rate they save and the quality of the signals they provide.

Although the discussion has been centered on the composite PAL signal and towards finding solutions which primarily meet the needs of the BBC, the UK, and hopefully the European Community, these solutions for PAL may also point the way for NTSC.


### Acknowledgments

The authors would like to thank their many colleagues in the BBC Research Department who have contributed to the work described in his paper, and in particular, A. H. Jones and D. W. Osborne who played an important part in its preparation. They also wish to thank the Director of Engineering of the BBC for permission to submit this paper for publication.


### References


1. P. A. Ratliff, "Bit-Rate Reduction for High-Quality Digital Television Transmission," International Broadcasting Convention 78, *IEE Conference Publication No. 166*, Sept. 1978.
2. A. H. Jones, "Digital Sound and Television Sampling-Rate Changing," *EBU Review 163, Technical:* 127–136, June 1977.
3. M. A. Weston, "A PAL/YUV Digital System for 625-Line International Connections," *EBU Review 163, Technical:* 137–148, June 1977.
4. V. G. Devereux and J. H. Stott, "Digital Video: Sub-Nyquist Sampling of PAL Colour Signals," *Proc. IEE, 125:* 779–786, Sept. 1978.
5. H. Nyquist, "Certain Topics in Telegraph Transmission Theory," *Trans. Amer. Inst. Elect. Engnrs., 47:* 617–644, Feb. 1928.
6. J. P. Rossi, "Sub-Nyquist Encoded PCM NTSC Color Television," *J. SMPTE, 85:* 1–6, Jan. 1976.
7. V. G. Devereux, "Differential Coding of PAL Video Signals Using Intra-Field Prediction," *Proc. IEE, 124:* 1139–1147, Dec. 1977.


---

# Prospects for Digital Video Recording

## *Transcript of a Panel Discussion from the 13th Television Conference*

*Editor's Note: When the future of videotape recording in tomorrow's television studio is inquired into, it becomes evident at the outset that there are at least two areas of dramatic growth and innovation — the one-inch helical formats and the new digital videotape recorders. The digital VTR for studios seems inevitable, but there are a lot of questions to be answered first: What is possible technically?; What does the user want?; What will such a machine cost to buy and operate?; Will there be compatibility problems among various machines?; What about existing perfectly good capital equipment?*

*The situation is changing rapidly. For several years the Independent Broadcasting Authority has been doing research on digital videotape recording and in August 1978 they demonstrated their first pictures from such a machine at the International Broadcasting Convention. This digital VTR was built to determine what kind of pictures could be played back if efficient encoding and error concealment were used to compensate for severe constraints on tape consumption. In February of 1979, Ampex created a big stir at the SMPTE's Television Conference in San Francisco by becoming the first American manufacturer to exhibit a digital VTR. Like the IBA machine, it was only an experimental model to show feasibility; it was housed in a conventional AVR-3 console. At a cost of high tape consumption, it showed very high quality pictures. At the NAB Convention in Dallas in March 1979, Sony in their hospitality suite joined the ranks of experimental machine exhibitors, and their digital VTR provided yet another point on the evolving curve of tape consumption vs. performance. Finally, at the Montreux International Television Symposium at the end of May 1979, no fewer than three manufacturers (Ampex, Sony, and Bosch-Fernseh) showed digital VTRs. The Ampex machine was an improved version of the one shown in February, and the Bosch-Fernseh one used the segmented-scan approach that they had pioneered for one-inch helical VTRs. Also, at Montreux, NHK of Japan described a concept they had for a digital VTR, and numerous discussions were held on such subjects as the future need for compatibility and digital VTR standards. Given this high rate of change of technology, manufacturers and users alike will want to be inoculated against future shock.*

*Over the months to come, we expect to cover in the* Journal *the latest technological developments in videotape recording and the best educated guesses about what the future holds. (We, of course, will not ignore new technology involving electronics and the film medium; exciting innovations with flying spot telecines are apparently underway on the West Coast.)*

*To provide background for this future coverage of videotape recording technology, we herewith present a transcript of the panel discussion on digital video recording held on 3 February 1979 at the Society's 13th Television Conference in San Francisco. The transcript is reprinted from the Society's new book* Digital Video Volume 2, *copyright © 1979 by the SMPTE. That book, incidentally, along with the first* Digital Video *book, provides further valuable background on this exciting, topical, technical subject.*

*The panel discussion followed the presentation of five papers on digital video recording: "Low Bit-Rate System for Digital Coding of the Television Picture," by Peter Rainger and P. A. Ratliff; "Picture Impairments Caused by Passing the NTSC Color Signal Through a Number of Codecs in Tandem," by Charles Ginsburg; "Separate Components Digital Video Recording is Needed and Possible," by Dominique Nasse; "Digital Video Recording: A Progress Report," by Joachim Diermann and Maurice Lemoine; and "Digital Video Recording: What will it do for the Broadcaster?" by Edward Herlihy. Five of these authors and four additional people with digital television expertise made up a panel constituted as follows:*

Donald V. West (Moderator), *Broadcasting* magazine;
Peter Rainger, British Broadcasting Corp.;
Charles Ginsburg (Chairman, SMPTE Study Group on Digital Television), Ampex Corp.;
Dominique Nasse, CCETT (a French TV research center);
Joachim Diermann, Ampex Corp.;
Edward Herlihy, Golden West Broadcasters;
K. Blair Benson, Video Corp. of America;
Arch Luther, RCA Corp.;
Marcel Auclair, Canadian Broadcasting Corp.

*As is usual, questions and comments were also entertained from the floor. Here is the transcript of the Digital Video Recording panel discussion.*

**Mr. West:** Our purpose this afternoon, the nine of us on the platform and you in the audience, is to try to sum up what has been determined about video, digital video recording over the last few years and what the immediate and long-range futures might be. In addition to the gentlemen who have presented papers this afternoon, we have three additional panelists, Blair Benson, Arch Luther and Marcel Auclair. I am going to ask Mr. Luther to give us his impressions first.

Let me tell you a little about him. He is Chief Engineer of the Commercial Communications Systems Division at RCA. That division embraces four principal areas of operation, broadcast equipment being the main one. He's been with RCA for 28 years. He is here this afternoon to represent the point of view of the equipment manufacturer. Mr. Luther.

**Mr. Luther:** I would like to take up briefly the issue of the objectives for digital recording in terms of system cost and system performance. One requirement for any new recording system to be accepted in the marketplace is that the system must have the proper relationship to existing systems in terms of both cost and performance parameters.

Nevertheless, the marketplace needs a *range* of these parameters, from low-cost systems that fulfill moderate performance requirements to high-cost systems which meet the most sophisticated performance needs that any of us can imagine. Where does digital recording fit into this cost and performance range? And what goals should we as digital designers strive for?

I think these questions can be approached by first comparing some of these fundamental characteristics of digital and analog recording to understand which areas of the cost/performance arena are best addressed by digital technology? Without spending a lot of time on this, I come to the conclusion I think most people here today also do: that digital recording can achieve higher performance levels than analog and this has been demonstrated. On the other hand, digital recording requires smaller wavelengths and smaller tracks on the tape to really be economical, and this demands greater mechanical sophistication and electronic servo and correction systems.

Furthermore, we can expect that digital recording will be initially more complex and more costly than present high-performance analog recorders. Therefore, it seems clear that digital recording is best suited to address the market at the high-performance, high-cost end.

To do that successfully, I would recommend that digital system designers seek to improve the performance parameters most often criticized in analog recording and that they put these improvements ahead of cost considerations. Some of the likely areas are signal-to-noise ratio, multigeneration capability, video bandwith and, very importantly, performance of sound channels. We should not let cost considerations cause us to compromise these issues. I would even make cost tradeoffs to achieve the performance objectives — for example, the use of four-times-subcarrier video sampling, rather than three-times. Or the use of full error correction rather than concealment. Or many other areas where you can improve performance if you accept the costs.

This approach of putting the emphasis on high performance allows the development of a digital recording system which will have initial applications which are not now being reached by analog recording. Later, as further development allows the cost of digital recording to be reduced, it will be possible to address other market segments and broaden the application of the system.

The standards for the systems should remain the same, however, so that a single standard would have the broadest long-term application. This would not be achieved if we make performance tradeoffs in the interest of early product introductions or initial low costs.

**Mr. West:** Our next speaker is Blair Benson who is Vice-President for Engineering and Technical Operations for the Video Corporation of America. He appears here this afternoon also representing the Video Tape Producers' Association, and essentially his is the point of view of the production house. Before joining VCA in 1976, Blair was Vice-President for Engineering of Goldmark Communications Corp., and before that — from 1945 to 1972 — he was with CBS as Director of Audio-Visual Engineering. Mr. Benson.

**Mr. Benson:** Since I think the major benefit from a panel discussion of this sort is an exchange between the audience and the panelists, my remarks will be necessarily short. As we have said, my role is to represent the viewpoint of the production house. It is the production house that makes both commercials and a variety of program materials, not only for broadcasting but also for educational purposes and for industrial use.

I might note that digital video is not in itself new to the production houses. We are already well-versed in the use of the digital noise reducer, for example, and it is gaining widespread use. We are going to see an increase in the use of digital video this year in the form of framestore processing equipment, such as the Grass Valley, Quantel and Vital framestores. These are going to add a new dimension to electronic post production.

Going beyond existing equipment, we have a vital interest in the future of digital video recording, particularly in avoiding the need for decoding and coding — going back and forth between the various black boxes and the digital video recorders and playback equipment. A year or two ago it seemed that multiple codecs in tandem would produce levels of degradation that might be unacceptable. Now, however, we are encouraged by Charlie Ginsburg's report that the degradation today is minimal. This finding opens up a whole new vista for this particular system design.

Furthermore, in regard to digital recording, I think it is essential that we have a system which has such a low noise level that multiple generations of recording and reproduction become possible — at least five to seven and possibly eight or even ten generations, in order to provide a maximum of flexibility in post-production work. This is imperative if we are going to compete with what has been done in the past with film opticals and film animation in the film labs. Based on the papers we have just seen on computer animation, it seems that computer animation *will* compete with film animation — but again this is tied in to digital recording and digital processing.

All this talk about digital recording is coming at a paradoxical time however. Two years or more ago, before the advent of the current one-inch helical equipment, I would have said, "This is something we must have. Let's rush the development. Let's get it to the marketplace." The problems with quad (high maintenance, high head cost, difficulty in maintaining quality in the face of banding and head separation and one-line error and so on) have been just monumental and expensive to cope with.

Now, two years have passed and the situation is different. I think we have reached a level of development with the one-inch equipment that makes the production house look at the digital approach with a jaundiced eye. Do we really need it? Can we afford it? The operating and capital costs for one-inch equipment are already coming down and the quality is up. It's solving a lot of the problems we had with quad, so unless digital video offers us some order-of-magnitude improvements in performance and some drastic reductions in costs, I don't see a great demand for it in the immediate future.

**Mr. West:** Our final panelist from whom we are asking comments is Marcel Auclair, Assistant Director of the Studio Systems Department at Engineering Headquarters of the Canadian Broadcasting Corp. in Montreal. He has been with CBC for 15 years in a variety of engineering posts and is on the panel to represent the view of a major broadcasting user. Mr. Auclair.

**Mr. Auclair:** It is my opinion that digital video recording is definitely the way to go. Still I would think that broadcasters in general are faced with the same problem we have had in the CBC — the lack of experience in maintaining digital equipment. We first encountered this problem in connection with the time-base corrector; we found that although the technology was quite perfect, we did not have sufficient technical maturity

in general across the network to properly maintain this equipment.

So, before any organization really contemplates using digital technology, I think they should consider that there will be a major impact not so much on the operating staff, but on the maintenance staff, to properly maintain and debug that equipment. Nevertheless, neither these difficulties nor any needs to achieve standardization should be allowed to forestall the development of any useful equipment — from a very highly portable piece of gear to a very, very complex machine that should be used only in the studio.

We have already seen such problems: standardization and the one-inch format; how to get quad to go portable, etc. The more broadcast grows, the more we want the flexibility to go outside. (I'm not referring here to ENG: I am referring to on-site shooting, using isolated cameras.) The broadcaster wants a very highly portable recorder, and if a desire for standardization gets in the way of the designer trying to come up with something small, that would be where we throw away the ball game.

Whatever other consequences the digital video recorder would bring for studios, we would anticipate that there would be a significant reduction of capital costs. If this doesn't happen, the digital VTR would not be very appealing to us. The other cost that should also be contemplated is the *operating* cost, and that also should be reduced appreciably relative to quad or one inch.

The necessity for set-up controls should be reduced as much as possible. Intelligent diagnostic systems ought to be part of the system to facilitate maintenance and debugging. It goes without saying that the digital VTR must be highly reliable. We agree with the view that we broadcasters should be more involved in the design or the proposed design of new equipment. We know the tools that we want, and we are in the field. It will be best for all of us if manufacturers come and consult with us first.

**Mr. West:** Now, we will invite questions and comments from the audience. We are very fortunate, it seems to me, to have assembled here people with so much information about digital tape recording. I would say that virtually everything known is known here. Do we have a question?

**Emil Kratochvil, KTLA, Hollywood:** I would like to comment first that I was quite impressed with the demonstration of the codec (coder/decoder) system evaluation tape. My question is: Has any attention been given to intermixing codecs of different manufacturers using different sample rates? Since the same model of codec was used in the demonstration, I assume they all used the same sampling rate. I would like to know if degradation of a signal has been studied, using different sample rates and intermixing them. If not, I should think that another demonstration would be in order.

**Mr. Ginsburg:** I will be very glad if some company chooses to undertake such an experimental program. It is a very big task and difficult to do. As far as I know, no experiments have been made to determine how the impairments vary as codecs employing different sampling rates are used. I would expect, however, that the three-times sampling rate which we used would be the worst case.

**Mr. Kratochvil:** You feel that would be worse than intermixing them? As we broadcasters use a signal, we don't necessarily know how many or which types of codecs it has been through. Then, we pass the signal through a codec having a sampling rate that could be different from that of the codecs it previously passed through, possibly degrading the signal.

**Mr. Ginsburg:** It seems to me that an agency that could properly be identified as completely objective would have to conduct such tests. Otherwise the hues and cries about parochialism in finding more faults with one manufacturer's equipment than another's would be deafening.

**Al Goldberg, CBS Technology Center:** I will direct this question to Mr. Ginsburg, in his capacity as chairman of the SMPTE Digital TV Study Group. The matter of whether the television plant will eventually become all-digital has been examined by your committee. It was pointed out that the lack of a digital VTR is a stumbling block, because — after all — why use an analog VTR in an all-digital plant? Therefore, would I be correct in assuming that if a digital VTR becomes available it will be a significant step forward toward the ultimate digital television plant? How do you see that as a factor in the design of the digital VTR?

**Mr. Ginsburg:** Well, digital videotape recording certainly appears to be do-able. There are a lot of questions yet to be answered. I think that if someone had the funds to make the installation of an all-digital television plant on an experimental basis, that it could be done at this time. Unfortunately, nobody seems to have the money to do it.

**Mr. Benson:** I'd like to add one comment. Regarding the all-digital plant, I can't foresee that as coming in the immediate future any more than I can the digital videotape machine. I do feel, however, that we are going to see new television plants which will employ fiber optics. In so doing, they will get away from all of this complexity of coaxial cables and connectors and what have you. I think that that aspect of digital is definitely the wave of the future.

**Mr. Diermann:** I would like to compare these advances to the development of the telephone system, where you still have crank telephones working out at the boondocks with international satellite connections. The studio isn't going to go digital from one day to the next. It's going to be an evolutionary process during which new equipment will need to interface on an analog basis for a long period of time and still have a digital port to be ready to go digital when its neighbors do. More and more of interconnections will be digitized by degrees, but, for both technical and economic reasons, the conversion won't happen all at once.

**Joe Roizen, Telegen:** All of the digital VTRs that have been so far demonstrated have involved segmented scanning. The IVC 9000 was used for the first IBA experiments and the BCN for the next set and then the Ampex quad for the next. We are now entering a period of rapid growth of one-inch helical Type-C machines which use a single head for field scanning. Are we going to see those machines disappear when the digital VTR comes along, or are people going to figure out how to make the helical machines work digitally and provide a handy dandy conversion kit for the customer?

**Mr. Diermann:** It seems to me that in digital VTR the question of how many segments you have for each television field or frame is no longer really meaningful — not as far as basic picture performance is concerned. You are dealing with a bit bucket. You might look on the digital VTR as taking a digital time-base corrector and placing the VTR right in the center. It isn't quite that simple, but that's the general principle. So segmentation does not create any of the conventional errors in a digital system.

Segmentation or the way you organize the recording on tape, of course, does relate in some way to the manner in which you might want to accomplish special effects (such as still frame, slow motion, the ability to see a picture at high tape speeds), so there it may play a role, for mechanical reasons or logistic reasons.

Now as to the second portion of your question: do you expect to see retrofit kits for existing formats? I really don't.

**Robert Liftin, Regent Sound Studios:** I would like to address this question to the panel. Right now in the audio field, we have a fiasco with three or four different digital standards for audio recording. In the video field, although Ampex does have a digital format, their machine was today demonstrated without the audio. The AES currently has a committee that is lumbering along deciding on a digital format for audio. I wonder whether the panel feels that the SMPTE should get involved in some way in terms of the standards for digital audio and somehow try to marry this together, as opposed to letting the whole issue be freewheeling.

**Mr. Benson:** Digital audio standardization is a hot potato at the moment. The SMPTE has had meetings and discussions with the AES, as to who should handle it. I will just mention that there is a Justice Department problem here which has to be solved first, and it appears that the Japanese may jump the gun and develop and agree upon standards in Japan before any action can be taken here in the U.S. because of our

legal problems. The AES is now going ahead with the committee to study this but how fast they will respond and come up with something remains to be seen. In the meantime, both 3M and Sony have digital systems which are going to be used. The Sony system, I think, is already being embraced by at least three major recording studios for making their masters. It works quite well and has excellent characteristics. Thus, there will be some use of digital audio in the U.S. in advance of standardization.

**Mr. Herlihy:** I think that the audio fiasco just mentioned could be a prelude for a horrible video fiasco. That's the thing that a lot of broadcasters are really concerned about — the proliferation of various digital video recorders into the marketplace, perhaps too soon. We could be faced with the same thing that the audio people are faced with right now. I don't think that it's going to be easy at all to get the manufacturers into one room and standardizing. I gather it was pretty difficult getting agreement on the Type-C format, and you can imagine what it will be like when none of them have really introduced anything. So it will be difficult, and it will be time consuming. I think, however, that we *do* have time to anticipate this problem and deal with it. Now, everybody is excited about the one-inch machines; they are buying them in droves. The price is pretty good, the quality is excellent, the features are things we have long waited for, and we are all rushing around, madly stocking up. So Blair Benson's question was a good one: "Do we need digital machines right now?" For the help it may be: some tape manufacturers claim there is a turnover cycle of five to seven years for videotape formats. They have seen this in the United States ever since videotape recording started. So, I think we have got the time to get ready. In five to seven years, or maybe ten years, we can expect to be dealing with digital video recording formats.

**Mr. Auclair:** Would it not be appropriate for the SMPTE to begin studying the matter of digital recording, with no commercial orientation other than for broadcasters to state what they want? How the box works on the inside is totally immaterial. What *we* want, for example, is a portable box of tricks that weighs ten pounds and can record for a given length of time. In a studio in Timbuktu, they may also need a simple recorder just to play a program. Someone else wants to have all kinds of effects — to edit and post-edit. Wouldn't now be the right time to assemble a group of broadcasters and write some kind of a white paper around digital VTRs and digital audio recorders?

**Roland Zavada, Engineering Vice-President of SMPTE:** Yes, it is possible for broadcasters to provide input. The Society is structured to study engineering problems by our concept of study groups whose purpose is to derive technical data, on an informational basis, that could be used to develop documents that might result as standards or recommended practices. I could speak with you afterwards, and we *could* make an invitation to users, broadcasters and any others that wish to review this problem from a study standpoint. We must be careful about this for several reasons. First, as Blair has noted, the Justice Department has been involved and concerned on some of the aspects of standardization prior to commercial introduction. (You will recognize that the Society's policy has been generally to *document* practice, not to *invent* practice.) The second reason is that we are also faced now with a significant Federal Trade Commission proposed rule-making in the entire field of standards certification and implementation, and the Society is addressing these problems through its legal counsel. That, however, doesn't preclude study of the problem and open dissemination of the derived information for the use of manufacturers and others in trying to develop specifications that could result in the highest possible degree of compatibility.

**Mr. West:** I would like to get my own question in here for a moment to the panel. As a journalist, I tend to approach these things much more in a "gee whiz" fashion than the engineers who are much more familiar with what is going on. I was really impressed that at 3:45 this afternoon, in this room, we saw the first demonstration by an American manufacturer of digital video recording. And I wonder how impressed other people were by what they saw. I would like to put a question, my first question, to Mr. Luther of RCA: What did RCA think of what Ampex demonstrated today?

**Mr. Luther:** I'm not going to make an official RCA statement, but my personal observation is that the Ampex machine has demonstrated what we all knew could be done with the approach that they took.

**Mr. West:** Next, I would like to get additional reactions from the panel and then I would like to hear a comment from the floor also on this point — what you potential users of this system thought. First, I would like to go to our European friends and ask Mr. Rainger and Mr. Nasse what they thought of the Ampex demonstration? Mr. Rainger, please?

**Mr. Rainger:** I thought that it was a fine achievement, one which I applauded with the rest of you. I think it is an excellent thing to do. You have to overcome hurdles before you get this thing working. There are three hurdles that have been jumped; we have seen stationary head machines, digital video recorders with helical-type rotating heads, and now transverse rotating heads. There are about 30 more hurdles to go before we have a working machine which meets all the requirements that have been listed, but a great deal has been learned and every hurdle cleared is another one out of the way.

**Mr. West:** Mr. Nasse.

**Mr. Nasse:** What impressed me in the demonstration was that, although the tape consumption was not so low as the IBA machine, it was not tremendously high and the picture quality was very superior.

**Mr. West:** Questions or observations from the floor? If there aren't any, I would like to go back to one of the gentlemen from Ampex, either Mr. Diermann or Mr. Ginsburg, and ask you to tell us what *you* think of the demonstration this afternoon? If you wonder about my question, I used to have a rule in working with Dr. Frank Stanton at CBS to ask, "Now that it's perfect, what's wrong with it?" Now that you have gotten this perfect, what's wrong with it?

**Mr. Diermann:** It's, of course, difficult to make a negative statement about something positive. Its operational cost is too high. Its weight and size are too great. It isn't portable, obviously. It doesn't have a number of the features and special effects that we have accepted as perfectly normal in the everyday one-inch environment. And, without going into detail, there are a number of internal questions that need to be solved. So, I agree with Mr. Rainger that there are at least 30, or possibly 31, problems ahead of us.

**Mr. West:** This next question is a follow-up to a concern that Ed Herlihy seems to have — that we may face a number of manufacturers flooding the market with various digital VTRs. My own uneducated impression is that there is a great reluctance on the part of any manufacturer to go into making digital VTR; and therefore I would ask you, Mr. Ginsburg, "Is it possible that the demonstration that you have given today was designed as much to discourage digital as to encourage it?"

**Mr. Ginsburg:** Not from *my* standpoint, it wasn't. Of course, you must realize that there is nothing on the market right now. The point of this demonstration today was to make a technological progress report.

**Mr. West:** One of the impressions that I have gotten from this session and from being in the hall is that there is almost a 180° difference in approach between the Europeans and the Americans in this field. Is that correct? And would any of you who have seen, as I have not, the IBA demonstration of last year and today's demonstration, comment on how far apart on a spectrum those two approaches are? Mr. Diermann.

**Mr. Diermann:** Yes, I would like to say something on this subject. I believe John Baldwin and we at Ampex started with totally different premises and at opposite ends of the spectrum. I believe he said to himself, "Let's see how we can make a digital machine with a tape consumption that is comparable to present analog systems (ten square inches or so per second) and let's squeeze a PAL signal system into what is

available, no matter what the picture performance." I really cannot personally comment a great deal on the picture performance because no test signals were used in London; he shoots from film and the viewing conditions weren't perfect. That's how John Baldwin, I believe, started: so much tape is what's allowed and now I squeeze the signal in and I use some bit-rate-reduction method like sub-Nyquist sampling. We, as I showed in the paper, started from the opposite end. We said to ourselves, "Let's not make a compromise as far as the signal system is concerned, and let's, for the time being, to take the first step, not worry about the tape consumption."

**Mr. West:** Mr. Rainger, if you have a comment on that point.

**Mr. Rainger:** The demonstration which IBA gave indeed did have an objective similar to that which you have just heard. The compromise, I think, was not very *much* of a compromise, in terms of picture quality, and such impairment as it introduced I have shown today could be removed without much difficulty. The major difference I saw between these two demonstrations is in the visibility of errors. For various reasons, which I am not in a position to explain, there were a lot more errors in the IBA demonstration than I saw here. Whether that is due to error correction or concealment I don't know, but the result here I thought was very good.

**Mr. Roizen:** I have had the good opportunity, Don, of seeing all of the machines at one time or another and rather close up, except this one. This was my first look at the Ampex machine and I was sitting about 20 feet from a monitor, and I still have 20/30 vision or so. The IBA machine does not work as well as this one. This one is far superior in terms of picture quality and in terms of the amount of error that you can see. There is no question about that. The IBA machine, when I saw it in London at the latest demonstration they gave, had very visible errors. In fact, after they had explained to me what I was looking at, I commented that it reminded me of the old days of Ampex with the early machines, because they had come up with the three things we always would tell people who were coming in to look at the VR1000. The first thing they said was that the picture source was lousy. Secondly, they said that they hadn't picked a good piece of tape. And thirdly, they used the title of my next book: "Don't go by that monitor."

But to get serious for a minute, Ampex has an advantage in the sense that they are using three times subcarrier to start with (a lower subcarrier signal). The pictures we saw in Europe were PAL; these are NTSC. NTSC is obviously somewhat easier in terms of the bandwidth required and so on. The other thing is that the IBA is using an error concealment technique which is a far way from being perfect. (In fact, what Peter Rainger said today about *his* $2F_{sc}$ approach may have a significant effect on what the IBA is doing with *their* $2F_{sc}$.) The IBA's machine at the International Broadcasting Convention was not being shown to the general attendance, but I requested to see the machine and was permitted to. While I was there, I asked one of the engineers if he could shut off the error concealment just so I could see what the picture would look like. He did, and the picture showed considerable impairment. It takes a lot of error concealment to make that system work. Perhaps what Peter was talking about may cure that problem. So, in effect, we have seen a very impressive and certainly the best demonstration of digital video recording on moving tape (not disks, not other means) that I think anybody has seen to date, and that certainly speaks well for what Ampex has done.

**Mr. West:** I think that alone — what you have said about the quality of the Ampex demonstration — makes the afternoon worthwhile.

**E. Stanley Busby, Ampex Corp.:** A question of Mr. Nasse and Mr. Rainger. In Europe I know they transmit audio around by a thirteen-bit system on intercity links, and I wonder, "Is the dynamic range that this offers greater or less than the dynamic range maintained by the FM stations in Europe." I have tried to find out what sort of dynamic range FM stations have in Europe and I haven't been able to find out.

**Mr. Rainger:** That's fairly simple to answer. The distribution system which they have been using for some years is thirteen bits but it's with companding. In other words, the signal is compressed and expanded before it goes through the communication system, and the net result is that the dynamic range of the signal that is being radiated by the FM transmitters is now better than it's ever been before, and people enjoy better quality than they have ever had before. However, it is worth saying that new equipment is being developed for distribution purposes on a two-megabit standard link, and these are all being based on fourteen-bit samples, not thirteen. I think that the change, however, is not made to get a better dynamic range, but to improve the signal/noise ratio under certain difficult circumstances.

**Patrick Ramsay, BBC, London:** Far be it from me to make a value judgment on the IBA demonstration. I am not an engineer, Mr. Chairman, which is perhaps why I have a touching faith in their ability to solve all technical problems. It seems to me that there may be a whole range of problems elsewhere which we have hardly touched on in these two days, although Mr. Oudin did make one reference to them. We are in the middle of a whole range of technical and technological changes. All the problems sooner or later are quite clearly going to be solved. But what about the people who are then going to use the resulting equipment? I would like to ask the panel what they think that the present changes we've been discussing for two days and the increasing rate of change are going to do to employment prospects within the broadcasting industry and to industrial relations within the broadcasting organizations.

**Mr. West:** May I suggest that Ed Herlihy field that first?

**Mr. Herlihy:** I had an appropriate discussion along those lines today. I was talking to a gentleman from the American Broadcasting Company who has just made a tour in major markets looking for maintenance engineers (as many of us are prone to do, from time to time; more so lately). In the United States I think it would be safe to say we are already in deep trouble just finding maintenance people. I can speak only from the view of our own plant where we employ some 100 engineers. We are already in trouble in the digital area. We are starting to spend money on schooling for our own people. We need more maintenance engineers and I don't know where we are going to get them. It is a serious problem; it's going to become *more* serious as the technology grows and becomes more complex. It is *certainly* something that the broadcasters have got to start thinking about. We are already late! Broadcasting today apparently isn't as glamorous to new engineers as the space programs and other things that are going on, and they are passing our business by. Some of them, I think, are missing a good bet.

As far as industrial relations go, I really don't see a big problem there.

**Mr. West:** Would any of the other panelists like to comment?

**Mr. Benson:** In the production business, maintenance is as much a problem as in broadcasting. But, as was pointed out in some of the papers on one-inch equipment, there has been a major step forward in reducing the amount of maintenance time and also maintenance costs for materials. For example, it used to take an hour or so to change a head on a quad machine and realign it; now you can do the whole job in 10 to 15 minutes on a helical Type-C format. Not only that, with the one-inch helical machines, you only have to change the head maybe every 1000 to 1500 hours, whereas with quads it's every 350 hours. So, I think our answer in a nutshell to the maintenance problem is that the design engineers will have to come up with continual improvements as they have in taking us from the quad to the one-inch machines. Perhaps going next to the digital recorders will bring about some savings in the same manner.

**Mr. Herlihy:** I think there is one more comment. I made it during the course of my paper. I think that, as we get more complex electronics and especially digital electronics, the manufacturers do have to start

thinking about "self-diagnosis." That is certainly going to cut the amount of time required to troubleshoot these items. I think as they get more complex, we have no choice but to demand that this kind of self-diagnosis be built into the equipment.

**Mr. West:** Mr. Rainger?

**Mr. Rainger:** I was going to say something which I hope will help on the maintenance question. As was mentioned earlier, we have a digital sound distribution system which to our delight has a very good fault record; it fails very rarely and it is designed so that it will indicate by lights which printed circuit board has a fault. We have the same thing for standards conversion, where we have a digital standards converter to support the obsolescent 405-line system. Both systems are self-diagnosing to the board. In this case, the question arises of how do you mend the board. The problem we have had to face is that, when it goes wrong so infrequently, the man has forgotten all about what is inside that particular unit, and you have to send it back to base maintenance for repair. This is what we are tending to do at the moment. We have automatic location to the board and base maintenance for the board itself.

**John Lowry, Digital Video Systems:** The question of finding maintenance technicians for television stations is a problem. It is, I think, an industry-wide problem from the manufacturers' point of view, too. To find good design engineers today is difficult, to say the least. Is there anything that we can do as a society to help promote the technology we are working with and do anything to get more young engineers into the television business. Certainly the space things are very attractive to people. Television doesn't seem to be attracting people, not in my opinion.

**Mr. West:** An interesting observation and one that I will not pass to the panel but to the SMPTE organization for whatever they will do with it.

**Vern Pointer, the American Broadcasting Company:** I think the comments that Blair Benson made earlier are close in line with my observations. We have seen technology make a breakthrough and give us now, in the new one-inch machine, a more cost-effective instrument. We still have maintained our quality; we have not sacrificed anything there; but our operations have become more cost effective. The new one-inch machine uses less tape, is smaller in size, requires less power and has many other features. It now gives us an editing approach and technique which is going to save us a great deal in terms of man-hours. Now, when it comes to the question of a new digital machine somewhere down the line, it is going to have to match all these features as we can't sacrifice any of them. We are not going to go backwards. I think these are the things manufacturers will have to address themselves to.

**Mike Frankenburger, Delcom Corporation:** I was wondering: In the opinion of the panel, since we are looking at about seven to ten year use of existing machines before the digital VTR is due, would not electronic storage by solid-state memories actually be able to reach the capability to do the same thing by then?

**Mr. Benson:** I will take a stab at answering that, having just looked into this in the case of bubble memories. If you run some calculations on, for example, the most advanced IBM developments on bubble memories, you will find you can only store even in the highest-capacity units merely a few frames or a few seconds of a television program. So we are a long way's off from a solid-state memory which can handle a commercial-length recording, let alone a program-length recording.

**Mr. Diermann:** The computer peripheral industry is, of course, looking into the ultimate replacement of rotating memories (disk drives) of which we have hundreds and thousands all over the world. A disk drive replacement will require fantastic bubble storage capabilities, and that in television terms is just a few hundred frames. I fully agree with Blair. We will all be very gray by the time that solid-state television program storage comes around.

**Mr. West:** I have a multiple-part question I would like to put to all the panelists. I think each of us leaving this room ought to have an answer to it, or at least the best possible guess that is presently available. First: Is digital tape recording inevitable? Second: Is it going to happen sometime — presumably as a replacement for analog recording? And third: What is the best guess as to when an operational machine will be ready for purchase at Montreux or the NAB Convention?

Who would like to go first? Charlie Ginsburg?

**Mr. Ginsburg:** Digital videotape recording for post-production work is inevitable. When people will start to use it is very hard to say. I would say within five years. As to when digital videotape recorders will be in use by broadcasters in general, that's even more difficult to say. I think there has been a consensus expressed here today that, in order to have appeal to broadcasters in general, digital VTRs are going to have to do all the things that the one-inch machines do now and be digital as well.

**Mr. Luther:** I would also agree that digital recording, at the top end of the market (post production, for example) is inevitable; it's going to happen and probably within five to seven years. I think the continued advance of analog recording, however, will make the generalized introduction of digital recording for all of the uses in broadcasting a very long time off.

**Mr. West:** Mr. Rainger? What is the European view?

**Mr. Rainger:** I think I would have to concur about the inevitability of digital recording. I think that's clear. But I think none of us in Europe believes it's going to happen tomorrow. It's a very difficult problem which is going to take a great deal of work to overcome.

**Mr. West:** One of the comments given to me in the hall and I'll volunteer to you is that digital video recording is chasing a moving target: the moving target of one-inch, which presumably is a far more exciting product than a lot of people thought it was going to be in the first place. The manufacturers are now committed to that, and they presumably feel that that technology will not stand still, so whatever digital developments are demonstrated now have to be compared eventually with an improved analog product. So, I accept the opinion of the experts that digital television recording is inevitable, they just haven't quite shown me *why* — at this moment. Mr. Rainger?

**Mr. Rainger:** May I rather *ask* a question? It seems to me that there is fairly broad agreement on the time scale in which these things will come about. We are talking in terms of an evolutionary approach to digital recording, not a revolutionary approach. I would like to ask the question, particularly of Mr. Nasse as to whether, in France, they see digital recording as that far away or whether they hope and believe it to be nearer?

**Mr. Nasse:** I think the question should not be asked only of a representative of the user's side. I think it's just as much a question which is up to the manufacturers. We agree that, for the European problem in general, the question of adequate standards is more complicated than for the U.S. We basically support the same point of view that digitization is more or less unavoidable and will start on the post-production side of the most sophisticated operations first. Thus, I think it is not possible to give an answer to the question without involving strongly the manufacturers' point of view, which I cannot do.

**Mr. West:** Are there other questions from the floor that have not yet been touched upon? If not, may I ask each of the panelists if there is a message that they want to get across that they haven't had an opportunity to do?

**Mr. Auclair:** I would like to make the point that we are finding the reliability and the complexity of digital equipment to be offsetting factors. A problem is that when it goes down, the maintenance engineer has

totally forgotten how to maintain it because he hasn't seen it for six months. The answer that the CBC had to come up with about a year ago was to establish a "fireman" squad, on duty 24 hours a day, that travels across Canada back and forth to help people. It is difficult, but we think we will lick the problem.

**Mr. Luther:** The problem could be solved perhaps by making the equipment less reliable? [*laughter*]

**Mr. Rainger:** I'd like to mention something which happened almost accidentally in the BBC, where there was this problem exactly. We had a man designing equipment to monitor broadcasting services. They were very complicated digital devices and presented just this sort of maintenance problem. And it became known that "Harry" designed this equipment, so everybody rang up Harry when it went wrong.

After a time, they began to use a teletype to get answers to their maintenance problems. Now, it occurs to me that the next step along the road is to write a computer program which has diagnostic routines built into it; that seems relatively easy to do. Now anybody can ring up this computer and the computer can print out the answer.

**Mr. Diermann:** I would like to put a little bit of oil on the water of maintainability of digital equipment. Yes it's true, as Marcel Auclair said, that when the performance of a piece of digital equipment decays, you won't know about it for quite a while because the error correction works harder and harder until all of a sudden it crashes. There is no graceful decay; it decays very, very fast. On the other hand, the service and maintenance of digital equipment — even if you don't have diagnostics — is indeed a great deal easier. We have a piece of digital videodisk recording equipment in our product line, and we definitely notice that it's much easier to bring up the signal system to working condition, because you simply have to ask the question, "Does it go or doesn't it go?" There is nothing in between. So I think we are making a mistake if in general we associate digital equipment with an increased degree of difficulty of maintenance.

**Mr. West:** that may very well be the last word. I want, on behalf of the audience, to thank the panel, and on behalf of the panel, to thank the audience. At this point, I'd like to turn the microphone over to Fred Remley who has a few closing remarks for the conference. Fred?

**Mr. Remley:** Thank you, Don. I think we should take an opportunity to acknowledge the effort on the part of the San Francisco section that went into planning this conference. Don Lincoln had to leave early to inspect his transmitter tower, but Carlos Kennedy is still here. Carlos, of course, is responsible for this excellent program and Don for the general arrangements. I think the 820 persons who registered for the conference all agree that it seems much longer than just two days, but at the same time we have learned more than we would learn in any normal two-day period, and that's good. I thank you all. We'll see you in Toronto next year. Good afternoon.

# Standards & Recommended Practices

## Proposed American National Standards

Proposed revisions of three American National Standards are published here for a trial period and public review: PH22.161, Dimensions of Magnetic Striping of 8-mm Type S Motion-Picture Film; PH22.162, Dimensions of Magnetic Striping of 16-mm Motion-Picture Film Perforated 8 mm Type S, (1–4); and PH22.163, Dimensions of Magnetic Striping of 35-mm Motion-Picture Film Perforated 8-mm Type S, 5R.

Comments should be addressed to Alex E. Alden, manager of Engineering Services, at Society Headquarters before 1 October 1979. The proposals have been submitted to American National Standards Committee PH22. All comments received through *Journal* publication will be reviewed prior to conclusion of action by that committee.

## Reaffirmed American National Standards

The American National Standards Institute approved reaffirmation of four American National Standards on 9 May 1979: PH22.76-1960, Threaded Lens Mounts for 16-mm and 8-mm Motion-Picture Cameras; PH22.94-1973, Dimensions of Image Areas and Mounts for Slides and Opaques for Television; PH22.117-1968, Spectral Diffuse Density of Photographic Sound Record on Three-Component Subtractive Color Films; and PH22.181-1973, Location of Super 8 Printed Area on 16-mm Motion-Picture Film, Perforated Super 8 (1–3). —*Alex E. Alden, Manager of Engineering Services*