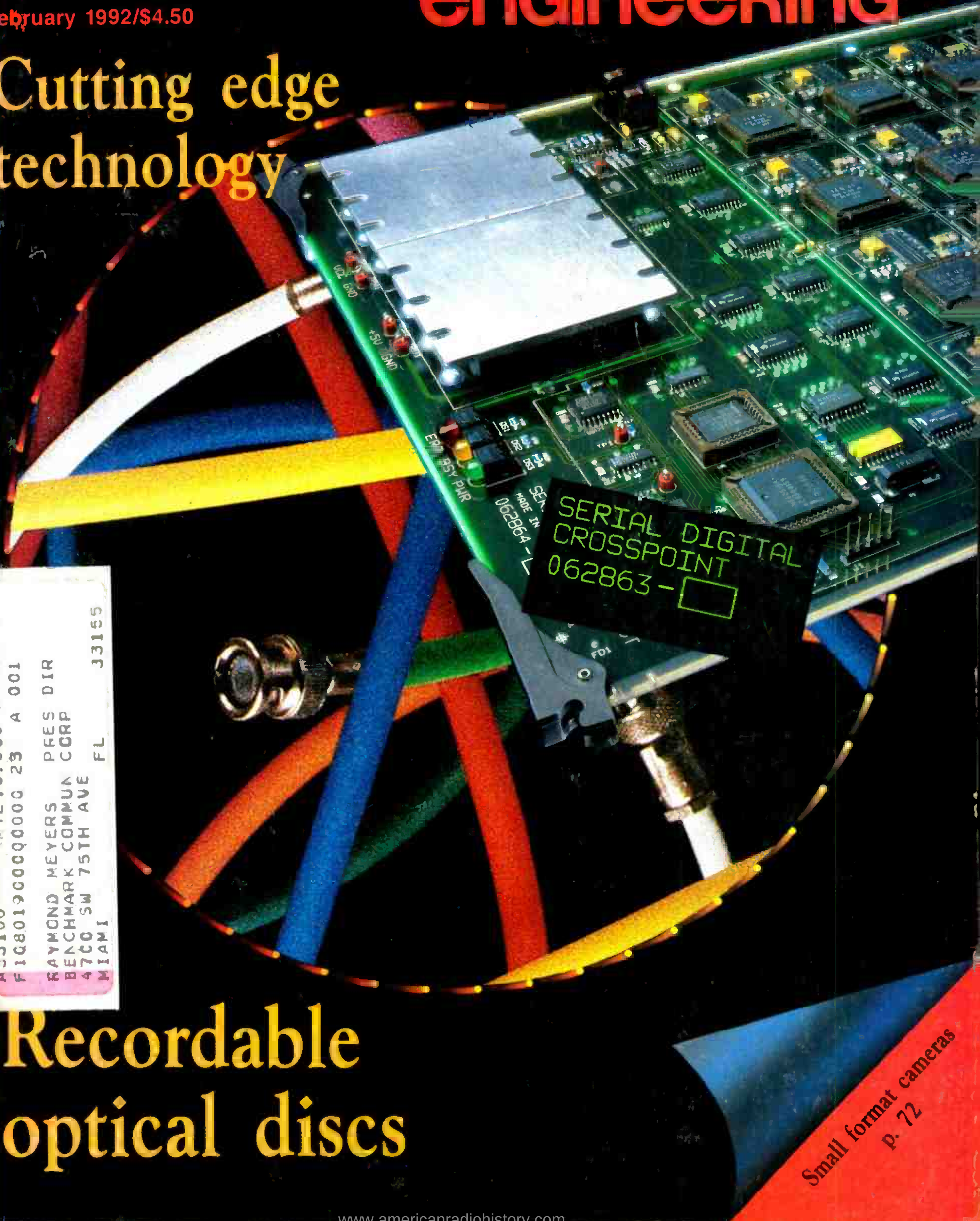
BROADCAST engineering

AN INTERTEC PUBLICATION

February 1992/$4.50

Cutting edge technology



Recordable optical discs

Small format cameras p. 72

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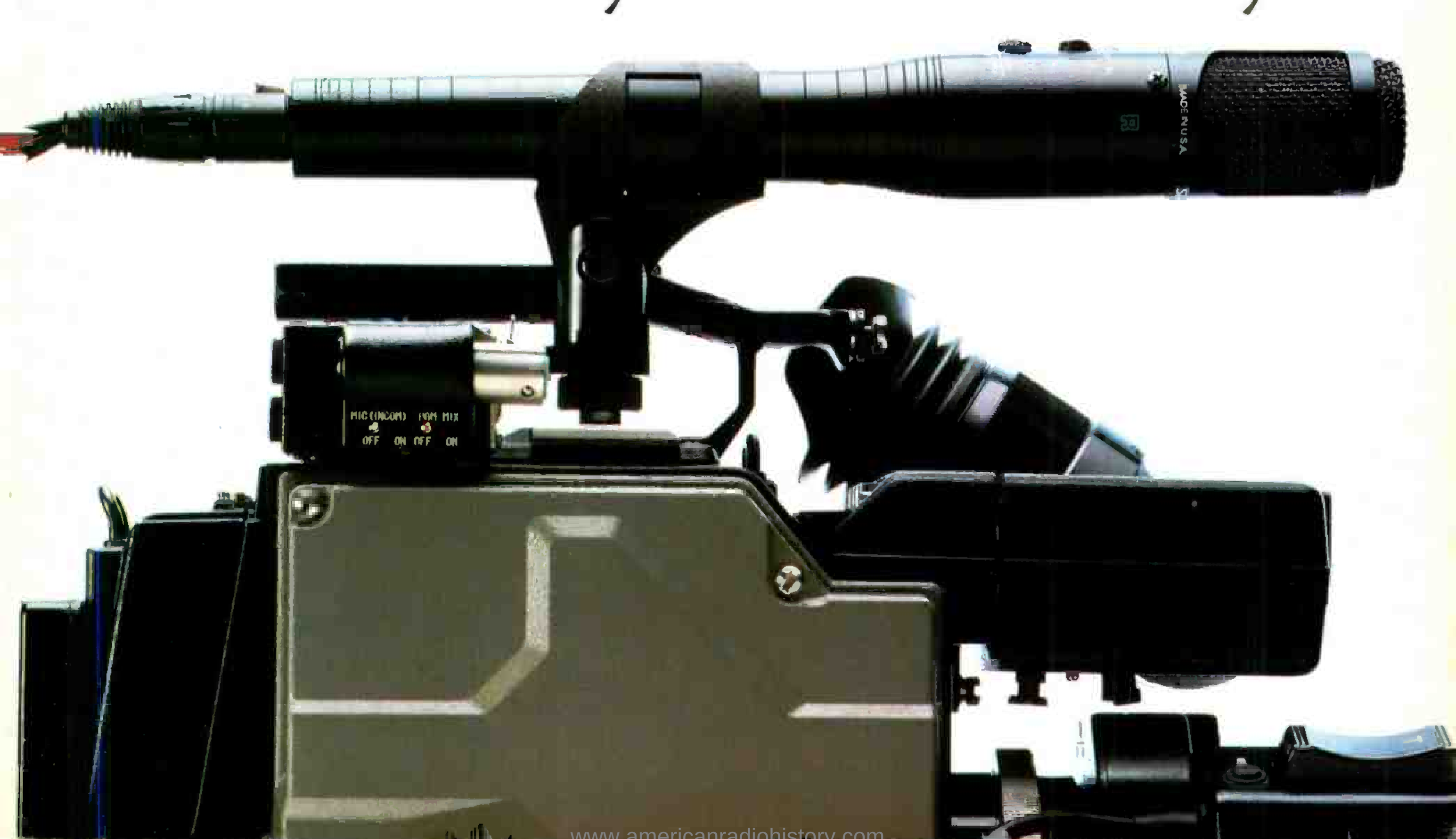

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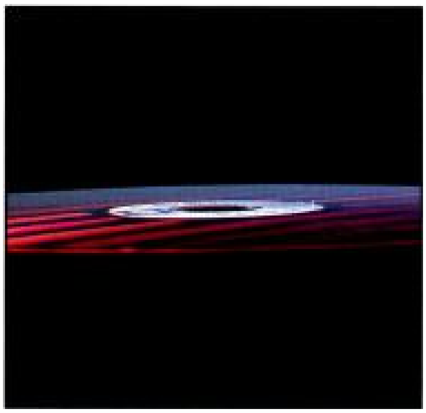

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CUTTING EDGE TECHNOLOGY:

When costs are up and profits are down, what's a station or production facility to do? In this business, engineers and managers have to take advantage of every break they can find. Sometimes that means looking for and using the latest technology before the competition does. Sometimes the key to financial success lies in using new technology before your competition does.

FEATURES:

OTHER FEATURE:

DEPARTMENTS

ON THE COVER

Serial digital video equipment continues to become more common as stations and production facilities discover its many advantages. The ease in installation and use make it a likely choice for those facilities upgrading or needing to modernize their equipment. The cover illustrates this by showing modern serial digital video hardware and the simple interconnect, coaxial cable. (Cover credit: Grass Valley Group.)

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Circle (5) on Reply Card

News

By Dawn Hightower, senior associate editor

SMPTE call for papers for fall show

A call for papers has been issued for the 134th SMPTE technical conference and equipment exhibit.

The conference is entitled "Images in Motion — The Second Century" and will take place Nov. 10-13, at the Metro Toronto Convention Centre in Toronto, Ontario, Canada.

Speakers at the program will explore innovations in imaging and examine advances and directions in established technologies. Authors who are interested in presenting papers must submit their name, company affiliation, address, telephone number and a 500-word synopsis to SMPTE headquarters, Attn. Marilyn Waldman, program coordinator, 595 W. Hartsdale Ave., White Plains, NY 10607, by June 15. The information should be submitted on forms provided by SMPTE headquarters. Authors will be notified before July 28 as to whether their papers have been accepted for the conference.

Two additional educational opportunities will complement the technical conference. An all-day seminar, entitled "The Post Experience," will feature a variety of post-production techniques using film-based technology. There will also be an all-day tutorial on multimedia.

An equipment exhibit will run concurrently with the technical program. More than 160 companies have already reserved space for the exhibition.

SBE extends its worldwide reach

The Society of Broadcast Engineers (SBE) has signed a cooperative agreement with the Broadcast Engineering Society (BES) of India. The agreement, signed in a ceremony during the first annual BES exhibition and seminar (held in New Delhi on Dec. 7), marks another milestone in SBE efforts to build a network of broadcast engineers worldwide.

The BES has approximately 800 members in India. It was founded in 1989 with the same basic goals and direction as the SBE.

Signing the agreement for BES was S.P. Bhatikar, president of BES. Representing SBE was Chuck Kelly, chairman of the society's International Committee. During the ceremony, Kelly praised the agreement affiliating BES with SBE as one which will allow increased communication and understanding within the profession of broadcast engineering.

The agreement with BES is identical to documents signed last October with the Korean Broadcast Engineers and Technicians Association (KBETA) and the Mexican Broadcast Engineers Association (AMITRA). It allows for the interchange of public documents between SBE and its affiliates, as well as providing for an exchange of information regarding the technical regulation of broadcasting in various countries. The agreement does not bind either organization financially and confers no voting privileges.

BOCA requests FCC to approve frequency coordination

The Federal Communications Commission (FCC) has been requested to approve frequency coordination during the 1992 political party presidential nominating conventions by the Broadcast Operations Coordinating Authority (BOCA). BOCA is a volunteer committee established to coordinate the use of RF equipment for the quadrennial events. The request to the FCC includes the assignment of temporary authority to BOCA for communications equipment in the unused spectrum space in UHF channels 16 and 18. Extreme frequency congestion is expected in New York for the Democratic National Convention during July and in Houston during August for the Republican National Convention.

BOCA chairman Mike Chiarulli of ABC indicated that requests received after Feb. 3 will be accommodated on an as-available basis. Due to frequency congestion in New York, no additional frequencies in the 450-455MHz business bands will be allocated. A proposal to use a "trunking system" to accommodate additional needs on a rental basis is being studied. BOCA is also coordinating the use of satellite transmission equipment from the sites of both conventions, including the parking areas available from the respective committees.

SMPTE to develop interformat image exchange

The Society of Motion Picture and Television Engineers (SMPTE) has begun working on a protocol that would permit

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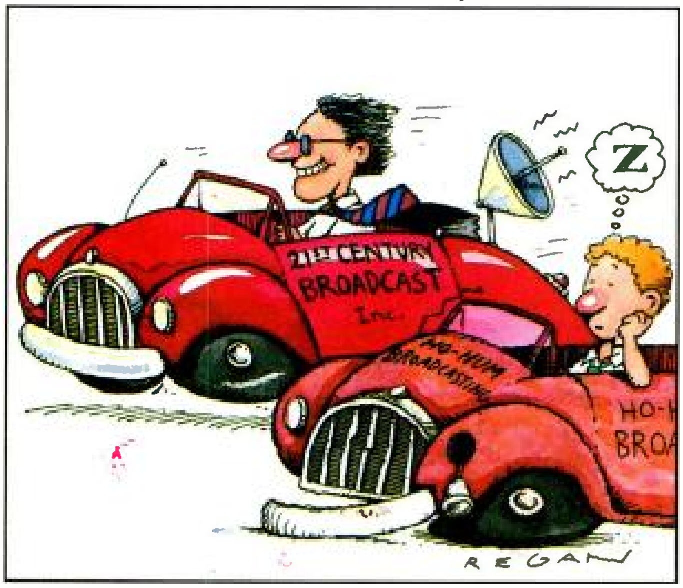
INTERTEC PUBLISHING CORPORATION

Editorial

Will you be left behind?

The key to success in any business is serving a need. Every operation within a business is somehow linked to that basic premise. For example, *finding a need to serve* is the basis of market research. *Implementing the service* is usually the province of engineering. *Controlling the costs* of such services is the accounting office's responsibility.

We broadcasters have been doing what we do without substantial change for decades. Refinements and upgrades in our systems and programming have certainly taken place, but the basic business understanding of our industry and how we can best serve it has remained static. During this time, the industry has prospered.



But the last few years have shown this long-established trend to be a fragile and reversible one. Downturns, diversification and dilution have taken their toll, leading to the conclusion by some, that broadcasting's bubble has burst.

One reaction to these conditions might be to search for the cause of this turnabout and attempt to counteract it. I believe a more fruitful direction is likely to be found in a total reappraisal of the marketplace, getting back to the common business mandate of serving a need.

Today, the most foresighted in our industry are doing just that — looking over the audience and assessing what needs exist, then figuring out how best to serve them. It's a new world, and it needs to be treated in a new way.

Many of these changes have been brought about by new technology. Broadcasting has forever been a pioneer and a beneficiary of technological development, but shrewd business acumen was also involved. The power of instantly reaching a mass audience, which broadcasting delivered for the first time, was not originally conceived of by Marconi and his cohorts. They had looked at radio as a point-to-point service only. The now seminal concepts of point-to-multipoint communication, news and entertainment programming, and advertiser support — all critical to the establishment of a burgeoning broadcast industry — were subsequent additions by de Forest, Armstrong and Sarnoff. These men approached the technology from a business direction and were motivated by what they saw as a potential for great profit.

Unfortunately, not all of their stories had happy endings, owing mostly to problems on the *business* side of their operations. This was a resonant lesson in the recent PBS program, *Empire of the Air — The Men Who Made Radio,* which chronicled these men and their times. A fascinating book and a radio drama both under the same name as the TV program also tell this story. These resources are highly recommended.

Those early broadcasters took the definition of engineering as "applied science" to heart, applying wireless transmission to broadcasting, for public service and private gain. Those who combined their pioneering vision with proper business sense (and a few who didn't) fueled a force whose momentum has propelled this industry for generations.

The issue is whether today's broadcasters will choose to regain that momentum by investing in their future. Some will choose to accept the status quo, hoping for someone else to improve their lot. They will suffer the consequences of their inaction.

Others, those who will be successful, will take control of their future and make the changes needed to survive in the 21st century. They will reap the rewards of those efforts. The question now becomes, will you be left behind?

Skip Pizzi, technical editor

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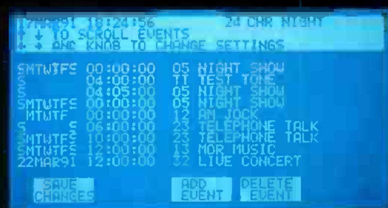

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"Hard look" policy to be modified

By Harry C. Martin

The FCC is proposing to liberalize its rules governing the acceptance of applications to construct commercial FM facilities.

The current "hard look" processing system has been in effect since 1985 and provides limited opportunities for amendments to correct tenderability or acceptability defects. The result has been the dismissal of many applications, with no opportunity for amendment.

Tenderability defects include errors, such as use of the wrong type of topographic map, incorrect plotting of the transmitter site coordinates or failure to complete a portion of the form. Acceptability defects include short-spacing, multiple ownership violations or defects involving non-compliance with FCC rules.

The hard look approach was designed to speed the processing of the large number of FM applications that were filed in response to the Docket 80-90 FM drop-ins.

Two options are being considered. Under option 1, the commission would perform a tender review shortly after receipt of applications. If tender defects are found, the commission would send a deficiency letter giving the applicant 30 days to correct the error. If acceptability defects are found later, the FCC would send another deficiency letter giving the applicant an additional 30 days to file a corrective amendment. Applicants unable to correct acceptability defects within the 30 days would be dismissed without an opportunity for reinstatement.

Under option 2, tender and acceptability review would be combined at one stage, which would include a "Notice of Receipt" of applications and then a "Notice of Tenderability and Acceptance." If, after the second public notice, an error still exists, a deficiency letter would be issued, allowing the applicant to correct the specific deficiency and any other errors in the filing. Applications still containing tender or acceptability errors after this opportunity would be dismissed without an opportunity for reinstatement.

The liberalization, if adopted, would not apply to defects resulting from the denial of a waiver request. In such instances, the commission will dismiss the application unless it includes, as an alternative to the waiver request, all information necessary to render the application tenderable or acceptable for filing.

The liberalization plan will apply only to applications filed after the effective date of the new rules.

Repeal of network/cable ownership ban

The commission again is considering repeal of the rule prohibiting common ownership of cable TV systems and national TV networks. As an alternative, it may permit network ownership of cable systems subject to safeguards that address competition and diversity concerns.

The commission wants to revisit the issue in light of continuing and far-reaching changes in the video marketplace. It noted that eliminating the rule may enhance network efficiency and generate public benefits. However, it also recognized the arguments made previously that complete repeal may undermine competition and diversity in local and national video markets. Therefore, it has solicited comment on options that would permit network ownership of cable systems subject to various constraints. The options include allowing networks to own cable systems in large or competitive markets, or where second competitive cable systems exist. The commission also will consider options that would allow networks to own cable systems up to a national subscriber limit, or subject to must-carry and discrimination safeguards.

Conflicts between FM allotments and applications

The FCC is proposing to use the deadline for filing petitions to deny against new and major FM applications as the cutoff point for rulemaking petitions that conflict with those applications. For minor modification applications, the cutoff date would be 30 days after acceptance of the application or grant, whichever is earlier.

Under current policies, new FM allocations generally take precedence over applications to which they are short-spaced, even if the applications have been on file for a longer period of time. This has caused undue expense and inconvenience to applicants whose "site preference" is considered of secondary importance to a new but conflicting FM allocation. The commission said using the petition to deny deadline as the cutoff date may be desirable, because it is well after applications have been accepted for tender and concludes a month after publication of a notice of acceptance for filing. However, the commission is seeking comments on whether an earlier cutoff point, such as the close of the filing window or the end of the amendment as-of-right period, would be preferable.

The commission is proposing to retain cutoff protection for dismissed applications until the dismissal is no longer subject to FCC review. Any changes that are adopted will apply to rulemaking petitions filed after the new rules' effective date, which will be 30 days after publication of the Federal Register.

Political programming policies codified

The commission has revised and clarified its political broadcasting rules to provide a comprehensive guide regarding licensees' political broadcasting obligations.

A July 1990 audit of 30 TV and radio stations revealed that political candidates often paid higher prices for airtime than commercial advertisers, primarily because they purchase time at non-pre-emptible, "fixed" rates, while commercial advertisers purchase time at "pre-emptible" rates. In addition, numerous inquiries were made to the commission in the wake of the audit. A single, up-to-date source describing the commission's political programming policies was needed, the agency said.

Policies and rules concerning reasonable access, equal opportunities, the lowest unit charge for advertising and maintenance of a public political file all were codified within Part 73 of the FCC's rules. ■

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

Part 2

Strictly TV

Camera video control

Matching multiple cameras

By Talmage Ball

Last month, this column reviewed the equipment and procedures needed to register and color balance a TV camera. On a single camera shoot, automatic setups are usually enough. For multicamera productions, at least one camera will probably need to be touched up. This is accomplished by using the camera painting and shading controls.

First steps

The first step to matching cameras is to chip them tightly. First check the encoders. This is done by viewing camera color bars on a waveform monitor and vectorscope. Checking for encoder errors now may save much twiddling later. Make sure each color vector is of the correct amplitude and phase. (See "Strictly TV," February 1991, for an overview of vectorscope usage.)

A problem with a bias light, lens aberrations or a light leakage may throw off black balance.

Next, check the *modulation shading.* Cap the camera, then raise the black levels to approximately 12IRE. The blacks should make one straight band across the waveform monitor. If the trace from one of the tubes bows up, down or tilts, that channel will need to be adjusted.

Black levels

To adjust the blacks, cap the camera. Raise the pedestal or master black level control to keep the blacks out of clipping. Adjust for minimal RF on the waveform monitor. The fuzzball on the vectorscope should be centered and tight. Restore the black level to 7.5IRE.

A problem with a bias light, lens aberrations or a light leakage, may throw off black balance. Check the balance against the black chips on the chip chart or against the felt patch (the *moustache*).

If color is seen in the blacks, first make sure it isn't the fault of reflected ambient light. Incandescent, mercury vapor and fluorescent work lights can cast light frequencies that are not visible to human eyes, but they can affect camera performance. If lighting is the problem, fix that first. Do not hesitate to ask to have these lights turned off as the cameras are being set up.

Chips ahoy

To use a chip chart properly may require moving all cameras close together and pointing them at the chart from the same angle. Off-axis cameras may detect different amounts of ambient light, therefore they will show different colors.

One advantage of a lightbox is that its internal lighting is consistent from camera to camera. If a lightbox is being used, tightly frame the shot to avoid contaminations from ambient light.

Zoom into the chart full screen. Start with the mid-range or gamma. Pick a chip that sits at 50-60IRE when the whites are at 95-100IRE. Using red and blue controls, null the excess chroma (make sure the scope is in *flat* mode). Not all camera controls have gamma controls.

Adjust the whites in a similar manner. However, while making this adjustment, either lower the whites to 90-95%, or turn off or raise high the white clip and knee settings. They can interact with the white level controls.

Flare affair

As the camera scans from white to black, some tubes will respond faster than others. This leads to inaccurate color tracking. A flare chart will help null these troublesome internal lens reflections. A flare chart can be made by mounting a black felt-lined box in the center of a white posterboard. Make a 6-inch hole to use for a black chip. Alternately, cut out the center of a chip chart and glue a box on the back. (See Figure 1.)

Focus on the posterboard. Bring the blacks up to 12IRE to be sure they aren't clipping. Set the whites to 100IRE. The blacks should still be balanced. If they are noisy, you may have a flare problem. Dial it out with flare compensation. Afterwards, recheck black balances. The two adjustments interact, so you may need to go back and forth a few times.

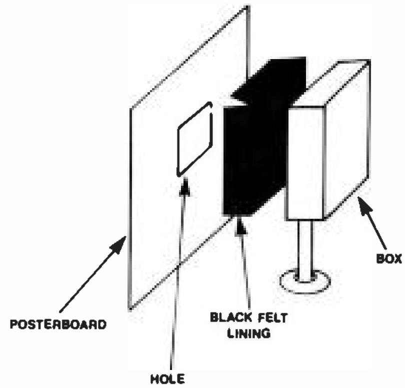

Figure 1. The flare chart is a convenient tool you can make yourself. Use it for checking black balance and flare compensation.

Clips and knees

After you have chipped the camera, push the whites into clipping (about 105IRE). If all clips don't engage at the same point, there may be a patch of RF near the clip point. This may shift the camera color on bright shots. Back off the clips, and reset them equally.

The knee circuits improve the camera's performance in high white areas. They help take off the shimmer. Check that knees track identically in all channels to avoid color shifts.

Finishing touches

Remove the chart, and focus all cameras on the same scene. Rapidly switch between cameras to see if there are any glaring differences. If one camera seems off, check to see if it is merely a reflection from a set piece, or cyc lighting. If it isn't, you may need to paint. More about that, and tips for CCD cameras, next month. ■

Ball is vice president, engineering, Bonneville International, Salt Lake City.

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Circle (9) on Reply Card

Some thoughts about the new AM rules

By John Battison, P.E.

By now, the initial impact of the new AM rules has worn off, and engineers are beginning to understand their meanings. Several of the old precepts have gone, and a few new ones need to be learned. One important new idea is the "improvement factor," which will be described later.

Filing for the new 1,605-1,705kHz band includes several tricky clauses that must be observed if it has any possibility of winning. Paragraph 73.30 of the new rules delineates the requirement for a petition for an authorization in the expanded band. The following are some highlights:

Successful applicants will be selected in descending order based on the calculated "improvement factor" (IF, not to be confused with *intermediate frequency*). The application with the highest improvement factor receives the lowest (in frequency) available channel.

If a desired channel is not available because it is already occupied by a higher-ranked station's allotment, the occupied frequencies in the market are examined to find out if an alternate channel is available.

If no channel is available for the applicant, it is discarded, and the next lowest improvement factor applicant is examined.

Who can apply

Until further notice, filing of petitions is limited to existing AM licensees (excluding Class C stations). The commission will periodically review the progress of movement to the new band and determine whether to allow application by new, non-licensed applicants.

An available allotment for which no full-time station has filed may be awarded to a licensed Class D station. In the event that more than one Class D station applies, ranking will follow these rules. First priority will be given to a Class D that: 1) lies within the 0.5mV/m, 50% contour of a U.S. Class A; and 2) is licensed to a community of 100,000 or more where there is no local full-time aural service. Class D's are then ranked in order of their improvement factors, and only stations with IFs greater than 1.0 are considered.

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

Filing for the new 1,605-1,705kHz band includes several tricky clauses that must be observed.

Stereo preference

A preference for stereo is given in the new band, but the ruling reads with significant potential for confusion. Here it is, word for word:

"When an allotment under consideration (candidate allotment) conflicts with one or more previously selected allotments (established allotments) and cannot be accommodated in the expanded band, the candidate allotment will be substituted for the previously established allotment provided that: the petitioner for the candidate allotment has made a written commitment to the use of AM stereo and the petitioner for the established allotment has not; the difference between the ranking factors associated with the candidate and the established allotments does not exceed 10% of the ranking factor of the candidate allotment; the substitution will not require the displacement of more than one established allotment; and both the candidate allotment and the established allotment are within the same primary group."

What this essentially says is that, all other things being equal, a stereo applicant will take preference over a mono applicant, and in fact, a stereo applicant could *overtake* a slightly higher-rated mono applicant under certain conditions.

Calculation of improvement factors

Paragraph 73.35 describes the calculation of the aforementioned improvement factors. IFs relate to nighttime and daytime interference conditions, and are based on two distinct considerations. First, how much service area is lost by other stations because of interference caused by an applicant's current station? Second, how big is the service area of the applicant's current station? These factors are considered as a ratio. Separate ratios are calculated for nighttime and daytime operations.

The description of the actual method for calculation of these ratios is somewhat tough sledding in the rules, but it generally takes the following approach: The interference areas of the applicant's current station are calculated for all existing co- and adjacent-channel stations. That area is subtracted from what the total service areas of those stations would be *without* the interference from the applicant's station (i.e., the total area that these stations would serve if the applicant's station did not exist). The result is used as the numerator in the ratio. The denominator is simply the applicant station's current interference-free service area.

The same general method is used for determining nighttime and daytime ratios, although the exact parameters of service and interference area measurements differ slightly between day and night calculations. Once calculated, the night and day ratios are added, and this single figure becomes the IF for the applicant station.

Obviously, the FCC's methodology awards allotments in the expanded band to those applicants whose current stations cause the most interference. In a sense, the greater benefit is experienced by stations who *don't* move to the new band (especially considering that they don't lose their old dial positions, familiar to existing listeners). But the *interfering* station has to initiate the petition to move to the new band. The stations being *interfered with* have no role in the matter (unless they also apply for expanded-band slots), and the FCC will not move stations involuntarily to the new band.

In the long run, this may help bring some listeners back to the band, along with the commission's other AM improvement moves. However, many feel that all these actions are too little, too late. Time will tell.

Editor's note: For the full text of the FCC's AM improvement rules, see "Report and Order, MM Docket No. 87-267: In the Matter of Review of the Technical Assignment Criteria for the AM Broadcast Service," Oct. 25, 1991. ■

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Part 2

Management for Engineers

Conflict resolution

Dealing with conflict

By Judith E.A. Perkinson

When dealing with conflict you can make it go away or you can make it worse. How you deal with conflict is the difference, it doesn't matter who started the conflict.

In order to deal with any conflict you should begin with a troubleshooting check list. Examine the conflict and ask yourself:

- Is it communication?
- Is it me?
- Is it *real* conflict?

What to do when it is communication

Communication problems are characterized by misunderstanding more than disagreement. The most counterproductive action you can take is to be self-righteous when dealing with miscommunication. It doesn't help if you assert that someone else "should have" understood. "Should have" reasoning has never solved a problem.

If a misunderstanding exists, the way to reduce or eliminate the resulting conflict is for you to take responsibility for the communication. The resolution of the conflict "should" begin with you.

In order to take responsibility for the communication you must make every effort to:

1) Make sure you understand what the other person is trying to communicate.
2) Make sure that the other person understands what you are trying to communicate.

To make sure you understand, ask questions, such as, "Are you saying...?" or "If I understand you correctly you want me to do..."

What to do when it's you

Be honest with yourself. Refer back to the issues covered in last month's column. Ask yourself — Did I overreact? Am I personalizing this? Is this happening because I avoided an issue? Am I being confrontive? Am I perpetuating the problem? Am I displacing my anger? Even if you're not comfortable being honest with the people around you, you must be honest with yourself.

If you're the problem, you have to make a choice. Do you want to continue the conflict or do you want to end it? If you want to end it then you will have to do something about the problem. One of the simplest, but not the easiest, thing you can do is to communicate the understanding that you are the source of the conflict and you want to find a way to resolve it.

What to do when the conflict is real

First you must understand what constitutes real conflict. It is when we are at odds with someone else's needs, opinions or purposes. When this happens, the resulting conflict must be dealt with in some reasonable and systematic way.

Many people may think that if two people are at odds then the end result will be that one will win and one will lose. If this is how conflict is viewed, it follows that instead of trying to be the one that wins we are also trying to make sure that the other person loses.

In reality, this approach to conflict resolution only guarantees one thing — everyone loses in the end. We lose friends, working relationships, resources, respect and security. The only thing we gain is one victory and an enemy.

When you are in conflict with another person you need to examine what you are at odds with. If purposes are at odds you must ask yourself if one purpose has to eliminate the other in order to exist. Can both needs be addressed? If not, can some agreement be reached that will ensure that there is equity in the resolution?

More often that not, when needs are at odds it is because each person has an idea of how those needs must be met and it is the method of meeting those needs that are in conflict. Look at what you *really* need and not at what you say you want. Once you have identified what you need the next step is to figure out how both of you can get what you need.

For example, Mike said that he wanted a maintenance report by 10:00 a.m., while Joe said that there was no way he could have it until 2 p.m. When both of them examined what they *needed* instead of what they *wanted* it was learned that Mike really needed a specific piece of information from the report while Joe needed extra time to generate the written report. When Joe agreed to give the specific information to Mike at 10 a.m., Mike agreed to give Joe additional time to complete the written report that supported the specific information. End of conflict.

If opinions are at odds the problem often becomes harder to solve. Opinions are important and it is often difficult to accept the fact that someone else has the right to feel differently. You must decide if you have a right to impose your opinion on another person. You could reduce conflict if you could agree to disagree. It sounds simple, but it is often difficult. We are all different, and it's how we deal with our differences that directly affects the amount of conflict we must deal with.

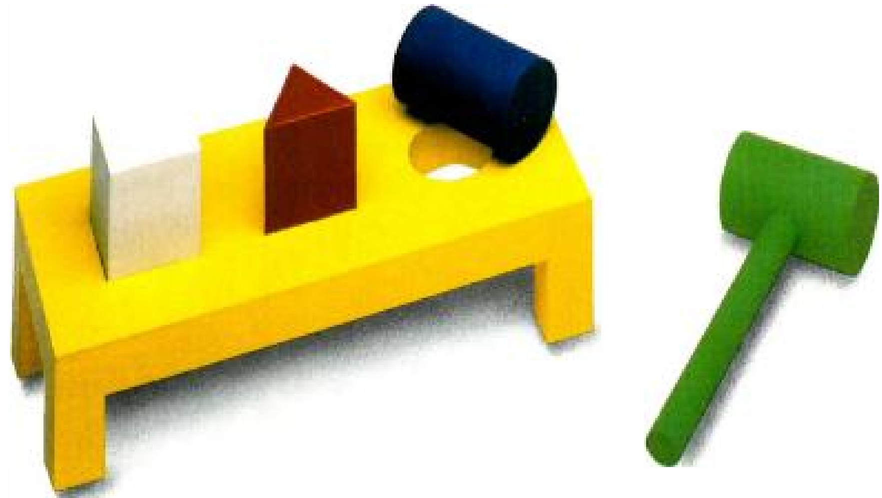
Attack the problem not the person

One last important element must be considered in dealing with conflict. You need to learn to attack the problem not the person.

One of the major barriers to resolving conflict is the tendency to attack people not problems. Many of us have been taught that when there is a problem the first thing to do is find someone to blame. Contrary to these teachings *the first step in problem-solving is not blame.* When you assign blame, the accused person becomes defensive, communication stops and conflict flourishes. Attack the problem and not the person involved in the problem, because solving the problem is more important.

There will always be conflict. So in order to deal with it you must first examine your role in creating conflict and make every effort to resolve to be part of the solution and not part of the problem. Next you must think about how you deal with conflict. When you can do this stress will be reduced and you will be a more effective manager. ■

Perkinson is a senior member, the Calumet Group, Inc., Hammond, IN.



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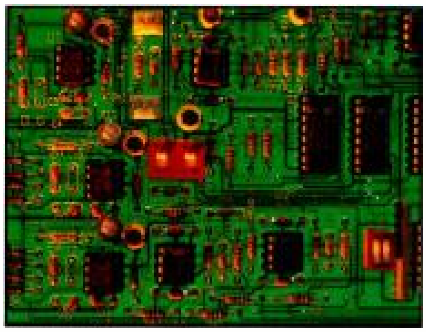


Digital video in computers

By Gerry Kaufhold II

In order to be able to provide effective decision support for station management, engineers will need to understand desktop video editing.

It takes three key technologies to bring complete video editing functions into desktop computers:

1. Video must be digitized and brought into the computer display.
2. This digitized video must be compressed and stored on computer-readable disks.
3. Broadcast-quality video must be output from the computer to video switchers and VTRs.

All three of these technologies will soon be available in low-cost silicon chip sets.

Analog to digital conversion

Analog broadcast video comes in two flavors — NTSC and PAL. Each of these has well-defined specifications.

On the other hand, color computer displays come in dozens of configurations, with a variety of resolutions.

It takes several operations to transform an analog video signal into a stream of digital bytes that can be displayed on a desktop computer.

Philips and Motorola, two semiconductor manufacturers, have recently announced low-cost chip sets that convert analog video from almost any source — NTSC, PAL, SECAM or S-VHS — into the CCIR 601 format. These chips were originally designed for use in high-end consumer televisions. They have been brought into multimedia as a way of expanding the early market for such chips.

Color space conversion

Color analog video signals were defined to provide compatibility with monochrome receivers. Color is a supplement to the luminance signal, and is provided as a difference between luminance and two chrominance values. This method of deriving color is called YUV color space.

Kaufhold is an electronics industry analyst based in Tempe, AZ.

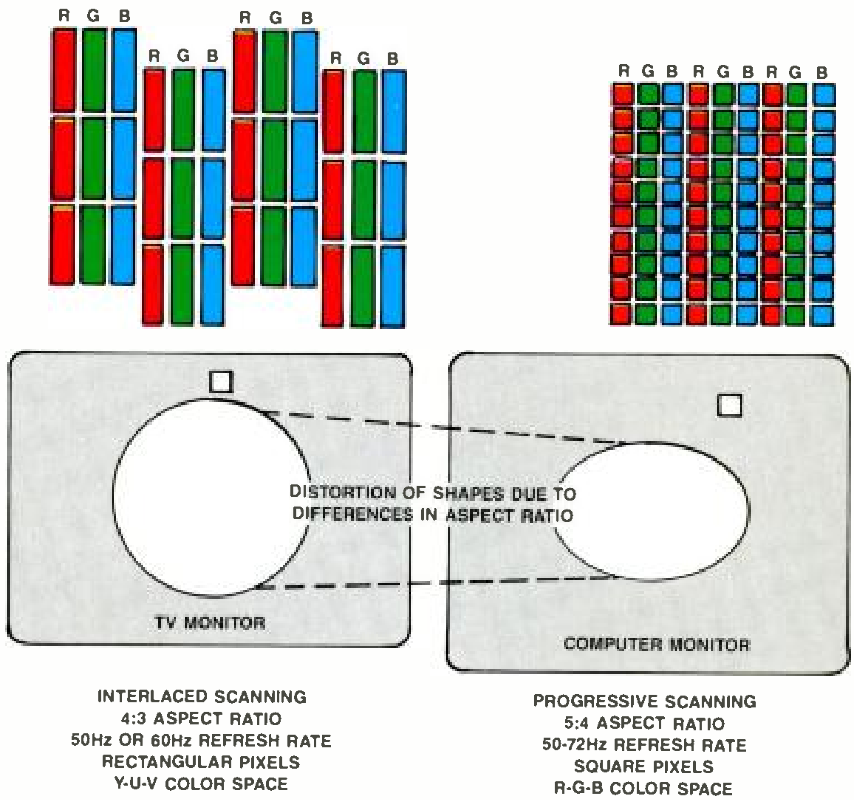


Figure 1. *This comparison shows several differences between video on a TV monitor and video on a computer display.*

Computer systems use a digital memory to hold a pixel-by-pixel image of the picture in their displays. Each memory location holds the color values of one pixel of the display. There are three colors: red, blue and green. Computers use RGB color space.

The chip sets that convert the analog video signal into the CCIR 601 format also perform color-space conversion.

Interlaced vs. progressive scanning

The computer stores digitized bytes of converted video in an area of memory called the frame buffer. A single frame buffer stores a pair of fields from the interlaced analog signal.

The computer display controller reads data from each *consecutive* location — effectively converting the interlaced video input into a progressively scanned digital output.

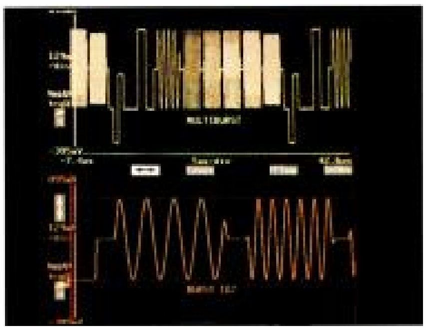
The frame buffer also helps convert the rate of screen refresh. The TV signal comes in at 25 or 30 frames per second. The computer display controller will read them out at any appropriate rate between 36 and 80 refresh cycles per second.

Rectangular pixels vs. square pixels

Figure 1 illustrates another difference between analog video and digital computer displays. A microscopic view shows rectangular pixels used for television. Square pixels used in computer displays are more densely packed. This produces a subtle distortion on a picture taken directly from a TV source. ■

Part 6

Troubleshooting



Optimizing 2-track analog ATRs

Routine maintenance

By M. Raymond Jason

The final installment of this 6-part series presents an overview of routine maintenance for analog 2-track ATRs, including a preventive maintenance schedule.

The two parts of any maintenance program are: 1) mandatory upkeep procedures, which include demagnetizing, cleaning, lubricating and aligning; and 2) exploratory performance testing to reveal progressive failure.

Demagnetizing

Magnetized tape-path components partially erase tape, and magnetized heads degrade an ATR's signal-to-noise ratio. Heads can become magnetized by a DC current generated by faulty or poorly designed upstream circuitry. Heads and other components can acquire magnetization from sudden accelerations (such as dropping) or from repeated exposure to rapidly changing transport solenoid fields.

Always turn off an ATR before demagnetizing it. The induced signal from the degausser is powerful enough to damage head pre-amp circuitry. Avoid degaussers with momentary on-off switches, because an accidental shutoff while touching a tape-path component can magnetize it to a level beyond the degausser's demagnetizing capacity.

Jason is an electronic engineer at National Public Radio, Washington, DC.

Cleaning

Three cleaning chemicals suffice for any tape machine: isopropyl alcohol, water and a mild alkali-based liquid cleaner (such as Formula 409). However, isopropyl alcohol is the best general cleaner. Unlike alternative solvents, it is non-toxic, readily available in pure form, and is less likely to penetrate and thereby damage bearings. It is also cheap and available in bulk from chemical suppliers (unlike expensive head-cleaning fluids). Many pinch rollers tolerate alcohol, but some tend to lose resilience. For those, use water. If in doubt, call the manufacturer.

Alkali-based liquid cleaners work better than alcohol on ceramic capstans, guides and erase-heads. However, you must finish by cleaning off the alkali cleaner with alcohol.

Aligning

In order to maintain a "sound" for your facility, the particulars of alignment are less critical than *consistency* of alignment over time and between machines. Naturally, all of your ATRs should be aligned to the same reference level and for the same tape stock. To keep azimuth consistent, use the same physical piece of tape for all azimuth alignments (or purchase a full reel of azimuth sweep or tone and splice sections of it into your other alignment tapes). Alignment tapes wear out, so replace them every year or two.

Because few ATRs exhibit perfect response, your bias and EQ alignments will usually involve some compromises. The engineers responsible for aligning a facility's ATRs should agree upon a common alignment technique, using the same procedures and target criteria. Ideally, you should not be able to distinguish the sound of one machine from another when each records and plays back pink noise. This is also a good test to run between formats, such as ATR-to-VTR.

Schedule

Preventive maintenance logically subdivides into four tiers of procedures, detailed in Table 1. Because these responsibilities are shared between maintenance technicians and operators in most facilities, the latter should be trained to recognize improper transitions between transport modes, tension problems, audio problems, noisy bearings and misadjusted brakes. The better an operator's vocabulary for describing ATR failures, the greater the potential for effective communication. ■

TIER	PROCEDURES	FREQUENCY
I	• Tape path cleaning • Visual inspection	At each reel change
II	• Degauss tape path • Electronic alignment • Azimuth alignment • Check tensions and brakes • Check head wear • Check pinch roller wear • Exercise switches • Check for bearing noise	Daily, weekly or monthly, depending on the facility's resources
III	• Check power supply voltages and ripples • Measure wow and flutter • Check pinch roller tension • Check EQ and heads with flux loop • Check bias frequency • Check erasure depth	Every 2 to 3 months
	• Lubricate bearings	Check manual
IV	• Clean relay and card contacts • Inspect reel motor brakes • Inspect reel motor brushes and rotors • Clean and lubricate fans • Rotate/replace worn guides and lifters	Semi-annually to annually

Table 1. A suggested preventive maintenance schedule for ATRs, broken down into four tiers. Tier I is performed by all ATR operators. Other tiers are handled by maintenance engineers. Note that tier III is exploratory in nature, and tier IV involves significant disassembly.

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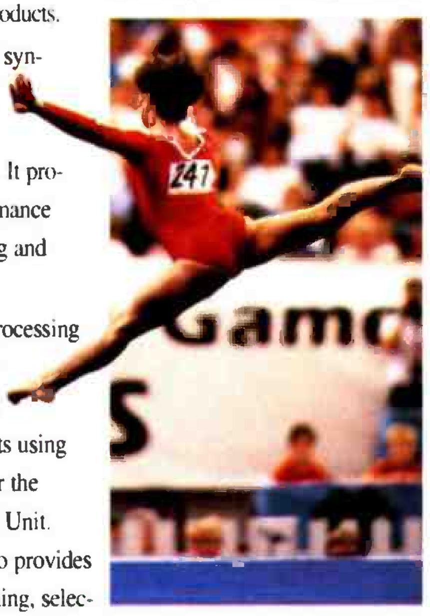

Rely on the VS210 for synchronizing feeds and you'll see no decoding artifacts or picture shifts. It provides transparent performance through 10-bit quantizing and 4-field memory.

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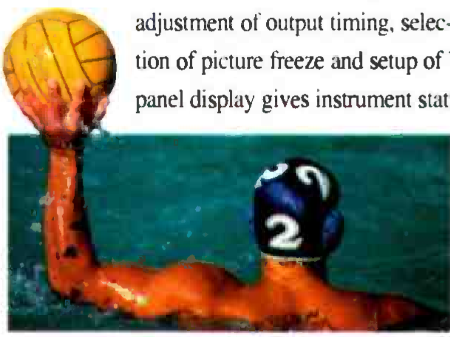

And for flexibility in system design, the VS210 provides composite analog and composite digital inputs and outputs.

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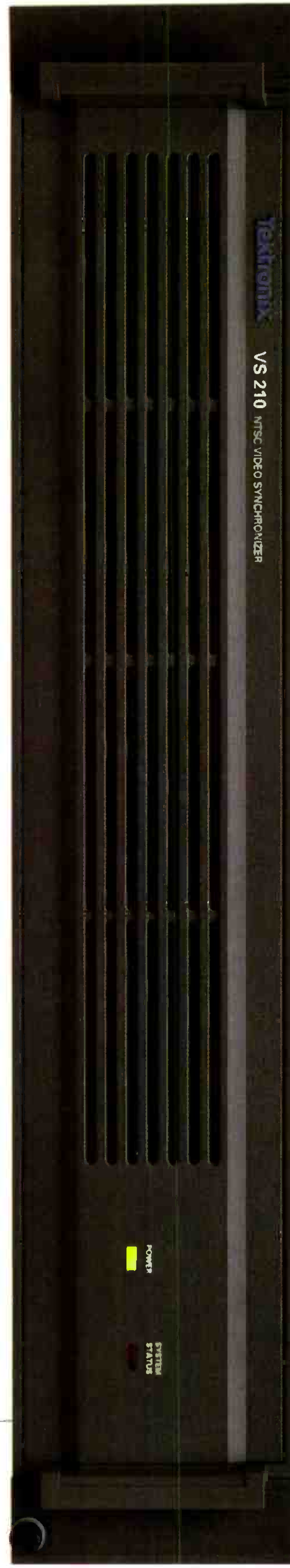

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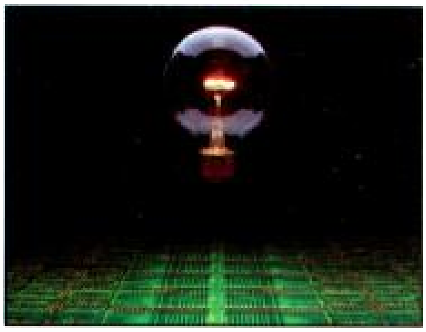


Color from monochrome?

By Carl Bentz, special projects editor

Thirty years ago, as color television moved into the smaller markets, several attempts were made to produce color pictures from black-and-white receivers. Among them were enterprising TV manufacturers who used color filters over the CRT. A light blue at the top for sky, green on the bottom for grass and a warm hue across the middle gave outdoor scenes a strange hint of surrealism.

A more scientific attempt was to gate signals from the three tubes in the camera. In theory, by sampling each color at the right frequency, even a P4 black-and-white CRT would produce pictures containing color tints.

Today, a visibly successful method does create saturated color images from a monochrome CRT with color filters and gating. It is vaguely reminiscent of the general idea of the CBS (sequential) color system, where the appearance of color depends upon the temporal integration of the three color image fields. A shadow mask image spatially integrates sets of three glowing RGB phosphor dots.

The secret of operation is in the gating performed by a special type of LCD called a *pi-cell*. Pi-cells rotate RGB information by 90° or leave it unaffected, depending upon the voltage state of the cell. Two such cells are used in conjunction with neutral and pleochroic (color) polarizers. Pleochroic polarizers pass only one color of light along one axis, but all colors are permitted along an orthogonal (90°) axis. The combination forms a liquid crystal shutter. (See Figure 1.)

Red, blue and green are sequentially switched to a single electron gun of the CRT at three times the field rate (180Hz). Synchronized with the signals going to the CRT, the two π-cell arrays with neutral and color polarizers control the amount of light of each primary color in the signal that is allowed to be emitted. (See Figure 2.)

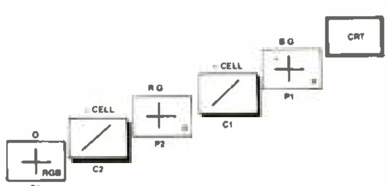


Figure 1. The color shutter is composed of neutral and color polarizers with two π-cell LCDs.

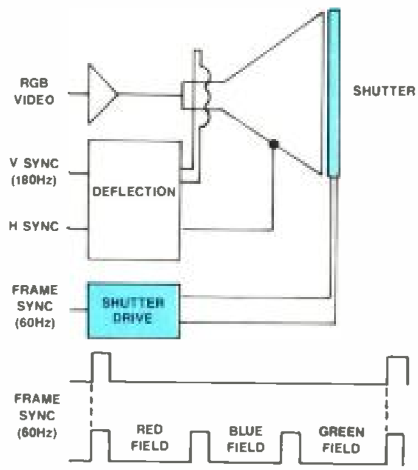
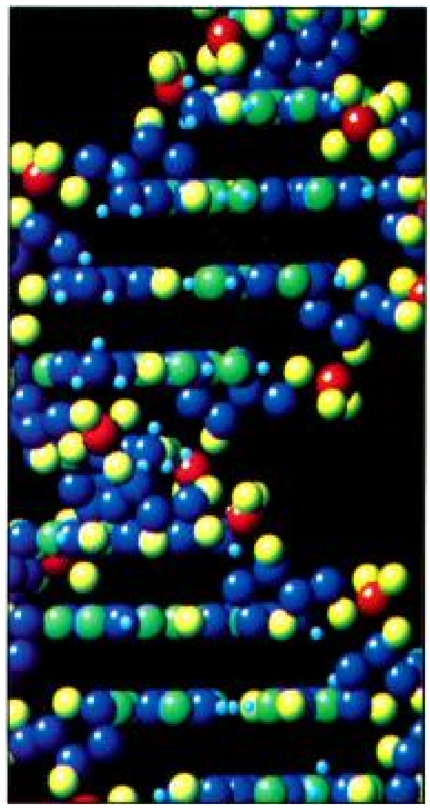


Figure 2. Vertical deflection is increased to a 180Hz field rate. Control of the state of the π-cells is synchronized with the color signal being fed to the CRT.

Actually, a P4 phosphor is probably not the most suitable for this application, because the light emitted by P4 has an overabundance of blue with a secondary emission of yellow, and they are at different persistence levels. The phosphor used with a shutter system ideally is peaked to the primaries.

The image produced with a shutter exhibits several advantages over standard P22 tricolor phosphor tubes.

1. The resolution is controlled by a single spot, the size of which can be maintained at about 10 mils in a monochrome display. (The beam spot of a 0.31mm CRT is approximately 22 mils.)
2. Inherent convergence is achieved because all writing to the screen occurs from a single electron gun.
3. A high degree of color uniformity is maintained across the entire screen and from monitor to monitor.
4. For a given screen size, the depth of the monitor cabinet can be less than that with a typical color CRT.
5. The system operates equally well with raster or vector displays and accommodates magnetical or electrostatic deflection.
6. A variety of screen sizes up to 19 inches has been successfully adapted to color with this system.



A small segment from a screen shot produced with a color shutter system.

The color shutter technology has been directed for use with graphic arts workstations and applications involving personal computers, instrumentation displays and desktop publishing systems. Although this type of monitor has not been officially introduced to the video production and broadcast worlds, you can expect to see more of this concept in the near future.

Acknowledgment: Background information on the NuColor Shutter technology was provided by Tektronix.

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It seems that everywhere we turn today, someone is crying that the sky is falling. Unemployment is rising, the trade deficit is front page news and many see little reason to hope for better times.

People have been crying wolf for years and today's headlines really aren't much different than in years past. What we've learned recently is that our industry isn't immune to the realities of economics. Stations have been forced to deal with the reality of lower profit margins and increased costs. In some cases, this has resulted in the loss of jobs.

Although these changes have been painful, there is room for optimism. In fact, sometimes the best opportunity for success is when times are tough — like now.

A company can deal with adverse economic situations in two ways. For one, the company can simply cut back, reducing expenses as much as possible. This tactic is just to stay alive, hoping that improvement in the overall industry's health will save it from disaster.

A second option is for the company to decide to take control of its future and invest in new tools to make it more productive, efficient and capable of providing a better product to the audience. The first scenario involves little risk. Of course, it also offers little chance of reward, either.

The second approach involves risk but at the same time can position the facility to leapfrog the competition as times improve. Savvy engineers or technical managers will look for those technology tools that can help their companies meet today's economic challenges.

Fortunately, today's broadcasters have more tools at their disposal to improve profits than ever before. Automated systems, digital production techniques, more efficient transmitters and many other areas are the beneficiaries of new technology.

Today's broadcasters have the advantage of technology that our predecessors could only dream about. So much so that our modern, efficient and reliable systems are often taken for granted. We expect CD-quality from our audio chains. Digital video techniques are commonplace. Today's hardware is light years ahead in terms of the sophistication and reliability that many of us cut our teeth on. Yet, we sometimes fail to use these new tools to our own best advantage.

To be successful today, engineers and managers have to look for every break they can find. Sometimes that means using the latest technology — before the competition does. It's no longer possible to be a "me too" facility. If you wait until everyone else has the technology, you'll be losing much of your audience.

Success in every area involves some risk. The key is for those trained in the technology to balance carefully those risks against

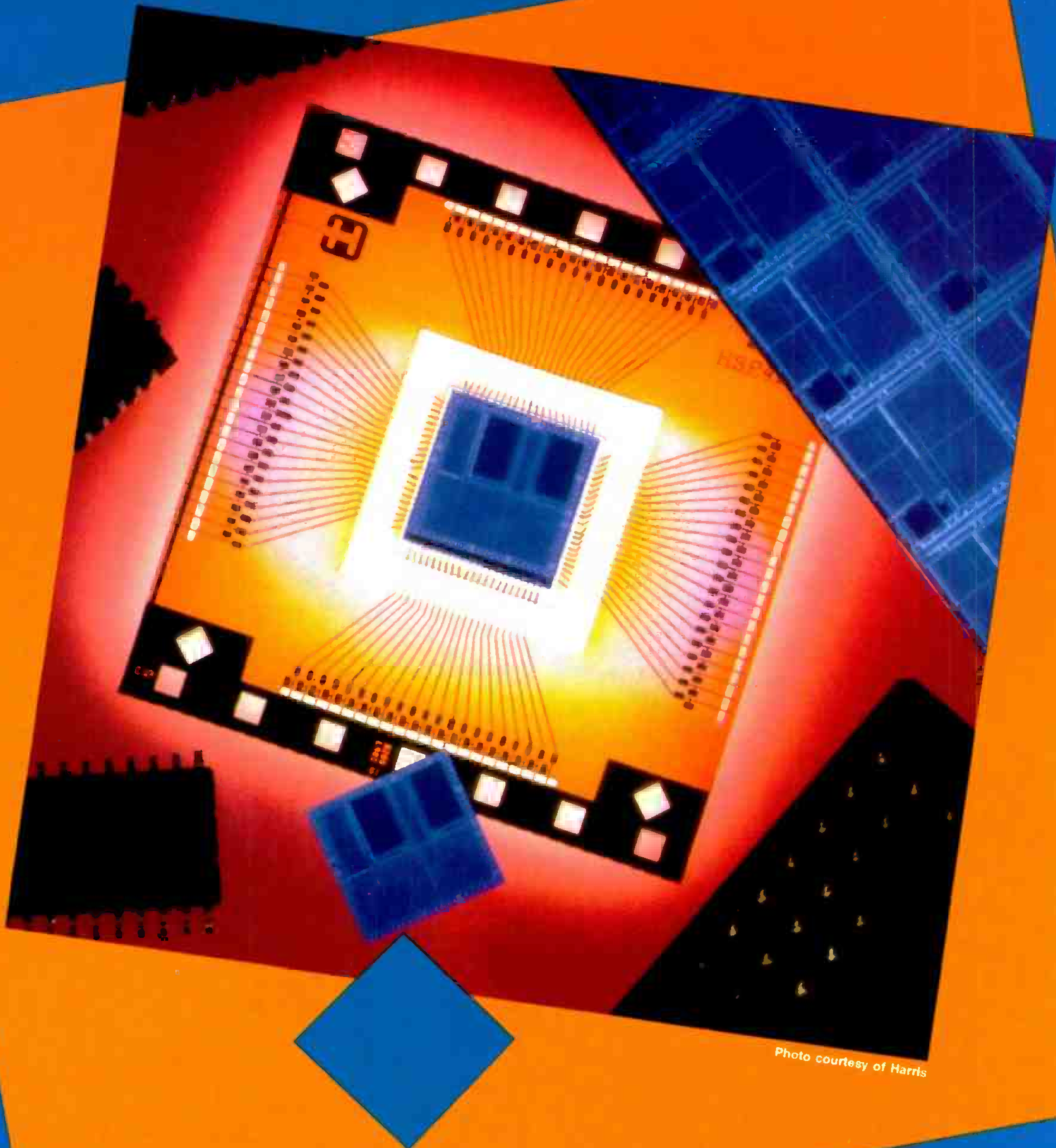

Photo courtesy of Harris

the rewards. Those who can do this are much more likely to find themselves leading, instead of following, the pack. What will your station do? Are you a follower or a leader?

This month's issue highlights several technologies that can be implemented today to improve your facility's operation. The only decision is whether you'll be first — or last.

Brad Dick, editor

With our line of production monitors, trying to

—natch these greens won't give you the blues.

Or yellows. Or browns. Or reds. That's because Sony's advanced line of production monitors feature the broadcast standard SMPTE C phosphors to assure true color matching of monitors throughout your facility. Which means your least critical monitor will always match your most critical monitor.

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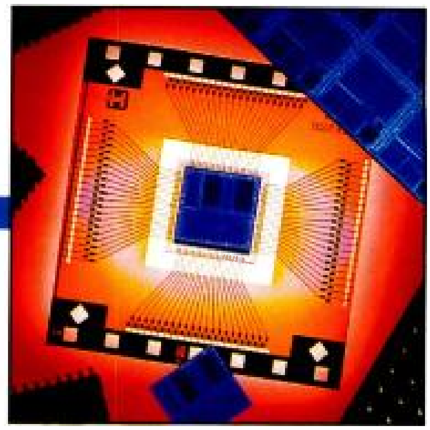
Optical disc video recording



Optical disc technology is "rewriting" the book on video storage.

By Skip Pizzi, technical editor

The Bottom Line

Optical disc recording is attractive to broadcasters in terms of cost, reliability and convenience. A videodisc machine holds fewer moving parts and requires less mechanical maintenance than a VTR. The random-access nature of the disc medium makes it ideal in some production applications for still and motion video. A variety of different formats exist, each providing somewhat different benefits. An understanding of these systems' particulars will help inform any purchasing decision, and allow optimal matching of project and product.

$

Recent developments in storage systems for computer platforms have resulted in dramatically improved capacities and performance, at significantly lower cost. This technology now has the ability to keep pace with the bandwidth and transfer rates of broadcast-quality video. Because of computers' need for random-access storage, these storage systems are all disc-based. As the technologies have merged, an increasing number of analog and digital techniques have come into use for recording video to optical disc.

The success of the compact disc (CD) and LaserVision (LV) videodisc formats have accelerated laser optic recording techniques. For the consumer market, these formats are exclusively playback-only systems (as yet). However, the industrial and professional markets have embraced *recordable* optical systems, primarily for their faster access time (compared to videotape) and their advantages (relative to magnetic discs) of high storage capacity, high reliability and removability. Such systems are already found in some of today's broadcast TV equipment, where their lower complexity and maintenance requirements (compared to VTRs) is another welcome attribute.

Recordable optical systems are available in erasable and non-erasable forms. The latter are commonly referred to as WORM (write once, read many) formats. Another acronym sometimes applied to any recordable videodisc system is DRAW (direct read-after-write). This refers to these systems' ability to immediately play back recorded video. They do not require the extensive post-processing (subcoding and directory writing) required by recordable CD formats for compatible playback.

The three basic categories for today's optical disc video systems and their attributes are listed in Table 1.

Playback-only (ROM) systems

The best consumer LV systems are capable of 425 lines of horizontal resolution and 48dB of video signal-to-noise ratio. As with CDs, these are playback only or read-only memory (ROM) discs, which are mass produced by a stamping process. (The pits on such a disc's surface are among the smallest items ever manufactured in mass production.) Slow motion/freeze frame, S-video outputs, and compatibility with the variety of audio and video sizes and formats currently available are common features found on consumer players.

At the industrial level, LV players have enjoyed growing acceptance in interactive applications for training, presentation and education. Serial control and a relatively short access time make them an extremely cost-effective choice for situations that require random non-linear playback without true instantaneous access. Their interactive control abilities have made them useful in training applications. Custom pressed LV discs are now available overnight, for as little as $300 — even in single quantities.

In the industrial and consumer worlds, these machines play discs manufactured in either the constant angular velocity (CAV) or constant linear velocity (CLV) laserdisc format per the IEC's LV and CD-V standards. Twelve-inch CAV discs allow 30 minutes of linear play and up to 54,000 still frames per side. Twelve-inch CLV discs allow 60 minutes of linear play per side, but still-frame and variable speed play features are only available on some high-end CLV players with digital storage.

Advantages for broadcast

The use of a non-linear, random-access playback system offers a significant savings in tape-shuttle time. The additional attributes of non-destructive editing and substantial reduction in preroll time can provide more chances and choices to get it right during a given production session. The simplicity of the hardware and the use of non-contact media add reliability, lon-

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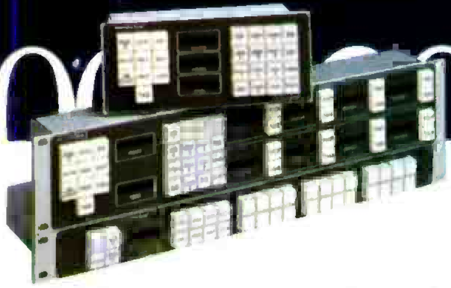

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However, to meet the needs of the post-production market or the broadcast industry today, any new video recording system must be at least technically equivalent in performance to existing state-of-the-art analog and digital tape-based formats. To be successful or simply survive, it must also demonstrate a significant advantage to the end-user in order to justify the risks and complications of an additional recording format. Furthermore, the use of erasable media is generally a plus, although write-once systems have their applications, primarily in archiving. WORM media is also much cheaper than rewritable for similar capacities, as shown in Table 1.

Write-once systems

A wide range of technologies is used in WORM optical disc systems. One commonly used technique employs selective laser heating to cause two metallic layers to alloy themselves into a metal of greater density, and therefore smaller volume, leaving a depression in the metallic surface at that point. This area will scatter the light from the lower-powered playback laser, while the undeformed areas will reflect it. A similar approach uses a reflective and heat-absorbing layer under a transparent polymer film. The record laser heats the reflecting layer, which melts the polymer film above it, causing that spot to no longer be reflective upon playback, because of the diffraction of the melted spot in the film. One further variant burns holes though a thin reflective layer, while another causes bubbles to form in it. In each case, reflectivity index changes are caused during playback.

Another method uses laser heating to cause an irreversible "phase change" from an amorphous to a crystalline structure, with the latter's higher reflectivity detected upon playback. Finally, dye-polymer techniques can be used, whereby record laser heating changes the color of a light-absorbing dye layer over a reflective surface. This system uses lasers of two different frequencies (i.e., colors), one for record and one for playback. Each of these systems has its strengths and weaknesses in terms of cost, durability, density and

TYPE	FORMAT NAME	DISC SIZE	ENCODE METHOD	VIDEO FORMAT	AUDIO FORMAT	DISC FORMAT	CAPACITY PER DISC	MEDIA COST
ROM	LV	12"	STAMPED	ANALOG COMPOSITE	AFM+OPT. 16-BIT PCM[1]	CAV	60 MIN.	N/A
						CLV	120 MIN.	
	CD-V	5¼"	STAMPED	ANALOG COMPOSITE	16-BIT PCM+ OPT. AFM[1,2]	CLV w/ OPT. CAV.	20 MIN.	N/A
		8"					40 MIN.	
		12"					120 MIN.	
WORM	PANASONIC OMDR[3]	9"	PHASE-CHANGE	COLOR UNDER	AFM	CAV	13 MIN.	149
		12"	PHASE-CHANGE	ANALOG COMPONENT	AFM	CAV	30 MIN.[4]	245 SS
							60 MIN[4]	395 DS
	SONY CRV	12"	ALLOY	ANALOG COMPONENT	8-BIT PCM[5]	CAV	48 MIN.	395
	TEAC	12"	ALLOY	COLOR UNDER	AFM	CAV	60 MIN.	299
							30 MIN.	299
				RGB				
				DIRECT COLOR				
ERASABLE	PIONEER LASER-RECORDER	12"	M-O	ANALOG COMPONENT	8-BIT PCM[5]	CAV	64 MIN.[6]	1,295
	PANASONIC OMDR REWRIT.	12"	M-O	ANALOG COMPONENT	AFM	CAV	30 MIN.[4,7]	1,150 SS
	ASACA	5¼" ISO	M-O	DIGITAL COMPOSITE	(STILL-STORE ONLY)	CAV	1,500 FRAMES	250
	ASACA HDTV	5¼"	M-O	DIGITAL HDTV	(STILL-STORE ONLY)	CAV	200 FRAMES	550

1. Sixteen-bit PCM is CD format, f_s=44.1kHz, 16-bit resolution. Audio format listed is for NTSC only. PAL/SECAM LV discs have either PCM or AFM, not both.
2. NTSC only. PAL/SECAM CD-V discs have no AFM audio.
3. OMDR format using 8-inch media (introduced in 1983) is incompatible with 12-inch OMDR (introduced in 1987). Eight-inch hardware was discontinued, but media is still available.
4. Higher-resolution option gives 20 minutes (36,000 frames) per side.
5. Eight-bit PCM is similar to 8mm/Hi-8 PCM audio, f_s=31.5kHz, 8-bit resolution, with analog companding noise-reduction added.
6. Thirty-two minutes in higher-resolution mode.
7. Sixty minutes. DS media expected mid-'92. OMDR rewritable is not compatible with either OMDR or WORM format.

Table 1. *Comparison of consumer and professional optical disc color video systems. LV and CD-V are essentially compatible with each other in NTSC versions, but all other formats listed are mutually incompatible. All audio formats are 2-channel. Capacities quoted are maximum per disc (total for both sides in 2-sided media). SS = single sided, DS = double sided, noted only where both types are available. Multiply running times by 1,800 to determine total still-store capacity in frames (e.g., 60 minutes = 108,000 frames). Media costs are list price per disc, in single quantities.*

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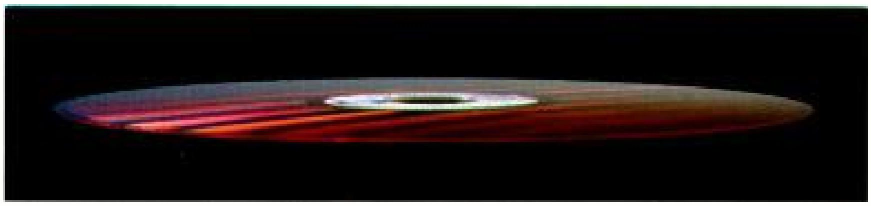

Photo courtesy of Optical Disc Corporation

longevity.

The non-erasable nature of WORM discs requires audio to be recorded simultaneous with video — no subsequent inserts or dubs can be made.

Erasable systems

Although erasable optical disc technology also exists in various types (such as reversible phase-change and dye-polymer methods), its most popular form is the magneto-optical (MO) method. MO technology, also known as thermomagnetic or optically assisted magnetic recording, combines the erasability of magnetic media with the density of optical techniques. It also tolerates many (approximately one million) rewrite cycles, with a projected 10-year minimum longevity.

Figure 1 shows a simplified MO disc. Its magnetic domains are arranged *vertically* for greater density, as opposed to lying flat along the tape, as they do in tape-based media. (Magnetic heads typically cannot take advantage of this density because their fields cannot be constrained to such small areas.) A blank disc begins with all its domains of uniform magnetic polarization.

During recording, the disc is exposed to a magnetic field that is too weak to coerce a change in the magnetic polarity of these domains (typical coercivity is approximately 25,000e). However, when a high-powered laser illuminates a small spot (1μm) on the magnetic layer, the temperature of this area (alone) rises to or beyond its so-called *Curie point* (around 150°C), at which time its coercivity drops dramatically and it now *is* affected by the weak magnet. As the disc turns and the spot cools, these domains retain their changed magnetic polarity. Meanwhile, as other domains pass by without heating (laser off), they remain unchanged from their original state. (See Figure 2.)

For playback, a phenomenon known as the *Kerr effect* is employed, whereby laser light reflected from a magnetic surface has its polarization slightly shifted as a function of the magnetic polarity at that point on the reflective surface. "North" polarity rotates the beam in one direction, and "south" rotates it the other way. A lower-powered laser is used for playback so that no further heating of the disc occurs. The direction of the reflected beam's polarization shift is sensed by an optical receptor, which then outputs a corresponding electrical signal. (See Figure 3.)

Unlike magnetic discs, MO systems cannot be re-recorded by simple overwriting. A separate *erase* step must occur before recording over previously used parts of any MO disc. Here, the high-powered laser simply stays on and scans the entire disc. But the polarity of the magnet is reversed from its record condition, turning all magnetic domains uniformly back to their state prior to recording. The disc is now ready for re-recording, using a magnet returned to its earlier polarity and selective heating from the high-powered laser.

On some systems, a dual head design allows one head to erase while the other is writing. This design is also used to speed access time during random-access playback, because one head is used to seek the next data address while the other is playing. Switching between heads is accomplished during the vertical interval, allowing real time non-linear editing. An example of this is shown in Figure 4. MO disc rotation speeds vary with systems, ranging from 1,800rpm to 3,000rpm.

In one of its most recent forms, MO is editor-compatible with video and 2-channel audio insert capability, and a capacity of 32 minutes of analog video or more than 57,000 frames per side, using a 12-inch disc. Video MO drives can read and write time code (usually as an option). Analog composite, component and RGB inputs and outputs are typically standard. These systems record FM analog component video with 8-bit noise-reduced PCM digital audio.

Disc encoding formats

In the CAV and CLV LaserVision modes, composite analog video frequency modulates a video carrier at 8MHz, and two discrete audio FM channels (AFM) are modulated ±100kHz at 2.3MHz and 2.8MHz. The three signals are added linearly and fed to a limiter that outputs a pulse-width modulated (PWM) signal, which is used to create the rectangular pits on a master disc. The CD-V variant adds a separate stereo digital audio carrier below the picture and AFM carriers (extending up to approximately 1.75MHz), using the 44.1kHz-sampled, 16-bit linear PCM format employed on audio CDs. This encoding is now common on most NTSC consumer LV releases as well. PAL/SECAM format laserdiscs use lower frequency carriers for the AFM signals (648kHz and 1,066kHz), occupying spectrum required by the digital audio carrier so simultaneous AFM and digital audio is not allowed. Separate PAL/SECAM LV discs are issued with AFM or digital soundtracks.

On the professional side, a wide variety of formats also exists. Some systems intended primarily for computer video applications can directly record full-bandwidth RGB signals, with each component recorded sequentially as a sepa-

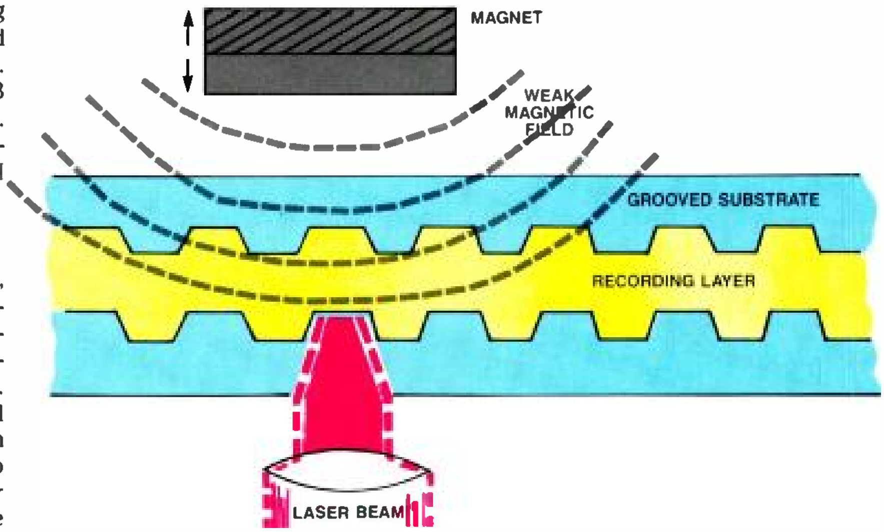

Figure 1. Simplified cross-section of a magneto-optical disc, showing alternating pattern of preformatted grooves in substrates of both sides of the disc. Whenever record laser is energized, recording layer is heated to a temperature at which the weak magnetic field affects its polarity. Magnet's polarity is inverted during erase mode.

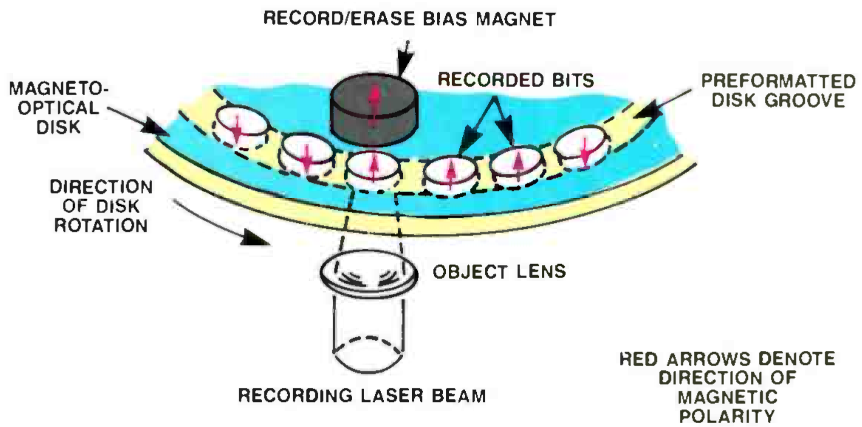

Figure 2. *MO recording process, showing vertical magnetic domains. Upward arrows denote bits that have been heated by laser and turned in polarity by magnet. Downward arrows are bits that have not been heated.*

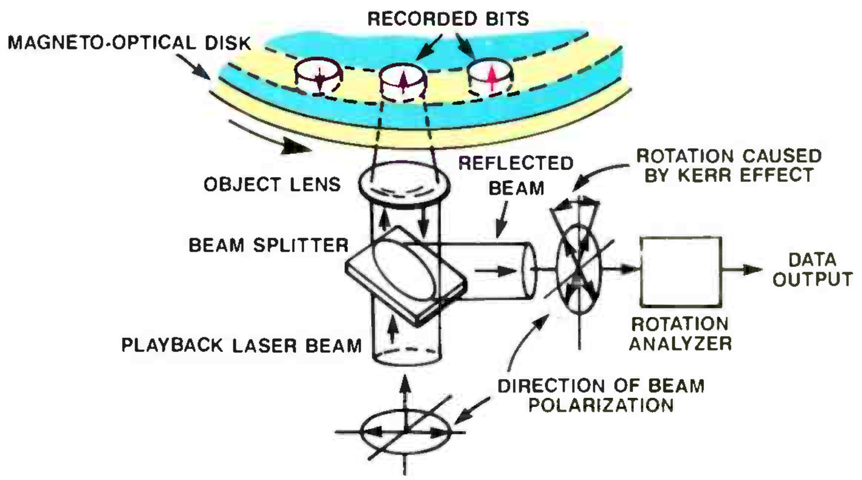

Figure 3. *MO playback process, showing slight variations in rotation of polarization plane of reflected light, caused by variations in magnetic polarity of disc surface.*

rate frame. Buffers are used to hold video fields while each component is separately recorded, and to collect the components for field reassembly during playback. Recently, this has become possible at real time, using a 90f/s recording rate.

Alternatively, some systems send the video signal through digital processing (flash-conversion) before recording. Here, the analog composite video input is decoded into Y and C components and sent through an analog-to-digital converter (ADC), quantized and clocked into a memory buffer. While in the digital domain, the color-difference signal is compressed down to a 0.7MHz bandwidth, taking advantage of the human eye's inability to discern color in small detail. The luminance signal is compressed at a 1.2:1 ratio. The luminance and color difference signals are then clocked out of memory through a digital-to-analog converter (DAC), frequency modulated, and (along with the audio information) recorded to the disc sequentially in the analog domain. The technique is called time-compressed analog component recording, and is used by some recent MO systems.

Another approach uses MO discs to record *digital* composite video. For fully digital MO applications (data, digital audio, digital video, digital 1125/60 HDTV), the ISO standard MO disc format is commonly employed. It uses a preformatted (CAV), 2-sided 5.25-inch disc with 650Mbytes of total data capacity. The discs must be manually turned over and reinserted in most drives, allowing 325Mbytes of continuous recording per side. Some systems — generally used for digital audio applications — place two MO drives in a single recorder, alternating between them for longer continuous record times.

Because uncompressed, high-quality stereo digital audio requires approximately 10Mbyte/min, the ISO format can hold approximately an hour's worth on each

disc (a half-hour per side). However, uncompressed digital composite video requires approximately 750Mbyte/min, filling up such a disc in less than one minute. Nevertheless, that translates into about 1,500 NTSC frames of digital composite video on removable media, which can work nicely as a framestore in some applications. Multiple drives can be slaved to an editing system's control, putting thousands of digital video frames on-line for quick access.

Some manufacturers of digital video MO systems (for NTSC and HDTV uses) have deviated from the ISO standard to increase capacity or transfer rate. This is necessary because a single 1125/60 HDTV still image takes approximately 6Mbytes of storage, and full-motion 30 frame/s (uncompressed) NTSC digital composite video (8 bit, 4fsc) requires a transfer rate of more than 12Mbyte/s. MO disc capacities of 1.2Gbytes or more are now available, as well as recorders using multibeam heads for transfer rates greater than 15Mbyte/s. (Standard MO drives have output data transfer rates around 1Mbyte/s.)

Application of digital audio and video bit-rate reduction systems may extend these capacities in the future. (See "Digital Audio Data Compression," pg. 52.) However, the multiplicity of incompatible formats is likely to remain or grow larger in the professional world.

Such format variety extends to blank media, both WORM and rewritable. In all cases, each format of videodisc recorder uses a proprietary media and/or proprietary formatting, with blank discs available only from the hardware manufacturer. In some cases, different models from the same manufacturer require different discs.

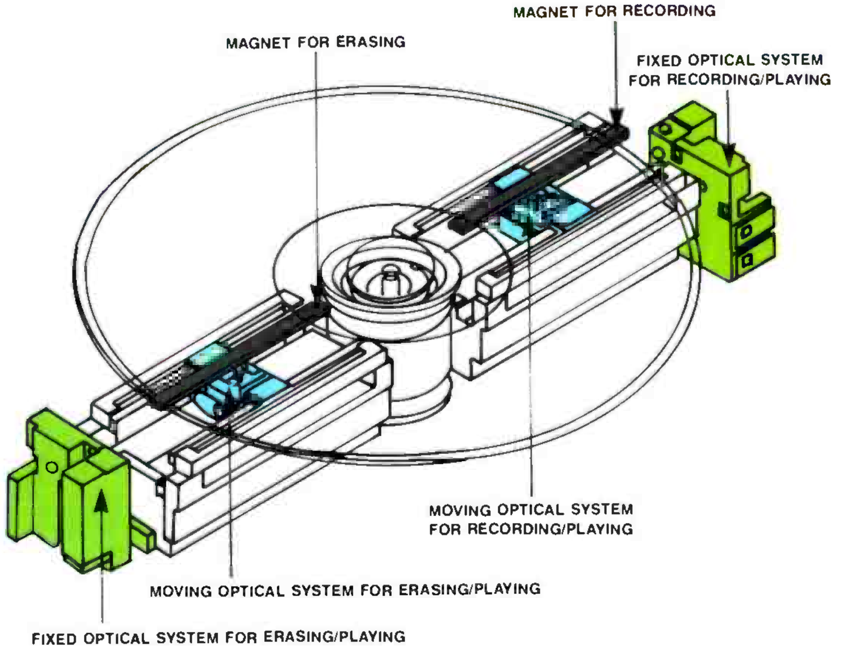

Figure 4. *Two-head MO drive uses one head for erase or play, and the other for record or play. This allows simultaneous erase/record, using both lasers at high power, or faster access during playback by using two play heads at low power. Lasers and receptors are mounted horizontally in fixed units, with prisms and lenses in moving units.*

Real world applications

Integrating videodisc hardware into a tape-based broadcast or teleproduction fa-

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...635A thrown in the path of a Seattle Transit bus and ran over repeatedly.

"Next time have exact change, pal."

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Kent – DJ from KPLZ, in Seattle.

"You Can't Keep a Good Mic Down"

...635A devoured by the jaws of a car crusher.

"Job stress."

...635A eaten by a lawn mower.

"Just a little off the top please."

...635A teed off by a wicked one wood.

"Par for the course."

...635A watched a bowling match from atop a headpin.

"Cheap seats."

Result of these heinous crimes:

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inflict 'serious damage' was a blast from a Seattle Police ***shotgun***. To fix this serious damage, we had to go to the trouble of hooking up a wire. ¶ ***Frustrated*** by our attempts at physical damage, we decided to try a ***psychological*** approach. A life insurance salesman gave our 635A an hour-long presentation, but the mic emerged ***unfazed***. There were no noticeable effects or damage. ¶ The microphone looks and ***sounds just fine*** after going through these torture tests. Of course, it's bent and twisted a bit, but then again, aren't we all? The *635A 'Hammer' from EV* is truly one incredible, indestructible microphone."

Alan – DJ from KPLZ, in Seattle.

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cility can allow each system to do what it does best. This implies the use of videodisc recorders for repetitive playback of short duration segments, still video storage and single-frame recording, with VTRs freed for longer-duration playback and multigenerational video effects layering and editing.

Most optical recorders are versatile in their interface capabilities to the analog video and audio signals found in today's teleproduction facilities. This makes their integration simple, as long as postproduction concerns are not locked to the acquisition format. Most optical machines can also handle true single-frame recording, whereas most VTRs cannot. This function becomes especially useful in capturing output from computer-graphic processes in which single frames are generated at less than real time. Some optical systems also include programmable interval recording (for single-frame "time-lapse photography"). In addition, most videodisc machines come equipped with one or more standard control protocols, further enhancing their integration abilities. RS-232 and RS-422 are most common. This feature makes videodisc players well-suited for cable TV commercial insertion, a recent popular application.

Real time non-linear playback allows a recording of a program to be aired in an edited form without re-recording it. Instant replay for sports programming is another ideal application for videodiscs. For this use, some systems include slow-motion playback and multiple cue-point marking on-the-fly.

Most optical machines can handle true single-frame recording, whereas most VTRs cannot.

Clearly, videodisc technology can provide a substantial increase in productivity — if your facility has a clear need for its application. Consider the following:

- Do you constantly produce many short-duration elements for live or edited productions with short shelf lives?
- Are these elements likely to change their order of appearance from one day of production to the next with little advance notice?
- Could you use the ability to prepare several edited versions of the same raw video without having to record each finished edit in its entirety?
- Would you like to be able to spend more time previewing the potential results of different edit decision points?
- Do you find that keeping tape machines in pause for extended periods of time contributes to increased machine maintenance and tape dropout?
- Are you doing auto-assemble editing that seems to involve a large percentage of time waiting for machines to find their next preroll point?
- Would you like to reduce the number of machines required to do complicated edits and layering in one pass?

If the answer to any of the above is yes, you may find that the virtually instant access, non-linear, non-contact medium of optical disc video recording offers some attractive advantages.

Although tape-based recording formats remain the medium of choice for many applications into the foreseeable future, optical disc video recorders will continue to find a welcome home in editing suites around the world.

Acknowledgments: Thanks to Sumio Ohya, ASACA/Shibasoku Corporation of America; John Adamson, Electronic Cottage International; Dave Oren, Fostex; Owen Smoot, KSL-TV; Lynn Yeazel, Panasonic Optical Disc Systems; Sandy Benedetto and Rob Goldfarb, Pioneer Communications of America; Nicole Bandel, Sony Business and Professional Products Group; and Jay Giles, Teac America, for their help in preparing this article. ■

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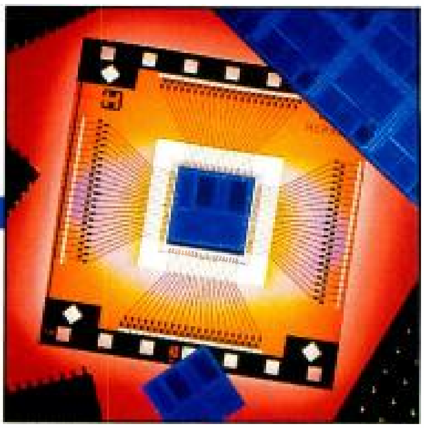
Data rate reduction technologies



New compression technologies take a byte out of data rate technologies.

By Tom Bentsen

The Bottom Line

The more pictures and sound that can be compressed onto a given media, the lower the costs to store, retrieve and transport it. Unfortunately, many new compression technologies will be just as enabling to competing information providers, such as cable and the telephone companies, as they are to broadcasters. If this technology delivers like it promises, market fragmentation due to VCRs could be just the beginning of the broadcasters' worries.

Just a few years ago, the word *compression* evoked memories of sleepless nights spent with the AM transmitter. In those days, engineers carefully adjusted Gates Level Devils and other appliances to squeeze as much audio as possible into FCC-compliant sidebands.

Compression in broadcasting grew out of the need to stuff more audio information, of which there was a lot, into bandwidth, which there was not enough of. Most early audio compressors evolved from the need to maintain higher average modulation levels within the limitations of the FCC rules.

Compression has recently come to the forefront with its use by digital audio and digital video advocates. Advanced TV (ATV) systems, in particular, depend on this technology. These systems must reduce a signal having approximately 20MHz luminance bandwidth and 7MHz chrominance bandwidth into the required 6MHz channel for transmission.

Station management must be aware of trends in compression to appreciate how the industry is progressing and to evaluate the competition offered by other carriers, especially telcos and cable.

Compression vs. bit rate reduction

The word compression and its kindred term, *bit rate reduction*, are often used interchangeably, which is not correct. The two techniques are different. In broadcasting, however, they both serve the same purpose — to reduce large visual or audio data rates to smaller, more manageable levels.

Compression reduces data rates by employing statistical and higher-order mathematical means to remove redundant information. What is kept and what is thrown out is based upon redundancies, relational dependencies, motion predictions and relative entropy levels. Bit rate reduction, on the other hand, reduces the data rate by discarding information that is superfluous or imperceptible under stated listening or viewing conditions.

Although compression can be used for any data type, bit rate reduction is most efficient when used with source information that is perception-based, such as audio, video or image information.

Bentsen is a broadcast engineer investigating advanced video systems for space-based and ground-based applications at NASA, Washington, DC.

Lossy or lossless?

Compression or data-reduction schemes are required any time the desired information is larger than the available channel. However, such systems aren't worth much if too much information is destroyed by the compression/decompression process. There is a trade-off between the degree of compression and the quality of the reconstructed image or sound.

The reduction of information for processing is either *lossy* or *lossless*.

Lossless compression implies that, when restored, the information is close to a perfect reproduction of the original. Lossless systems typically use low compression ratios of 3:1 or less. This produces few perceived artifacts or errors. This is highly desirable for preservation of critical information but not if a large amount of information must be sent in a short time or through a narrow bandwidth.

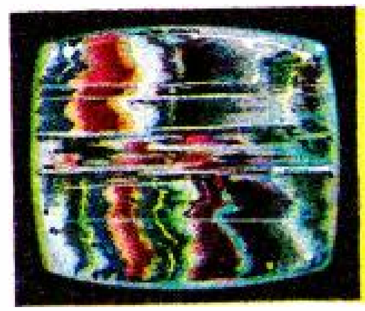
Lossy compression systems are popular. However, they have various trade-offs that can produce perceptible *artifacts*. The real skill to employing compression is how well these artifacts are reduced, disguised or rendered imperceptible.

Bit rate reduction systems may end up offering the greatest potential for broadcasting. This is because their potential lays in removing components of the picture or sound that cannot be perceived. This is called *conservation of information*.

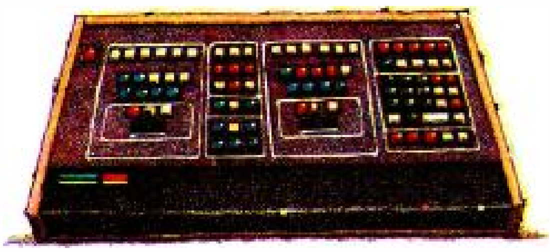
Continued on page 42

B-rolls

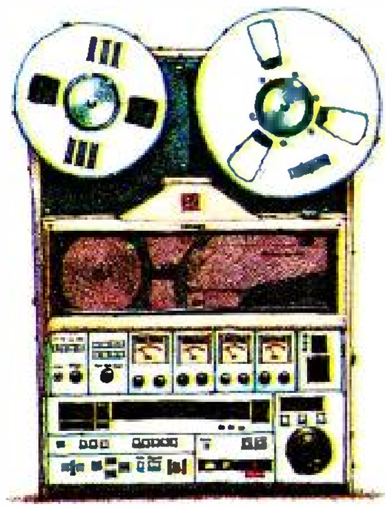
Production Switchers



Fuzzy Freeze Frames



Separate Edit Controllers



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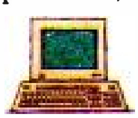

interface, and the real heart of the system, the NEC VUES VSR-11 solid state recorder.

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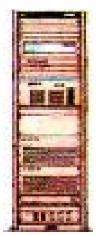

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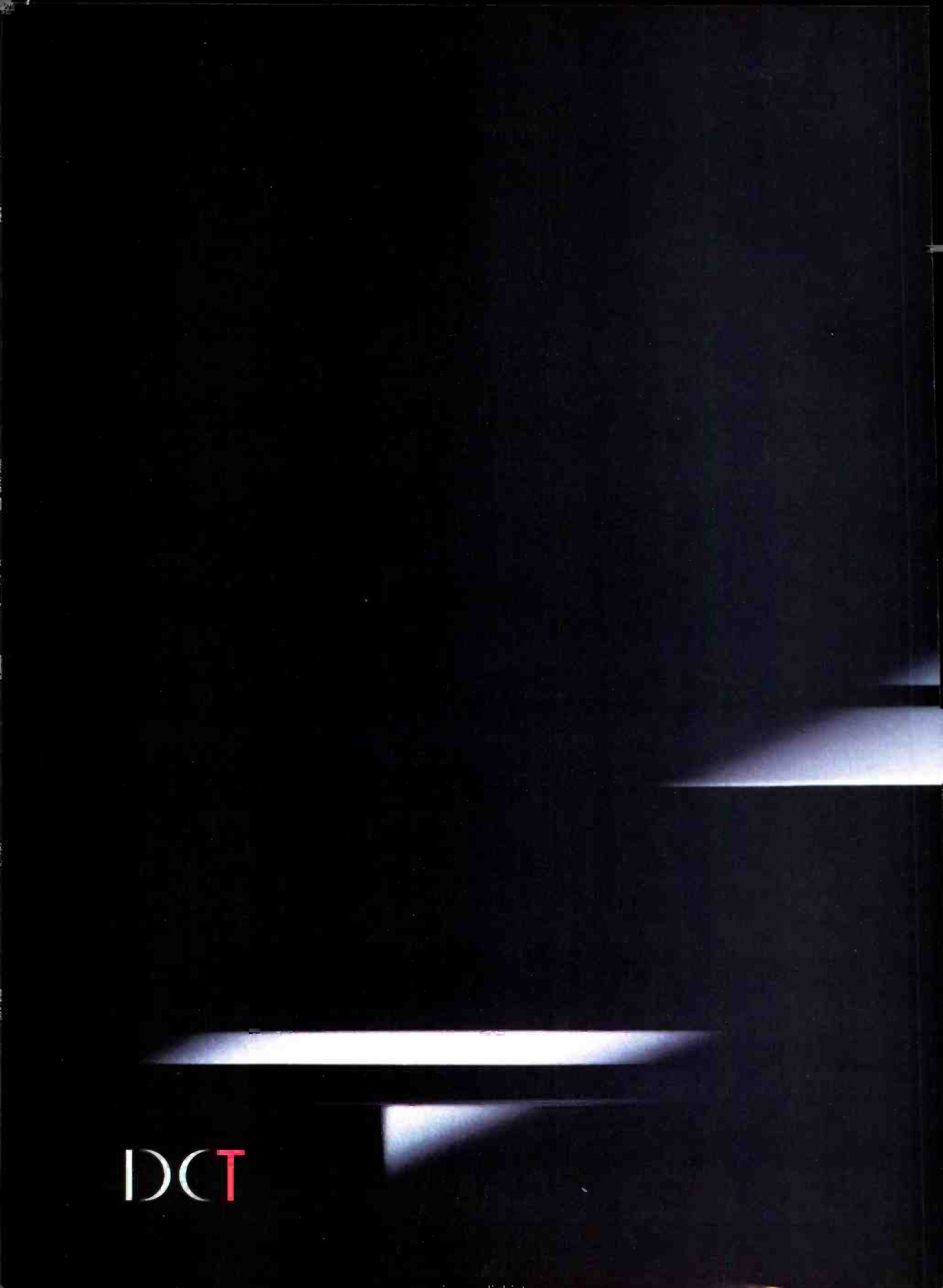
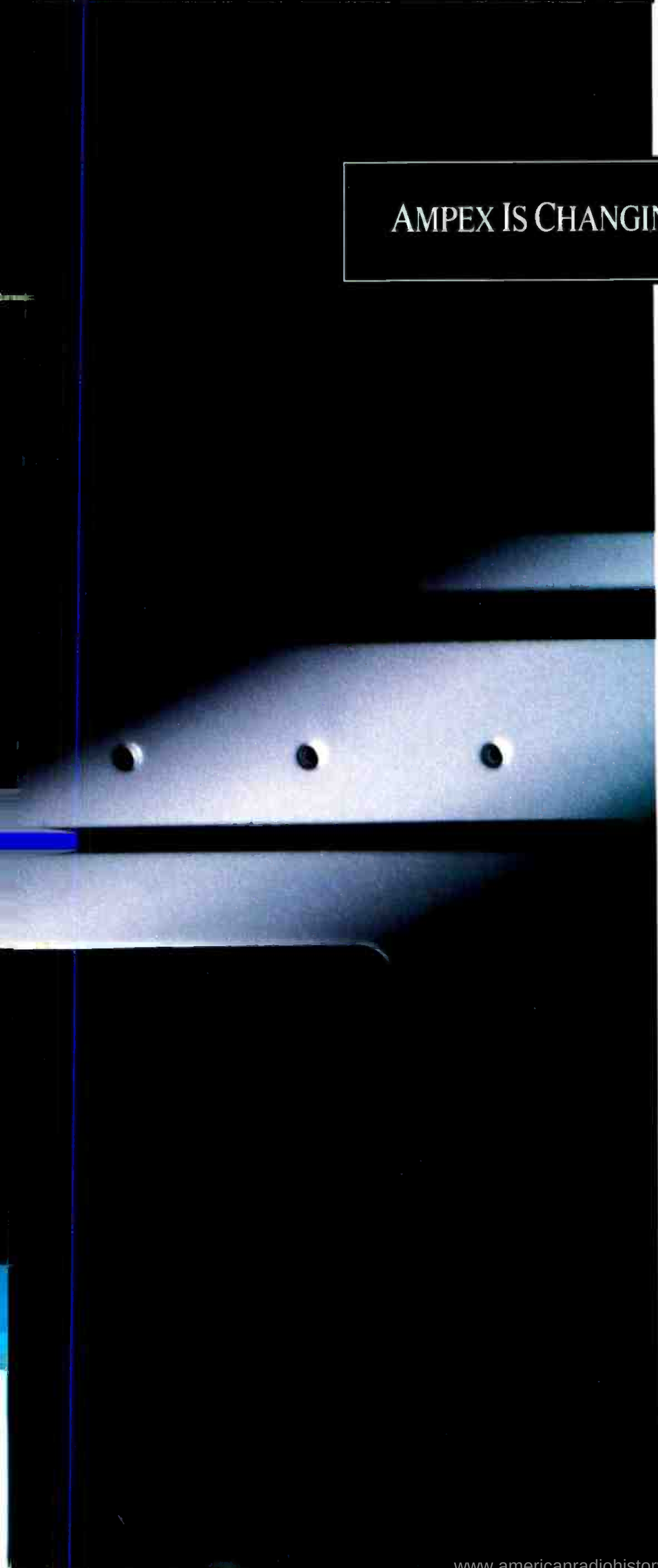

DCT



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Continued from page 38

About algorithms

The means to implement a particular compression technique is called the *algorithm*. An algorithm is an instruction set that defines how the input information is disassembled, compressed or truncated and coded. The algorithm may also include an error-detection and error-correction system that packages the data for transmission or distribution.

The instruction set's complement resides on the receiving end. It is used to reconstruct the waveform to its original format.

Data reducers

Most data-reduction schemes use one of three technologies: digital compression, analog compression and perception-based bit rate reduction.

Digital compression systems for audio typically use digital signal-processing (DSP) chips and techniques to perform the data reduction. These techniques and materials are well-proven and reliable.

Reduction for video is slightly more complex. Video consists of individual but related frames, which can be compressed. It also consists of a sequential series of frames, which can also be compressed.

Intraframe coding operates on the spatially redundant information in a single video frame.

Interframe coding reduces spatial and temporal redundancy from several video frames at a time, using motion prediction and spatial compression techniques. This can result in higher compression rates than intraframe coding.

Digital coding systems

There are several variations of digital coding, the simplest of which is *quantization*. These systems can be either scaler or vector, with vector quantization (VQ) being the more popular. VQ breaks each frame into blocks. It then compares each block to a series of sample blocks in a *code book*, from which it obtains *image vector addresses*. The system then transmits the addresses.

The VQ decoder uses the addresses to call up blocks from an identical code book. The fidelity of the reconstructed image depends on how well the addressed code block matches the original image block. This, in turn, is determined by how many blocks are in the code book.

Waveform coding, perhaps better known as *differential pulse code modulation (DPCM)*, is easy to implement. The system works by assigning a numerical value to pixel blocks, based on pixel intensity. It then compares the current pixel to the previous one and transmits the difference.

DPCM systems are often adaptive. This means that most of their processing power can be allocated to the parts of the image that most need it. DCPM systems offer a rate-reduction efficiency comparable to transform coding.

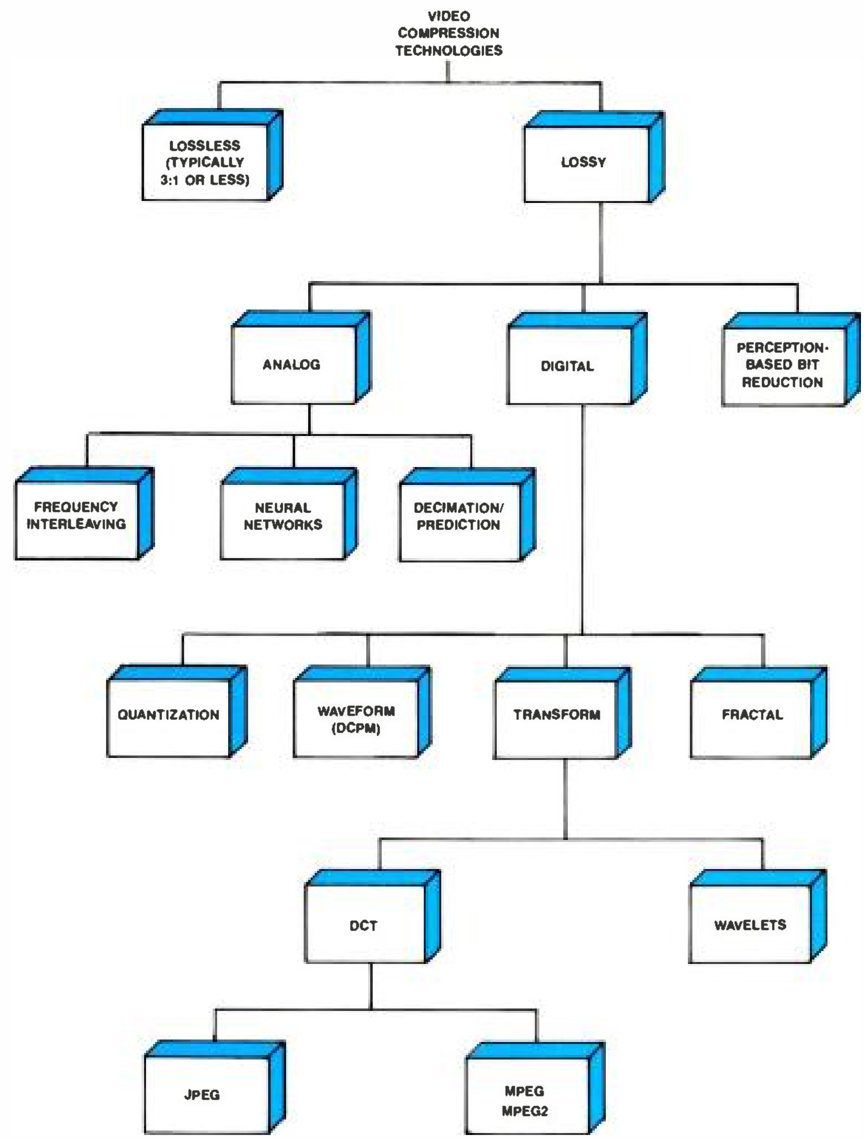


Figure 1. *A family tree of compression technologies shows many paths. Few have been exhaustively explored.*

Transform coding

There are several types of *transform coding* (also known as *function expansion*).

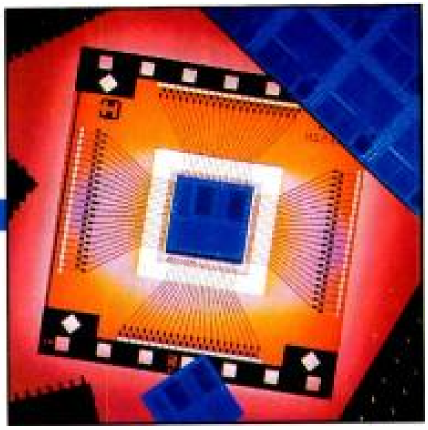
Transform coding is based on mathematical transforms, such as the discrete Fourier transform (DFT), discrete cosine transform (DCT) and others. These transforms shift pixels from one domain, say spatial position, to another, say occurrence in time, or to temporal. Such reorganizations often make compression easier. An analogy would be shuffling students in a classroom so that the tallest students sit in the back, rather than seating them by alphabetical order. This may make it easier for pupils to see but makes it harder to pass out papers. Similarly, sorting the pixels in a video sequence by frequency rather than by position on the screen may make them easier to compress but also confusing to look at.

DCT is particularly efficient for images, and it is becoming widely used. An example of DCT coding is the newly standardized joint photographic experts group (JPEG) algorithm. This system works by breaking up the screen into blocks of pixels and creating coefficients that describe the relationship of one pixel to another. It takes less time to transmit the coefficients than it would the data itself. JPEG data reduction is typically 30:1 to 50:1.

JPEG operates on individual frames. However, JPEG compression can also work on moving video by merely sequencing images. Several manufacturers of broadcast non-linear editors employ this technique. One manufacturer has implemented a JPEG VTR on a Macintosh computer.

The motion picture expert group (MPEG) system uses some principles of JPEG. It further employs a combination of motion-compensation techniques, such as

Distributing serial digital video



Digital video doesn't just live inside the VTR or effects box anymore.

By Marc S. Walker

The Bottom Line

Distribution switchers have become an established part of analog TV facilities, and will be just as important in digital video systems. Serial digital distribution and switching provide many advantages, in component and composite forms, but it also creates some new problems. Up-to-date methods and devices are coming on-line to solve these problems, making complete digital systems practical. Using serial digital distribution for interconnection opens a new world of opportunities for video production.

Digital signal storage and transmission has dramatically changed the way we store and move audio and video signals. The sales of audio compact discs have surpassed vinyl records. Digital VTRs have replaced analog VTRs in applications where the highest quality is needed, especially in multigenerational production and dubbing systems. This trend is certain to continue, and as more devices in a production facility become digital, it follows that interconnection between them should also be accomplished in the digital domain. Although this presents some challenges, it also provides numerous advantages over current interconnection methods.

Analog systems are subject to a variety of problems that cause signal degradation, usually in the form of noise and distortion. The transmission signal is a directly modulated form of the actual program signal, making it vulnerable to noise and distortion upon reception. In digital systems, an analog signal is sampled and quantized into a set of binary numbers, which are used to make a digital transmission signal. Such systems are also subject to noise and distortion, but as long as the numbers can be recovered, the original program is not affected.

Bandwidth

The price paid for these digital advantages is an increase in occupied bandwidth. A signal must be sampled at a frequency greater than twice the maximum frequency found in the original analog program. Each of these video signal samples must be quantized with at least 8-bit (and preferably 10-bit) accuracy. This results in a bit rate requiring more than 16 or 20 times the bandwidth of the analog signal. The chroma signals for component video require additional bits for transmission, resulting in a final bit rate occupying approximately 40 times the analog video bandwidth. See Table 1 for some examples of digital video format's data rates.

But the data rate story doesn't end there. The bandwidth required by a digital video datastream suitable for *distribution* can vary significantly from the initial digital signal conversion. When serially coded for distribution, the digital signal bandwidth can range from slightly more than half of the bit rate to somewhat more than the bit rate. This implies that there can be anywhere from a less than 1:1 to a nearly 2:1 relationship between data rate (in bits/sec) and bandwidth (in Hertz).

The increased bandwidth causes its own set of problems and costs. The first digital video systems used parallel transmission to keep the bandwidth requirement on each wire to about the same value as the analog signal. These cables are larger and more expensive than standard coax cables. The cable connectors are also larger, having 25 pins, which increases the cost and time needed for installing connectors.

Advances in technology have made it cost-effective to use serial digital transmission of standard resolution video signals. In these systems, all of the digital video databits, synchronization, and other signals are transmitted through a single coax cable. In many cases, existing video cable within a TV facility can be used.

HDTV's impact

High-definition television affects a digital video signal primarily by increasing the data rate required. The basic system functional blocks and concepts will be similar to standard digital video systems. Full-bandwidth digital HDTV will require data rates approximately four to six times higher than the present component digital video signals. This higher data rate translates into higher costs for faster digital circuitry, more power for the faster cir-

Walker is manager, advanced development at BTS Broadcast Television Systems, Salt Lake City.

cuits, and correspondingly higher costs.

Gallium arsenide integrated circuits are available for operation at these higher data rates, but this is new and expensive technology. Cable losses are greater at the higher frequencies, reducing the length of coax cables that can be used between distribution amplifiers or repeaters. Coax cables may not be useful, except for short distances, making fiber-optic transmission necessary for longer distances. If the use of fiber-optics becomes comparable in cost to coax transmission, fiber will replace coax, even for short distances.

Whether these higher bandwidths are required for HDTV is a subject of some debate. Image compression holds promise as a way to reduce the data rate up to 75% without affecting the perceived quality of the video image. This will bring the required bandwidth down to a rate near that of the present standard-resolution, serial digital component video system. If the image compression is truly transparent, why should VTRs record the full bandwidth? If VTRs operate with compressed signals, why not run the entire system on a compressed rate? It will be a question of how soon compression is available, and how much it costs. Compressed systems will have many advantages, and should succeed if their cost is lower, and the quality is comparable to uncompressed HDTV systems.

Meanwhile, various analog HDTV standards are in place, with parallel digital standards nearing completion. Standards for serial transmission of HDTV have not yet been set. All eventual HDTV standards will be affected by the issues of image compression, transport media, digital signal coding systems, and cost, current and projected.

Parallel interconnection

For many years, the European Broadcasting Union (EBU) and the Society of Motion Picture and Television Engineers (SMPTE) have worked on setting standards for digital video signals and the interconnection of digital video devices. This has resulted in the familiar CCIR 601 and CCIR 656 standards. CCIR 601 defines the 4:2:2 digital component video system, as applied in D-1 format VTRs. CCIR 656 describes a parallel interconnection scheme between digital video devices. It provides for transmission of 8- to 10-bit digital video, using a twisted pair of wires for each bit's path. Up to 10 data signals, signal ground and a clock signal are transmitted through a cable with 12 twisted pairs, using 25 pin connectors. This cable has a maximum length of 50 meters, unless equalization is provided. CCIR 656 was a good way to get started in digital video distribution, but having obvious disadvantages for wide-area distribution in its length limits, cable size and cable/connector costs.

The proposed serial transmission systems use standard, high-quality coax cable and BNC connectors. These cables and connectors are smaller than the parallel cables and are easier to build. When upgrading a facility to serial digital transmission, many of the existing coax cables can be used. Coax cables do have losses (as will be discussed) but compensation can be made for them.

Serial signal fundamentals

For simplicity, this article refers to serialized transmission of the parallel data structure of CCIR 656, and its standard-resolution, component digital video. The approach that will be described is a proposed standard for serial digital video transmission (see the References at the end of this article), covering 4:2:2 component and 4_{sc} NTSC composite formats. Transmission of a *composite* digital video signal has some differences, including a lower data rate, but they are not critical to this discussion.

The serial transmission standard is designed for 10-bit data, and can also handle 8- or 9-bit signals. Because the clock rate for the CCIR 656 parallel data is 27MHz, with 10 bits per clock cycle, the serial data rate is 270Mbit/s. The single-wire nature of serial transmission requires clock information to be transmitted with the data. To obtain a serial datastream, parallel data is converted to serial in a shift register. In that form, it is not well-suited for direct transmission, and must first be appropriately coded.

Self-clocking systems can be used, such as the bi-phase coding used for time code, but these require bandwidths somewhat greater than the bit rate. Non-return-to-zero (NRZ) coding needs bandwidth only a little greater than half of the bit rate, but clock recovery becomes difficult if there are long strings of consecutive "1s" or "0s."

SYSTEM	SAMPLE RATE	WORD RATE	8-BIT DATA RATE	10-BIT DATA RATE
NTSC	14.32MHz	14.32M	114.5Mbit/s	143.2Mbit/s
CCIR 656	13.5MHz	27M	216Mbit/s	270Mbit/s
EDTV	18MHz	36M	288Mbit/s	360Mbit/s
EU95	72MHz	144M	1152Mbit/s	1440Mbit/s
SMPTE 240M	74.25MHz	148.5M	1188Mbit/s	1485Mbit/s

Table 1. *Data rates for several digital video systems. Word rate is total data words/sec generated. The two righthand columns show data rate generated when those words use either 8- or 10-bit resolution.*

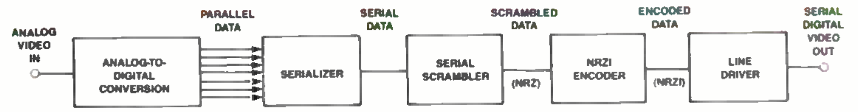


Figure 1. *Basic block diagram of serial digital video conversion process.*

Therefore, two operations are performed on the serialized data. First, the data is scrambled with a pseudo-random sequence, using a specified scrambling polynomial, to break up long strings of consistent data patterns, such as a flat-field video signal. Second, following the scrambling operation, the data is made polarity independent by NRZI (NRZ-inverted) encoding. Thus a "1" in the scrambled data is converted to a transition (low-to-high or high-to-low, depending on the current state) in the encoded datastream. A "0" in the scrambled datastream is encoded as no transition.

The scrambled signal appears much like a random stream of data. There is no easily discerned pattern in the data until it is descrambled. Certain unique synchronization codes are present in the descrambled digital video signal, allowing the receiving deserializer to determine the beginning of certain digital words, and thus know how to divide the serial signal up into parallel digital words.

A phase-locked loop (PLL) is used at the receiver to generate a local clock locked to the incoming data, and to operate the descrambling and deserializing circuitry. The PLL must be of good quality, because intervals of up to 39 bit-periods may occur between transitions of the data signal, and the clock must remain locked during these outages.

There is space available during the horizontal and vertical blanking intervals to allow transmission of other digital data. One proposed usage for some of this space is the transmission of digital audio channels, somewhat like sound-in-sync in analog video systems. The audio is inserted before the scrambling process, and the signal must be descrambled in order to locate and use the digital audio.

Coax cable considerations

Most TV engineers are familiar with the high frequency losses that take place in a coax cable. The losses in decibels per unit of cable length increase with the square root of the increase in frequency. Thus a cable with 3dB of loss at 10MHz will have 6dB of loss at 40MHz.

There is a slight time delay difference between low-frequency and high-frequency signals in coax cable. Combined with the frequency response losses, these phase shifts cause the well-known pulse rounding, smear and high-frequency rolloffs that have plagued analog video on long coax cables. Similar distortions take place with a serial digital signal's waveform, but they are more severe because higher frequencies are used.

When the effects of the distortion become longer in time than one bit-interval (3.7ns for 270Mbit/s), a given pulse becomes affected by the preceding pulse or pulses. This is called intersymbol interference (ISI). Figure 2 shows how intersymbol interference can shift the zero-crossing time of pulses. When the interference extends over more pulses, the distortion and resultant jitter becomes worse. As the cable loss distortion increases, it becomes impossible to recover the digital data without correcting for the cable losses with proper equalization.

Figures 3a, 3b and 3c show the rounding and losses that take place in the cable, as evidenced in the waveform of the recovered datastream. Figure 3a shows the output of a short cable, with all pulses of full amplitude and having good zero crossings. Some overshoot is on the leading edges, but this is not a problem. For the 100m cable in Figure 3b, notice how single bit-interval pulses do not reach the final peak amplitude before they change directions. All pulses still cross through zero, but the width and timing of the pulses are distorted and will cause displacement of the edges at the output of a bit-slicer or comparator. The timing displacement will appear as *jitter.* Figure 3c shows the output of a 300m cable. Notice

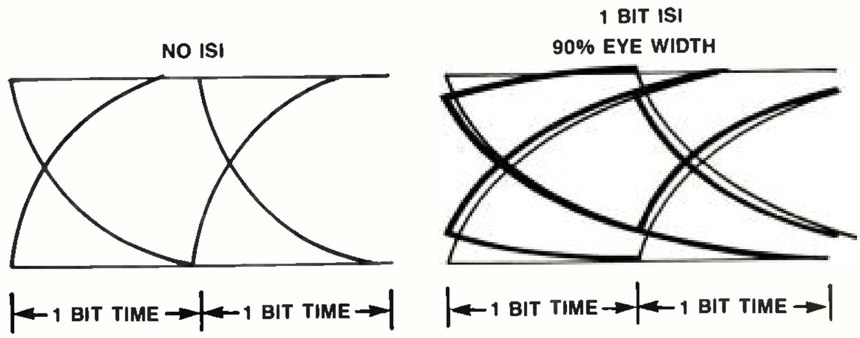


Figure 2. *Comparison of bitstreams with and without intersymbol interference.*

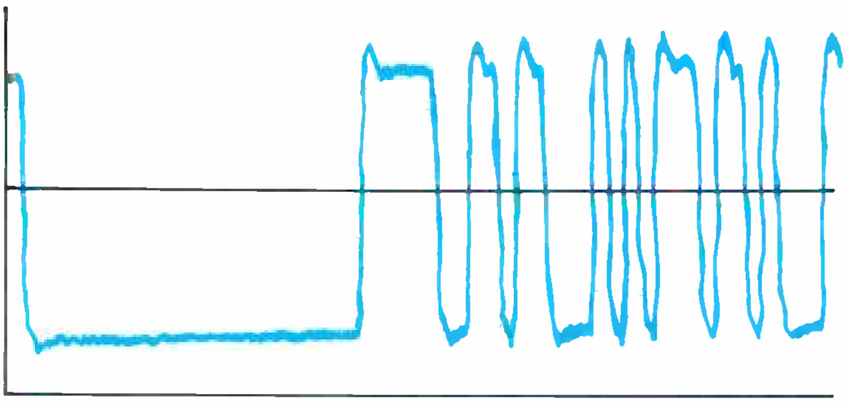


Figure 3a. Data pattern through a short cable.

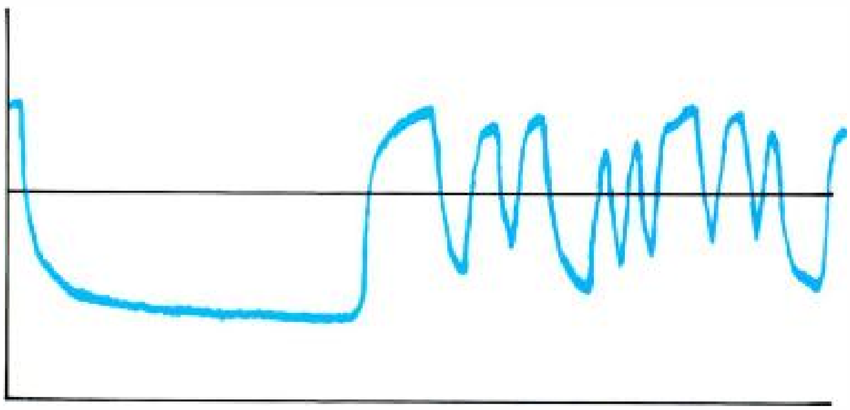


Figure 3b. Data pattern through a 100m cable.

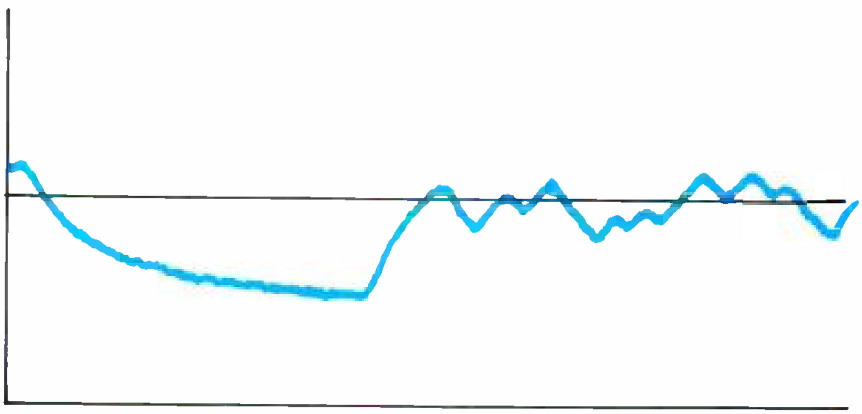


Figure 3c. Data pattern through a 300m cable.

the additional rounding of pulses and attenuation. Some of the single bit-interval pulses do not even cross zero, because longer pulses have preceded them. Data will be lost unless proper equalization is applied. With such equalization, data can be recovered completely. It is important that the equalization extend from the period of the long pulse strings to that of single pulses. Proper equalization will eliminate ISI and minimize the jitter it causes.

Improper cable equalization can make matters even worse, however, by increasing ISI. Cascading several such equalizers with cable and amplifier sections in series will cause an accumulation of jitter. But if the equalization is properly adjusted, the increase in jitter will be minimal. If a distribution amplifier or other line receiver has a phase-locked system to recover data, it can tolerate larger errors in equalization, as long as the resulting jitter is within the capability of the system to lock up and properly sample the digital data. PLLs must be carefully designed, because they can be a source of jitter. This is especially the case if the loop bandwidth and damping have not been properly set. The resulting jitter will then accumulate as the PLLs are cascaded.

Because the waveform of the serial digital signal is predictable in shape, it is pos-

Courtesy of Digital Magic

sible to automatically equalize for normal coax cable losses. For example, the system can be designed to adjust the equalizer for fast rise times with no overshoot, or it can be designed to achieve a given ratio of high-frequency component amplitude to low-frequency component amplitude. Other schemes for automatically adjusting the equalization are also possible.

Video system structure

Analog systems gradually degrade in quality with increased complexity and distances because the transmission signal is the image signal. Once the analog signal has been created, each device that follows will at best only minimally degrade the signal. As the length and complexity of the video signal path increases, the quality of the video decreases further. Even digital devices inserted into the analog system will cause distortions due to the repeated analog-to-digital and digital-to-analog conversions.

With digital systems, the image signal and the digital transmission signal are separate, in the sense that the image is undisturbed as long as the digital signal can be recovered. Fully digital systems will produce no noticeable degradation until they reach the "breaking point," where performance rapidly degrades as disturbances increase. Each time the signal is serialized in such a system, the digital signal is newly generated, minimizing the chance of ever reaching a failure condition.

Some users have proposed systems with up to 10 distribution amplifiers or switchers between a source of serial digital video (such as a graphics generator) and its ultimate destination (such as a digital VTR). Care must be exercised in the design of serial digital video systems to ensure that ISI and jitter don't increase to a level that is unacceptable as the number of devices in the path increases. If the destination device can properly receive the signal, no distortion to the video image will occur in transmission, even in such complex routings. But if ISI and jitter accumulate to the point that errors occur in receiving the signal, the video signal will be significantly impaired, or even completely ruined.

Consistency in the face of change

Video and audio signals are the final product of the TV facility. The details of the signal formats are important for generating, transporting, and using the signals, but they aren't the only factor affecting the facility design. Unless there are significant changes to the operational structure of the TV facility, the support infrastructure of control systems will remain much as it is now.

VTRs must still be started and stopped, editing systems will still be used, distribution switchers will be controlled, presentation automation systems will operate VTRs, telecines, audiotape players and presentation mixers. These functions are essentially independent of the audio and video signal formats, but are a direct function of the human operational interface and overall system structure.

Digital signal storage and transmission allows multiple generations of storage and many stages of switching and transmission without causing any degradation of the original image. Serial digital transmission has many advantages over parallel digital transmission, including the use of video coax cables rather than the more expensive multiconductor cable and connectors. Serial transmission also works over longer distances than the parallel interface. New advances in technology are making serial transmission reliable, cost effective and readily available. Serial digital video transmission will replace parallel transmission in virtually all applications.

At the rates needed for HDTV, serial transmission is more difficult, but it will become available in a few years. Image bandwidth compression techniques may eliminate the need for higher bandwidth in digital HDTV signals.

Serial digital video distribution is the system of the future for TV facilities.

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FOCUSED ON THE FUTURE

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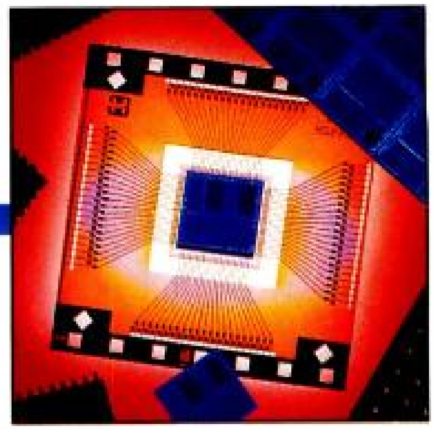
Digital audio data compression



Here's a technology that will define the future of broadcast audio.

By Stephen Smyth

The Bottom Line

Bit-rate reduction (or data compression) for digital audio is essential when the application involves transmission of any kind. Whether wireless or wired, digital audio signals occupy far more bandwidth than equivalent analog transmissions. Therefore, systems that can reduce spectrum requirements without impairing quality are valuable indeed. They make digital transmission practical and economical. Several systems are now available that allow high-quality digital audio to be transmitted in less than a quarter of the bandwidth previously required.

With the wide-scale acceptance of compact discs (CD), the benefits of digital high-fidelity audio have been dramatically brought to the attention of consumers and professionals. The clarity and robustness of the CD medium has been unmatched by any other previous domestic replay technology. And in recent years, the demand for high-quality sound has filtered through to many other areas of the entertainment industry.

Responding to this growing demand for improved sound quality, many audio companies and broadcasting authorities have stated their intention to develop digital audio media, promising a wide range of future digital services. Digital audio is currently being broadcast in a limited fashion as a companion to a variety of TV and radio programming. During the next decade, digital radio services via satellite and terrestrial transmission will become a reality, while HDTV and ATV systems will incorporate digital multichannel capabilities. Over the past 20 years, worldwide telecommunications have also been moving steadily toward an all-digital network, promising a host of new audio services in the future.

Digital bandwidth requirements

Although digital audio recording and transmission offers many sonic and operational advantages over its analog counterpart — immunity to noise, enhanced audio bandwidth and multiple generations without signal degradation — it is clear that a digital audio signal occupies an extremely wide transmission bandwidth. For example, the digital transfer rate from compact disc is more than 1.4Mbits/s (44,100 × 16 × 2 = 1,411,200, i.e., sampling rate × bits-per-sample × two channels for stereo). This output represents a bandwidth of approximately 1.5MHz — more than 60 times that of the original analog signal. For storage media, this has not been a limiting factor in the development of workstations and on-air replay systems, but it can be a fundamental problem in transmission applications.

For digital audio to enjoy widespread use throughout the broadcast industry, bandwidth of the digitized signal must be reduced. A variety of innovative systems that significantly reduce the bandwidth of CD-quality digital audio is now available. For a number of reasons, the transmission of higher-quality audio will be the most demanding and persistent application of such data-reduction techniques. Broadcasting's spectral space is finite and is being squeezed constantly; broadcasting also demands real time transmission.

Several techniques are now available that reduce the data rate of standard 16-bit PCM audio signals so they can be carried over 64-, 96-, 128- or 256kbit/s lines (depending on the sampling frequency and bit-rate reduction ratio). This allows their transmission over ISDN, fractional T-1 channels and Switched-56 links. Common compression ratios vary between 4:1 to as high as 12:1.

The precise term for this process is *bit-rate reduction*, but the title *data compression* already has come into widespread use for such devices. In traditional data processing circles, this is a misnomer. By its strictest definition, compression in the digital context implies a complementary expansion and exact bit-for-bit reconstruction of the original data at some later point prior to final output (a so-called "lossless" approach). On the other hand, most digital audio bit-rate reduction systems do *not* return the digital signal to an identical datastream ("lossy" techniques). Nevertheless, the recent convention is followed in this discussion, and the term data compression will be applied generally to include bit-rate reduction systems as well.

Lossless or lossy techniques?

One common application of data compression that serves to illustrate the differ-

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ence between lossless and lossy compression is the fax machine.

To produce reasonable compression, lossless systems, such as those used in a fax machine, require a variable bandwidth to operate and some statistical knowledge of the incoming data. This technique is obvious while watching the speed of a fax transmission. A complicated document requires much more time to transmit than a blank page. Document speed changes as the scanning element moves from a blank area to dense text — it adjusts the bandwidth of the scanner input to maintain a fixed output bandwidth of 9,600 baud (bit/s) into the telephone line.

Real time audio transmission, on the other hand, requires a fixed input bandwidth and fixed output bandwidth. As a result, a lossy compression system must be used, which inevitably corrupts the digital audio data. Therefore, for lossy audio compression systems, the primary aim is to ensure that any corruption of the original data is inaudible.

Redundancy or irrelevancy?

The majority of digital audio systems use linear pulse code modulation (PCM) techniques to digitize an analog audio signal. High-quality systems, such as the CD format's 16-bit linear PCM, result in data rates that greatly exceed the information rate of the original input. For this reason, digital PCM data is highly redundant and generally extravagant in terms of bandwidth.

Lossy audio compressors attempt to eliminate any signal component that cannot be heard by the human ear.

Redundancies in PCM data can be identified in two important areas: 1) *objective redundancies* (hereafter referred to as redundancy), which are measurable and quantify certain numerically predictable characteristics of audio signals, such as waveform periodicity; and 2) *subjective redundancies* (hereafter referred to as irrelevancy), which result from the psychoacoustic phenomena of human hearing. (Elimination of redundancy is also referred to as statistical compression, while irrelevancy removal is often called perceptual coding.)

Figure 1 illustrates these principles in graph form. The top curve in each of these music samples shows the amplitude/time response, while the lower is the amplitude/frequency trace of a short 32mS sample. Note that the upper waveforms are highly periodic and repetitive, and that the spectra are weighted predominantly toward the low frequencies below 4kHz. Using these two fundamental properties, schemes can be devised that examine the audio waveform either in the time domain (the familiar amplitude/time response) or within the frequency domain, by performing a Fourier transform on the relevant waveform.

Removing objective redundancies

All digital compression techniques, both lossless and lossy, aim to remove objective redundancy to some extent prior to transmission or storage. The fidelity of an audio signal will not be affected by this lossless process, because the redundancies will be added back into the core signal during playback, providing perfect reconstruction. However, only modest amounts of data rate reduction can be achieved with this approach.

Therefore, to supplement the compression obtained through objective redundancy, lossy audio compressors also attempt to exploit subjective irrelevancy in digital data. In other words, they eliminate any signal component that cannot be heard by the human ear. Elimination of certain fre-

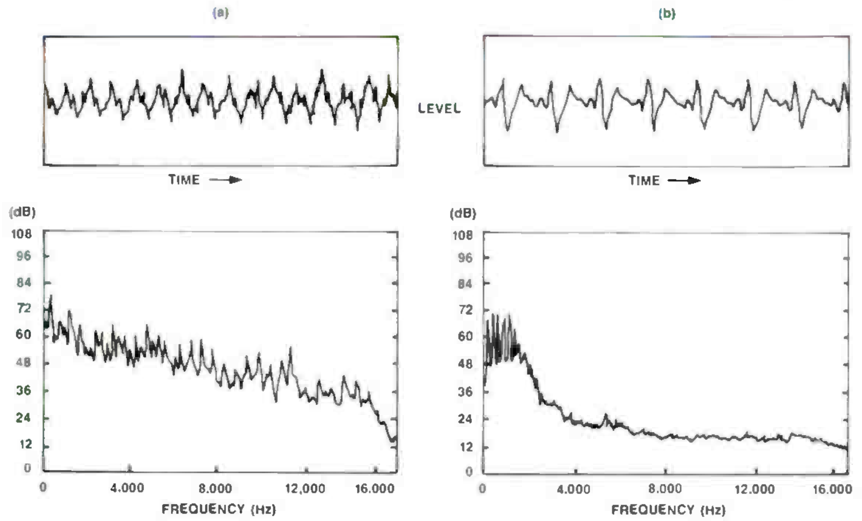

Figure 1. *Objective and subjective redundancies in PCM data. The waveforms shown here, (a) classical guitar and (b) trombone, represent the amplitude/time response (top), and the amplitude/frequency trace of a short 32mS sample (bottom). The time domain waveforms are highly periodic and repetitive, and the spectra are weighted predominantly toward the low-frequency region.*

quencies does imply an irrecoverable loss of information, but the lossy algorithm assumes that the information wasn't needed in the first place. The removal of irrelevancy is probably the single most contentious issue for audio coders: Its operation is entirely subjective, yet it represents the primary method of compressing audio data.

An "ideal" digital audio data-compression system would first remove all objective redundancy (because this process is essentially free and incurs no information loss), and then remove all subjective irrelevancy from the remaining audio signal, which does incur information loss. "Critically perceived" signals, such as pure tones, are often highly redundant but have little subjective irrelevancy. These would be easily compressed through lossless, statistical means, with little or no information lost. Conversely, "non-critical" or noisy signals, such as wideband and complex waveforms, have little or no redundancy, but are perceptually highly irrelevant. These would also be easily compressed through perceptual coding, but at the loss of irrelevant information. Because most audio signals encountered in broadcasting (music, speech and so forth) lean toward the latter model, lossy algorithms predominate in typical audio data-compression applications.

Redundancy in time/frequency domain

Techniques to calculate and exploit redundancy can work in either the time domain (for example, by differential coding) or in the frequency domain by adaptive bit allocation.

Mathematically, these techniques are the same. For a signal-to-noise ratio similar to 16-bit linear PCM, fewer than 16 bits can be used on average, but at the cost of a reduced range of optimized signals.

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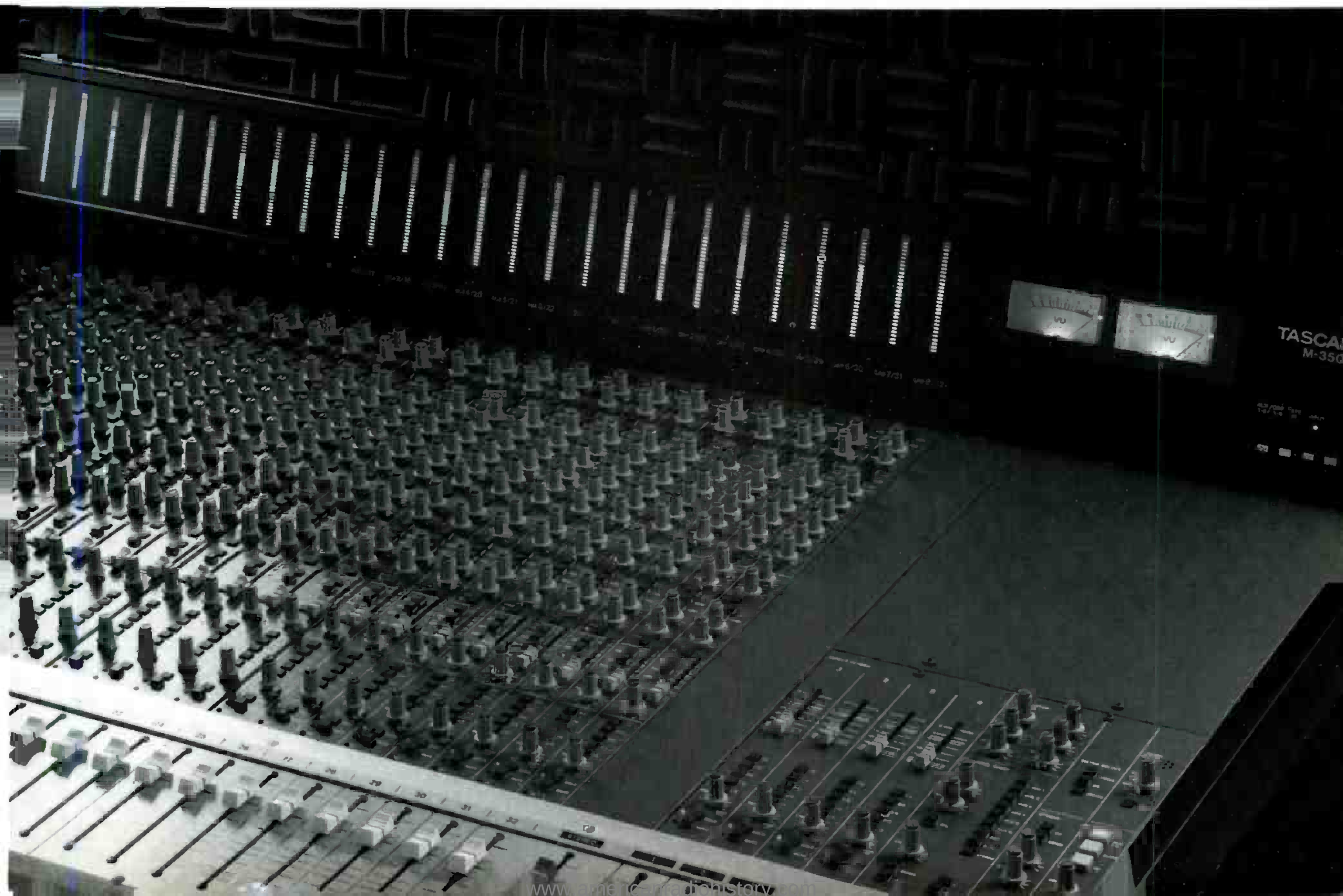

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Continued from page 55

The trick in the design of any compression system lies in trying to match the range of optimal signals with those critically perceived by the human ear. In an ideal system, it is only these signals that need to be coded at a high resolution, while noisy non-critical signals can be coded poorly, if at all.

All real time audio coders represent a compromise between often mutually exclusive parameters.

In practical coder design, redundancy is exploited in the frequency domain by matching the coding resolution to the energy of the signal at each frequency — high energy frequencies are allocated more quantization bits than low energy frequencies. The ability to extract such redundancies is dependent on being able to resolve them; this process is influenced by the size of the transform window. Up to a certain limit, larger windows provide a better frequency resolution and allow more redundancy to be removed. The penalty is an increase in the coding delay and a decrease in temporal resolution.

In the time domain, redundancy is removed by subtracting a predicted signal from the input signal, leaving a residual error signal that is hopefully smaller in amplitude than the original input signal. It is only this error signal that is then coded for transmission (differential PCM [DPCM] or delta-modulation). A simple predictor circuit just uses the last sample as the prediction for the next sample. Complex predictors analyze previous samples (backward prediction) or future samples (forward prediction) to generate more accurate predictions. Backward linear prediction does not cause any coding delay, but it cannot track fast-moving high frequencies. Forward prediction needs to delay the signal, but it is more accurate and can exploit more redundancy.

In order to strike a compromise between coding delay, the amount of redundancy removed and computational complexity, it is feasible to design a hybrid system that functions in the time and frequency domains.

Irrelevancy

Irrelevant parts of an audio signal are those deemed inaudible to the human ear, because they are masked by higher-level signals at generally lower frequencies. Unlike objective redundancy, irrelevancy is not a property of the signal itself, but a psychoacoustic function of the human ear. Irrelevancy is determined by characterizing and modeling human hearing, then applying this model, or an approximation of it, to the audio signal.

The final result is a frequency-dependent noise-masking threshold, which provides an indication of the level of noise at any frequency that may be injected into the original signal without audible effect. Any part of the original signal that falls below this masking threshold may be removed.

Figure 2 shows the noise-masking threshold for a trombone signal. Signals below this threshold are masked by high-level, predominantly low-frequency signals, and can effectively be removed without subjective effect. In addition, those parts that remain can be coded to the level of noise indicated by the threshold at that frequency.

Thus, the noise-masking threshold serves to remove irrelevant spectral parts of the signal and to reduce the required level of coding accuracy for the remainder. Irrelevancy can only be determined within the frequency domain, and requires good frequency resolution. These restrictions imply a large transform window size, and therefore a reasonably large coding delay.

Frequency-domain coders work entirely in the frequency domain. They attempt to exploit irrelevancy by adapting the instantaneous coding resolution to match the audio signal's quantization noise threshold, as determined by psychoacoustic analysis of the current window's spectrum. (See Figure 2.) Hence, it is the noise-masking threshold that determines the bit allocation for normal audio material. Because audio signals are transformed into the frequency domain by these processors, they are commonly referred to as *transform coders*.

Time domain coders work primarily in the time domain, and do not normally use irrelevancy, because it requires an accurate spectral analysis of an input signal. To offset this problem, time domain techniques, such as adaptive differential coding (ADPCM), do implicitly model the hearing process, with the result that a degree of irrelevancy can be exploited without a direct frequency analysis. An example of an implicit assumption would be that the ear is not that sensitive to loss of information at the onset of waveform transients. Differential coding techniques exhibit similar characteristics (i.e., they lose more information during transients than while coding static signals). As a result, such techniques are well matched to this characteristic of human auditory sensitivity.

Hybrid time/frequency domain coders attempt to achieve the best of both worlds by working in a small number of essentially time domain subbands, but performing spectral analysis in parallel in order to determine and remove irrelevancy. This function can be achieved by using a straightforward bit-allocation procedure (subband APCM), or by using differential encoding (subband ADPCM).

Table 1 lists the primary technical parameters of several transform, subband APCM and subband ADPCM digital audio data-compression systems currently being offered or proposed by various companies and standards organizations.

An additional function implemented at lower bit rates by some systems is the use of "joint stereo" coding. This exploits the significant redundancy between audio channels found in a typical stereo program (i.e., center channel information common to both channels), further reducing bit rate by coding this data only once. The result (typically at 128kbit/s for a stereo pair) is often subjectively superior to compression at the same overall data rate produced by

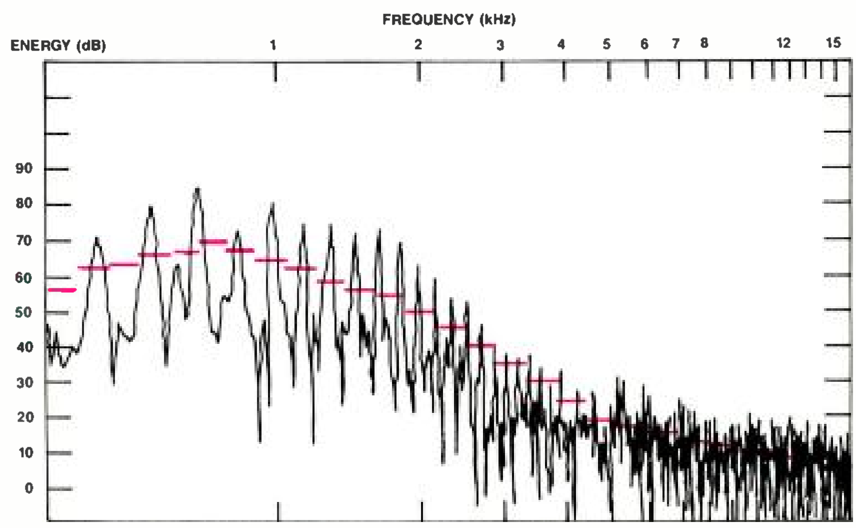

***Figure 2.** Noise-masking threshold generated by a trombone signal. Stepped lines indicate masking threshold in each of the "critical bands" of human hearing. Signals below this threshold are masked by those above it, and can effectively be ignored without subjective effect.*

CODING SYSTEM	PRINCIPLE OF OPERATION	NO. OF BANDS	BLOCK SIZE	BIT RATES	PROCESSING DELAY	FREQUENCY RESPONSE
APT apt-X100	Subband ADPCM	4	.....	192	2.5ms	24kHz
				176	2.7ms	22kHz
				128	3.8ms	16kHz
ASPEC	ATC w/ 50% overlap	.....	1,024 or 256[1]	128	80ms	20kHz at all rates
				96	145ms	
				64	167ms	
CCITT[2]	Subband ADPCM	2	.....	64	1.4ms	7kHz
Dolby AC-2	ATC w/ 50% overlap	.....	256	128	45ms	20kHz at all rates
			64	192	8ms	
ISO/MPEG Layer 1[3]	Subband APCM	Var.	.....	192	12ms	20kHz
ISO/MPEG Layer II	Hybrid transform & subband APCM	Var.	Var.	128	40ms	20kHz at all rates
				96	60ms	
				64	80ms	
ISO/MPEG Layer III	Transform	.....	32	128	80ms or more for all rates	20kHz at all rates
				96		
				64		
MUSICAM	Subband APCM	32	.....	128	19.84ms[4]	20kHz at all rates
				96	18.70ms[4]	
				64	18.51ms[4]	
Sci-Atlanta SEDAT	ATC w/ 50% overlap	.....	1,024	128	50ms at all rates	20kHz at all rates
				96		
				64		
				54		

1. ASPEC varies "window" size between normal (1,024) and short (256), depending on nature of audio. Short window is used on transient material to avoid pre-echo artifacts of transform coding.
2. CCITT G.722 is a widely used system for high-quality voice transmission via telco data lines.
3. ISO/MPEG layers I, II and III are proposed standards for contribution, distribution and broadcast applications, respectively. They are hardware independent, and are as yet unimplemented.
4. These times are for *decode only*. Encoder delay is variable.

Table 1. *Primary technical parameters of several professional digital audio data-compression systems. Block size cites number of samples per block for transform coders. Bit rates are quoted in kilobit per second, per audio channel (double these numbers for stereo). Delay times are approximate values encountered in a typical hardware implementation. (ATC = adaptive transform coding; ADPCM = adaptive differential pulse code modulation; APCM = adaptive pulse code modulation.)*

two separate left and right channel codings (twin 64kbit/s mono processors).

Assessment of audio coders

All real time audio coders represent a compromise between often mutually exclusive parameters. Audio quality is the most important factor (see "Evaluating Data-Compression Artifacts," July 1991). However, other operational parameters, such as coding delay and computational complexity, may mitigate against the use of certain classes of coders. The list of secondary factors that can be used to assess coders includes error ruggedness, embedded auxiliary data, ease of frame synchronization, ease of editing of compressed data, the effects of post-compression audio processing or digital signal processing (DSP), ruggedness in "tandem coding" applications (wherein a digital signal makes multiple passes through data compression cycles), and the cost of hardware implementation.

A ranking of these secondary factors is of little value here, because different applications will place varying demands on coders. For example, although error ruggedness is of fundamental importance for transmission systems, it is of no practical importance for hard disk storage. The following summarizes the key parameters of audio coder assessment.

- *Subjective audio quality.* The primary assessment of audio coders must remain with their audio quality. Tests in this domain are performed by subjectively comparing coded audio with original 16-bit uncompressed audio, using human listeners. Ideally, such tests should prove that the audible difference between compressed and uncompressed audio is statistically insignificant.

ISO/MPEG has conducted two rounds of tests, primarily involving two coders — ASPEC and MUSICAM. Neither proved adequate for broadcast use in the first round, although ASPEC was considered audibly superior. In the second round, a hybrid "layered" algorithm combining features of both coders was able to partially meet ISO's broadcasting requirements. The requirements have also been modified by dropping the criteria for error protection in source coders.

Nevertheless, there remains little published data subjectively comparing audio compression algorithms. Many critical, independent tests have been conducted, but these are generally for proprietary purposes, and results are not readily available. Open, subjective testing of a wide range of coders and more of their parameters, is sorely needed. The best hope for this at present rests with CCIR Task Group 10/2, which is currently conducting tests toward developing standards in low bit-rate audio coding for broadcast.

• *Coding delay.* This parameter defines the delay that a compression scheme introduces into a real time audio signal during coding. For many 2-way transmission applications, such as audio conferencing and off-air monitoring during live broadcasts, coding delay causes problems. For other direct broadcast services, the presence or absence of delay is irrelevant.

• *Error ruggedness.* In normal transmission applications, audio coders have to be robust against digital errors that inevitably occur in the network. Any corruption of the compressed data should be inaudible. If any degradation *is* audible, it should be graceful. Random bit errors and burst errors must be considered.

No single audio data-compression system can optimally cover all of the possible applications today.

• *Tandem coding, post-processing and editing.* The quality of compressed digital audio degrades after each coding pass even in the digital domain. Key questions are, at what point does the degradation become audible, and to what extent is the ability to process the audio restricted by its compressed nature? Also, to what time resolution can the compressed audio be edited?

• *Auxiliary data transmission.* Coders should provide the ability to pass auxiliary data embedded within the compressed datastream. This allows control and other information to be transmitted within the bandwidth, albeit with a slight drop in audio quality.

Conclusion

No single audio data-compression system can optimally cover all of the possible applications today. Algorithms now on the market prioritize their performance in various areas, in order to tailor them for more specific uses. Therefore, it is crucial that broadcasters become conversant with the pertinent parameters, and become better equipped to judge such systems in the context of broadcast applications. It is an area in which the use of data compression will become increasingly widespread.

Editor's note: For additional details on the current state of digital audio bit-rate reduction, see *Proceedings of the 10th International AES Conference,* "Images of Audio," Session B.

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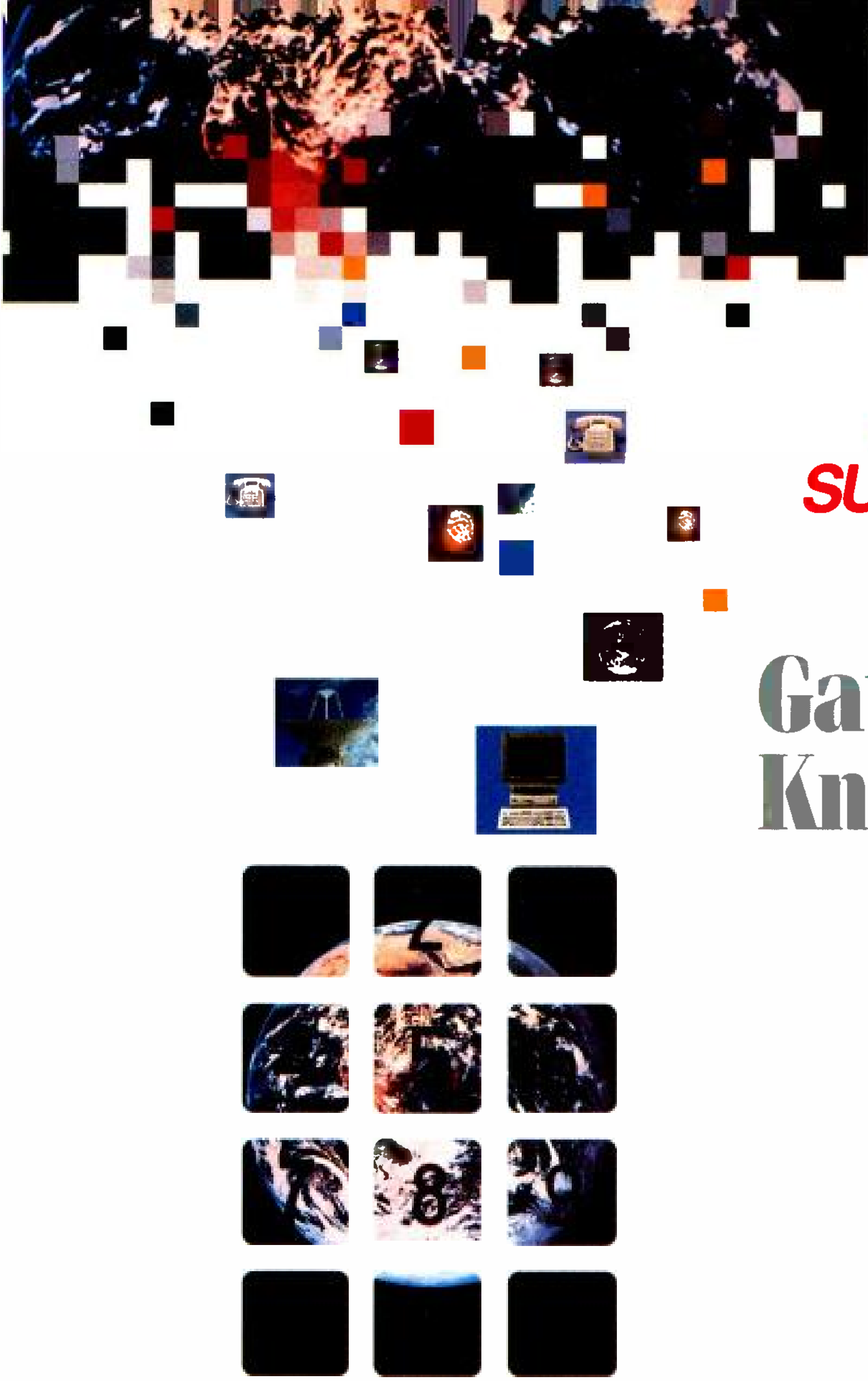

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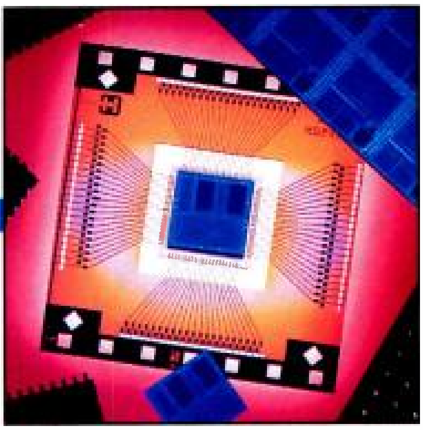
Choosing a broadcast lens



Knowing what to look for will see you through.

By Bob Manis

The Bottom Line

Buying a camera involves more than just the camera, it also involves the selection of a lens. With many of today's new, smaller cameras, it is possible to spend as much money on the lens as on the camera. Therefore, it just makes good sense to spend as much time and thought on selecting the camera lens as the camera itself. Knowing the full range of options available today may help you net a higher price and/or performance ratio.

As the adage says, "a chain is only as good as its weakest link." The same holds true when purchasing cameras. Broadcast equipment buyers have been known to labor for months, even years, over the camera decision. Yet, when it comes to the selection of a lens, these same savvy people often give little time or consideration to the camera's lens. It's important to realize that regardless of the camera's capability or performance, the final image quality also depends on the lens.

In the broadcast lens industry there is healthy competition among the major players. The result is that today, lenses are available to accomplish almost every task, providing wonderful picture quality, often while helping the buyer remain within individual budgetary restraints.

The key to buying the right lens is having a clear-cut understanding of needs, expectations, budgets and technology. It is reasonable to expect high quality and high performance, while remaining within the budget. However, these goals can be met only if enough time and thought are put into the purchasing decision.

Start at the beginning

Application. Application. Application. Understanding your application is fundamental to lens selection. Many types of studio applications range from local newscasts to million dollar music videos. Example factors to consider include studio size, camera locations and whether you'll be producing news/talk shows or soap operas.

The requirements for field-production equipment also vary. A large mobile facility that contracts for major sporting events will need different camera-lens combinations than a station doing ENG for the local news.

Often, several outside influences need to be considered. A rental house will strive to buy equipment that its customers are familiar with and request. A mobile facility will more likely be concerned with durability and proven reliability. Only after you understand what your applications will be can you move on to lens specifications.

What's in a number?

The first specification to check is the image size. As a rule, top-of-the-line CCD cameras have 2/3-inch image size. Less-expensive cameras usually have a 1/2-inch image size. The newer 1/2-inch format requires a smaller chip, which reduces the camera cost. The pricing, performance and field of view of a lens are generally not affected by the image size.

Once you know the image size, the zoom ratio needs to be considered. The zoom ratio is the ratio of the focal length at the telephoto end of the zoom, to the focal length at the wide-angle end. This ratio describes how much the image size on the monitor can be changed. For example, if a lens has a zoom ratio of 14×, the image at the telephoto end will be 14 times larger than the image at the wide-angle end.

The laws of physics are always at work, so this advantage isn't gained without a trade off. The trade off is that the bigger the zoom ratio, the smaller the angle of view. The farther you can reach, the less you get to see. A wide-angle lens is suited for indoor situations where it is not possible to move far back from the subject.

For studio production, a 16:1 or a 20:1 lens is often best. If outdoor sporting events are the primary application, then a powerful telephoto zoom (greater than 30:1) is the way to go. A local TV station using the equipment primarily for ENG, should consider a lens with less telephoto capability and a larger angle of view, typically a 14:1 or 18:1.

Another important parameter to con-

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sider is F-ramping, sometimes called F-drop. When zooming with the iris wide open, the lens becomes slower. This means that less light reaches the back of the lens. The result is that the F-number gets higher and higher. This is the F-ramp. (See Figure 1.)

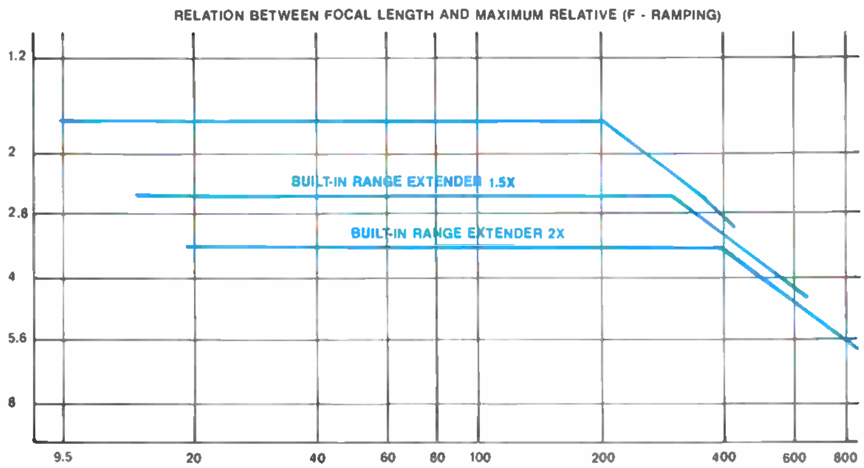

Figure 1. The chart illustrates the relation between focal length and maximum relative aperture — F-ramping for a modern lens. As the lens zooms in with the iris wide open, less light is passed through the lens.

It's important to realize that regardless of the camera's capability or performance, the final image quality also depends on the lens.

F-ramping becomes important in terms of the actions of the auto-iris or of the video control operator. If the curve is too steep at frequently used iris settings, it is harder to compensate rapidly for changes in scene luminance. A slow ramp will provide a less severe drop, which is easier for the auto iris or video control operator to cope with.

Understanding your application is fundamental to lens selection.

With so many types of lenses available, it is easy to sink into a sea of numbers. Be careful. Comparing figures from a spec sheet could lead you to eliminate the best overall lens for your application. Experienced lens buyers know that looking only at the specifications does not accurately reflect all of the important aspects of a lens.

New options

The improvements in today's CCD camera technology provide more options for lens-camera combinations than ever before. For instance, some facilities have found that attaching a studio lens to a high-quality portable camera allows them

The zoom ratio describes how the image on the monitor can be changed. For example, if a lens has a zoom ratio of 14×, the image at the telephoto end will be 14 times larger than the image at the wide-angle end.

to achieve a higher-quality performance than their budget might otherwise have allowed. Additionally, because studio lenses are designed to be driven via semi- or full-servo controls from the back of the

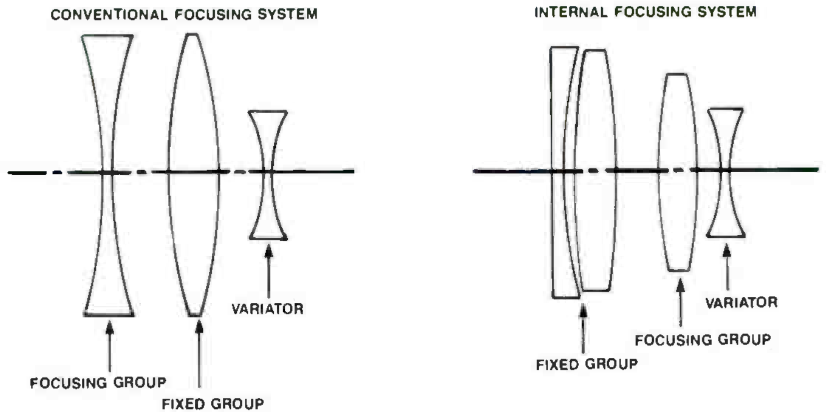

Figure 2. Comparison of conventional focus lens system (left) with an internal-focus system (right). In an internal focus lens, the focusing group mounts separately from the front element, and "floats" within the lens. The fixed group remains stationary during focusing.

camera, not the front, like ENG lenses, interfacing is often easier.

Another hybrid configuration that is becoming commonplace is to mate high-end ENG lenses with economically priced CCD cameras. These reasonably priced cameras are often capable of providing good images. Adding a high-end lens enhances their performance level, yielding sharp, high-resolution picture quality.

Such creative options, brought about by CCD advancements and new lens technology, opens the door for quality improvements while providing budgetary advantages.

New technology

Another area to consider is the lens focus system. Internal focus lenses have been designed to take advantage of the excellent properties of CCD cameras. In an internal focus lens, the focusing group is mounted separately from the front element. In essence, the focusing elements "float" within the lens. This design helps reduce distortion and allows for better control of aberration. The fixed group remains stationary during focusing, which improves response time and reduces smearing caused by raindrops or dust. Figure 2 illustrates both types of focusing systems.

Internal focus has another advantage. Because the front element is fixed, a single or double fully rotational matte box can be attached to the lens. This allows the use of specialty filters and further enhances the versatility of these lenses. Another advantage of internal focus lenses is that a square lens shade can be used. When the hood matches the image aspect ratio, ghosting and flaring are reduced.

Accessories

Understanding the advantages and uses of accessories is useful in obtaining maximum lens performance. Following is a list of some common accessories you may want to consider.

- *Specialty filters.* They offer a wide range of optical illusions. Some common filters are polarization, star, neutral density and cross.

With so many types of lenses available, it is easy to sink into a sea of numbers. Be careful — comparing figures on a sheet of paper can lead you to eliminate the best overall lens for your application.

- *Wide converters.* Shifts the focal length range to the wide-angle direction.
- *Wide attachments.* Widens the angle of view, but zooming cannot take place.
- *Fisheye attachments.* Distorts the image the way a fisheye lens does.
- *Matte boxes.* Attaches to the front of a lens to hold filters.
- *Tele-side converters.* Provides extra telephoto reach.
- *Close-up lenses.* Brings objects in closer with extreme clarity.
- *2× extenders.* Doubles the focal length. They are often built into zoom lenses.

Test drive

You wouldn't buy a new car without taking it for a spin, right? A broadcast lens is also a major purchase and deserves the same consideration. Ask lens manufacturers to supply lenses for a shootout. Different applications and conditions demand lens specifications that enhance your unique situation. In addition to standard engineering tests, don't hesitate to put lenses to the test under real life conditions.

Know your resource

After all the testing, there is one other important consideration — the lens manufacturer. Find out about the company's history, its after-sales service, reliability of its lenses, and how well regarded the sales and support staff is. Talk with others in the industry. Ask questions, and then ask some more.

Still photographers have known for years that the quality of the glass determines the quality of the picture. When purchasing cameras, remember that the final image quality depends, to a large degree, on the quality of the lens. You can ensure that your pictures are as high quality as possible by spending the time and effort needed to choose the right lens. ■

manufacturers to achieve high and linear MTF.

It is the same for geometric distortion. Lens manufacturers must strive to maintain a distortion level that optimizes camera performance.

Ghosts and flares

An experienced tube-camera ENG photographer would never shoot a bright object, such as the sun's reflection, from a chrome car bumper. However, because CCDs are much more tolerant of bright light, camera operators routinely point CCD cameras at bright objects.

When light enters a lens and reflects or is dispersed by the inside of the lens barrel or a lens element, it is called flare.

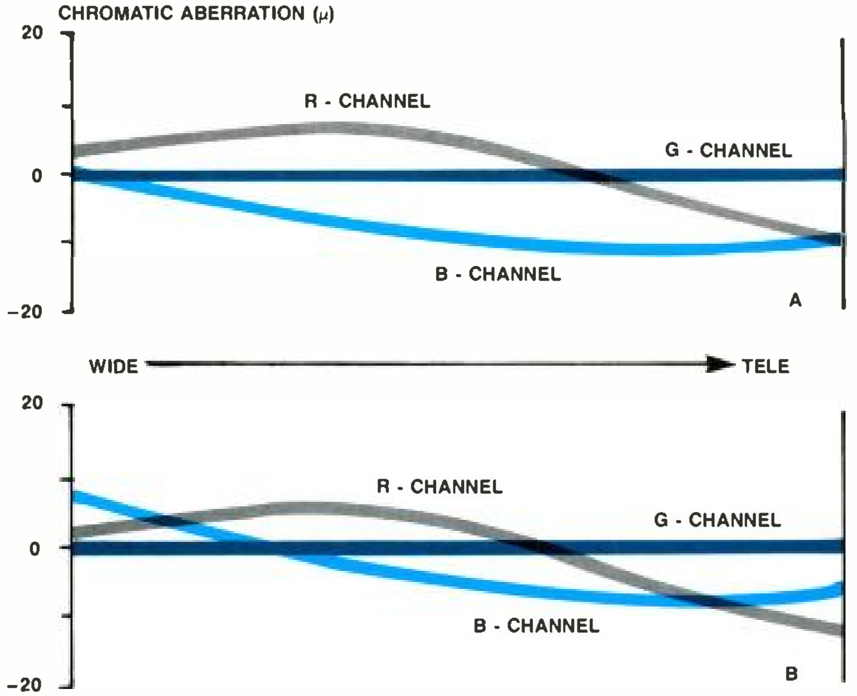

Figure 1. *Lateral chromatic aberration in a lens designed for a tube camera (A), and for a CCD camera (B). The graphs show that performance of the CCD lens is better throughout most of the zoom range.*

When light enters a lens and is reflected or dispersed by the inside of the lens barrel or a lens element, it may reach the image plane as an unrecognizable image called *flare.*

Ghosts occur when light of high luminance is similarly dispersed or reflected, but reaches the image plane in a recognizable shape.

a longer record time was more or less inherited. Hi8 systems offer 120-minute operation with MP or ME media. The same size of housing is used for other lengths, including 20- and 60-minute units.

S-VHS offers a standard record time of 120 minutes from T-120 or ST-120 cassettes using cobalt-enhanced magnetite iron oxide. Shorter units of 30- and 60-minute lengths are packaged in the same housing size.

S-VHS has a companion format called S-VHS-C (compact). The VHS-C adaptation, with a cassette housing of nearly one-fourth the size of a standard cassette, originally offered only 20-minute TC-20 units. To play these in a standard transport required a special adapter. The latest generation of S-VHS transports with an F/C (full/compact) designation permit either length of cassette to be used. Figure 2 illustrates the threaded tape path of the two cassette sizes.

- *Tape speed*

A popular feature of consumer VHS is the multiple speed operation during record, with automatic playback speed selection. A similar feature has been incorporated into some professional S-VHS products. A 3× setting triples the length, but some loss of resolution may be experienced.

The 20-minute limitation of VHS-C was removed when a thinner tape was developed with the introduction of a 30-minute cassette. The 3× feature results in a 90-minute running time.

- *Headwraps*

Figure 3 illustrates the Hi8, S-VHS and S-VHS-C tape-to-head contact. Because of the smaller diameter of a VHS-C deck, an additional pair of heads is added to the drum in order to arrive at the same recorded footprint. The second set of heads tends to create noise as they slap into the tape. This has prompted some VHS-C transports to be designed with a full-size head drum.

- *Audio tracks*

Various options for Hi8 and S-VHS incorporate combinations of longitudinal audio (with fixed heads) and hi-fi audio tracks using FM techniques and frequency multiplexing with the video. Some Hi8 models offer digital PCM audio, which is gated into the signal stream at the beginning of the diagonal head pass.

Dubbing new information onto the longitudinal audio tracks does not present a problem. However, replacing the hi-fi audio does, because the FM audio is recorded deeper than video along the diagonal tracks. An attempt to dub new FM audio would destroy the video information. As a result, dubbing of FM audio is not available as a feature.

Although some formats use an audio track to provide LTC time-code information, Hi8 and S-VHS use VITC code. Time-code data is relegated to a small portion of the video track between the PCM audio and video on Hi8.

- *Stills*

When the camcorder uses digital signal processing, interesting features can be achieved. One possibility is the recording of still or "digital snap" images. Information for the still image is recorded in the area usually designated for PCM audio. During playback, one of three modes can be selected — typical moving images, still images or picture-in-picture.

- *Noise reduction*

Noise reduction for video may be incorporated into the recorder circuitry. Because the frequency for the color information is at a lower frequency than video, the resolution is lower and may exhibit noise degradation. Some equipment includes digital adaptive noise-reduction circuitry. Enhanced comb filters with multiple delay lines produce effective chroma enhancement by detecting and sharpening object edge transitions in the playback mode.

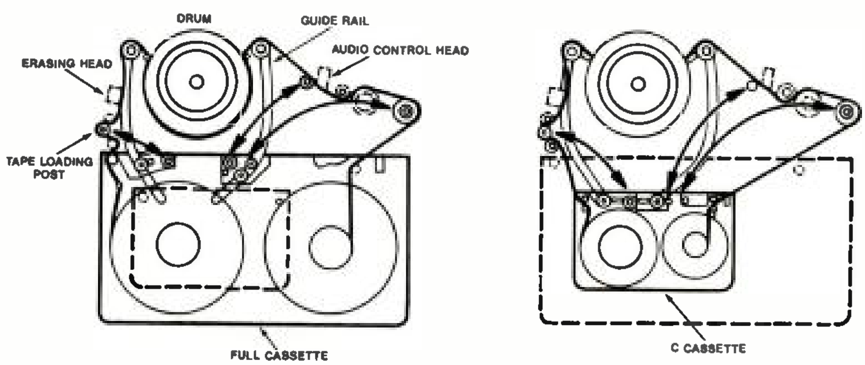

Figure 2. *The threaded tape path in the F/C S-VHS transport showing stand and S-VHS-C media.*

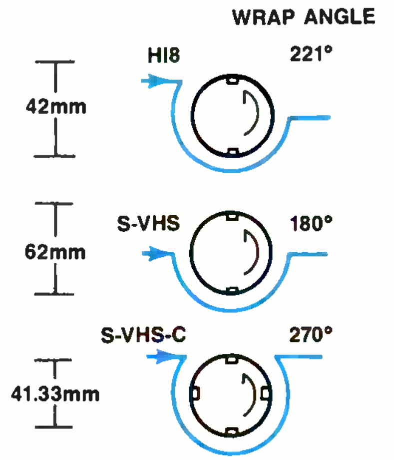

Figure 3. *A comparison of Hi8, S-VHS and S-VHS-C tape wraps. The length of the video track and its angle across the tape are specific to each format and are related to the angle of tape-to-head contact. The head diameter and tape wrap difference between S-VHS and S-VHS-C requires additional heads to accommodate compatibility.*

- *Translation please*

Differences in luminance and chrominance carrier frequencies make Hi8, S-VHS and U-matic signals mutually incompatible without some means to translate between the formats. For the facility that already uses U-matic equipment, some transports include an integral U-matic translator with dedicated 688kHz color input/output access. A variety of external format translation products are now on the market for this purpose.

- *Keeping track of video*

Servos in the transport are used to monitor signals and maintain automatic tracking. Such a feature is not new. It is noteworthy that Hi8 systems use special tracking pilot signals at frequencies below the chroma information. S-VHS equipment uses the more established approach of a control track and constant seeking of maximum RF output to maintain the optimum picture quality.

By and large, all recorders will offer the typical attributes found in other recording formats. An LCD panel displays status information on recording times, audio channel use, battery conditions and so forth. LCD or analog meters show audio levels. Level controls for standard and high-quality audio may be provided for each channel.

Camera attributes

The camera portion of Hi8 and S-VHS camcorders, like the transports, generally have most of the features and functions that are expected on other cameras. However, there are a few noteworthy items.

Continued on page 78

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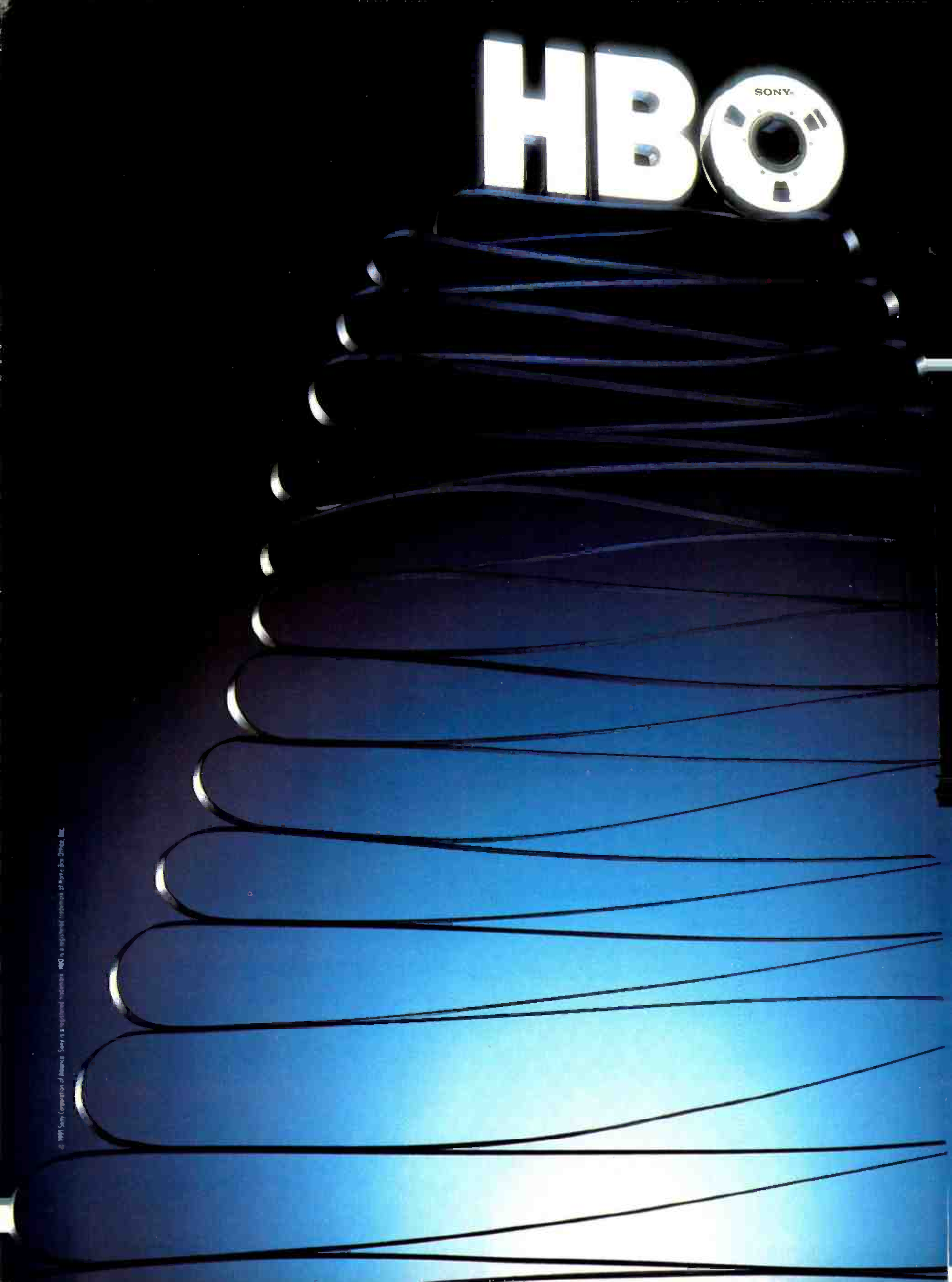
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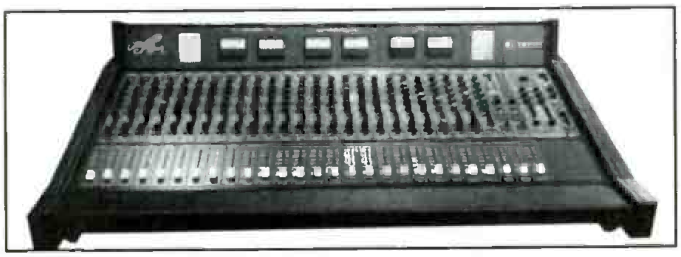

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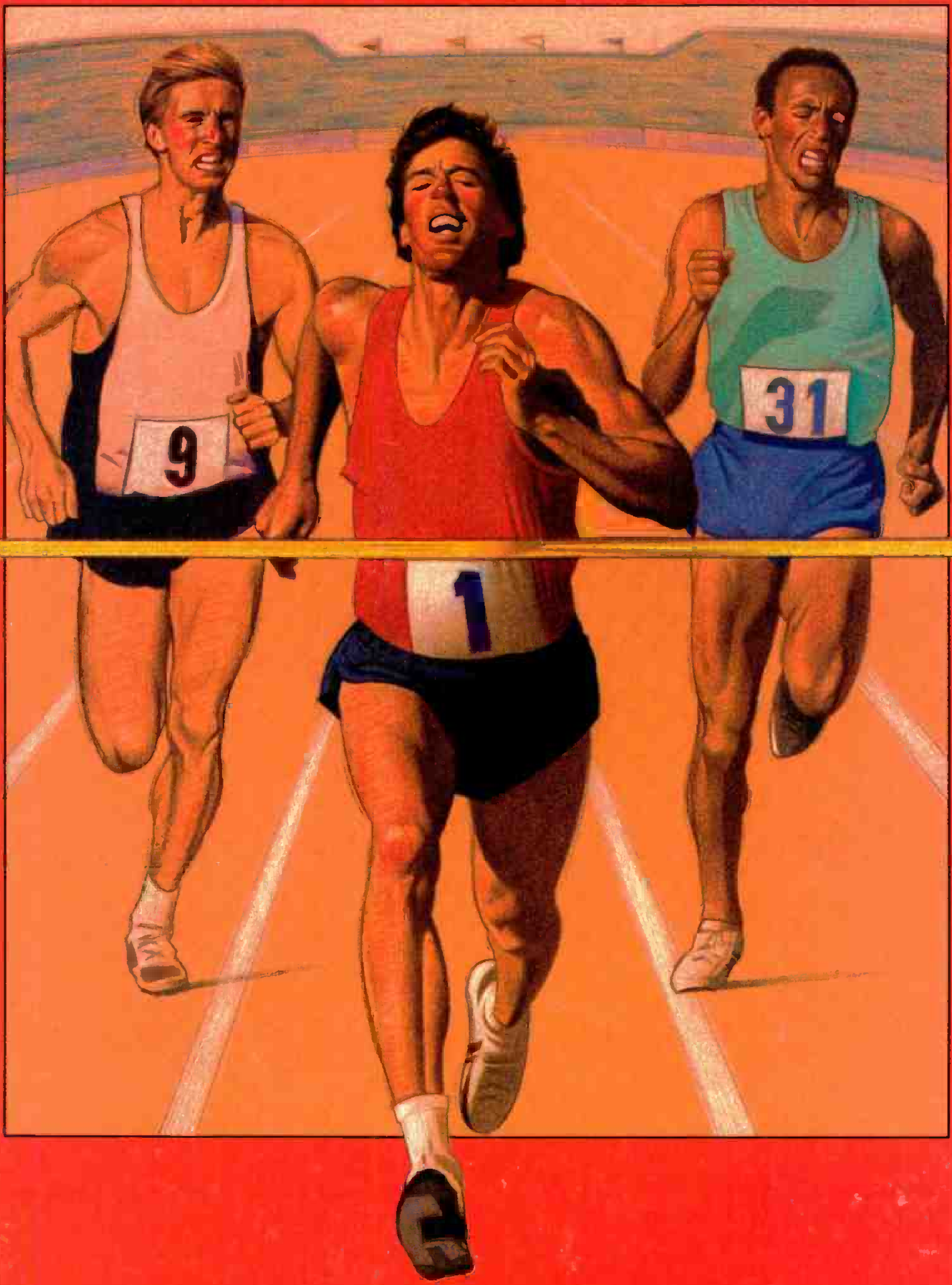

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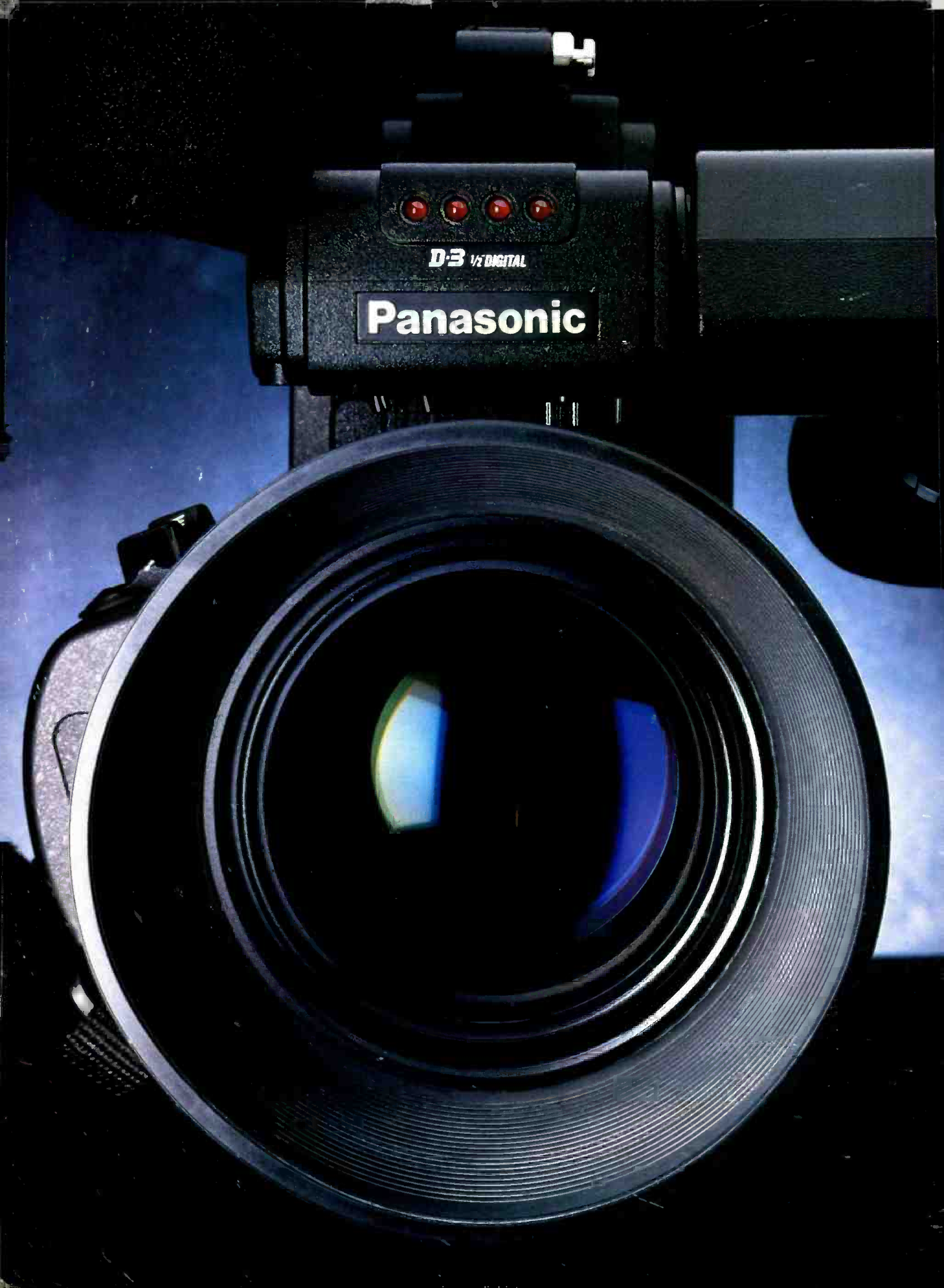
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36 USC 380

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PREPARING TO COVER THE OLYMPICS:
Covering the Olympic Games is an expensive and time-consuming proposition. Viewers will turn on their TV sets and watch the Games unfold before them, unaware of the cost, time and equipment it takes for the Olympics to be broadcast. Our Olympics Special Supplement will provide unprecedented coverage of the detailed technical aspects that are involved in televising the Winter and Summer Games.

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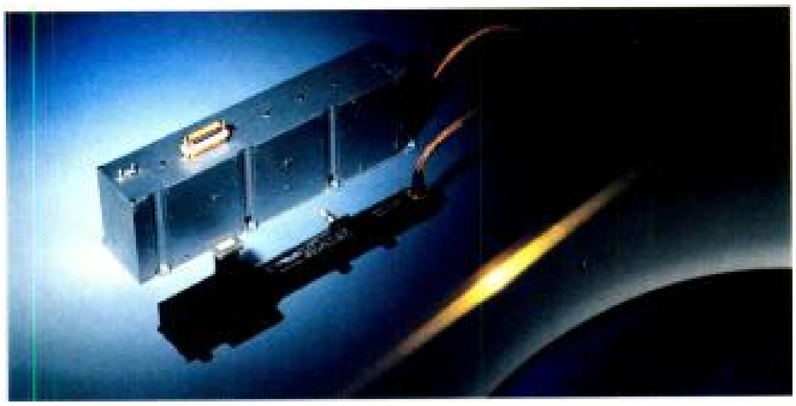
Electron Tubes, HDTV and the Olympic Games



Satellite TWT amplifier

The Olympic Games of Albertville and Barcelona are the arena for a new challenge, that of high-definition television. In cameras covering the events, in the satellite transmission systems and in public displays, electron tubes are contributing to this success. Thomson Tubes Electroniques is engaged in this technological leap forward with its projection cathode-ray tubes, Primicon® pick-up tubes and transmission tubes.

Competing in the Olympic Games

Displays : HDTV will allow viewers to watch large images "comfortably", so giving a greater feeling of presence. Front- or rear-projection units combining red, green and blue CRTs offer the large-screen capabilities necessary for this. Already on high-end simulators such as used for pilot training, the application of projection techniques to TV is opening up new forms of communication.

More advanced dispenser cathodes, new focusing techniques or new phosphors have all contributed to the resolution and brightness of projection CRTs. Furthermore, this work has also led to considerable gains in overall efficiency for the display systems.

Thomson Tubes Electroniques developed the 9-inch diameter TH 8467 for high-definition front-projection units with screen sizes of up to 170 inches or more. The electronic cinema can now become reality, and multi-media stations, videoconferences or high-resolution graphics applications will all benefit from this technology.

TH 8467 projection CRT

HDTV pictures of the winter and summer Olympic Games are being projected to audiences using Thomson's TH 8467.

At the picture source, electron tubes offer the performance required for HDTV cameras. They combine high resolution with excellent light sensitivity and low lag, which is why the THX 898 Primicon® pick-up tube is in cameras covering the events.

Picture transmission : Thomson pioneered high-power uplink TWTs with such tubes as the TH 3640 (3 kilowatts, C band) or the TH 3591B (600 watts, Ku band). These tubes are in service throughout the world, with more than 1000 TH 3591Bs having been produced. In a family of medium-power klystrons, the TH 2454 (3 kW, C band) offers an enlarged instantaneous bandwidth of 80 MHz. These 3 tubes are powering the satellite uplinks at Albertville.

In space, Thomson is a leading manufacturer of communications satellite TWTs. It has developed the latest generation of Direct-Broadcast Satellite tubes which are equipping the future American and European satellites now being built. With the Ku-band TH 3754 (100 to 160 watts), Thomson Tubes Electroniques has brought the state-of-the-art to 60 percent efficiency, and a tube weight of 800 grams for an output of 120 watts.

Telecom 2 is equipped with Thomson 55-watt tubes from the same family, and is transmitting the Albertville pictures to the outside world.

Thomson Tubes Electroniques' long-term commitment to the development and manufacture electron tubes for radio and television has led to such tubes as the TH 563 UHF tetrode (42 kilowatts vision only). Thomson alone offers high-power UHF tetrodes, and as the first tubes are logging 20 000 hours, more transmitters are turning to this solution. Our advanced technology is employed in satellite transmission and direct-broadcast services worldwide, with our comprehensive range of klystrons and TWTs. Our foresight prepared us for the future and HDTV. Whatever your projects in radio or TV, you should be gaining from Thomson Tubes Electroniques, the leading-edge in electron tubes.

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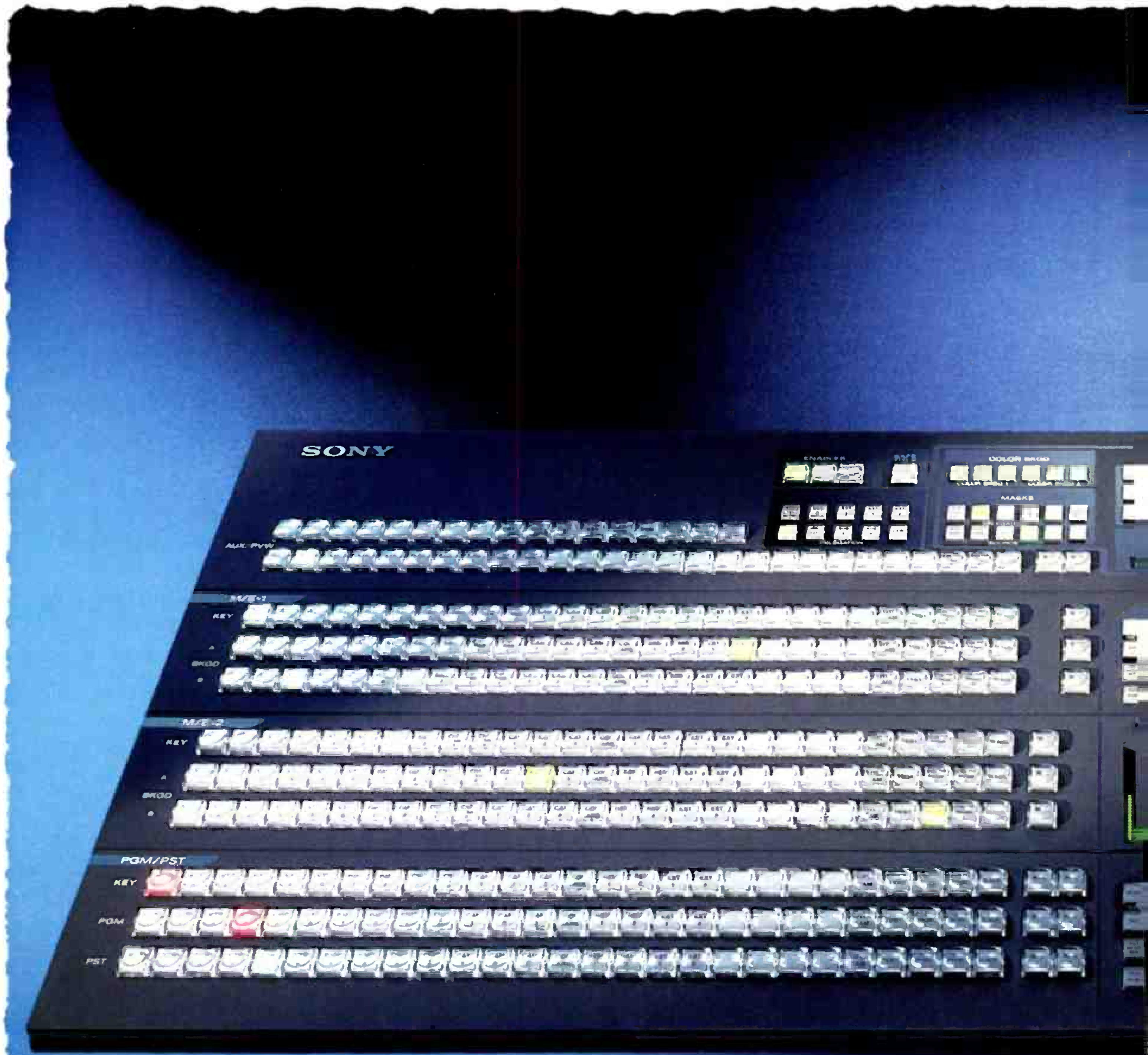
With Sony's digital switcher and eff



If you're still hesitant about switching to digital, then you probably haven't experienced Sony's DVS-8000 Digital Switcher and the DME-5000 Digital Effects System.

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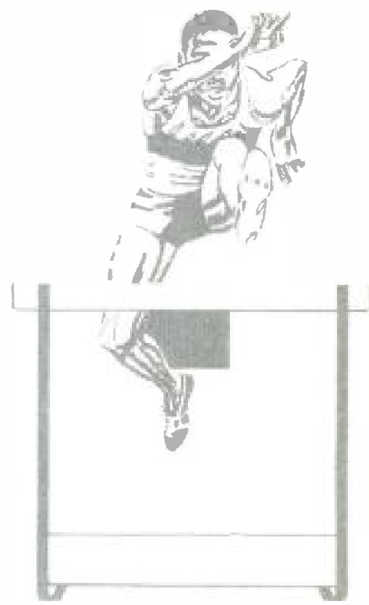
SONY

Preparing to cover the Olympics

Written by the *Broadcast Engineering* staff



The first Olympics to be broadcast on television was the Berlin competition in 1936. Despite the ominous backdrop of an increasingly threatening Germany, the event made history because of impressive performances by an underdog black American athlete. Television brought the spirit of competition and athletic excellence to a larger audience than ever before. Thanks to this infant technology, the Olympic Games had become a part of the world experience.

As the audience for the Olympics grew, the commercial possibilities also expanded. In 1960, the International Olympic Committee (IOC) for the first time sold broadcast rights to the event, held in Rome. The price tag was $1.4 million.

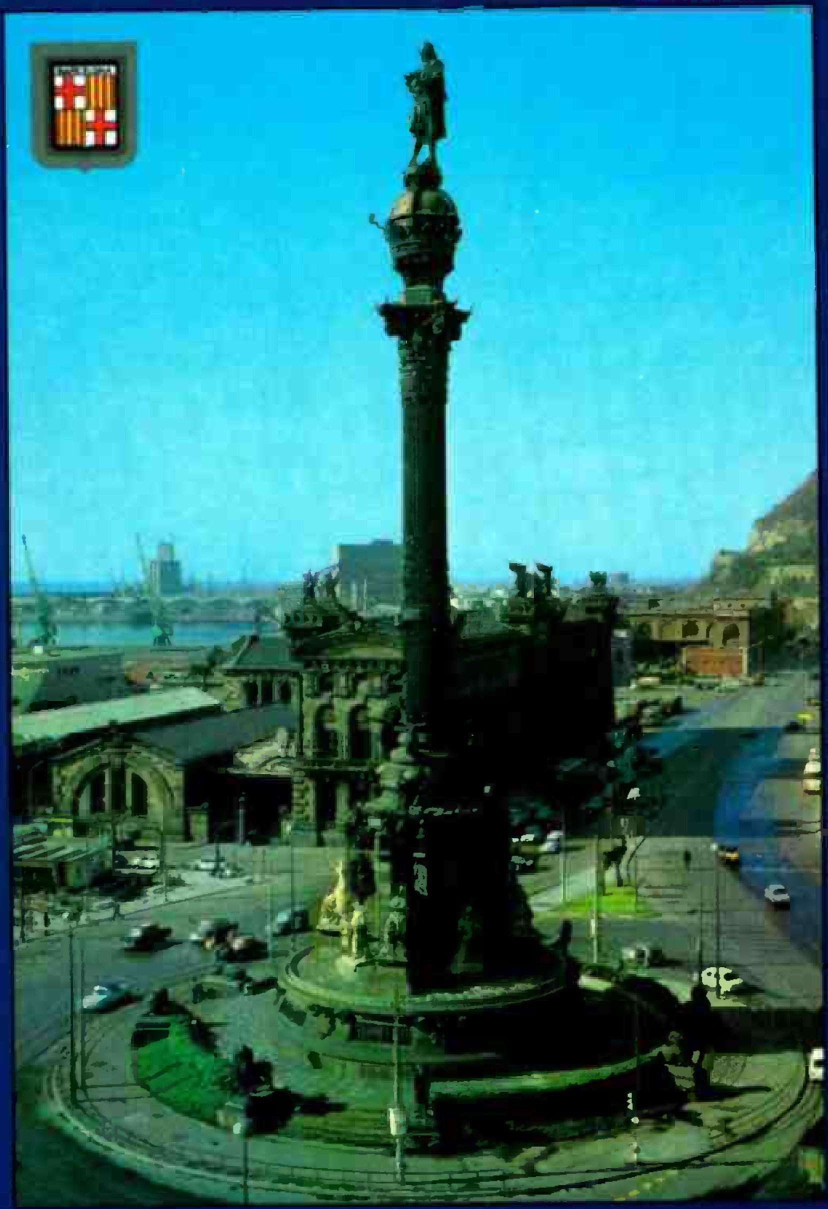
In Tokyo years later, satellite technology appeared and the Games were first broadcast live to the United States. In Montreal in 1976, satellite links were used to relay 70 hours of programming.

In Los Angeles in 1984, a bidding war pushed fees for the broadcast rights through the roof. ABC purchased the exclusive rights to broadcast in North America for $225 million, compared to the $85 million that NBC had paid for the previous Olympic Games in Moscow. And the end is not in sight.

Covering the Olympic Games is an expensive proposition. It is an exercise driven by the desire on the part of viewers to see more, and by the need of the IOC to cover higher and higher operating expenses. All of this is, however, invisible to the general public. Viewers turn on their TV sets and watch the Olympics unfold before them. In the final analysis, that is the real payoff for broadcasters.

This Olympics Special Supplement provides unprecedented coverage of the technical aspects of the Winter and Summer Games. Information gathered by the *BE* staff and experienced correspondents in France and Spain come together in this supplement to examine the detailed technical planning that has gone into the Olympics.

Brad Dick, editor




Covering the Winter Games


©DG 1991

The idea of French candidacy for the Winter Games was launched in 1981 by Jean-Claude Killy. Five years later in Lausanne, Juan Antonio Samaranch, President of the International Olympic Committee, announced that the XVIth Winter Games would be held in Albertville.

Olympic competition is nothing new to the French Alps. Winter Games were held in Chamonix in 1924 and Grenoble in 1968. The Grenoble competition was the first to be broadcast in color to Europe.

Today, instead of a town, the entire 1,600-square kilometers of the Savoie area are involved. Ten resort venues are being used, ensuring a variety of landscapes and optimum use of the features of each site. Transportation is complicated by this decentralized approach; transportation times can reach up to 90 minutes between two points.

The games take place from Feb. 8 to 23. There are 119 events or matches, with 57 medals to be awarded. Eight demonstration sports are also being presented.

Organizing the event

Every project needs a coordinating body, and the Winter Games are no exception. In 1987, the *Organizing Committee of the Olympic Games* (COJO) was formed. Its prime task was to find business partners. Estimates put the cost of the Winter Games at 4 billion French francs, including construction of sports facilities. The French government contributed approximately 20% of this total. The balance came from broadcasting rights and marketing revenues — each of them accounting for a little more than one billion — and various types of "official sponsorships."

Another mission entrusted to COJO was to appoint a host broadcaster, who would be in charge of all TV and radio events and ceremonies and provide all the rights holders with needed services.

Bids were invited in mid-1988, and two proposals were received: one by TF1, and the other from a consortium of French broadcasters (A2, FR3 and Radio France). The latter was selected and a public company, *Olympic Radio and Television Organization* (ORTO '92), was created as a subsidiary of the three parent firms. In December 1990, *Telediffusion de France* (TDF) joined the group.

CBS is the major rights holder, reportedly paying a total of $243 million to broadcast the games. The *European Broadcast Union* (EBU) secured broadcast rights for a reported $25 million. EBU brings together 20 or so European broadcasters (including the BBC, RAI, ZDF, RTB, A2, FR3 and TF1). Other broadcasters in Albertville this year include:

- NHK (Japan)
- Australian Channel 9
- CBC (Canada)
- O'Globo (Brazil)
- Mexico TV
- New Zealand TV3
- OIRT (Eastern Europe)

Capturing the action

To help ORTO '92 service its customers — the rights holders — seven *service providers* are collaborating within the 14 event venues and the *International Broadcast Center* (IBC) at Moutiers. The service providers are:

- *Société Francaise de Production* (SFP)
- FR3
- UER/EBU (Finland, Sweden, Piagne and Norway are involved at Les Saisies, Germany at La Paigne, Italy at Les Arcs, Switzerland at Pralognan and Spain at Tignes.)
- TDF

Armand Chemama, a French-based correspondent for the Intertec Publication, *World Broadcast News*, contributed portions of this article.

- Radio France, which will set up and operate 500 commentary positions
- France Telecom, which will handle all transmission links
- VCF, a senior French facilities house

Various camera pickup tricks are being used, including:

- Hand-held cameras
- Vertically hanging cameras
- Remote-controlled cameras
- Special position cameras above and below ski jump positions

Commentator booths are staffed by a 140-person Radio France team. Equipment in the booths includes the following:

- A video monitor of the international signal from the venue.
- Three additional video signals from other venues (making possible remote commentaries).
- One or more competition results display monitors.

Commentary signals are transmitted to the IBC by France Telecom in digital form. Bandwidth is 7kHz on a 64Kbits/s standard circuit; 15kHz circuits are also available.

COJO's main computer center at Albertville is linked to each of the venues, where 1,500 IBM PS/2 computers are used to gather and distribute information. Swiss timing provides information about speeds, provisional rankings and timekeeping. Chyron Infiniti graphics generators are used to provide names, countries, flags, competitive information, start lists and final results.

COJO's main computer center at Albertville is linked to each of the venues, where 1,500 IBM PS/2 computers are used to gather and distribute information.

Video signals are distributed to the venues through 18-channel temporary networks. The circuits include three PAL channels for the three international signals coming from other venues (and received by satellite), one PAL channel for the international signal produced at the venue, three to seven PAL channels for the results system, and three SECAM channels for TF1, A2 and FR3 terrestrial broadcast distribution.

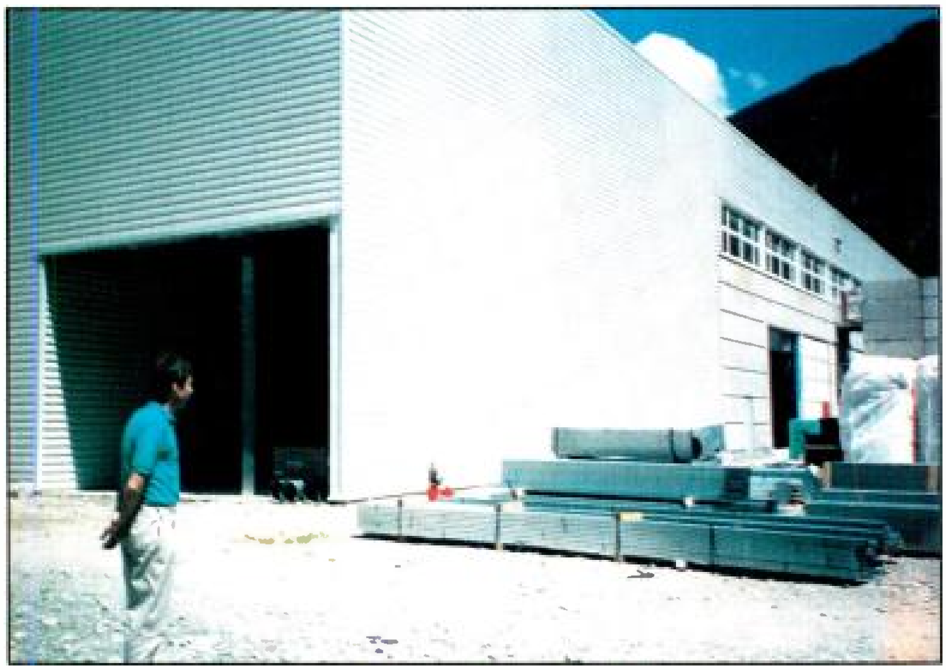
Inside the IBC

The IBC at Moutiers is the heart of broadcast coverage of the Winter Olympic Games. IBC serves the following functions for rights holders:

- Provide clean international feeds.
- Coordinate unilateral feeds (specifically requested by a rights holder).
- Provide and coordinate commentary circuits.
- Production of two 30-minute daily summaries.
- Service of video multiple copy and record requests.
- Coordinate bookable production facilities, including five component editing suites.

Video (approximately 50 circuits) and audio (approximately 600 circuits) signals produced at the venues are transmitted by France Telecom to the International Broadcast Center through 29 links. The signals are distributed among microwave, optical fiber (2,000km in mono mode), and satellite, using Telecom 2A (launched on Dec. 17, 1991). TDF designed and operates the Moutiers IBC, located at the junction of three valleys leading to the Olympic sites, and near La Lechere, which houses the main press center and press conference room.

Cable tray assemblies used in the CBS facility. Note the through-wall ports.



Outside view of the International Broadcast Center facility under construction in Moutiers.

The IBC building comprises two main levels. The lower houses CBS, NHK and CBC, and the upper houses ORTO '92 technical areas. Two incoming signal-routing switchers (50×50 and 20×10) are used. Video programs leave Moutiers using two different means:

1. Optical fiber routed to Paris, and then sent by *Service d'exploitation radio télévisuel extérieur* (SERTE) to the Pleumeur-Bodou and Bercenay-en-Othe satellite transmission centers.

2. Direct satellite link at Albertville. A total of 30 satellite channels will be used during the 3-week Games.

HDTV coverage

The 1992 Winter Games is the theater of the largest high-definition TV coverage (in the Eureka 1,250/50 format) in history. Coverage is provided by *Savoie 1250*, a partnership joining three French ministries, France Telecom, TDF, SFP, ORTO '92, Thomson Consumer Electronics and Philips Consumer France. Nearly 200 hours of HDTV programming are being produced at Albertville, Méribel and Courchevel.

Images in the 1,250/50 standard and 16:9 aspect ratio, with digital stereo sound, are supplied by more than 35 cameras and 30 VTRs, through some 15 vans operated by 300 technicians. Technical support for this effort is being provided by RAI, RTVE, ORF Thames TV, A2, FR3 and SFP. The programs are edited at the Albertville Center and broadcast using HD-MAC coding.

Approximately 50 viewing sites have been established in Europe, including 27 in France. The sites are outfitted with HD-MAC decoders and will use HDTV direct-view and projector systems to display the live images.

Building the CBS facility

As the lead broadcast rights holder, and the pipeline through which the United States will view the Winter Games, the task facing CBS was formidable. As with any major sporting event, the design of the technical plant was dictated by the programming requirements faced by the network.

After the program needs had been identified, the technical plant began to take shape — on paper at least. The requirements and basic equipment interconnection system was designed and specified by CBS. The contractor (Sony Systems Division) made refinements as necessary and built the facility to CBS specs. Quality control was an important part of the entire process. Correcting mistakes or oversights at an early stage was necessary to prevent costly construction delays.

Design work on the project officially started on April 1, 1990. The hardware was completed and tested by the end of summer. Testing the system required about one month. Statistics help to give an idea of the size of the facility. The CBS plant consists of the following hardware:

- 191 equipment racks. The greatest concentration of racks can be found in the transmission center, through which all signals enter and leave the facility.
- 36 consoles or workstations. Eight dedicated editing rooms are provided for the CBS staff, plus separate areas for graphics and viewing.
- Two 48-foot remote trucks. The trucks were rolled into the IBC facility during construction and integrated into the CBS plant. The trucks act as self-contained production centers.
- Approximately 100 videotape recorders (44 digital VTRs, 22 Betacam SP VTRs, three type C VTRs, plus a variety of U-matic, Hi8 and VHS VTRs).
- At least 354 video monitors. Various grades are used depending upon the application.
- A routing system of at least 2,240 crosspoints, not counting local dedicated routers. There are three main routers: the NTSC router, which is 144×184 at seven levels; the PAL router, which is 40×40 at six levels; and the graphics (RGB and key) router, which is 32×16 at four levels.
- Eight Sony BVE-9100 editors, used in the editing suites.
- 160 RF drops serve the CBS staff.
- More than 80 miles of cable to interconnect all of the hardware.
- More than 10,000 rack screws were used to hold it all together.

A portion of the CBS broadcast facility at the IBC under construction. The door visible in the photograph is where the two OB trucks entered.

Construction of the CBS facility was done as a 2-stage process. First, the entire plant was constructed by the network's system subcontractor in Sunnyvale, CA, and tested. The racks were then broken down and shipped to Moutiers. Second, they were reassembled on site at the IBC.

For construction purposes, the CBS facility was divided into the following subsystems:

- Edit suites
- Play to air/dub
- Graphics systems
- Router system
- Sync and reference systems
- Quality-control system
- Converters, frame synchronizers, proc amplifiers
- Edit suite digital video effects subsystem
- Audio cross-connect
- Control room/studio systems
- Audio sweetening and music
- Intercom system
- Clock system
- RF system

Careful coordination between each element was necessary to ensure that the project proceeded in a timely manner. CBS engineers viewed each stage of the project at predetermined points in the process to ensure that everything was built according to their specifications. CBS engineers have been on site since early September.

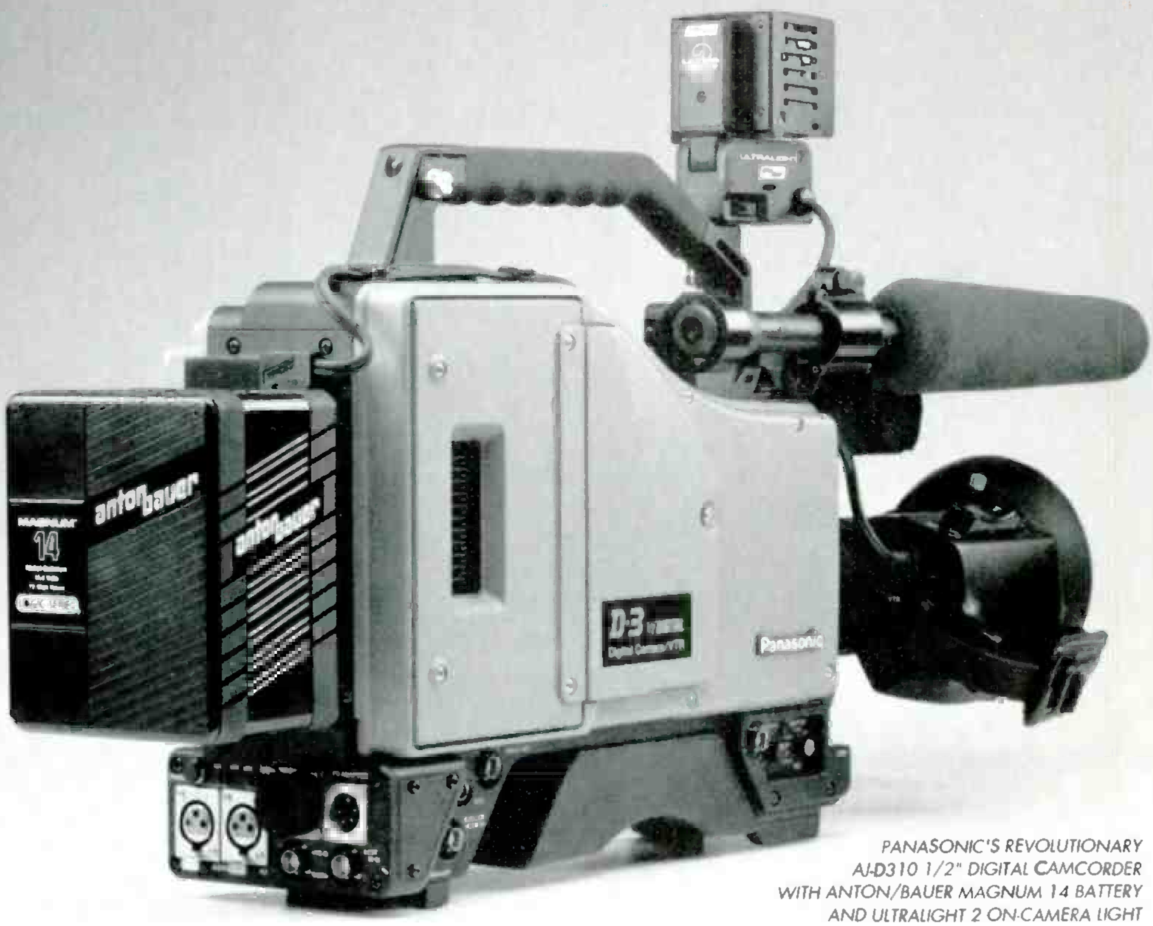
The games end on Feb. 23, and decommissioning begins the next day. Under the terms of the lease CBS has for its portion of the IBC building, the network must be out by March 15. This represents a tight schedule. Planning for quick disassembly and storage was an important part of the initial CBS design efforts.

Edit suites

Editing raw videotape into packaged segments is the basis of most non-live sports programming. It follows, therefore, that the eight edit suites for the CBS facility had to be efficient and comfortable for the people who would use them.

CBS engineers built one small and one

Performance Matched



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large edit suite themselves to make sure their operators and producers were comfortable with the configurations. The remaining six edit suites were constructed by the system contractor to those specifications.

Months before the Winter Games, CBS production people began using the new edit suites in New York. This afforded the opportunity for producers and operators to become familiar with the rooms.

60Hz or 50Hz?

The French IBC facility contractor provided power drops from the ceiling to feed individual equipment racks in the CBS area. The power standard is an interesting one: 110V, 50Hz. The contractor converted the 3-phase 220VAC to 3-phase 110VAC with power transformers. To confirm that the broadcast equipment would work properly with this AC feed, the CBS systems contractor (Sony) ran the hardware on a generator adjusted to provide 110V, 50Hz at its facility in Sunnyvale. Tests indicated that the equipment would perform correctly on this somewhat strange power source.

The 50Hz AC feed is well within range of most hum-reducing equipment intended for 60Hz. The lower frequency does cause transformers to generate more heat. The increased temperature, however, was not appreciable.

The unusual power supply suggested the need for a more robust ground system, just in case. The heavy ground system, and meticulous attention to proper grounding at every piece of equipment, provided for a trouble-free facility from the beginning. Installers were faced with a formidable task in getting the CBS plant up to operating condition in time for operators to begin learning the equipment in January. Installers did not want to chase ground problems in an effort to solve one abnormality or another.

More than 35 HDTV cameras and 30 VTRS will be used with 15 remote vans to help produce the high-definition programming.

Documentation

Detailed documentation of the facility was important not only for construction and testing, but also for troubleshooting on site, if needed. A database of all cables was created by the systems contractor and then sorted by various key categories, such as wire number or function.

The scope of the CBS facility demands detailed records. There are more than 18,000 video cables and even more audio wires. The total wire number count is in the area of 22,000. The longest cable run, from the main studio to the transmission area, is approximately 350 feet, once it is routed.

Control room inside a 2-camera HDTV OB van.

Next time...

Although the 1992 Winter Games will last only three weeks, CBS has future plans for its IBC broadcast facility. After the competition, the facility will be broken down, and the trucks and people will be sent home. However, the heart of the facility — the racks, wiring and electronic glue that makes it all work — will be put into storage for the next Olympic event covered by the network.

Stay tuned... ■

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Barcelona: the world's biggest remote

The 1992 Summer Games will be a showcase for new telecommunications and data processing technologies. Electronics in general, and communications in particular, are closely linked to the Olympic Games. New technology will play an important role in bringing the Barcelona competition to the world.

Telecommunications for the Summer Games can be divided into two sectors:

1. *Public telecommunications*. It deals with the adaptation of technical, management and public service telecommunications infrastructures in Barcelona to ensure that the systems will function in the Olympic areas in general, and in the Olympic venues in particular.

2. *Private telecommunications*. It deals with the provision of equipment, wiring, infrastructure, terminals and service exclusive to COOB '92, coordination for setting up public telecommunications infrastructures at the Olympic venues, and the management and coordination of all the private services.

The Barcelona '92 Olympic Games will have a staggering 170,000 telecommunications users, including:

- 9,021 internal telephones for COOB '92 personnel
- 5,960 public telephones
- 2,293 telephone booths
- 691 fax machines for COOB '92 personnel
- 586 public fax booths
- three video conferencing rooms

Other notable telecommunications and information systems include:

- *Results Management System*. The Barcelona Games will feature an integrated system for results management. This will avoid any contradictions or incoherence in data. It will also provide a valuable service for spectators, the sports organization, the media and TV viewers. The results management system will be based on an independent structure at each competition venue. The system will feed the scoreboard, provide information panels for the TV screen, display results on the radio and TV commentators' personal computers and provide printouts of results. The results of all the competitions will also be transmitted to a central computer.

- *Olympic Family Communication and Information System* (SCIFO). Members of the Olympic family and organization staff will have a powerful instrument of communication during the Olympic Games. SCIFO will send messages and provide access to all the information required by the Olympic family and staff to carry out their specific tasks. The SCIFO consists of a central computer and about 2,000 personal computers connected to it. A single database can be consulted from any terminal. Members of the Olympic family will be able to send personal messages, which will be left in electronic mailboxes.

- *CATV system*. The distribution of TV signals of competition from any number of venues will be available to members of the Olympic family, journalists, judges and referees and members of the COOB '92 organization. The system incorporates an optical fiber network which, for its size (250km of optical fiber) and the number of receivers (12 venues), is the largest in Spain for the application of CATV. The CATV system will deliver 16 signals to approximately 7,500 TV sets.

Maybe what happened Dec. 27, 1991 didn't make the 6 o'clock news...

Televising the Games

It is estimated that as many as 3.5 billion people will watch the Barcelona Olympic Games during its 3-week run. That estimate is more than 500 million viewers from the Summer Games in Seoul. No other event in world history will be seen by so many people.

The enormity of this audience has led to new innovations, and new ways of doing things. For the first time, an organizing committee has created its own organization, the *Radio and Television Olympics* (RTO '92) in order to guarantee top-quality signal transmission to the broadcast rights holders. RTO '92 will produce more than 2,000 hours of broadcasting, in addition to 50 hours of summary programs.

RTO '92 is in charge of supplying the necessary environment sound, slow-motion camera effects, repetitions, timing, graphics, competitors' names, results, the world and Olympic records and other data. Moreover, RTO '92 will establish trials and timetables, and determine camera placement and commentator positions.

The main function of RTO '92 is to produce the international radio and TV signal, but, in addition, this organization is responsible for providing the following services:

- The transport of international signals from the venues and distribution to the transmitters at the International Broadcast Center (IBC).
- Provide the rights holders with the services and infrastructure necessary for their purposes.

It is estimated that as many as 3.5 billion people will watch the Barcelona Olympic Games during its 3-week run.

- Provide the rights holders with detailed information about the Games and relevant matters, within the Olympic context, before and during the Games.

All of this has been designed to provide the necessary services to almost 7,000 accredited radio and TV staff expected to cover the Olympics.

The IBC facility

All video and audio signals will be routed through the IBC. The building houses a distribution center, which will relay the incoming signals from the stadium, other Olympic sites and the "beauty" cameras; the latter provides background views of the stadium and the Barcelona area for continuity. Signals will come in on a patch panel for routing; little need for switching is expected as all 40 direct feeds will be available to broadcasters. Figure 1 shows a master block diagram of the IBC facility.

There will be some 75 incoming circuits. Signals will pass through the telco room to broadcasters' individual facilities and to the RTO '92 production areas.

A central facilities area will house a VTR machine room, where the signals from all venues will be recorded, and edit suites and post-production rooms, which will produce the two daily summaries of the games. A TV studio, video edit suites, radio studios and off-line booths will also be available for hire by individual broadcasters. The commentary and data circuits, radio circuits and signals from off-line

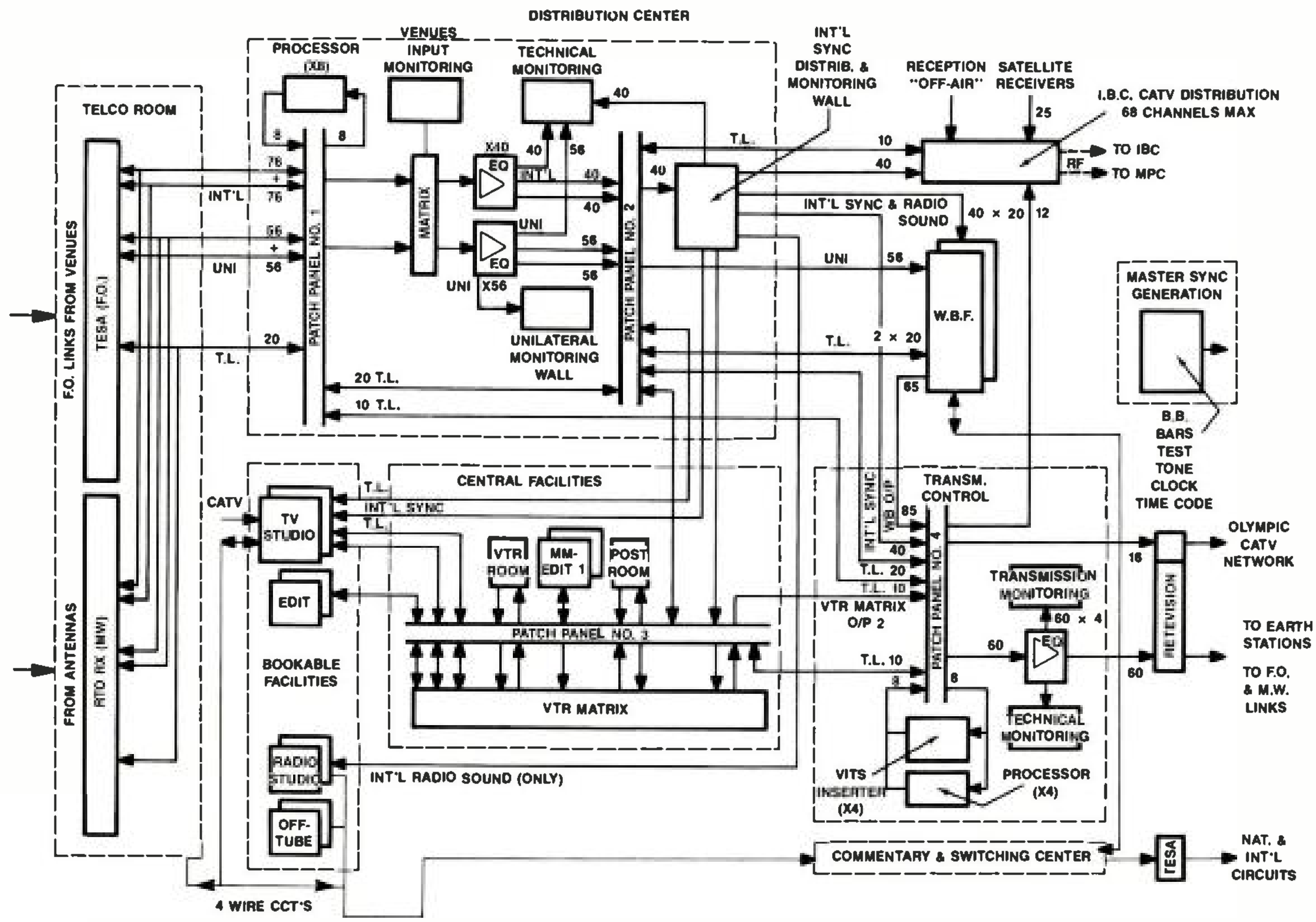


Figure 1. Signal-flow block diagram for the International Broadcast Center of the Barcelona Olympic Games. (Note that in the diagram, T.L. refers to tie lines; WBF refers to "world broadcast feed;" 4-wire circuits refer to commentary and talkback feeds.)

booths will be managed from the commentary switching center.

Processed signals from the RTO '92 and individual broadcasters will be relayed to the outside world via the transmission control and telco room. The Olympic TV network, which will be managed by the telecommunications division of COOB '92, will also receive its signals via transmission control.

A standard package of "international" signals will be available to all participating broadcasters, including a complete program without commentary as the most basic service. All subscribers will be able to use individual feeds from venues, and broadcasters will also be able to book additional special *unilateral* feeds and production facilities. The EBU, for example, will take approximately 30 direct (*multilateral*) feeds and perhaps 10 unilateral feeds reflecting the particular interests of its members.

Synchronized audio will be recorded on multitrack recorders (4×24 track) to allow broadcasters to book pictures plus commentary in their own language. By prebooking, several different commentaries can be replayed simultaneously from a single 24-track reel.

At the main arenas and certain other venues, space will be made available for special requirements, including unilateral cameras. Broadcasters will be able to rent space for their own equipment, or to lease any production facilities that they may require (including service and training).

Graphics

Graphics will play an important role in the TV presentation of the Games. Graphics will be standardized on a new CG 4733 series anti-aliasing character generator (Pesa). For sports coverage, graphics needs are less elaborate than in a large postproduction facility: the advantage of the CG 4733 character generator for logos and text is the speed with which the images can be brought up in real time. Furthermore, the unit will accept results data directly from a host computer to provide on-screen information and results (including time-related data) without operator intervention.

The CG 4733 character generator (Pesa), which will provide graphics for TV presentation of the Games.

Various graphics templates have been designed to provide an overall style for a given channel. Broadcasters will be able to customize the same incoming computer data (timing, statistics and competitor background) that is fed to everyone, to generate graphics in an individual look and layout. The same basic timing and data signals can be used in different fonts and sizes, as well as different on-screen configurations, according to individual requirements.

At least 66 of the new CG 4733 series character generators will be used for the Games. They will be used by RTO '92 in the IBC and at main venues and the remainder will be used at other venues and for unilateral coverage.

Inside the network

To meet the necessary communications and control requirements, a complex network of fiber, copper and radio links has been designed. The RTO '92 network can be divided into three large subsystems:

1. The optic fiber network
2. The microwave radio link network
3. Backup and security system

Optic fiber will be used in Barcelona in the areas of Montjuc, Diagonal, Val d'Hebrón, Park del Mar, Badalona and the Collserola Telecommunications Tower to prevent the possibility of interference and/or signal disturbance in these areas of radio frequency saturation.

Two link categories, based on the required level of protection, have been established in order to protect signals generated in each venue:

1. *Special category link*: These are the links to be established between the IBC and the Collserola Telecommunications Tower, and between the IBC and venues situated in the Montjuc area. Two alternative routes will be between the venue site and the IBC transmission room.

   To establish the dual routes, two optic cables for two different ducts will be installed. In each transmission room RTO '92 will install duplicate equipment for each video channel connected to the fibers via an optic fiber distribution unit. The signal will be transmitted and received simultaneously by both routes so that in the event of malfunction of one of the routes, there will be no interruption in signal reception.

   This type of link will provide coverage of approximately 60% of the international and unilateral signal circuits.

2. *Normal category link*: These links connect the venues situated in the Val d'Hebrón, Diagonal, Badalona and Parc del Mar areas with the IBC. Backup transmission equipment will be installed in the transmission room at each site. This provides, in the worst of cases, a 2:1 ratio between active equipment and backup equipment. The connection of video signals in baseband to the transmission equipment, and subsequently to the optic cable will be executed via manual distribution units. This configuration allows recovery of the service in the event of transmission system malfunction. A similar redundant system will be installed for receivers at the IBC.

As part of its turnkey contract with RTO '92, Pesa is constructing all basic broadcost facilities for the Summer Games. Shown is one of the prototype small production consoles.

Approximately 25% of the international and unilateral signal circuits will be covered using these normal category links.

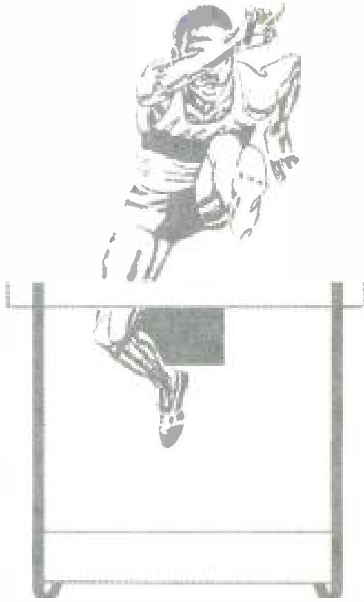
The main microwave site for the network will be the Collserola Telecommunications Tower. Microwave links will provide coverage for the rest of the international and unilateral signal circuits.

Turnkey system

Following international tenders, the contract to supply a complete turnkey system for the IBC was awarded to Pesa Electronica SA of Madrid. Pesa was nominated as "supplier of broadcast equipment to RTO '92" and is responsible for installing and commissioning the entire system, training staff and providing engineering and maintenance services. Pesa is also equipping the main Montjuc Olympic Stadium with five production and control facilities and a continuity studio, together with four studios and continuity for the nearby St. Jordi Sports Palace, where the gymnastics, volleyball and handball events will be held.

Under the contract with RTO '92, Pesa is cooperating with Matsushita Electric which, through its subsidiary Panasonic, is supplying D-3 format ½-inch composite digital camcorders and VTRs for the Summer Games. Pesa will be responsible for integrating the digital VTRs into the IBC facilities.

NBC covers the Summer Games



Since the first live international relay from the Rome Olympics in 1960, televising the Games has assumed major importance. Today, hundreds of millions of people may watch any given event live; many more will watch edited highlights. Plans for broadcasting the 1992 Olympic Games in Barcelona by TV networks around the world are ambitious. Clearly, none is more ambitious than NBC.

The network will not only produce material for airing through the NBC-TV network, but also special in-depth programming through pay-per-view (PPV) cable, in association with Cablevision. Three PPV channels, programmed 24 hours a day, will be available to cable subscribers around the United States.

For the first time in Barcelona, it will be possible to transmit any event live, even though there will be more venues than at the Seoul Olympics; 10,000 competitors from 170 countries will take part at 44 venues or courses. There will be full coverage of all 28 competition sports (including the wide-ranging categories of athletics and swimming), three demonstration sports and the opening and closing ceremonies.

NBC will have it all. And the price to "have it all" is dizzying — $416 million for U.S. broadcast rights.

NBC was the first North American network to broadcast the Summer Olympic Games, obtaining the exclusive rights for the Tokyo competition in 1964. NBC also captured exclusive rights for Moscow in 1980, Seoul in 1988 and now Barcelona.

Getting ready

The Olympics is a techno-athletic contest of sorts. Like the Games themselves, broadcasting the Olympics is a 3-week rush. After several years of intensive planning, it is all over in a few days and there are no second chances to get it right. Events cannot be rerun for the sake of the cameras.

Planning for the Barcelona Olympic event began about three years ago. The Summer Games are held in July and August, and working backward, rehearsals are in June and the system checkout is in May. From January to April, the NBC studios, edit rooms, graphics suites and other facilities within the IBC are installed and tested. Physical construction began in December of last year; equipment was shipped to the site in September.

To meet the shipping schedule, equipment was ordered starting at the beginning of this year. That means important purchasing decisions had to be made in the fall of 1990. This task can be formidable, because some of the technology expected for mid-1992 may not have been fully developed — much less field-proven — a year-and-a-half before the Games.

Digital or analog?

In 1990, when system design decisions had to be made, there were no really large, totally digital video production systems available. Furthermore, it made little sense to risk so many unknowns on an event where there is absolutely no delaying the broadcast. Opening day is opening day. Period.

Performance in Barcelona would be technically better in digital, but not necessarily operationally better, in view of all of the unknowns. Plus, the cost for a digital system today — of the type NBC is building in Barcelona now in analog — is staggering. Therefore, the basic system including the routing switcher is analog.

Basic tape recording, however, is a different story. It would be digital *or* analog either way. Operations personnel are more familiar with analog tape systems, but at this point in time, many people also have some experience with digital systems, especially in edit rooms.

Analog tape equipment might have been substantially less costly, but the fea-

Portions of this article were adapted from a paper given by Charles Spicer and Charles Jablonski of NBC at the fall SMPTE conference in Los Angeles. The title of the paper was "Summer Olympics, Barcelona 1992: Decisions, Decisions."

tures of digital outweighed the higher costs. Digital D-3 technology was chosen by NBC for studio and camera-recorder functions because it provided editing speed, four audio channels (independently editable) and multigeneration quality. The size and availability of D-3 for camcorder use was another important factor in the NBC decision.

The graphics router system being installed by NBC uses component-digital serial technology. Tests of the basic system were conducted in New York last year, and results indicated that serial digital signals can be handled with standard coax, patching, connectors and other typical elements found in a large video facility.

NBC is committed to high-quality audio. For events, such as the Olympics, with wide crowd shots and lots of background music and sounds, stereo is a big plus. Although it does cost more, the NBC facility router is equipped to handle stereo on all feeds.

Putting on the show

To fill its appetite for images, NBC will take just about every feed it can get: approximately 31 PAL feeds from RTO '92 and 24 additional unilateral feeds. Because the IBC is being constructed as a PAL system, NBC will also construct its facility in PAL. To minimize PAL to NTSC conversion artifacts, all storage, mixing and manipulation of the images will be performed in PAL. Conversion to NTSC will be made just before satellite transmission.

Personnel in Barcelona will be a mix of U.S. and European operators.

System construction

NBC designed the facility now being installed at the IBC in Barcelona, and specified the equipment to be used. The network contracted with the Nexus consulting firm (based in the United Kingdom) to perform the actual system construction. Under the NBC agreement, Nexus will design, build, install and commission the system in Barcelona. The project comprises in excess of $25 million worth of studio equipment. The NBC Center includes the following elements:

The NBC Olympics Center at the IBC during the early phases of construction. Note the overhead HVAC ducts.

- Three production studios and control rooms
- Eight editing suites
- One large edit suite
- Four voice-over booths
- A graphics area including a 601 serial component digital routing system.
- 40 VTR D-3 recorders
- A video, audio time-code and key routing switching system with more than 200,000 crosspoints
- A "non-standard formats" VTR area
- Three pay-per-view control rooms, which are also available for editing
- A central technical area with 120 racks of equipment for distribution, switching, source routing, standards conversion and video synchronization

There will be six outgoing satellite circuits to the United States and two incoming circuits.

Most of the NBC facility was assembled and tested at the Nexus plant in Southampton, England. Following system testing and commissioning, the equipment was disassembled and shipped to Barcelona, where it is now being installed. ■

Spotlight on D-3

By Philip Livingston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As an official sponsor of the Summer Olympic Games, Matsushita Electric, better known as Panasonic, will provide approximately 200 broadcast cameras, 2,000 monitors and more than 1,200 Panasonic D-3 1/2-inch composite digital VTRs. These will be used by more than 40 world broadcasters in Barcelona, including the BBC, CTV, NBC and Televisa. The host organization (RTO) will use almost 400 units with many of the digital recorders located in central VTR rooms. All incoming signals will be recorded in digital composite format, PAL 625-line. Conversion to other standards will either be carried out in the destination country or on site prior to transmission via satellite. The U.S. network providing Olympic coverage will be using D-3 studio VTRs, the new D-3 camera/recorders and Panasonic field and studio cameras. One major broadcaster will also have one of the world's largest routers with approximately 218,880 crosspoints.

The choice of the 1/2-inch composite digital VTRs was crucial. D-3 fits easily into the composite environment within which most broadcasters will be working at the Games; the same format can be used for camcorders, EFP, studio post-production and play-to-air. Furthermore, the studio machines can accept all three sizes of cassettes (60-, 120-, 240-minute) without adapters.

Inside the D-3 format

The first digital VTR standard developed was component D-1, followed a short time later by composite D-2. Both of these formats use cassettes that offer greater convenience than the 1-inch type C format. However, because the tape is 19mm wide, the cassettes are rather large and do not compare well operationally with the compact 1/2-inch MII and Betacam that have become popular worldwide. Especially noteworthy is the fact that these digital formats cannot be easily adapted for ENG/EFP applications, where the 1/2-inch analog formats are widely used.

It is possible to use D-1 or D-2 in the studio and 1/2-inch analog VTR for ENG/EFP, but this method invites several problems. One is that dubbing, with its inherent signal degradation, is necessary. Another is that provisions for using and storing two physically different styles of cassettes must be made. Both these modes entail considerable complexity and operational inconvenience, in addition to increased tape and storage costs. Also, using an analog source tape for a digital VTR does not allow the high quality of the digital video and audio recording to be fully exploited, especially as digital-processing cameras come into widespread use and as the image-capturing process improves.

These trends led Matsushita/Panasonic, in conjunction with NHK, to develop the D-3 composite digital 1/2-inch cassette format, which can be used for portable and studio VTRs, camera/recorders and library machines. However, achieving more than twice the recording capacity of the composite D-2 format required lowering the error rate despite the higher density recording, and improving tape interchange despite the narrower track pitch.

Several new developments have allowed these challenges to be met:

- A new *8-14 code* modulation method, developed by NHK, allows for 14% greater recording density and improved recovery when compared to the D-2 *Miller squared* coding scheme.
- A field-wide error-correction strategy implemented in an LSI processor provides random and burst error correction capabilities several times greater than D-2 without increasing redundancy.
- A format "footprint" structure that improves digital audio "robustness," espe-

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cially for repetitive edits, because audio has a greater susceptibility to degradation than video.

- An azimuth recording method with guardbands only at the editing points, which are especially susceptible to tracking errors. These guardbands minimize the error rate at the editing points and throughout the entire edit.

- A low-tension tape transport allows gentle head-to-tape contact, producing decreased head wear, increased tape life and improved interchange.

- A reduced drum diameter lengthens head life by reducing relative head-to-tape speed and decreases power consumption, size and weight.

- A super-structured nitride film head improves the recording capability over the entire frequency range.

These new techniques have produced a digital VTR that use a family of ½-inch cassettes with a recording time of up to four hours.

Recording system

Figure 1 shows the location of recorded tracks of the ½-inch digital format, often referred to as the *footprint*.

After the video signal is sampled at four times the color subcarrier frequency, quantized and rounded to 8 bits, it is divided into two channels. Both channels are $\pm 20°$ azimuth recorded by head pairs at a rate of six helical tracks per field. The audio signal is sampled at 48kHz for each of the four audio channels, quantized at 16 to 20 bits and recorded at both edges of the video helical track, two sectors per edge. In addition to the helical tracks, there are also three longitudinal tracks for cue audio, control track and time code. It is important to note that the video and audio digital signals are recorded directly, without use of the traditional RF carrier.

Various channel-coding schemes have been developed over the years, but no one method has been generally recognized as the best for digital recording. In the digital VTR field, different channel codes are also used, as seen by the use of Miller squared for D-2 and *scrambled NRZ* (S-NRZ) for D-1. S-NRZ has the advantage of a relatively modest high-frequency bandwidth requirement. However, because of its large low-frequency (DC) content, it is relatively easy for intersymbol errors to occur. In addition, the error rate is substantially influenced by the content of the input signal. Miller squared is DC-free so its low-frequency characteristics are excellent, but it has the disadvantage of having relatively large high-frequency demands. Both these schemes rely upon real time complex polynomial mathematical manipulation of the signal.

By contrast, the 8-14 coding method is a code book scheme using four different look-up tables, each with a 14-bit equivalent for every 256 8-bit word. Word selection is based upon the *digital sum value* (DSV) of the preceding word so the continuous bitstream written to tape has no DC bias, and so that the individual words and the word "junctures" will have not less than two or more than seven identical bits in succession.

This approach makes the new 8-14 code DC-free like Miller squared, but requiring only 14/16 (87.5%) of the high-frequency requirements of Miller squared. In other words, higher-density recording is possible without the disadvantages of S-NRZ or Miller squared. Intersymbol interference can be more readily suppressed and error propagation prevented. The well-centered bandwidth allows simplified equalization and azimuth recording to be used with minimal crosstalk from adjacent tracks. Therefore, the new 8-14 code offers a core technology that combines the strong points of S-NRZ and Miller squared, while allowing more than twice the capacity of D-2 for high-density recording.

One of the fundamental differences between a digital and analog VTR is that error-correction techniques in the digital domain enable complete signal recovery despite deterioration in the S/N ratio of the RF channel.

Error correction

One of the fundamental differences between a digital and analog VTR is that error-correction techniques in the digital domain enable complete signal recovery by mathematical reconstruction despite deterioration in the S/N ratio of the RF channel. Exact error correction is not possible in the analog device; this point greatly enhances the reliability of digital VTRs. However, if a digital VTR does not have good error-correction capabilities, then it is not much different from an analog VTR, especially in regard to dubbing performance. Therefore, the error-correction capability must be maximized without unreasonable hardware and software complexity.

The D-3 video and audio data block structure use the Reed-Solomon product code block as the error-correction method. The eight checkbyte inner code is the same for video and audio, as in D-2. However, the video and audio outer code contain eight checkbytes, twice that of D-2. In addition, a more powerful error-correction process has been developed, and as a result, random error-correction capability is improved. Thus, error-correction capability for a random error of a few bytes to several hundred bytes is enhanced significantly.

More importantly, the D-3 product code block for audio and video covers one field, whereas that of D-2 covers one-third of a field. Additionally, the 1-field physical distribution on the tape makes the maximum correctable burst error length about three times longer (6,912 bytes) than that of D-2.

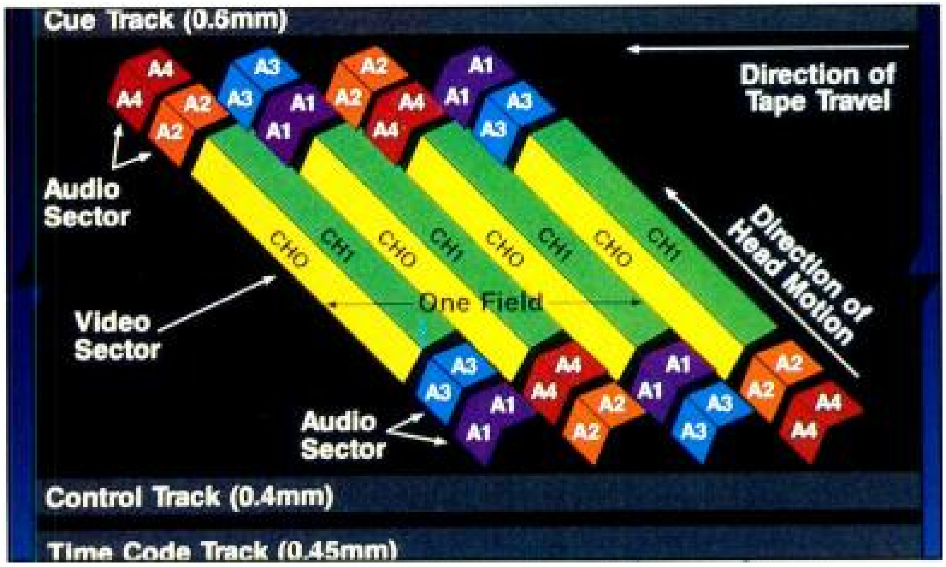

Figure 1. Location of recorded tracks in the D-3 format.

These error-correction capabilities result in a digital format that is robust and resilient to degradation. This is the case even in non-ideal conditions, without being substantially more complex or costly.

Digital audio

Digital audio signals are more susceptible to degradation than video, because human hearing is more attuned to errors than the eye, and this is exacerbated by editing. When an audio channel is edited, it is not only the audio sectors at the edit in/out points adjacent to the prerecorded sectors that are affected but all the adjacent audio sectors in between as well. This results in the new and old sectors being subject to degradation due to tracking error. Digital audio, therefore, requires an even more robust recording scheme than video, and to answer these concerns the following steps have been taken in D-3:

- The error-correction power of the outer code structure is increased by making the check block eight bytes long. Because the audio outer code is 16 bytes long — quite short in comparison to the video code (136 bytes) — audio correction capacity is dramatically increased in comparison to that for video.

- The sample shuffling range is increased to cover one field. This distributes contiguous samples of the audio signal onto different sectors so that a burst error one sector long is converted to single occasional errors in continuous samples of the audio signal. Thus, highly precise interpolation can be produced from the samples adjacent to an erroneous sample.

- Samples of the same audio channel are distributed to adjacent audio sectors to be recorded by head pairs in the direction of the track pitch. As a result, during editing of a single audio channel, one sector is not degraded by the editing of an adjacent channel. In other words, potential degradation is reduced by half.

- By sector shuffling, which distributes the sectors of each audio channel to the opposite edges of the tape, more effective compensation can be made for longitudinal tape damage or defects.

- Interference factors arising from single audio channel editing are reduced by a recording method with guardbands only at the editing point.

Editing point guardbands

In order to maintain reliable interchange for the D-3 format with a track pitch about half that of D-2, several fundamental items had to be improved:

- The reduction of interchannel crosstalk and intersymbol errors through the use of the new 8-14 modulation code and azimuth recording.

- The improvement of random and burst error-correction capabilities without additional cost or complexity.

- Improvement in the handling of digital audio.

These three items have been discussed previously. A fourth, improving the recording footprint after editing, also needed attention.

Interchange errors can be attributed to two factors. First, are the linearity errors caused by drum machining tolerances or tape weave. Second, are track shift errors caused by differing head height or tracking misadjustment.

Using two VTRs with opposing maximal errors, the worst-case error rate is at the in/out insert points when observing a tape that was recorded on one machine, insert-edited on the second machine, and then played back on the original machine. In this case, the degradation in the recording can be clearly identified. First, the track being recorded over by a track of the same azimuth may not be fully erased and, to some extent, may still remain intact. This is the so-called "same azimuth incomplete erasure" problem. The other factor is that adjacent tracks are also partially erased by the new information being recorded "off-track" or out of alignment. This is the "track-shaving" problem. Of the two, the incomplete erasure problem is the more serious, requiring a tracking error of only half that of the track-shaving problem to produce an equivalent increase in error rate.

The basic D-3 digital format recording footprint uses azimuth guardband-less recording. In addition, at edit points only, a guardband is added through the use of flying or rotary erase heads that are slightly wider than the total track pitch. Also, for the edit area other than the edit in/out points, the entire track pitch (width) is erased prior to recording. This results in greatly reduced errors because of the "same azimuth incomplete erasure" problem. Therefore, a significant error rate reduction has been achieved at edit points and throughout the edit duration as well. (See Figure 2.)

These new techniques overcome the traditional limitations of narrow track recording and result in a practical broadcast recording system suited to repeated editing and robust tape interchange.

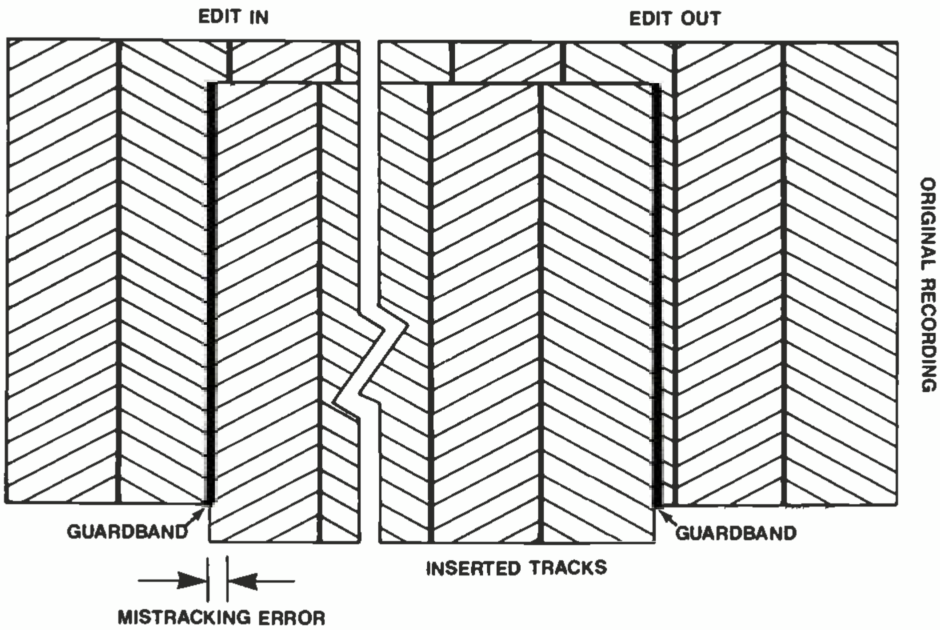

Figure 2. Editing improvements with guardbands in the D-3 format.

Low-tension transport

A major improvement inherent in the D-3 format is the use of significantly less tape tension — approximately 30 grams, or about one-fourth that of D-2. This has been made possible by extensive study of the effect of the head pole piece shape on the aerodynamics at the tape/head interface when metal particle (MP) tape is used.

Because MP tape is considerably more flexible than oxide tape, it flows more fluidly as it rides on the air film between the tape and head cylinder. Therefore, careful design of the head "shoulder" area provides the intimate contact required between the head and tape at a tension that does not wear the head or tape excessively. In addition, by keeping the upper and lower cylinder portions stationary, and rotating just the center "head disk," only the proper volume of air is generated (the head spins at 5,400rpm). ■

The way we see it, the Olympics is no place for amateurs.

HK-355 FIT CCD Studio/Field Camera

The emotion one experiences when watching Olympic athletes compete is in large part stirred by the knowledge that these incredibly gifted, dedicated individuals are driven by only one thought: being the best.

Which is why those who broadcast the games should demand the same high levels of performance.

This year many of the studio and hand-held cameras at Barcelona will be supplied by Ikegami Electronics. They'll include our flagship HK-355 FIT CCD studio/field camera, HK-355P companion portable, and a large number of HK-323, HK-323P and HK-381 tube cameras.

Because broadcasting the Olympics is no place for amateurs, these fine broadcasters will be using Ikegami cameras:

BROADCASTERS	CAMERA QUANTITY	
	HK-355	HK-355P
Television Espanora (Spanish State Television)	81	53
TV Madrid (Madrid Local TV)	6	5
Canal Sun Andalucia TV		6
Basque TV	11	7
Galicia TV	9	2

These professionals, along with the athletes will go to Barcelona to perform at their very best. Ikegami, too, will focus on just one thing: supplying the best cameras and monitors. Only the best make it to the Olympics.

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Olympic stars

During the numerous hours of programming broadcast from the Winter and Summer Olympic Games, nearly everyone will take a few minutes now and then to watch and listen as their favorite participants challenge others from around the world and the record performances from past Games. History will record those who take the gold, silver and bronze as the "stars" of this Olympiad.

As observers, each of us will have our own favorites and stars, whether they win medals or not. Behind the scenes, many others of the broadcast and production industry should be given star status as well. These are the numerous products that make it possible for the world to enjoy this quadrennial event.

In early December, *Broadcast Engineering* invited manufacturers serving the production and broadcast businesses to indicate products that would make Olympic debut performances in the 1992 Olympic Games. The following information is taken from the responses to that request. Parenthetical values denote the number of units supplied, when that information was provided.

If you wish to receive information about these products, please circle appropriate numbers on the Reader Service Card bound in this supplement.

AUDIO

beyerdynamic:
- *ENG/EFP omnidirectional dynamic microphone*; internal shock-mount system for reduced handling noise; contoured for extended upper frequency response 201
- *MC833 stereo condenser mic*; three shock-mounted diaphragms create smooth, wide-range response; M-S or X–Y stereo micing; handles high SPL for sound effects, crowd ambience 202
- *TE 170 miniature VHF camera-mount wireless receiver*; adjustable headphone gain control; compatible with 170 series transmitters 203
- *DT108, DT109* headsets 204

Clear-Com:
- *Matrix Plus intercoms* used in HDTV Vision 1250 production vans 205

Comrex:
- *DXR, DXP digital audio encoders, decoders;* with G.722 compression algorithm for ISDN; rack-mount, portable versions; 7.5kHz full-duplex audio on digital lines or 56kbit/s or 64kbit/s services 206

Fidelipac:
- *Dynamax CTR90 series cartridge recorders* (240) 207

Graham-Patten Systems:
- *D/ESAM 800 digital edit suite audio mixer* (24); to 56 inputs, analog or digital; 16 full-function mixing channels; four digital and four analog outputs; any input assignable to any fader and any output 208

Neutrik:
- *PROFI series* professional phono plug spring-loaded shell protrudes to make ground connection before the signal path; "bolting system" avoids accidental disconnection and improves ground contact 209
- *SPEAKON speaker connectors;* protected, heavy-duty contacts 210

Philip Drake Electronics Ltd.:
- *PD5050 20-bit digital audio conversion unit;* 1-rack unit package holds three Eurocards for conversion at 44.1kHz or 48kHz rates; 16-/18-bit dither selection; PD9372 AES/EBU to SDIF-2 conversion option 211

RAMSA:
- *500 series speakers;* WS-A550 low-frequency and WS-A500 high-frequency modules; bass response to 30Hz 212
- *WS-SP2A signal processor,* crossover; stereo or dual mono channels 213
- *WP-9220 power amp;* 200W/channel into 8 loads; high slew reduces TIM 214
- *WM-S1 miniature electret cardioid mic;* semi-rigid support rod for various mounting requirements makes no noise when flexed 215

Shure Brothers:
- *FP410 portable automatic audio mixer;* IntelliMix circuitry controls number of active mics, activates mics on voice, not ambient noise; transformer-balanced inputs; rear-panel jacks link several mixers together 216
- *SM89 shotgun microphone* 217
- *VP88 stereo microphone;* single-point condenser design with two independent elements for M-S stereo; switch selects L/R or single-output cardioid or bidirectional mic modes 218

Siemens Audio:
- *Neve 6608 48-input mobile console*; dual-input mono/stereo channels; multiple mix-minus; 4-band parametric EQ; silent switching; reset function from microprocessor-controlled system 219
- *AMS AudioFile PLUS workstation;* 16-output, 8-input hard disk digital audio recorder, editor; 4-hour audio storage expands in 4-hour blocks; analog and digital signal handling 220

Soundtracs:
- *Megas Mix consoles;* 4-bus systems; four frame sizes for 12-2 to 32-4-2 configurations; three types of input modules, two dual group module options; meter bridge; supplied for Winter Games 221
- *SPA sound reinforcement consoles;* front-of-house or monitor applications; frame for 24, 32, 40 and 48 inputs; eight auxiliaries, four parametric equalizers with switching for pre/post fader use; local auxiliary on each channel; supplied for Winter Games. . . . 222

Studer ReVox:
- *A807 4-channel 1/2-inch center TC audio recorders* 223
- *900 and 962 audio mixers* 224
- *990 audio consoles* (11); 24-, 34-input, with in-line multitrack monitors; extensive mix-minus facility for multiple dedicated line feeds; snapshot storage of console configuration for instant recall 225

Telex Communications:
- *CS9700 intelligent intercom systems;* 300×350 matrix integrates communications within the broadcast facility as well as sources and destinations at outside locations; supplied for Winter and Summer Games 226
- *CS9500 intercoms;* 3 supplied for individual venues 227

VIDEO

angenieux:
- *15×6.5; wide-angle f/1.6 zoom lens* for studio, EFP 228

- *Super 1000;* 1m lens systems (30) 229
- *14x ENG lenses* (70) 230
- *F10-400; 40× HDTV lenses* in Thomson production vehicles (10) 231
- *15× HDTV lenses;* for use with BTS cameras (10) 232
- *40× lenses* on Sony cameras (2) 233
- *20× lenses* for BTS LDK9 (11) 234
- *14×7 lenses* for BTS LDK91 (8) 235

Anton/Bauer:
- *Magnum 14 Logic series Nicad battery;* closely matches power and voltage requirements of Panasonic digital 1-piece camcorders ...236
- *Magnum quad charger* with interactive link between battery and charger restores maximum capacity, reduces cell imbalance, memory and other poor performance factors; 4-position charger, 3-charge termination techniques.............................237
- *Ultralight 2 Automatique on-camera light;* operates only when VTR is recording ..238

BTS:
- *KCH HDTV tube cameras;* use fiber-optic or analog cables 239
- *HDTV CCD portable camera* 240
- *HDTV slow-motion recorders;* 104s storage capacity 241
- *BCH1000 HDTV VTRs*..............242
- *HD-MAC decoder*.................243
- *HDTV synchronizer*................244
- *RMH 1000 HDTV video mixer*.......245
- *HDTV monitors* 246

Chyron:
- *Scribe iNFiNiT!* graphics, title generators (38); optional frame buffers; video capture; Transform; 64Mbyte memory expansion; advanced font utility and intelligent interface features 247

egripment:
- *Skymote moving camera cranes* (15); elevates cameras for unobstructed view of the event; 15 supplied for Summer Games 248
- *Hothead remote camera pan/tilt heads* (40); mounts to camera cranes or in fixed positions; 40 supplied for Summer Games 249

EVS Systems:
- *LVS live slow-motion solid-state video recorders* (5); RGB/YUV or 4:2:2 parallel 525-, 625-line modes; NTSC, PAL encoder/decoder option; 12.8s expands to 64s; variable speed range from standard to still 250

For A:
- *Multi-Viewers;* simultaneously displays multiple video signals on one monitor; internal synchronizer permits the use of non-synchronous inputs; 4-image, MV-40D; 9-image MV-90C; 16-image MV-160A; MV-160 includes 2-page 9-, 12- and 13-image displays from 32 inputs...251

Fujinon:
- *A14×8.5EVM hand-held lens* for 2/3-inch cameras; 5-position grip; MOD 0.65m; five speeds from 7s to 1s for end-to-end zoom; f/1.7-2.0 at maximum length; integral extender...........................252

Grass Valley Group:
- *Model 250 video production switcher;* E-MEM effects memory; keying, key mask and silhouette key edging; program/preset mixer; interface to DPM-700, kaleidoscope effects, manipulation systems; six aux buses; control for titling, input processors 53
- *Model 110, 200 and 300 switchers*....254
- *Kadenza digital picture processor* 255
- *VPE-251 editor;* mid-price system with BINS, SWAP and 16,000-line EDL; controls 14 VTRs; battery backup 256

Hitachi Denshi:
- *SK-F300 studio* (4) and *SK-F3 ENG CCD cameras* with RGB triax (4) 257
- *HV-C10 cameras* (PAL/NTSC); used in fixed-position applications (25) 258
- *X-One A docking ENG camera;* 750-line resolution; 60dB S/N; auto-knee, flare compensation; variable shutter (2)..............259

Ikegami:
- *HK-355 studio* (107), *HK-355P portable* (67) *CCD cameras;* triax, multicore or FO cabling; 450,000 pixels for 800-line resolution; variable shutter; same control equipment operates both models 260
- *HK-323, HK-323P CCD cameras* and *HK-381 tube type camera*....................261

Panasonic Broadcast Systems:
- *AJ-D350 1/2-inch digital composite VTRs;* 20-bit digital audio on four independent editable tracks; ±15% pitch correction; AT tracking video heads 262
- *AJ-D310 1-piece camera recorder* with 1/2-inch D-3 format; supports all three S-type cassettes; camera section equivalent to AQ-20D 263
- *AQ-20D digital processing camera;* digital serial output; 3 2/3-inch CCDs with 750-line resolution; docks to AU-410 MII VCR ...264

Quantel:
- *Paintbox/Picturebox graphics and still-stores* 265
- *Flash Harry editing*................266

Ross Video:
- *RVS 630 production switchers* (2) 267
- *RVS 210A video switchers* (5) 68

Sachtler:

% Reporter series; -20H on-camera mini light uses 20W or 75W G4 lamps as a fill or eye light; -50H mini lights accept 30W, 50W and 100W; both units include an easy-focus feature; produces a flat field of light from spot to flood 269

Sony:
- *BVE-9100 edit control system;* available for NTSC, PAL, PAL-M; 32-bit processor; CPUs on interface boards; controls four audio channels, 14 VTRs in simultaneous roll or 12-play, 8-record; four GPI ports, expandable to 32; color display..........................270
- *DVR-20 D-2 videotape recorders;* 2nd-generation composite digital VTR; includes features for improved editing efficiency; digital audio in jog mode; digital audio crossfades; auto edit tracking; CTL/LTC confidence 271

Thomson Broadcast:
- *625-line cameras* (100) 272
- *TTV 1647, 1647.S Sportcam series;* microlens CCDs for greater sensitivity; compatible control units for system integration; multicore EFP system for TTV1647.S through CA25 adapter; triax with CA84 module 273
- *TTV 1542 studio/OB CCD camera;* contrast compressor restores dynamic range of the CCDs; dynamic lens correction; contour, aperture, physiology correction; triax link ..274
- *IMPULS* 8- or 16-input, 8-key input 4:2:2 component video switcher; 4-layer M/E for 2-foreground, 2-background manipulation; linear, chrominance and luminance keying; key compose and key management; 6-bus routing feature 275
- *COLORADO* 4:2:2 digital color processor. D-1 or analog, eight multifile memories hold 400 scenes each; controls RGB white, black and gamma levels; cut, dissolve transitions..276
- *4:2:2 KEYER* serial composite digital processor with mix and key facilities; 10-bit architecture 277
- *SYNONYM* 4:2:2 component mixer; 11-source; independent keyer modules with USK, MSK, DSK 278
- *TTV 3305 Betacam SP VCR,* operates with TTV1647.S as camcorder 279
- *TTV 7651, 7661 separate A/D, D/A converters;* for RGB, YCrCb analog, serial/parallel digital signals 280
- *TTV 7671 combo A/D-D/A converter* .281
- *Serial digital routers* TTV 5775 16×4, TTV 5790 32×16, TTV 5791 32×32; all systems with expandable matrices 282
- *Digiphase 4-channel;* automatic phasing of digital 4:2:2 component signals; manual mode acts as digital delay line; split screen shows adjacent channels for easy setup; image freeze 283
- *Also HDTV cameras* (25), equipment for HDTV digital suites (4) and 625-line digital suites (15) and various digital recorders and Betacam SP equipment

Videotek:
- *Prodigy production switchers;* composite and component versions; three primary buses serve these 8-input systems; 100 programmable routine memory; keying facilities include RGB option; two supplied 284

Vistek Electronics Ltd.:
- *Vector VMC standards converter;* incorporates V4501 vector motion estimation generates vectors based on detected motion between fields for reconstruction of moving images in correct spatial positions 285
- *Vector V4401 standards converter;* basic unit; may be upgraded with VMC package...286

SUPPORT

BASYS Automation Systems:
- *D-Cart digital audio management system,* multi-user hard disk editor; 55-hour mono capacity supports 15 play channels, 10 record feeds, 12 workstations with edit functions; from Australian Broadcasting Corporation ...287

BTS:
- *HDTV OB vehicles* (7)..............288

Graham-Patten Systems:
- *UTECS universal TV equipment control system;* to seven workstations; to 255 remote systems can be assigned to each UTECS unit through quality-control routing switcher for centralized equipment adjustments ...289

Grass Valley Group:
- *SMS-7000 signal management system;* serial digital router handles analog, digital or hybrid mix of both formats; 64 square matrix, expandable to 1,024 square with 100 levels of control 290
- *MAX-9000 A/D, D/A converters*......291

Nesbit Systems:
• *ETS v 1.0 equipment-tracking system:* bar code system for shipping, receiving, location tracking, reconciliation; PC LAN modem access feature; "packaged" items may be tracked as one unit 292
• *VTL videotape library system;* archive, retrieve, report generation; bar code scanner and label printer identify and track location of tapes; searches on one or more fields; synopsis window provides description 293

Philips TV Test Equipment:
• *PM 5639 portable hand-held color monitor analyzer;* a "standard observer" with dielectric interference filters to simulate the human eye 294

Philip Drake Electronics Ltd.:
• *Venue Intercommunication Signaling Apparatus;* custom intercom with portable equipment rack; control panels for general use and studio VTR operators; 4-wire lines between venues and London-controlled by portable PC; paths, keys, functions assignable by software 295
• *9375 A/D, 9367 D/A converters:* 20-bit sampling; adjustable DC offset; improved distortion, response performance 296
• *9000 series video DAs* (155) 297

RF Technology:
• *RF-233C/AC transmitters* (26); AC/DC power supply, switch-selected output level; wideband RF output 298
• *RF-200D receivers* (14) and *UPL-200/1 transmitters* (14); 250mW and 2W systems ...299

Scientific-Atlanta:
• *7775B video exciter;* Ku-band complies with NTC-7, RS-250B; for NTSC/B-MAC, IF; ATIS feature; remote control; provides three audio subcarriers 300
• *7530I international video receiver;* NTSC, PAL, SECAM, sound-in-sync; Ku-/C-band compatible, automatic polarization; 525-/625-line switch; remote control; three audio subcarrier channels 301

• *8860/8861 antenna control system;* manual or automatic antenna positioning for SA antennas; AdapTrack option predicts, learns orbit; can track inclined orbit satellites; azimuth, elevation, two polarizations controlled 302

Tektronix:
• *VITS 200 NTSC inserter;* for VITS, full-field test/text messages; 8-field sequence for use with BTA ghost canceler reference; 12-bit digital signal generator 303
• *VS211 PAL frame synchronizer;* 8-field memory avoids decoding, encoding; 10-bit A/D, D/A conversion with $4xF_{SC}$ sampling; analog and composite digital I/O facilities.........304
• *VM700A/Opt 40* for audio measurements; used with ASG 100 audio generator; channel separation vs. frequency plots; THD+N vs. frequency; high resolution and view harmonics spectrum modes; generator unit includes 4s non-volatile memory to store voice message 305

Videotek:
• *Model TVM-621/P combo waveform/vector monitor;* 3-input unit displays parades, waveform/vector overlays and vector overlays; 12 function/filter combinations; R–Y mode for differential phase measurements (46) ...306

Editor's note: The preceding information lists a wide range of equipment, but certainly not everything needed for the complex Olympic coverage. Our information request went to more than 250 manufacturers. Those responding including broadcast organizations from many different countries, will take part in relaying the Games to the viewers.

These organizations will use new products and new technology that we are not informed of, because some groups are reticent to announce their involvement in an event.

It is interesting to note that *Vision 1250*, the European HDTV consortium, will relay the Games to the European audience in high-definition pictures and six channels of audio (stereo + 4 monaural commentaries) by satellite. Approximately 150 receivers have been located in major cities and towns throughout Europe in places easily accessible by viewers. No doubt some of the products of Vision 1250 will find their way around the world in the near future. ■

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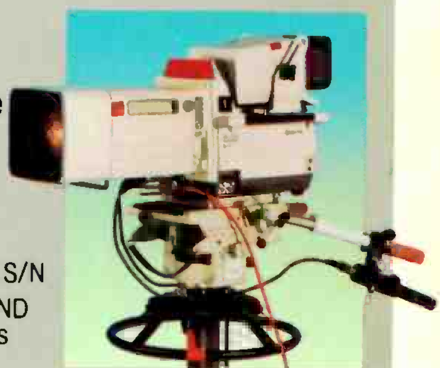

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