9th-order filters, which provide more than 75dB of attenuation for frequencies greater than 28kHz.

It's important to keep in mind that the digitized audio described here is not the bitstream used for encoding the audio signal. This complex scheme of A/D and D/A is used to provide a high-quality digital delay of 10.8ms for the audio signal. A less sophisticated technique also could be used with the basic ADM encoding scheme.

### Sliding band pre-emphasis

The required pre-emphasis curves are developed by differentiating the audio signal, then normalizing it to a constant peak level with a fast-acting linear limiter. The produced control signal is frequency-weighted and applied to a peak rectifier. The rectifier output is, therefore, a measure of the input signal's frequency spectrum.

The rectifier signal is converted to a control bitstream by a delta-sigma modulator at a clock rate of 12.5kHz. This datastream is delayed 10.8ms in the logic interface

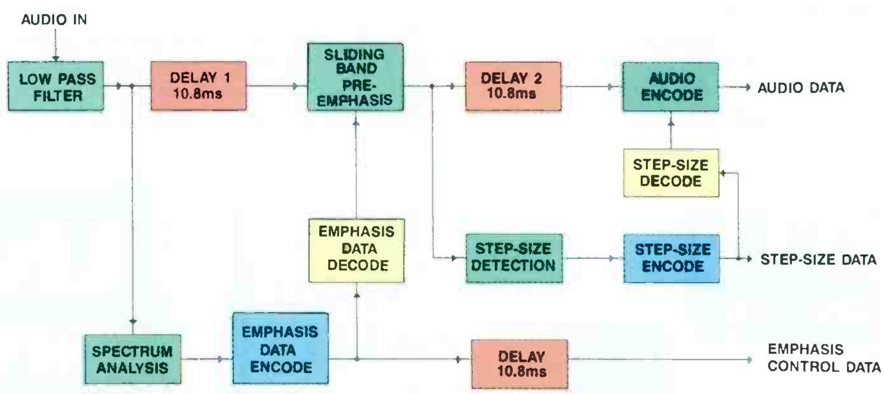



*Figure 3. The basic Dolby ADM system shown here relies on D/A and A/D conversion techniques to delay the audio prior to processing by the control signals.*

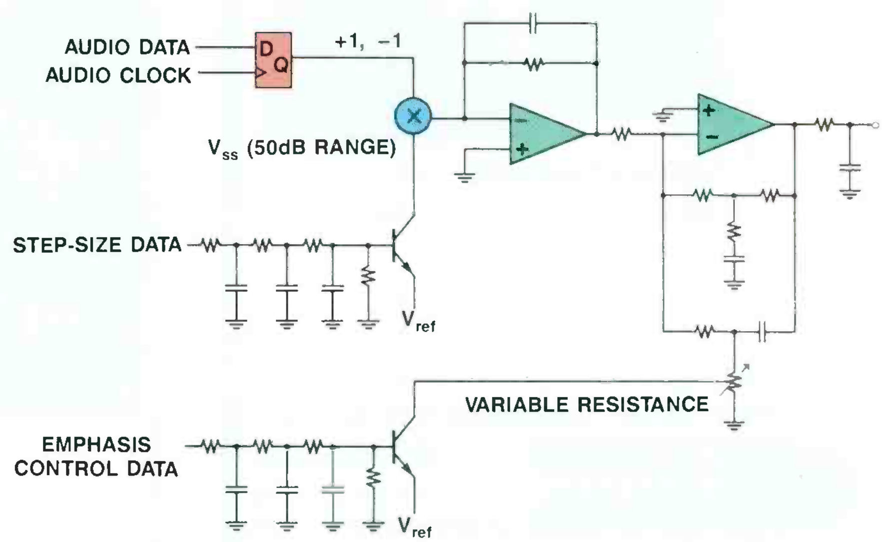



*Figure 4. A single-channel consumer decoder requires three data bitstreams: audio, step-size data and emphasis-control data.*

module so the control data will remain in step with the delayed audio. This is the first of the required signals for decoding. The analog version of this signal is used by the sliding-band pre-emphasis circuit to adjust the dynamics of the signal according to the pre-emphasis curves shown in Figure 2.

The emphasized, processed audio is again delayed in a section of the A/D-D/A module, pre-emphasized with a fixed 25$\mu$s pre-emphasis and passed on to the delta modulator.

The final control signal, step size, is developed by first measuring the slope of the delayed, pre-emphasized input signal. The logarithm of the slope value is then digitized into a serial control bitstream by a delta-sigma modulator representing the step-size control data. This set-size control data is then locally decoded and applied to the delta modulator.

The delta modulator receives the emphasized, wide-dynamic-range audio from the second delay and a control signal indicating the signal's slope from the step-size control circuit. The audio is coded by a delta modulator into a bitstream at the audio clock rate (approximately 300kHz), producing the third and final signal needed for the decoder.

### Decoder advantages

One of the primary advantages of this encoding system is that expensive decoders are not required. Each decoder audio channel, as shown in Figure 4, receives three data bitstreams. The two control bitstreams, emphasis control and step-size control, operate at low bit rates of approximately 12.5kb/s. The audio rate is much higher as explained previously.

The control signals are recovered by lowpass filtering the bitstream and exponentiating the resulting voltage. The step-size control bitstream contains the logarithm of the required step-size coded as delta-sigma modulation. The product of the audio data and the step-size control signal is integrated in a leaky integrator.

The de-emphasis control signal is handled identically, but instead of producing a variation in gain, it produces a variable pole frequency in the de-emphasis network. The final single pole of the de-emphasis network yields enough attenuation of clock and spurious output signals that no output filter is required.

ADM offers many advantages compared with other digital-encoding schemes. Broadcast applications, such as terrestrial microwave links and direct-broadcast satellite (DBS) may find the technique especially applicable. Look for several implementations in the near future.

**Acknowledgment:** Portions of this material were adapted from material provided by Dolby Laboratories and "An Audio Broadcast System Using Delta Modulation," by Kenneth Gundry, which appeared in the November 1985 issue of the *SMPTE Journal*, Vol. 94, No. 11.

# Eventide BD980 broadcast delay

By Robert Van Buhler

In this age of litigation and license challenges, a delay unit is a necessity for prudent broadcasters. The new Eventide BD980 meets the needs for a basic, high-quality delay. It also offers several innovative features that make the on-air use of delay much easier.

The BD980 is a flexible product, based in part on the new technology used in the device. The unit is quite different from most delay devices, including others made by this manufacturer.

### Operation

From an operational standpoint, the main improvement compared with previous models is the ease of getting in and out of delay. This is the point in a broadcast where mistakes are made easily, particularly by combination board operator/announcers, who are forced to divide their concentration between program content and execution.

The common practice for exiting delay is to play a recorded element (in delay), switch the monitor from pre-delay audio to post-delay and wait for the delayed audio to end. The operator then returns to real time, either bypassing the delay unit or dumping to real time.

This exit process can be automated with the BD980 using the wait and exit feature. Assuming the delay time is 10s, pressing the wait and exit button causes the BD980 to time out the 10s until the program coming through is output. The device then switches to real time, or zero delay. This feature offers the operator a 1-button exit from delay, which requires no special monitoring, just adequate time.

It also is possible to ramp the delay down to zero or real time over a relatively short period. The operator can return to the delay mode by ramping up to full delay, which is four, six, eight or 10 seconds.

Some of these features may not be important in all operations. However, drive-time talk radio programs need delay for obscenity protection. At the same time, switching to and from 2-way radio conversations with traffic reporters (who often take their cues off the air) requires leaving delay to join these reports. Although there are other ways to get around these problems, having a delay device that automatically fades into and out of delay is most useful.

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

> ***Performance at a glance***
>
> - *Frequency response: 20Hz – 20kHz ±1dB*
> - *Distortion: <0.2% at 1kHz, reference level*
> - *Dynamic range: 90dB from clipping to noise floor*
> - *Delay: 2 channels, each with 10s maximum delay*
> - *Input characteristics: 10kΩ, balanced, maximum level +24dBm*
> - *Output characteristics: maximum level, +20dBm into 600Ω*

### Transition techniques

Delay transition techniques involve sampling the audio and looking for "holes," or program pauses (dead air). These audio gaps then are "stretched" to pick up delay. In some cases, the BD980 does this a little too well. If set to catch up to maximum delay at the fastest possible rate, the device can exhibit the same kind of peculiar distortions noted on earlier units, where low-volume syllables are stretched, as the dead spots would be.

If the unit is misadjusted, the result can be an excessive slowing of tempo with voices and music during the transition to delay and an amusing upswing in tempo when exiting. The phenomenon seems to be most noticeable on high-rotation commercial and image jingles. As with any piece of high-performance equipment, a moderate and experienced hand is prudent when making adjustments.

The user has no real excuse for chronic misadjustment, because the device has a 32-position rotary switch to incrementally set the catchup time for automatically increasing or decreasing delay. As with previous models, the delay can be set for either fixed rate catchup (osc), picking off the pauses or both modes combined (osc/pause).

The manual section titled "Trying out the BD980" should be read and practiced repeatedly before the delay is installed. This allows the user to develop a skillful hand at setting the various delay parameters and helps ensure familiarity with the many optional control features before going on-line.

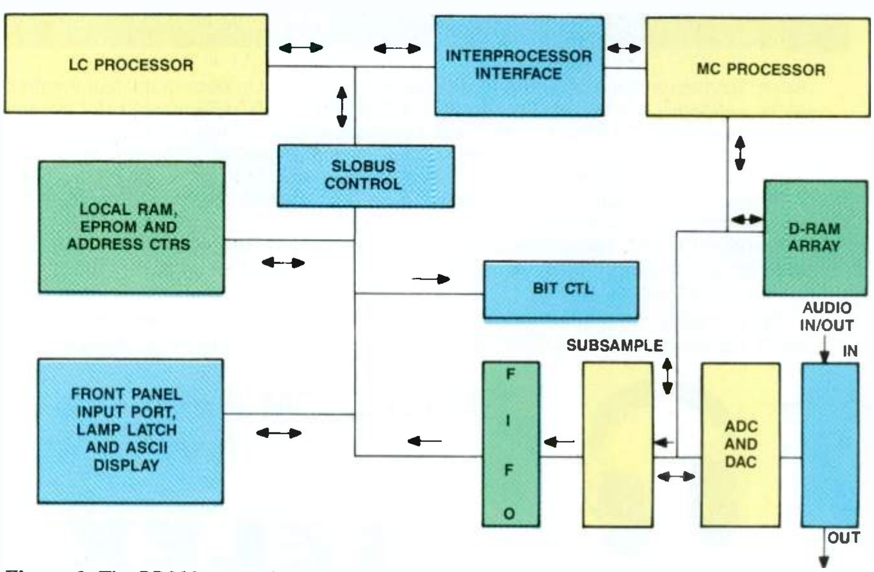



***Figure 1.*** *The BD980 resembles a small computer in many ways.*

### Microprocessor control

The unit performs its functions in several distinctive ways. As one might expect, the device is a form of computer system, with an input, output, memory and central processor. A simplified block diagram is shown in Figure 1.

The unit has two complete microprocessors, employing 16-bit TMS32010s. One chip functions as a memory controller (MC processor), which manipulates the digitized program material passing through the unit. The other chip, called the Lupine controller (LC processor), acts as the host processor for the entire unit.

The input audio is first digitized by a 16-bit analog-to-digital converter, then stored in RAM. Audio passing out of RAM under control of the MC processor is converted back to analog at the output ports by 8- and 16-bit digital-to-analog converters.

The other TMS32010, which is the LC processor, controls all the housekeeping necessary to perform the operational functions. These functions include: front-panel controls, end of line, dump-and-exit relays, sending instruction scenarios to the MC processor and executing the algorithms required to detect silence. The LC processor is fast when compared with the typical personal computer functioning at 20MHz, which is twice as fast as its boot speed of 10MHz.

The SLOBUS control, shown in Figure 1, is the basic interface between the LC processor and its controlled external devices. A separate interface allows communications between the LC processor and the MC processor.

Software to operate all this hardware is contained in two EPROMs containing four distinct programs. Two programs are used to execute self-test functions, and two are operational programs. The program data for the MC processor is extracted by the LC processor and loaded into program RAM. The LC processor downloads its own program from the RAM.

One EPROM also contains a separate region where text strings for the front-panel display and switch-preset definitions are stored. The information is extracted on demand from the EPROM, rather than from RAM. This prevents excessive data clutter in the program RAM, which is not large. This configuration permits the RAM space to be devoted exclusively to execution codes, rather than to a combination of codes and data.

### Diagnostics

As with most microprocessor-based devices, diagnostic programs are available to indicate the status of system features. The BUTTONS test displays the legend of each front-panel switch as it is pressed, verifying function. The MEMORY test inspects and reports any errors within the audio RAM. The test also pinpoints the location of any defective chips.

The ROTRY SW test examines and displays the position of the CATCHUP RATE switch. Because these switch positions relate to specific EPROM instructions, it is essential that in addition to continuity, proper sequence is indicated.

The DIPSWITCH test indicates the setting of internal dip switches. This test is important because the internal switches determine activity in front-panel controls, the length of maximum delay and other selectable parameters.

Other features include: CMOS RAM, RELAYS, LAMPS and DISPLAY tests. There is an ALL TSTS mode, which can be terminated by a QUIT function. Although many of these tests seldom need to be run, they are invaluable if maintenance is required.

### Options

Available options include an ASIO RS-422 serial interface board for remote control. All the front-panel functions and displays are available through this port. This feature presents the intriguing possibility of automating the routine entry and exit from delay. Such flexibility might be useful for the operator or engineer who is chronically forgetful about getting in and out of delay.

### Stereo compatible

Previously, stereo applications required the use of two delay units, such as the BD955. Each device was connected to one of the audio channels. One BD955 then was configured as a master, and the other as a slave. The master unit's timing oscillator was used to sync the slave unit.

Because each of the earlier models had its own power supply with its own sensitivities, a significant power-line bump sometimes forced the two units out of synchronization. This occasionally produced the bizarre effect of one channel ending up in full delay, and the other in or nearer to real time. With the newer BD980, which is a fully integrated stereo unit, that should never happen. A single BD980 is far less expensive than the two BD955 units that previously were required for stereo.

The manual suggests the possible use of the device to time compress production recordings. The process usually is done by changing the elapsed time of a spot announcement, while electronically altering the pitch of material to compensate. The BD980, with a skillful producer in control, can be adjusted to do this over a limited range.

The BD980, unlike a Harmonizer®, offers the significant advantage of not requiring a variable-speed tape recorder for time compression. However interesting this may be, it seems logical that a station that can afford to buy this delay also can purchase a Harmonizer® which offers significantly more flexibility in performing this common production chore.

If any suggestion could be offered to the manufacturer, it would be to offer an optional digital extension unit of the LED display. Such a remote display then could be remotely placed in a studio, providing full status of the delay unit.

The engineer will find the Eventide BD980 a state-of-the-art product that greatly reduces the chance for human error associated with program delay. The device deserves a high compliment for being well-thought-out and user-friendly.

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

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

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

## The ultimate option

One question to which no technical answer has yet been found is that of how to deal with repeated barrages of obscenity. Or how do you handle program content that is inadvertently libelous and requires repeated dumping?

The typical solution requires the use of a cartridge reproducer with a cover jingle or sounder. A switching network removes the delay program material from the program chain and connects the jingle or sounder for an interval equal to the amount of delay time employed. The delayed program is automatically switched back on line after the cover interval, and programming is resumed.

The advantage of this method is that it can be repeatedly employed. Unfortunately, using a delay's dump-to-real-time function is a 1-shot event that must be reloaded by building up to at least half the normal delay. If broadcast delay manufacturers can create an alternative to the cover sound, that would be the ultimate option.

# New products

## NTSC digital test signal generators

*Multidyne Electronics* has introduced its MAGNUM line of NTSC digital test signal generators. The MAGNUM 10, MAGNUM 16 and MAGNUM 16M produce high-quality test signals. Depending on the model, the instruments offer from 10 to 16 test signals, 16 selectable video messages, dedicated blackburst output, 1kHz balanced tone output, a high-clarity audio identification message lasting from three to six seconds and transformer primaries adjustable for 117V/230V, 50Hz/60Hz. All models offer three APL modes, bounce test, RF audio and video output on TV channel 3 or 4, and temperature-compensated 14.3MHz oscillator for better than 5ppm subcarrier stability without any warm-up time. Proprietary algorithms and circuit designs maintain low differential phase and gain, <0.1° and <0.5% respectively. The available signals include: SMPTE color bars, full-field color bars with multiburst, composite, NTC7, multiburst, 5MHz horizontal sweep with markers, modulated ramp, black-and-white ramp, black-and-white stair step, cross-hatch with dots, safe margins signals, red field and multipulse. Some matrices combine two or more signals to facilitate testing of lines and monitors. The video messages are keyed into the test signals. The audio messages interrupt the tone. All models are warranted for three years. For more information call 1-800-422-4474.


**Circle (350) on Reply Card**

## Modular console

*Broadcast Electronics* has introduced the Mix Trak 90, an on-air console for radio broadcasters. Users can choose a 12-channel or 18-channel mainframe and equip it with a wide variety of modules and options. Using the optional Source Sequencer, console operators can program a series of events that can be activated at the touch of a single switch. Microphone and line input modules are available, each with Penny & Giles linear faders, VCA gain control, Hall Effect switches and balanced patch points.

**Circle (351) on Reply Card**

## Editing system

*CMX* has announced the 330A editor, which offers five ports plus a general purpose interface port and permits the connection of up to eight devices. The EDL list provides for 500 events and 500 lines for notes, dedicated video/audio keys and short-cut wipe dissolve.

**Circle (352) on Reply Card**

## Time base correctors

*For-A Corporation of America* has announced the following products:

- The FA-740 parallel effects time base corrector has the capability for operating as two independent TBCs. It uses 8-bit quantization and internal analog component signal processing, as well as independent time base correction, freeze-frame and dropout compensation for A and B channels. Each channel has an independent signal-processing amplifier.
- The FA-200 digital time base corrector offers full-color, full-frame time base correction for ½-inch and ¾-inch VTRs, and produces a standard NTSC signal output from V-lock and non-V-lock-type VTRs. It features built-in RS-170A standard sync pulse generator with gen-lock.

FA-740 parallel effects time base corrector

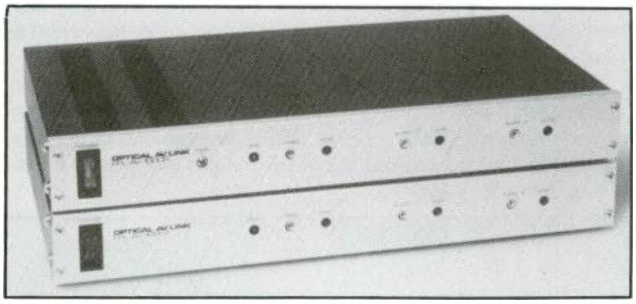
**Circle (353) on Reply Card**

## Dub fader

*Accurate Video Systems* has introduced the DFB-87 dub fader, which is compatible with the Super VHS and ¾-inch SP formats. Features include adjustable video and dub chroma levels and a professional T-shaped fader bar.

**Circle (354) on Reply Card**

## Multiplexers



*Alcoa Fujikura* has introduced two fiber-optic video/stereo multiplexer systems, the FFL-AV-1000 and 2000 series. Designed for direct connection to a VTR and monitor, the systems accept standard NTSC video input and operate at either 850nm or 1,300nm, for transmission distances greater than 10km. Two audio channels are provided. Optionally, in the FFL-AV-1000, one audio channel may be used for TTL level data. The systems also feature full AGC automatic level adjustment and integral power supplies.

**Circle (355) on Reply Card**

## Replacement battery

*Alexander Batteries* has introduced the BP-1-11, an 11-cell replacement for the Sony NP-1. It is rated at 13.75V with a capacity of 1,500mAh when fully charged. The 13.75V starting voltage allows the video recorder or camera to pull all of the 1,500mAh capacity out of the battery before the equipment cuts off or the battery falls to the 11V point (or one volt per cell).

**Circle (356) on Reply Card**

## Coaxial cable

*Andrew* has introduced the following products:

- The HJ4-75 is is a ½-inch diameter, 75Ω air-dielectric heliax coaxial cable. It is suitable for earth-station antenna applications because it allows pressurization of 75Ω components with a low-attenuation, flexible feeder. A type N connector, the 74AW-70, is available to interface with 75Ω equipment connections.
- The FSJ4-75A is a ½-inch-diameter, 75Ω, flexible heliax coaxial cable with a low-loss foam dielectric. It features a 1¼-inch-diameter minimum bend radius, allowing routing in tight places.

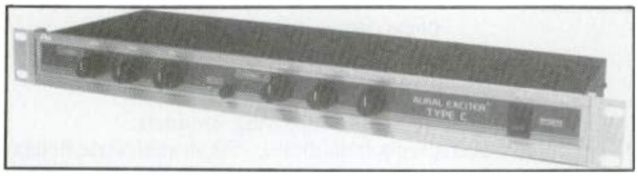
**Circle (357) on Reply Card**

## Exciter improvements and interface

*Aphex Systems* has introduced the following products:

• The 103A aural exciter is an improvement to its type C exciter. It features reduced output noise, less noise enhancement of noisy signals and continuous operation from −10dBm to +4dBm.

• The model 114 stereo 10-4 box features active, servo-balanced circuitry that converts +4dBm (or +8dBm) line levels to −10dBm (hi-fi) levels and back again. It has both XLR and RCA type connectors for quick hookups.




The 103A aural exciter

**Circle (358) on Reply Card**

## Interface

*Ariel* has announced the SDI signal-to-disk interface, which allows host-independent, real time, full-bandwidth data acquisition to disk, as well as signal editing and processing for any PC. The company's DSP-16 data acquisition processor, combined with a high-speed SCSI interface and the DSPDISK software, permits recording and playback on up to seven high-capacity memory devices. The SDI systems are available with 50Mb or 250Mb internal or external disks, or optical (WORM) disks for archives, allowing hours of storage at maximum bandwidth.

**Circle (359) on Reply Card**

## Translator

*Audio Kinetics* has introduced the following products:

• The VTL Translator, housed in an IU 19-inch rack-mounting case, is designed for conversion of vertical interval time code (VITC) to standard longitudinal time code (LTC). The LTC then may be used to drive time-code-based automation systems and synchronizers. A special mode is used with video editors that requires stationary or play speed LTC at all times.

• The Pacer Pad2 has added features including all slave transport functions that can be accessed from the pad, including direct record; the time-code generator can be set and started from the pad; a remote calibration facility has been added; and a "Mark Master" facility, which permits the specification of a point of interest on the slave by entering it into the sync point memory, has been added.

**Circle (360) on Reply Card**

## Hardware/software enhancement

*Fairlight Instruments* has introduced a hardware/software upgrade for the Series III digital audio work station, the MFX package, which incorporates the Cue-List software program and a custom console for audio post-production sweetening. The Cue-List software serves as a time-code-based master controller for all the Series III's functions.

**Circle (361) on Reply Card**

## SCA generator

*Broadcast Technology* has introduced the model 1000 dual-channel SCA generator. Its SCA carrier frequency is 67kHz and 92kHz simultaneously. Optional mute and compressor modules are available.

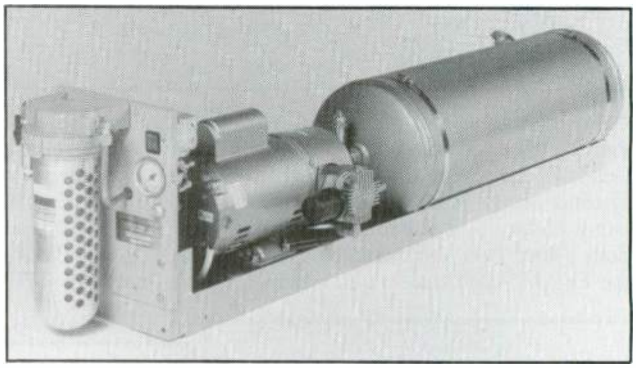
**Circle (362) on Reply Card**

## Replacement module and air dryers

*Dielectric Communications* has introduced the following:

• The nitrogen replacement module can replace nitrogen tanks as a dry air source. The unit weighs less than 100 pounds, and contains a compressor, storage tank and a dessicant dryer of indicating gel capable of drying up to 4,400 standard cubic feet of air before color change indicates replacement.

• Dry-Pak air dryers are twin-tower desiccant dryers that can be integrated into existing compressed air lines or fitted into an upcoming air system. These dryers are capable of delivering up to several hundred SCFM of dry air, and provide dew points down to −100°F.



Nitrogen replacement module

**Circle (363) on Reply Card**

## Processor

*Eventide* has introduced the H3000 Ultra-Harmonizer pitch change and effects processor. It features stereo pitch change; diatonic pitch change; full, high-end signal-processor capabilities; and complete MIDI implementation. The processor has a 40 character by two-line backlit LCD display that shows all parameters and provides dynamic labeling for the four SOFTKEY buttons.

**Circle (364) on Reply Card**

## Tower anchor

*Foresight Products* has introduced the Duckbill Manta Ray Anchor, which is installed at ground level by one man with a jack hammer and a drive gad. The equipment, which can be carried in a pickup truck, has an average installation time of less than 20 minutes in normal soil.

**Circle (365) on Reply Card**

## Remote-control accessories

*Gentner RF Products* has introduced two accessories for its VRC-1000 remote-control unit:

• The antenna monitor interface accessory provides an interface to most commonly used directional antenna array monitors. All monitor outputs are provided continuously, enabling continuous limit checking and accurate automatic logging.

• The dc amplifier accessory provides dc isolation for a sample voltage that is floating, as needed by the unit's metering inputs. It isolates analog signals up to 1, 000Vdc above ground.

**Circle (366) on Reply Card**

### Color filters

*The Great American Market* has introduced GamColor, a line of deep-dyed polyester color filters. The filters, for use with all light sources, feature a scratch-resistant surface, durability in high-heat applications and even, consistent color.

**Circle (367) on Reply Card**

### Broadcast console

*Harrison Systems* has announced the AIR-790 on-air broadcast production desk. Along with Penny & Giles 3000 series 104mm linear faders and CMOS switching for assignment buses, features include two main stereo outputs, two separately derived main mono outputs, an auxiliary send with level trim and clean-feed bus.

**Circle (368) on Reply Card**

### Time base correctors

*Hotronic* has introduced the following products:

- The AF71 TBC/frame synchronizer with freeze frame/field and the AE61 time base corrector are modified to Y/C input and output, compatible with S-VHS, VHS, U-matic, with or without 3.58MHz subcarrier feedback. In S-VHS mode, Y/C output and composite output can be used simultaneously.
- The AF71B TBC/frame synchronizer with freeze frame/field (field 1 or field 2 selectable) has two frame memories, 8-bit resolution, 4x subcarrier and adaptive comb filter. It accepts noisy satellite feed and can be updated to 3.58MHz subcarrier feedback and S-VHS.

**Circle (369) on Reply Card**

### Imaging system

*IDR* has introduced the IDR Imaging System, an integrated full-color image-processing system that displays multiple still video images together with graphics and test on an RGB analog TV monitor. It allows the user to display multiple windows of still video images, graphics or test, along with one full-motion video window, from any composite video source.

**Circle (370) on Reply Card**

### Transmitter/receiver

*Microwave Radio* has introduced the 40MX, 40MR, 40GHz transmitter and receiver, a compact 28-channel broadcast-quality video set with two audio channels capable of operating over distances up to one mile with the antennas supplied (one 15dBi, one 25dBi). An optional 1-foot parabolic antenna (39dBi) can extend the range.

**Circle (371) on Reply Card**

### Post-production system

*New England Digital* has introduced the PostPro 8-track direct-to-disk digital multitrack recording and editing system for film and video post-production. It offers direct digital transfer to Sony, Mitsubishi and AES/EBU standard recording formats.

**Circle (372) on Reply Card**

### Inverter

*Nova Electric* has announced its 2kVA inverter system, which includes a built-in solid-state transfer switch. It may be used as part of an uninterruptible power system or as an off-line system. The transfer time in either configuration is 1ms.


**Circle (373) on Reply Card**

### Recording system

*Pacific Recorders & Engineering* has announced a spectral recording system designed for the cartridge machine user. The system gives audio performance equal to or better than 16-bit linear PCM digital recording, on existing analog audiotape equipment.

**Circle (374) on Reply Card**

### Time base corrector

*Prime Image* has announced the DUB·TBC+, a component dub TBC available with digital effects, including posterization, sepia and mosaic. It is compatible with component Y/C-688 type, component R−Y/B−Y and NTSC composite video signals in VTRs and VCRs.

**Circle (375) on Reply Card**

### Audio equipment

*Orban Associates* has introduced the following products:

- The 9105A OPTIMOD-SW audio processing system is designed for international short-wave broadcasts (both conventional AM and SSB) to punch through noise and interference, with 3dB to 4dB more loudness than OPTIMOD-AM.
- The 222A stereo spacial enhancer is a tool that detects and enhances psychoacoustic directional cues present in all stereo program material—increases spacial definition, brightness and impact.

- The 642B parametric equalizer/notch filter features switchable 4-band stereo or 8-band parametric equalization/notch filtering and tunable 12dB/octave Automatic Sliding Besselworth low-pass filter and tunable 18dB/octave high-pass filter.
- The 764B programmable parametric equalizer/notch filter is a stereo analog parametric equalizer, fully programmable to remember 99 full sets of control settings for instantaneous recall.
- The 787A programmable mic processor is a 3-band parametric equalizer, de-esser, noise and compressor gate, integrated into a system that stores up to 99 different control settings in memory for instant recall.

**Circle (376) on Reply Card**

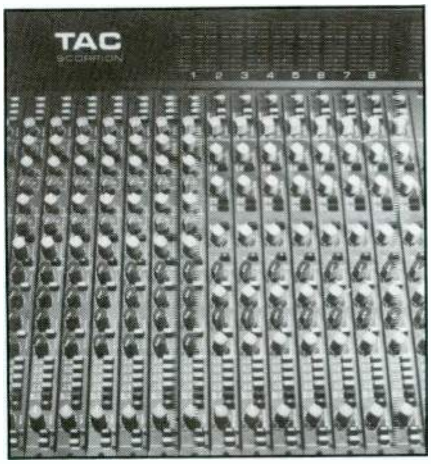
### Power conditioners

*Topaz* has introduced its line of "Super-Quiet" ESCORT micro power conditioners. They feature audible noise of 40dBA. They are available in line-cord/receptacle models from 70VA to 2kVA.

**Circle (377) on Reply Card**

### Stereo module

*Total Audio Concepts* (TAC) has announced the S1200 for the SCORPION range of mixing consoles. It features two electronically balanced line inputs with an impedance of 10kΩ. Gain for both inputs is controlled from the same rotary pot, covering −10dB to +30dB.




**Circle (378) on Reply Card**

### Pre-amps/amplifier

*Symetrix* has introduced the SX200 series of half-rack products that include the SX202 dual microphone pre-amplifier, featuring two microphone pre-amps with variable gain; 15dB pad; +48V phantom powering; left, right and left plus right outputs; the SX204 headphone amplifier, a 1-in, 4-out amplifier using proprietary high-voltage converter technology to drive high-impedance phones, while providing ample power for low-impedance phones; and the SX201 parametric EQ/pre-amp, featuring +15dB boost and −30dB notch filter capability, with unbalanced pre-amp input, balanced/unbalanced line-level input and balanced line driver output.

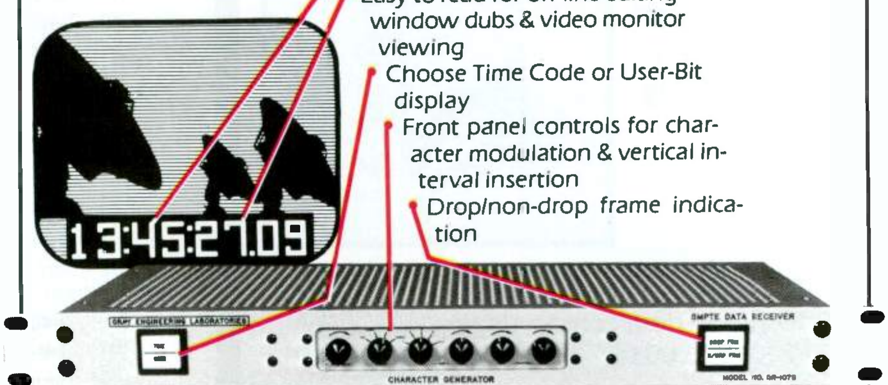
**Circle (379) on Reply Card**

### Imaging device

*Ultimatte* has introduced the Ultimatte-300. It is available in NTSC or PAL, and has the capability to reproduce shadows, transparent objects, fine strands of hair, the color blue and blurred objects.

**Circle (380) on Reply Card**





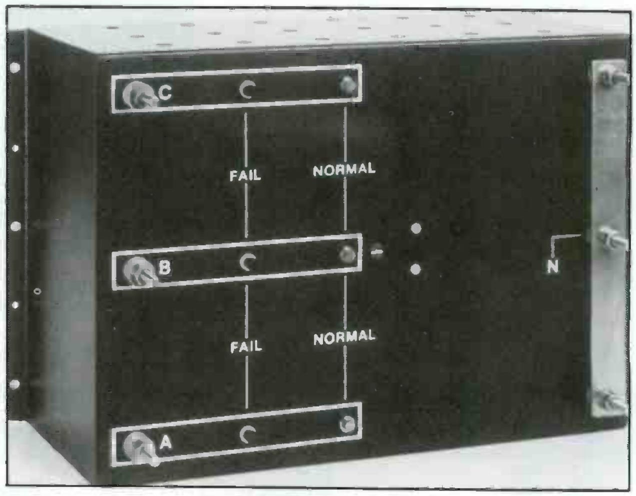
## Oscilloscopes

*Tektronix* has introduced the 2245A and 2246A PaceSetter oscilloscopes. They are 100MHz scopes that offer cursors readout and automatic setup. Also, the 2246A allows users to store/recall up to 20 front-panel setups. The 2246A offers more convenience and productivity features than the 2245A, including store/recall setups, smart cursors and voltmeter measurements.

**Circle (381) on Reply Card**

## Surge suppressor

*Transtector Systems* has introduced the ACP500-120MV surge suppressor, designed to prevent power disturbance problems frequently experienced in mobile vans equipped with computer systems or other sensitive electronics. The 14.5"x10"x6" unit features 1MW suppression capability.




**Circle (382) on Reply Card**

## Transmitters

*Vector Technology* has introduced a line of FM transmitters from 1kW to 40kW, plus an add-on power amplifier of 25kW. The line features a solid-state control system, a 12-phase power supply, built-in automatic power control and operator-selected VSWR protection or fold-back operation.

**Circle (383) on Reply Card**

## Grid antenna

The Mark antennas division of *Radiation Systems* has introduced the Mark Category "A" 6-foot grid parabolic antenna. Users can upgrade their systems from Category "B" with minimal, low-cost modifications. Because of its small size and low weight, more antennas can be placed on each tower and still not exceed maximum specified wind loading depending on the application.

**Circle (384) on Reply Card**

## Automation system and audio editing

*Soundcraft* has introduced the following products:

- The FAME (faders, auxiliaries, mutes and equalizers) automation system for the TS12 console exploits the console's flexibility by using the power of a 68000 16-bit microprocessor. The system features real time switching of three auxiliary send on/offs, channel cut and EQ in/out. The console is SMPTE/EBU time-code based.
- The Digitor records up to six minutes of stereo programs

into RAM memory. The program then may be edited in various ways, from basic copying, moving and deleting sections, to pitch transposition. The audio is recorded full 16-bit, 44.1kHz (switchable) sampling.

**Circle (385) on Reply Card**

### Insulator

*Rohn* has introduced a 24-foot, 80,000-pound guy line insulator for applications requiring high mechanical loads, such as FM installations needing insulated (invisible) guy wires near the antenna. The fiber-glass rods are equipped with galvanized end fittings, shipped in single 24-foot lengths.

**Circle (386) on Reply Card**

### Software

*Microtime* has introduced the Version 4.3 system software for Ani-Maker and Image-Maker 3-D graphics and animation systems. It includes scene scripting, velocity profiling and enhanced texture map performance.

**Circle (387) on Reply Card**

### Phase addition management system

*Seven Seas Audio* has introduced Audio Image Control, which allows broadcasters to improve the image, width and depth of the soundstage of 2-channel sources. The system recovers information lost when multitrack mixes are summed and compressed.

**Circle (388) on Reply Card**

### Tool kit

*Jensen Tools* has introduced the JTK-11 tool kit, designed for maintenance of broadcast equipment from control room to remote transmitting station. It contains more than 50 tools, and offers an optional 3/8-inch electric drill, 13-piece drill set, portable Vacu-Vise and Fluke 8021 digital multimeter.

**Circle (389) on Reply Card**

### Digital audio work station

*WaveFrame* has introduced the AudioFrame digital audio work station. The system includes modules for sound synthesis, storage and editing, signal processing and mixing and mastering, all housed in one compact unit. The user controls the system via an IBM PC. All software runs under the Microsoft windows environment.

**Circle (390) on Reply Card**

### Power line protectors

*MCG Electronics* has announced the SPC series of heavy-duty ac power line protectors. The 8"x8"x4" units are designed to protect sensitive electronic equipment against lightning transients and surges.

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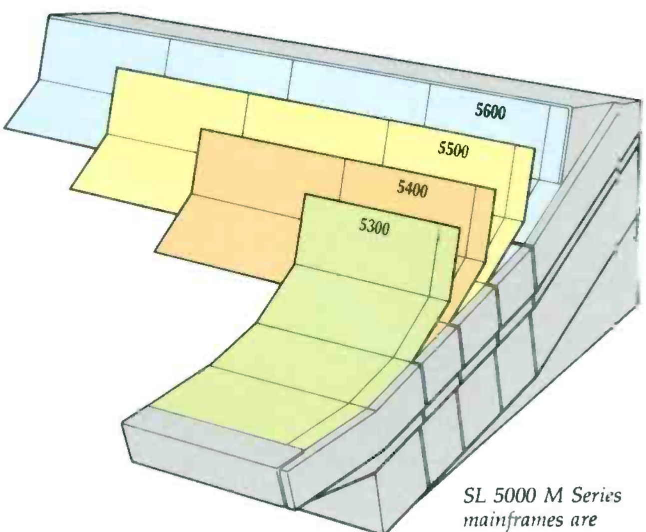


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