THE TRANSFER OF VIDEOTAPE RECORDINGS TO FILM

A Review of Current Processes

Bernard Happé
B.Sc.,F.R.P.S.,F.B.K.S.T.S.

34th FIAF CONGRESS

May 28 - June 2 1978
Brighton

General Introduction

For a number of years videotape recordings have played a vital role in television broadcasting and a very large proportion of the programmes seen to-day are in fact transmitted from such recordings.
But despite the outstanding quality and convenience of videotape, there is still a lively interest in converting an electronic picture into motion picture film and a summary issued in 1976 listed some 25 major organisations in the United States and Western Europe offering such a service on a regular commercial basis.

It may well be that the ready availability of such technology will be of interest to the film archivist and this afternoon I shall endeavour to outline the general characteristics of the methods currently in use and demonstrate the results which are being obtained.

Basic Considerations

Unfortunately it is not sufficient merely to point any cinematograph camera at the screen of a television receiver and film the picture shown. Four characteristics of the electronic image must be taken into account:

1. The interlaced linear structure of the television picture. The number of lines used varies in different parts of the world - 525 lines in the United States, 625 lines in Britain and in much of Western Europe, 819 lines in France and some associated areas.
2. The extremely short period between successive TV images. If a regular cine camera were used, many of the lines making up the picture would not be recorded while the camera shutter was closed. For telerecording, it is necessary to have a camera mechanism with a very rapid pull-down between frames, preferably shorter than 2 milliseconds. This is difficult with 35mm film, so most telerecording uses 16mm cameras of special design.
3. The relation between the TV field frequency and the film frame rate. In European practice the broadcast standard of interlaced fields at 50 Hz can be recorded as a film equivalent of 25 frames per second, but the American standard is based on 60 fields or 30 complete pictures per second. To convert this to film for projection at 24 pps, it is necessary to eliminate one complete

TV field in every five or to combine two and a half TV fields for each frame of film exposed.

4. The colour coding system used also differs from one country to another: in the United States it is the NTSC system, in Britain and much of Western Europe PAL and in France and Eastern Europe SECAM.

Each of these factors must be considered in designing equipment for transferring videotape to film and it does not always follow that each organisation carrying out this work can necessarily accept all sources of recordings. This is particularly the case with the varieties of colour videotapes.

But before we start to consider some of these systems in more detail, let us look at a practical example of the use of monochrome film transfer in an archival application, for which I am indebted to Visnews of London. As this audience knows particularly well, the handling and reproduction of old films photographed or printed on nitrate-based stock presents many problems and when the Visnews company acquired their vast library of 35mm historical news-reels from Movietone News and others, they decided to convert it all to monochrome 2" videotape for permanent storage with safety and accessibility.

For initial inspection when required, transfers to ½" helical scan videotape are made for viewing and when the required sequences have been finally selected for production use, a transfer to 16mm B & W film is made from the 2" master videotape. A 625-line signal is fed through appropriate image shaping circuits to give a picture on a monochrome monitor screen which is photographed using a special 16mm Moy camera with a fast mechanical pulldown time of 1.8 milliseconds. The result is a regular B & W negative which can be printed or inter-cut with normal material.

The following examples are from Gaumont Graphic of the period of 1915-17 and were prepared for me by Denis Craven of Visnews for inclusion in a paper which I gave at the Uniatec Conference in Moscow in 1976, which explains the Russian subject matter.

Current Colour Recording Methods

Turning now to the available methods for transferring colour videotape recordings, it should be noted that the normal input for all such systems is from 2-inch quadruplex videotape of broadcast quality in NTSC, PAL or SECAM standards. Narrow gauge tape systems using helical scan are bound to yield lower picture quality and transfer facilities from these are not always available.

It is convenient to divide the current methods into three main groups, the first covering the direct photography of a colour television image display, either a single shadow-mask tube or a three-tube assembly. The second group includes methods which involve the preparation of colour separation images and the third those which use laser beam recording.

In the first group, the direct photography of a shadow-mask colour tube has the advantage of simplicity and uses colour film from which copies may be made directly by regular laboratory processes. Both colour negative and reversal stocks are used, with Eastman negative type 7247 proving very popular.

The American Teledyne CTR-2 is an example of this system, with the whole equipment mounted as a single unit, including the CBS image enhancer and decorder. A high-brightness shadow-mask tube is used and the levels can be individually adjusted for the red, green and blue signals to match the sensitivity of the film stock being used. The DBM-64B camera uses compressed air to transport the film instead of a mechanical shuttle pin and the whole pull-down operation, including registration is completed in one millisecond, within the interfield period.

In Europe, a number of organisations have developed their own groupings of equipment for this fundamental approach, among them Visnews, ITN and Vidtronics in England and Cineprint AB in Sweden. I shall show an example of this method from Vidtronics, whose separation negative system will also be described later. A fast pull-down camera is used with an improved shadow-mask monitor and the electronic circuits embody all the advances in decoding and image enhancement which has been gained in their long experience. The system is available for transfers from PAL, SECAM and NTSC standard recordings.

The Demonstration Films

Just before we view this example I should perhaps explain the general plan for our demonstration films this afternoon. To make comparison easy, we shall as far as possible, use the same subject matter for each transfer process and for this first series we are greatly indebted to the B.B.C. and to Peter Tigwell who has prepared and made available a compilation of varied videotape recordings showing a wide range of subject matter. Most of these are extracts from videotape productions but in one sequence from the Colditz series, the original photography was on 16mm film which was then embodied in the broadcast videotape and which has now been transferred back to 16mm film. The last item in this assembly, from the feature film "Sweet Charity", is an example of a 35mm anamorphic release print unsqueezed and scanned to videotape for broadcasting and again retransferred to 16mm.

But in one or two instances it was not possible to use this same videotape to demonstrate a transfer system and here I shall be showing a regular example of the process as used commercially.

Later in the afternoon, we shall be able to show you direct comparisons of some of these transfer processes using videotape recordings made from archival material, which will be described in due course.

Triniscope Systems

Although the use of a shadow-mask display has the advantages of direct presentation and simplicity, its limitations must be recognised: the phosphor dot structure restricts the image resolution, light output is low and despite recent advances the colours of the red, green and blue phosphors available are far from being well matched to film stock sensitivities.

One method of overcoming these disadvantages is to use a separate video display for each of the three colour signals and combine these optically for photography. Monochrome cathode ray tubes eliminate the dot pattern and permit higher definition than the TV signal itself provides. The spectral characteristic of each display can be accurately matched by colour filters to the individual film layer sensitivity and high efficiency phosphors with negligible after-glow are available. The additive combination of the three sources produces a high-brightness display for photography.

The price which has to be paid for these advantages lies in the accuracy required in the alignment and registration of the three tubes and their combining optical system with its dichroic reflectors. Electronic alignment must also ensure that the line structure on the face of each tube is identical at all points.

In Great Britain these problems were solved in the Videoprint system operated by Colour Video Services since 1969. In this equipment the three tube display is photographed using a Teledyne camera with a fast pneumatic pull-down and a resolution three times that of a standard 625 line broadcast television signal can be obtained. The tube mountings allow very accurate alignment of the three images and the scanning can be controlled to provide precise registration.

In the United States the Teledyne three-tube recorder CTR-3 operates on the same general principles and is designed as a complete unit for installation in a film laboratory, including automatic exposure control.

My next demonstration film is a transfer made by Colour Video Services from the B.B.C. compilation videotape and is preceded by a short section of their standard identification chart, which is included in all such copies.

Colour Separation Systems

An alternative method of eliminating the problems of the shadow-mask tube is to record the three Red, Green and Blue signals as separate photographic images on black and white film, combining these at a subsequent printing stage. This was the approach adopted by the Technicolor Vidtronics process in 1968, although since that time they have come to favour the direct method demonstrated earlier, on the grounds of economy.

In the original Vidtronics method the videotape is run three times, to display the individual colour signals separately and a black and white negative film record is made of each component. Since only a monochrome image is recorded, a high resolution cathode ray tube and fine grain negative film can be used. The Vidtronics process of transfer was the only one to employ 35mm, which was considered essential in maintaining the necessary accuracy of registration between the three separate records. Because 35mm film was used, the pull-down time of the camera was comparatively long, some 5 milliseconds, and partial field storage was employed by means of a long-decay phosphor and a graded neutral density filter on the screen. The separate treatment of the colour signals allowed decoding and electronic image enhancement in the optimum form for each record.

After processing, the three separation negatives were used to make prints by regular film laboratory methods: where large numbers of copies were required, they were used directly in the Technicolor dye-transfer process to make either 35mm or 16mm prints, the optical reduction stage for the latter being carried out during the preparation of the matrices. Alternatively, colour reversal intermediates were made by triple printing from the separation negatives in either 35mm or 16mm form.

Transfers were made by this Vidtronics process from all broadcast standard videotape recordings, NTSC, PAL and SECAM, but the example I am to show is a 16mm dye-transfer print from a PAL original.

Electron Beam Recording

Another system involving the preparation of separation images in black and white is Image Transform, but unlike Vidtronics the three colour signals are recorded as positive images in successive frames on one strip of 16mm black and white film and electron beam recording is employed. This has the advantage that the film is exposed directly without the use of a cathode ray tube screen or a camera lens and a very high definition image can therefore be obtained which is free from the optical defects of flare and halation. The film movement is continuous at an effective rate of 72 frames per second, to allow the three images to be recorded in real time and each frame contains all the lines of the videotape image but only the red, green or blue information. The shape of the electron beam spot is elliptical, being expanded vertically so as to minimise the line structure of the TV image.

After developing, the three separate images are combined to produce a 35mm colour inter-negative on a special optical printer. Each frame printed is exposed three times through a filter wheel with three colour sectors which rotates to synchronise with the three frames of the master recording and the inter-negative is thus triple-printed with the three red, green and blue records. From the colour inter-negative so produced, colour positive copies can be made by normal laboratory methods on any suitable print stock, although the processing of the separation master and the inter-negative itself is carried out under special conditions by Image Transform themselves.

Image Transform have always placed special emphasis on their electronic signal processing technology for noise reduction and image enhancement, with the resultant improvement of picture detail and sharpness. The application of these techniques to standards conversion on videotape allows the system not only to accept NTSC, PAL and SECAM 2-inch quadruplex recordings but also to work from narrow-gauge helical-scan tapes by way of a 2-inch intermediate.

The example which follows is especially interesting as a demonstration of the manner in which losses at various stages of transmission can be overcome. The occasion was the 1976 Winter Olympic Games at Innsbruck, where the event was televised as 625-line PAL. A tape recording of this was converted to 525-line NTSC by the BBC Standards Converter and transmitted by satellite to ABC in the United States.

ABC supplied a 525-line videotape of this transmission to Image Transform, who transferred it to produce the 16mm colour positive print from which some short extracts are now to be shown.

Laser Beam Recording

A method of direct recording on colour film which avoids both the use of a screen phosphor display and the complication of separation records makes use of three simultaneously modulated laser beams of red, green and blue. The equipment for this principle was initially developed in the United States by CBS for the NTSC system, but it has been modified and further improved by Rank Video in this country. Their first channel was for use with PAL recordings but a second is now available to work direct from NTSC recordings, rather than by way of a standards converter, as originally. Rank Video also have facilities for transfers from various forms of helical-scan cassette systems.

Essentially, the process employs three separate colour laser beams, for red, green and blue light, each of which is modulated by the appropriate colour signal from the video recording. The three beams are combined by dichroic reflectors into a single composite beam which is scanned directly over the surface of the frame of film to expose it line by line. The horizontal scanning traverse is produced by a rotating multi-facet mirror drum, while the vertical movement from line to line comes from an oscillating mirror. Using a rapid pull-down camera mechanism, each frame of film is exposed to a complete interlaced pair of fields without any image storage being required. The whole system thus operates in real time, directly recording on the film without the intervention of any phosphor screen or camera lens, and can offer the advantages of high definition, freedom from flare, perfect colour registration and good colour saturation so as to produce at a single step a colour negative which takes normal processing and printing.

The example which we are now to see is Rank Video's transfer from the BBC compilation tape once more.

The Sound Record

So far we have dealt only with the reproduction of the picture image from the videotape. The transfer of the sound record presents no particular problems, a transfer recording being made from the videotape on to magnetic film or quarter-inch audiotape with sync pulses. From these the optical transfer to provide a photographic negative for making married prints follows regular well-established practice.

Comparison Summary

To summarise at this stage, therefore, we may comment on the various systems so far described as follows:

1. Direct Photography
   (a) of the colour mask tube - comparatively simple in equipment and direct in use, and therefore economical in cost, but with some limitations of picture quality for both definition and colour reproduction.
   (b) of a trinoscope display - more critical in initial installation but direct in use when once established - capable of showing an improvement in picture quality with only a moderate increase in cost.
2. Separation Methods: capable of very high quality but inherently expensive in time and materials because of the additional film processing stages involved.
3. Laser Beam Methods: costly in initial installation and equipment but direct in use when once established and capable of high quality picture reproduction.

It is worth noting that all these methods except the direct shadow-mask are capable of providing a much higher standard of picture image resolution than can be obtained from television broadcast practice. This has been particularly recognised by Image Transform, who have devised their Image 655 system, designed specifically to produce 35mm film prints for theatrical presentation from special videotape recordings made without the limitations imposed by broadcast transmission.

Transfers from Archival Film

We now come to the demonstration which will be of very special interest to this audience: the use of videotape recordings and subsequent transfer as a means of reproducing archival films in comparison with the established photographic procedures.
From the resources of the National Film Archive the Curator, David Francis, and his senior Technical Officer, Harold Brown, have selected a number of examples of black and white and colour films of various periods and extracts from these original copies were transferred to 2-inch quadruplex videotape by the BBC. These recordings were edited and given identification captions and then four further videotape copies were made by the BBC as the source from which film transfers were to be made by various organisations. At the same time, a photographic print was made from the originals by conventional means, that is to say, by printing a reduction duplicate negative or intermediate and making a positive print from this in the usual film laboratory way.
To allow you to compare the results obtained by these various procedures, we shall run the next series of demonstrations continuously, without interruption from me, showing the copies of the same series of extracts in the following order:

1. A photographic print by regular methods
2. A transfer from videotape made by Vidtronics using their direct method
3. A transfer from videotape made by Colour Video Services using triniscope
4. A transfer from videotape made by Image Transform using electron beam recording
5. A transfer from videotape made by Rank Video using laser beam recording

Electronic Film to Film Transfer

With this series of comparisons, my own contribution to this afternoon's session is complete, but before concluding I should like to open a question which may have occurred to a number of you - is it necessary to use a videotape recording as an intermediary when working from film originals ? Is it not possible to go direct from film on a telecine through the electronic reproduction transfer sequence to another film without the videotape stage ? Where the transfer system operates in real time and a telecine can be directly linked to the film transfer equipment, this is clearly a possibility and I am glad to tell you that Mr. Fred Nunney of Rank Video will be the following speaker and will discuss this aspect of the problem.

However, before handing over to him, I should like to express my thanks to all my friends who have helped me in the preparation of this contribution by making demonstration material available. I will mention them strictly in their order of appearance this afternoon:

Denis Craven of Visnews
Ron Egerton of Vidtronics
Fred Wynall of Colour Video Services
Les Werschker, the European representative of Image Transform
Tony Jackson and Fred Nunney of Rank Video

and of course a special thanks to the BBC for their numerous contributions, and especially to Peter Tigwell for his personal help.

And a final word of thanks to the projectionists in this theatre, who have been confronted with an extremely complicated programme of demonstrations this afternoon.

Thank you.

Further Technical Information

An international survey of companies and systems available for transferring videotape to film appeared in Screen Digest for August 1976 and a general summary by Bernard Happe was published in the BKSTS Journal for March 1977. Technical details of some of these processes have been given as follows:

Vidtronics John Mulliner BKSTS Journal November 1969

Colour Video Services Ron Venis BKSTS Journal November 1969 and in a paper at the SMPTE Conference of September 1975

Image Transform (General) Les Werschker BKSTS Journal February 1978
(Signal Processing) John Comandini SMPTE Journal August 1977
(Film Recording) Comandini and Roth SMPTE Journal February 1978

Rank Video Dr. F. Gloyns, A. Jackson and F. Nunney in a paper at the 12th UNIATEC Congress in Moscow, October 1976