TECH NEWS

by Rodger J. Ross

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FILM POST-PRODUCTION ON VIDEOTAPE

From the start of television right after WWII, broadcasters turned to the film industry for program materials, and an enormous new market was created, not only for old feature films, but also for new programs on film, specially made for television. The first problem encountered in reproducing films in the television system was the difference in frame rates. A frame rate of 30 per second had been adopted by television engineers in North America, while the standard motion picture frame rate is 24 per second.

It may seem odd that a television frame rate of 24 per second was not adopted at the start to make that system compatible with motion picture. But there were two main reasons why a different approach was necessary. First of all, television picture monitors and receivers were being operated at much higher brightness levels compared with motion picture projection, and this made the flicker problem worse. Besides, it was desireable for several reasons to drive the television scanning system at the same frequency as the alternating current from electrical power outlets – 60 cycles (Hz) per second in Canada and the USA.

Pictures are produced in the television system by a scanning process. An electron beam in a picture monitor or receiver is driven back and forth across the inner surface of the face of the picture tube, causing a phosphor layer to glow and emit light, varying in brightness as the energy in the electron beam rises and falls. The North American television system has 525 horizontal lines in each frame, divided into two fields. The field consists of all the odd numbered lines, and the second field, all the even lines. As scanning proceeds at the rate of 60 fields per second, the even lines are traced in between the odd lines on the face of the picture tube, starting at the top, to make up 30 complete frames per second. With the higher field rate, flicker was reduced considerably at the same time.

An ingenious solution was devised to fit the film frame rate into the television scanning rate. Motion picture projectors were modified to pull down the film in what came to be known as the 2-3-2 sequence. By means of an off-centre accelerator in the projector mechanism, a picture frame is held steady in the gate during the scanning of two television fields, and then the next picture frame for the duration of three fields. With this arrangement five television fields are scanned while two film frames are being projected or an average rate of 2 1/2 fields per frame – that is, 2 1/2 x 24 (60).

The Vidicon Tube in Telecine Cameras

The practice was adopted at an early stage of projecting film pictures directly into a television camera in an equipment layout that came to be known as telecine. Setting up two film projectors and a slide projector around an optical multiplexer and the television camera enabled multi-reel feature films to be broadcast without interruption. Cameras for telecine service were fitted with vidicon tubes which turned out to be particularly suited for reproducing films. An interesting – and very useful – characteristic of the vidicon tube is that scanning can continue during periods when the projector shutter is open with no noticeable effects in the resulting television pictures provided that a couple of relatively simple requirements in light application are met.

The vidicon tube is an extremely simple device, consisting of an electron emitter (heated filament) at one end, and a flat face plate at the other end, the inner surface of which is coated with a photoconductive layer. Surrounding the tube in operation are focusing, alignment, and horizontal and vertical deflecting coils to which voltages are applied, driving the beam back and forth over the photoconductive layer, in a fixed pattern of lines, fields and frames.

In 1953 when R.G. Neuhauser of the RCA Tube Dept. described the vidicon at an SMPTE technical conference in New York, he made the comment that "one might well wonder how a tube so small as the vidicon can be made to produce a picture from film equal to or even superior to that from a broadcast quality image orthicon tube." A type of vidicon suitable for use in telecine cameras is 6 in. long and 1 in. in diameter, with the flat face plate at the front end having a useful photo-area of about 9.5 x 13mm. This is only slightly larger than a 16mm motion picture frame.

Inside the tube a sharply focused electron beam sweeps back and forth over the illuminated face plate, and a tiny current measured in fractions of a microampere is generated, varying in relation to the light intensity in the different parts of the image projected on it. In a color camera there are three tubes, and an optical system splitting the projector light beam into red, green and blue components. The outputs of the three tubes are combined to produce color video signals that can be distributed via cables, recorded on videotape or broadcast directly to the public.

Automatic Signal Level Control

The invention of the vidicon telecine led to the development of a method for broadcasting film that had unfortunate consequences for the motion picture industry. With previous methods – for example, with the old iconoscope tube – an operator had to be assigned to telecine camera control to make electronic adjustments to compensate for the erratic behaviour of the tube itself. In contrast, the vidicon gave a much more stable output, with maximum and minimum signal levels almost directly related to the light intensity in the lightest and darkest portions of the film images. The task of the television technician assigned to the operation of a monochrome vidicon telecine was reduced to making adjustments of the camera controls affecting maximum and minimum signal levels, to compensate for film density variations and maintain as nearly as possible uniform peak white and black signal levels at the output.

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One reason for this approach to film reproduction was that the vidicon tube responded to a very wide range of light variations. According to equipment designers at the time, broadcasters were being supplied with films so variable in density that the operators had to deal with changes of 100:1 in films from different sources – that is, the light at the vidicon face plate in picture highlight areas was sometimes 100 times greater from some films than from others. Telecine output could not be allowed to vary to this extent, and a method was devised for controlling the light entering the camera, consisting of a remotely controlled continuously graded neutral density disc in the projector light beam. The telecine operator rotated the disc in the light beam by turning a control knob marked "gain" to keep the peak white signal level at approximately 100 units on the scale attached to the face of a waveform monitor, a special type of oscilloscope used for this purpose. A separate electronic pedestral control was used to keep black levels at appromimately zero –slightly under 10 units in some operating modes – on the waveform monitor scale. The standard composite video signal has a total amplitude of 1 volt, including the synchronizing pulses. The waveform scale is divided into two sections by a zero line – 41 units below zero line for sync and 100 units above this line for the picture signal, with a narrow guard band between zero and 10 units for what is known as set-up. Broadcasters always try to maintain signal levels as nearly as possible fill the waveform scale – in this way viewers at home can be given pictures with bright highlights and deep shadows, so necessary for best possible picture quality.

Monitoring signal levels and making occasional adjustments of gain and black level controls proved to be an exceptionally tedious task for television technicians. It was not long before equipment disigners found ways to automatically control signal levels – claims were made that the automatic controls not only released technicians for other more interesting work, but at the same time responded more quickly to film density variations, giving a more uniform signal output. Soon, almost every broadcasting station in North America was operating telecines with automatic controls, with little regard for the quality of the pictures obtained from films. When the pictures were poor it was assumed that the film was itself faulty. It should be noted at this point that the entire North American broadcasting industry, with the exception of the major US television networks, had in the beginning adopted 16mm as the standard television film format.

Proposals for Uniform Highlight and Shadow Densities

The only way out of the deadend that automatic telecine operation imposed, seemed to be to try to persuade filmmakers to pay more attention to controlling highlight and shadow densities and thus cancel out the effects of automatic signal level controls. But at an SMPTE section meeting in Montreal in Oct. 1957, this proposal was given a poor reception. Several in the audience protested that instead of asking filmmakers to change their practices, the television system should be modified to accommodate any film considered to be acceptable in direct projection.

As it has turned out in the meantime the protesters were a lot closer to hitting the nail on the head than they realized, but at that time it was unrealistic to expect any change in the television engineering approach to film reproduction. It was only through a completely unrelated development that a far more promising way was found to achieve a breakthrough.

This development was videotape, invented in the mid-1950's as a means for temporarily storing the signals from live television cameras. Before videotape, all television programs had to be broadcast live – a dreadful strain on both performers and technicians. The announcement by the Ampex Co. of their videorecorder using 2 in. magnetic tape was greeted in television circles with rejoicing, and in short order just about every television station had one, and often several machines. The most astonishing characteristic of the video recorder was that the picture obtained in playback from the tape were almost identical in appearance with the original picture from the live television cameras.

Television Program Production on Videotape

But a far more important consideration than excellent technical quality, as it turned out, was the possibility offered by video recording for producing programs on tape in a manner similar to film editing. Many people outside of the broadcasting stations were attracted by this possibility and production centres were organized to make programs for the broadcasters. One of the most popular – and profitable – activities in these centres was – and is – the production of television commercials, but many full-length entertainment programs have been made in this way also.

It was only a small step for these production centres to acquire telecine equipment so as to be able to reproduce film footage supplied by, or made for, their clients. Film footage first has to be transferred to videotape to be incorporated into the programs. As the transfers from film to tape are being made, clients are likely to be on hand watching the television pictures as the video signals are being recorded. In this kind of a situation an operator would have to be assigned to make whatever changes in telecine camera controls that may be needed to enhance picture appearance. It is most unlikely any client of a production house would tolerate unattended telecine operation with automated signal level control.

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