smooth-surface magnetic coating is of paramount importance in preserving the quality of the video signal. In addition to average smoothness, one must also be concerned with a host of sporadic disturbances, such as streaks, scratches, nodules, dust, dents, creases and poor splices, any of which, if allowed to occur in the tape, would probably cause a beautiful pyrotechnic display on the TV screen. Unfortunately, the beauty of this is not appreciated by the networks and elaborate quality control methods are practiced in the factory in an effort to eliminate these defects. Considerable progress has been made since the first production runs of video-recording tape, and efforts to increase the already high standards of perfection achieved in video-recording tape are continuing. The difficulty of this problem can be appreciated when one realizes that a single roll of video-recording tape has an area as large as a tennis court and we are looking for flaws much smaller than a grain of sand.

As a bit of diversion from the half-hidden and microscopic problems discussed thus far, one perfectly obvious mechanical problem presented itself. In the Ampex machine an attempt is made to direct the tape through the various head stations and rollers by means of edge guiding. Any slight misalignment in the machine guiding or curvature to the tape causes a tendency for the tape to wander up or down between the guides. The 2-in. wide 1-mil Mylar base tape is not stiff enough to edge guide, but will fold or buckle. This causes loss of signal from the audio or control tracks, and in severe cases the tape creases and bunches in going through the capstan pinch. While everyone agrees that there is a tape-guiding problem, it is often difficult to know where machine alignment leaves off and tape curvature begins. Unfortunately, the factors which contribute to tape curvature are inherent in the Mylar base, and the only solution, for the moment, is to reject rolls which exhibit this tendency. Rigid quality control has all but eliminated this as a problem in the field.

In spite of the considerable number of problems encountered in the development of video tape, manufacture and use of this product are going ahead on a commercial basis. As there is almost zero margin for error in each of several dozen manufacturing steps, over 50% of the output is rejected as not meeting quality standards. However, laboratory and production research are continuing in an effort to improve both the performance and reliability of video-recording tape.

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Discussion on Video-Tape Recording

Chairman and Moderator

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Mr. Harmon: Many in our audience are a great deal more familiar with film than they are with the peculiar waveshapes that the speakers have been discussing this evening, but, speaking as a broadcaster with a little more familiarity with the electrical waveshapes than with film, I should say that Ampex, particularly on this project, has gone far off the beaten path in solving some very substantial problems in a unique way to make a major contribution to the television industry.

(*Anon*): The great tolerance of a television signal in its video portion is amazing, compared with its complete intolerance in its synchronizing portion. Why is it that we don't see more of the apparent degradation of the video part of the signal? Does it have degradation in that area?

Mr. Dolby: There is, of course, degradation of the picture as well as sync, but the effect of raw VTR signal on a stabilizing amplifier is by no means indicative of the real degradation. By comparison, a normal television receiver, which is designed to accept a certain degree of noise in the sync, would give a very fine-looking picture from direct VTR output. However, the integration action of the oscilloscope and film does give an exaggerated appearance to the noise seen in the illustrations. In fact, many picture lines may go by before a single spurious pulse appears in the VTR output.

Mr. Lewin: What success has there been in re-recording of video signals?

Mr. Ginsburg: The re-recording has been very satisfactory. The last one I saw performed in the field was about four months ago and involved a loss of about 50 lines in resolution and very little loss in signal-to-noise ratio. As a matter of fact, I have been told that, in one case, master control at CBS Television City, in selecting the better-looking tape from the output of two machines, selected the one which was actually a dub of the other. This situation occurred as a result of someone forgetting to push the record button when supposedly recording the show in duplicate, after which they made a dub of the original to use for back-up during playback.

Mr. Newmayer: In kinescoping, making a film of the video tape, do you run into any complications other than banding and shutter block which you'd get from an ordinary program? Is there any distortion that would be induced through the equipment or the frequency?

Mr. Ginsburg: No, there are no complications introduced in the process of making a film from video tape.

Mr. Zambuto: With regard to the linearity of the demodulation characteristic, is that curve theoretically derived from the assumption that your pulses, in other words your modulated waves, are actually square waves?

Mr. Anderson: No, that theoretical curve was drawn with or direct from sine-wave operation.

This discussion was held on April 29, 1958, during the Society's Convention in Washington, D.C.

Mr. Zambuto: Did you check what happens if the wave is square?

Mr. Anderson: Well, it usually ends up being a sine-wave anyhow, because of the upper cutoff frequency.

Mr. Zambuto: In the matter of splicing, it is quite evident, of course, that in the region of the butt-weld you are going to exceed the curie point. What happens there?

Mr. Machein: It is very important to determine this point of temperature and, of course, it will largely depend on the backing you are going to use. Up to this point we have been concentrating on basic questions of how to cut and splice so we are not in a position to present a final solution to this question right now. We have a welding machine ordered and in development, but it's a little bit early to give you a final answer backed by numbers at this point.

Mr. Harmon: I believe Mr. Ginsburg said that there is considerable hope that the voltage which could be read off the tape would be greatly increased at some later date because of improvements on the tape or improvements in the heads or some other mechanism. May I ask him to comment?

Mr. Ginsburg: I don't think I mentioned the tape in this connection. The tape manufacturers are doing very well, but there is lots of room for improvement in the efficiency of the heads.

Mr. Lewin: In regard to splicing, what do you do about the displacement between the sound and the picture?

Mr. Machein: The displacement between sound and picture is a constant displacement and it is somewhat similar to the displacement that occurs on film. I must admit I haven't thought of this as very serious because it's an established technique as far as motion pictures are concerned.

Mr. Lewin: If you make a cut at a certain picture frame don't you lose the sound which is in advance of that? You are dealing with a single system here and not the conventional double system.

Mr. Machein: Preferably you will choose a point for cutting your picture which is either on the end of a scene or where the sound is not significant; or you would have to find a way to delay the sound.

Mr. Smith: What physical tolerances are allowable in splicing during the vertical blanking interval? If I understand correctly, you splice between the track where the vertical blanking begins and the track where the vertical blanking ends, is that correct?

Mr. Machein: That's correct.

Mr. Smith: What tolerances do you allow in the actual "cut" between the tracks?

Mr. Machein: We must assume that the front portion of the vertical blanking will be held constant by the positioning servo and that the spacing between two tracks is 5 mils. In relation to the longitudinal motion of the tape, we found that an accuracy of ± 1 mil is sufficient. It may be interesting to note that we have made quite a number of splices, with conditions as severe as possible, making observations with the naked eye and using a razor blade. Five out of seven splices went through very satisfactorily.

Mr. Fine: How much azimuth error is tolerable in the heads of your different machines for optimum reproduction, between two machines?

Mr. Ginsburg: In considering all the tolerances that we have to meet in order to play tapes back interchangeably, it turns out that the azimuth alignment is a minor problem.

Mr. Harmon: What happens if this azimuth alignment is out? I assume that it would first appear as a difference in level coming out of the individual heads, but is there also a phase problem, a timing problem if this is out in that direction also?

Mr. Ginsburg: The phasing problem would not be of significant importance, the primary consideration being visibility of banding noise. This effect would be the result of the azimuth alignment on a given channel on the playback machine being different from the azimuth alignment of the corresponding channel on the record machine.

Mr. Harmon: As I understand it, there is a device which adjusts the gain from each head. You have separate pickup channels so that this might be taken care of if it was constant. On the other hand, if it was random it would be difficult to handle such a problem.

Mr. Ginsburg: The use of an FM system allows us to pass the recovered modulated wave through rather conventional amplifier and limiter stages. Therefore, variations in the amplitude of the r-f signal will not result in variations of the demodulated signal amplitude but merely in variations of the signal-to-noise ratio.

Mr. Hughes: In the recording of a composite NTSC signal, would this azimuth error in position between successive heads become more critical or do I misunderstand some of the physics involved? Is azimuth error allowable between successive heads?

Mr. Ginsburg: "Azimuth alignment" refers to that alignment which makes the gap perpendicular to the plane of rotation.

Mr. Hughes: I perhaps misunderstood the word. I meant the position of the heads on the periphery of the drum, at 90° intervals, 90° plus or minus how much?

Mr. Ginsburg: The positioning you are referring to is what we call angularity, or rotational alignment.

Mr. Harmon: On this delay-line detector, can you give us some information on its sensitivity and its noise level, signal-to-noise and such characteristics? It certainly is admirably simple. What are these characteristics in terms of some of our other types of detectors for FM signals?

Mr. Anderson: I must confess I don't remember all those figures. I do know the conversion sensitivity was quite a bit better than we had found in the slope detector. This made it a very attractive type of translation device, but I don't remember all of the signal-to-noise figures and the conversion factors.

Mr. Harmon: Certainly it's simplicity in itself.

Mr. Anderson: Yes, and nothing to go wrong, very straightforward.

Mr. Zambuto: I can conceive of at least two different types of flutter possible in this machine because of the two different motions. Can you give any idea of the tolerances in that?

Mr. Ginsburg: We can eliminate the factor of longitudinal tape flutter. This has primary bearing only on the audio track performance. Hence, it is simply necessary to conform to high-quality audio-tape recording tolerances.

Mr. Zambuto: Wouldn't that also affect the relative signal level because it would displace the rotating head with respect to its own track, so the head wouldn't read the whole of the track but only a part of it?

Mr. Ginsburg: No, by the time the flutter in the longitudinal direction gets that bad, the audio is so bad that you wouldn't want to use the tape anyway. Errors in the time base characteristic of a program played back from tape are, to a very large extent, a function of the oscillations of the rotating drum about its proper time varying position. For the usual case in which drum displacements take place in a sinusoidal fashion, it is desirable to keep F squared times A equal to or less than 3, where F is the natural hunting frequency and A is the peak amplitude of the displacement expressed in rotational degrees.

Mr. Zambuto: With respect to the future uses of this device, it has been said that possibly it could be mounted on a truck for recording certain events. Exactly how portable do you think this equipment is at the present moment?

Mr. Anderson: The best answer I can give to that is the fact that I said, "a truck." The equipment weighs, if I'm not mistaken, about 1350 lb and it does require a lot of portable space and portable power to move it around.

Mr. Zambuto: I wasn't thinking just in terms of power, I was thinking in terms of what may happen to the equipment during transportation. In other words, what kind of shock isolation should the equipment be given and do you think this would be feasible? What transportation difficulties would you expect?

Mr. Anderson: The original piece of equipment that was shown last year at the NARTB was self-contained in one console. It was taken out of the console to make it more accessible to the broadcaster. As a measure of the reliability and desirability of the equipment, that particular recorder was shipped to Chicago by truck from the airport, bounced on a DC-6 all the way back and I'm sure it was pushed off the DC-6 on to a truck and then back to Redwood City. That same equipment was trucked again to Los Angeles, trucked to Monterey, and I think it's been trucked around the Bay area several times. As far as I know, no damage has ever resulted from any of those operations.

Mr. Solow: Mr. Miner said that he wanted to elicit some comments from the audience, so it is perhaps fitting that I stand up here and let these evil geniuses look upon the kind of human being they're going to render extinct in the near future. In my opinion, the real impact of videotape recording on television will come through programming, as Mr. Miner suggested, rather than through a straight technological competition with film. In this respect, video tape is different from the introduction of audio tape in radio because in that instance there was a contest between recorded and live radio programs, whereas now video tape represents really the live technique versus a film recorded show. I fear, on behalf of my own welfare, that video tape will change programming to the extent that film will be used less, because

live TV is not very popular with actors and actresses. In the half-hour and hour presentations in the live form, all sorts of tensions, frantic costume changes and scene changes are, of course, necessary and, as a result, many actors and actresses refuse to appear on live TV. Of course, the tension arises from the fact that a fluffed line is going to be heard by the entire audience, or some disarray in the dress of a male actor who has just made a quick change may be evident. So, even without any further perfection in the technique of splicing, isn't recording in segments — starting with a fade-in and ending with a fade-out — possible, so that an hour's show can be leisurely performed in front of television cameras, together with a video-tape recorder, in perhaps the space of 6 or 7 hours preceding the broadcast. Then everybody can go home, relax and look at the show on the air and it will, essentially, be a live show. In this way your video tape will enhance the ease of presentation of live TV and render film shows less necessary as time goes on.

Mr. Harmon: One thing that would bother me about this, in what you say, in going to "black" as we call it, in television, this is fine, but suppose you have a fluff in the middle of a television field, how do you splice this?

Mr. Solow: Do it over again. Do it in easy segments.

Mr. Harmon: But you're still going to have to go back to a vertical period somewhere to make the splice?

Mr. Solow: That's right. You'd divide an hour's show perhaps into six 10-min segments.

Mr. Harmon: I thought you might be suggesting to the Ampex gentlemen that here's a neater way to splice, just go to black for a couple of dozen fields and cut anywhere you want and let your picture roll.

Mr. Solow: No, construct the script originally in the form of segments that would start with a fade-in and end with a fade-out, so that each segment is successively put in the can. You could then splice without worrying about revealing the scan lines, and just play the whole show. Of course, as more machines are delivered to the networks, I can also foresee, with added horror, that each television camera can have its own tape recorder connected to it, and then after all of the performance has been completed, the show can be played back over several monitors in the manner that live TV is played back, and a technical director can then punch one tape in following the other, and make lap dissolves and fades and that sort of thing. I suppose that is in the offing, too. So it's a dim future.

Mr. Miner: I think the general area that you're discussing resolves itself, in great measure, to the operating agility of the people who are using the equipment rather than the actual abilities of the equipment itself.

Interchangeability of Videotape Recorders

By CHARLES P. GINSBURG

New requirements are placed on video-tape recorders when tapes are to be recorded on one machine and reproduced on another. The nature and extent of these requirements are discussed for both monochrome and color.

Some of the greatest problems involved in the interchangeability of video tapes, whether in monochrome or color, come from the fact that the pictures from the tape are segmented. An average of a little more than 16 picture lines is read out as each head describes an arc of 90° across the tape. There are 16 of these picture line groups in a field. Because of the segmentation, small variations from one band to another in noise, in frequency response or in time position will be visible and objectionable. If we make the reasonable assumption that the response characteristics of the four r-f electronics channels which carry the signals to and from the heads are matched, the variations mentioned above can be discussed in terms of electrical and magnetic behavior and mechanical positioning of the heads.

Noise Banding and Frequency Banding as a Function of Variations in Head Performance

Let us say that the process of recording a signal on tape and then recovering it constitutes a transmission channel. On the VR-1000 Videotape Recorder, we have four such head-tape transmission channels. These channels vary among themselves in two ways of special interest to the interchangeability problem:

(1) Slight variations exist in the impedance frequency characteristics of the several channels. This is due to very small differences in head circuit resonant frequency, including variations in the source impedance of the amplifier circuits driving the heads during recording, as well as loading impedances presented to the heads during playback.

(2) Attenuation characteristics due to magnetic losses and to gap effect vary slightly from one head to the next. Since we are working with magnetic gaps whose dimensions approach the shortest wavelengths which are recorded on the tape, there may be variations in attenuation resulting from an inability to hold the gaps to exactly equal values for all heads.

Consequently, in comparing the transmission characteristics of the four channels, we will find:

(1) Differences in the amplitude vs. frequency characteristics accompanied by differences in delay distortion. This would be the case for variations caused by differences in the resonant frequencies.

(2) Differences in the amplitude versus frequency characteristics not accompanied by differences in delay distortion. This would be the case for variations caused by differences in the size of the magnetic gaps.

The tendency toward noise banding and frequency banding will increase somewhat when tapes are to be played back interchangeably. The optimizing of the recording current for a given head is, by definition, a process by which the best possible picture is obtained, and results in the best possible current setting in view of the playback as well as the record characteristics of that particular head. Theoretically, there are several reasons why an optimum recording current setting for a given head will not necessarily be the best setting if a different head assembly is to play back the same tape. Fortunately, in practice, this matter is of secondary importance.

The azimuth alignment requirement for the head gaps, i.e. perpendicularity with respect to the transverse magnetic tracks, is considerably tighter for interchangeability than it is for an operation in which a tape is to be played back only with the same head assembly with which it was recorded. Within extremely wide limits of azimuth errors, there is essentially no decrease in head resolution or head output in the latter case, since the control system is so designed that each of the four heads will play back the particular set of magnetic tracks which it recorded. However, if the azimuth is different in playback than in record,

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