TECH NEWS

by Rodger J. Ross

FLYING SPOT SCANNERS
FILM POST-PRODUCTION ON VIDEOTAPE 3

In England and Europe, as well as some other parts of the world, the television system operates at 25 frames (50 fields) per second, instead of 30 frames (60 fields) as in North America. The use of this lower frame rate greatly simplifies the scanning of motion picture film. Existing films shot at the standard rate of 24 frames/sec. can be speeded up slightly in the telecine transport to match the television scanning frequency, while films being made specially for television can be shot at 25 frames/sec. and then played back in telecine at the same rate.

The ability to reproduce films in the television system without the need for frame rate conversion enabled equipment manufacturers in England and Europe to take an entirely different approach in designing telecines, as compared with the North American practice. The outcome was the development of what is known as the flying spot scanner.

Cathode Ray Tube as Light Source

In the flying spot scanner a cathode ray tube (CRT) is used as the light source, instead of a tungsten lamp as in motion picture projectors. The cathode ray tube is similar in most respects to a small television picture tube, in that an electron beam is driven back and forth inside the tube, exciting a phosphor layer coated on the inner surface of the flat face plate, and producing a uniformly illuminated raster. A lens focuses the rapidly moving spot of light on the tube face at the plane of the film in the gate of the film transport mechanism. The light passing through the film is collected in an optical system which makes the red, green and blue separation, and then directs these three light beams into photomultiplier tubes where the video signals are generated.

If the eye could act quickly enough it would see a tiny, rapidly moving spot of light sweeping back and forth across the face of the CRT, but as the entire frame scan takes place in one twenty-fifth of a second, the eye sees what appears to be a uniformly illuminated rectangle. Since the television system must react very quickly in order to trace out picture information, the system "sees" the rapidly moving spot of light. When film is being held stationary in the gate of the telecine, a picture frame is actually scanned by the spot of light from side to side and top to bottom.

From this brief description it should be easy to see that the color and intensity of the spot of light will be modified (modulated) by the film image as it passes through the film. Then, in the following optical system, after color separation has taken place, the output signal/levels from the three photomultiplier tubes will rise and fall in relation to the intensity of the light modulations.

Two Television Fields from Each Film Frame.

This method of reproducing film in the television system is basically much simpler than the North American practice of projecting films into a television camera. But in practice it is not possible just to scan the film frames one by one, because the telecine output must be in the form of two interlaced fields for each film frame. Rank Cintel in England has been making flying spot scanners for many years, utilizing a continuous film transport and a twin-lens optical system in which the scanning for two consecutive fields on the face of the CRT is imaged on the film at two different positions in its travel. The continuous motion of the film contributes about half of the required height of vertical scanning, and a rotating shutter allows light to pass through alternate optical paths. This most ingenious system has been utilized most successfully by broadcasters in England and Europe, giving excellent picture quality.

The flying spot scanner has a number of important advantages. First and foremost, color separation takes place after the film images have been scanned, thus eliminating altogether any possibility of color misregistration and the annoying color fringes sometimes seen in pictures from vidicon telecines. The pictures from film obtained in flying spot scanners were for a long time so much better than the pictures from live television cameras that an entirely different approach to film reproduction was taken in television centres operating on the 25-frame scanning standard. For the most part, manual operation of telecines has been the normal practice, although in recent years some European broadcasters have gone over to automatic signal level control to save operating costs and some have been installing camera-type telecines to take advantage of the greater programming flexibility and lower equipment costs that multiplexed telecine chains offer.

The Flying Spot Scanner in the United States and Canada

Many attempts have been made by equipment manufacturers to adapt the flying spot scanner principle for use by television stations operating at 30 frames/sec. but without noticeable success. North American broadcasters have become so much attached to the camera-type telecine, valuing especially its versatility and flexibility and its ease of operation with automatic signal level control, that any other system for reproducing film had little chance of adoption. Those who saw in the flying spot scanner the possibility of producing much better television pictures from film were confronted with the additional handicap of frame rate conversion – it turned out to be very difficult to devise a practical system for obtaining 60 interlaced television fields per second from film running at 24 frames/sec. Rank Cintel adopted a method in their flying spot scanner known as "jump scan". With this method the scanned portion of the raster on the CRT was shifted electronically into five different positions for every two film frames, to obtain the necessary five television fields, or 2 1/2 fields per film frame. But it was ver difficult to entirely suppress the 12-cycle flicker that resulted from slight differences in the brightness of the raster in the different positions on the face of the CRT.

Digiscan System of Frame Rate Conversion

All of these problems have been

eliminated by the development recently of Rank Cintel's Digiscan system of frame rate conversion. This development has made the flying spot scanner very attractive for North American service, and a considerable number of post production companies have already installed or are planning to acquire this new film reproducing equipment.

With the Digiscan system, scanning takes place at the film frame rate – 24 frames/sec. – and the required number of television lines are generated to make up two complete television fields for each film frame. The odd and even television lines are "written" into different computer memories or stores. The odd lines are then read out of the memory for the first television field, while the even lines are read out to produce the interlaced field. As the Digiscan system stores the luminance and chrominance information (brightness and color) separately, two fields of storage are needed for each, or four altogether. The operation of the system is completely automatic. The system can also scan out still frames when the film transport is stopped.

Multi-Format Telecine Operation

The Rank Cintel Mk II flying spot scanner is designed in such a way that a change-over from 16mm to 35mm film can be effected by simply interchanging the unit containing the film gate and transport mechanism. This is a big advantage in a post-production operation where clients may bring in either or both film formats to be transferred to videotape. To accommodate the two film formats a camera type telecine chain would have to include a separate projector for each format to give the same degree of flexibility.

The flying spot scanner was developed in a television environment where manual adjustment of the video controls was the normal method of operation, the objective being to obtain the best possible television pictures from film. This type of equipment is fitted with a more comprehensive range of controls as compared with camera-type telecines commonly found in North American television stations. For example, controls are available to alter the gammas of the three color output signals. With this type of control it is possible to completely change the appearance of the television pictures by raising or lowering the signal levels from the picture middletones relative to the highlights or shadows. Gamma correction is particularly helpful in reproducing films in which the images in all three layers have not been exposed in the same portion of their characteristic curves, or when these relationships have been disturbed by faulty processing of the color film.

Post Production Operations with TOPSY

Available also with the Rank Cintel Mk III flying spot scanner is a device known as "Topsy". With this device corrections of the telecine controls made during previewing of a film can be stored in a memory (floppy disc), and recovered later on, automatically, scene-by-scene, during the transfer of the film to videotape. This enables preparation of the transfers to tape to be carried out in much the same way as color film negatives are prepared for printing in the motion picture laboratory. However, during a film preview in telecine, the change in picture appearance produced by a given shift in the setting of a telecine video control can be seen as the change is being made, by observing the television picture monitor display. If the desired improvement in picture appearance is not obtained with this particular setting of the telecine control, the film can be rewound and the scene can be run through again with a different control setting. Stopping, rewinding and restarting of the film transport can be accomplished much more easily and quickly and with far less risk of film damage, as compared with an intermittent pull-down film projector.

Advantages and Disadvantages

From this brief and rather sketchy description it can be seen that the flying spot scanner is quite different than the more familiar camera-type telecine. The biggest difference is that film projectors are not used – instead, the film transport is an integral part of the scanning system, and the film is moved continuously through the gate where the images are scanned by a moving spot of light. A television camera is not used in the flying spot scanner – the light passing through the film images is collected in photomultiplier tubes to generate the video signals. These devices are basically similar to the photocells used in generating sound in a film projector, except that the output signals are amplified many times within the tubes, as the name suggests.

It would be misleading to leave the impression that the flying spot scanner is inherently superior to the vidicon telecine insofar as the ability of these devices to generate high quality pictures from film. But anyone who has had the task of lining up a vidicon telecine would almost certainly agree that a great deal of time, effort, skill and determination is needed to achieve a condition of film reproduction acceptable to filmmakers. From what has been seen so far it appears that such a condition is easier to achieve in the flying spot scanner operating with the Digiscan system.

Long time Supervisor of Technical Film Operations at the programming centre of the CBC, Mr. Ross is the author of two books, ***Television Film Engineering*** *and* ***Color Film for Color Television,*** *has won the Agfa-Gevaert Gold Medal awarded by the Society of Motion Picture and Television Engineers, and is presently Chairman of the SMPTE Board of Editors.*