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[54] **DUAL COMPRESSION FORMAT DIGITAL VIDEO PRODUCTION SYSTEM**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 298,104, Aug. 30, 1994, and Ser. No. 50,861, Apr. 21, 1993, Pat. No. 5,450,140.

[51] **Int. Cl.**[6] **H04N 5/76**

[52] **U.S. Cl.** **348/722**; 360/14.1; 360/14.3; 358/311

[58] **Field of Search** 348/722, 616; 360/13, 14.1–14.3; 358/311; 395/146; H04N 5/76

[56] **References Cited**

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[57] **ABSTRACT**

An audio/video production system is implemented on a PC-based platform, preferably utilizing various forms of removable magnetic, optical, or magneto-optical storage media. Specially modified cameras or other sources provide digitally data-compressed audio and video program materials in two formats, a first format having a higher data-compression ratio and intended for use in off-line systems to develop edit decision lists, and a second format having a lower data-compression ratio and intended for use in on-line editing and to produce the final representations of the programs. Off-line editing decisions may thus be developed on a PC using removable storage media, and final representations of the programs may be produced on-line in accordance with stationary-head or rotary-head digital-tape-based formats, such as DAT, 6-mm or 8-mm tapes. In an alternative embodiment, automatic and unattended editing, or extended program playback of more than 40 hours duration of digital video, is available.

39 Claims, 2 Drawing Sheets

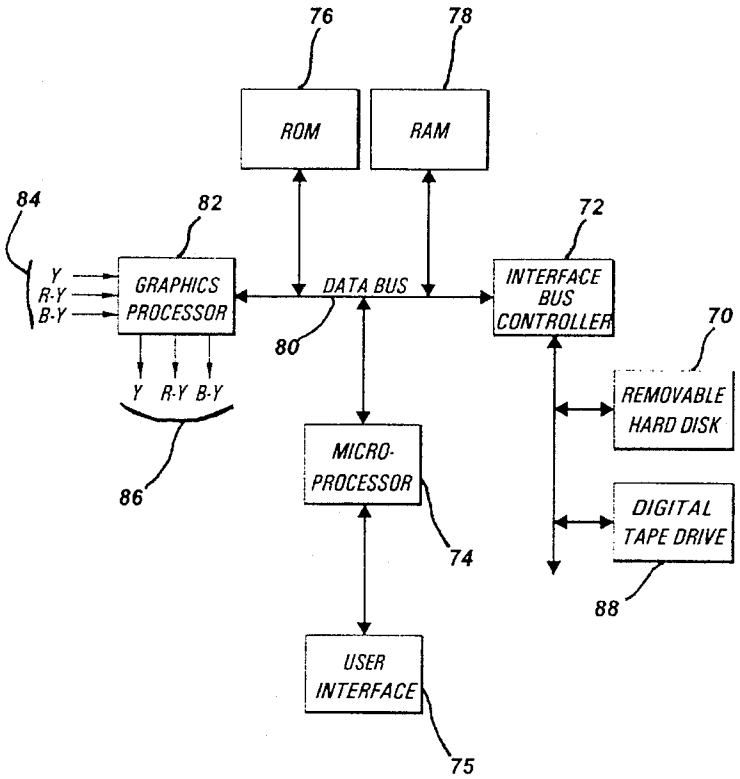


Figure 1

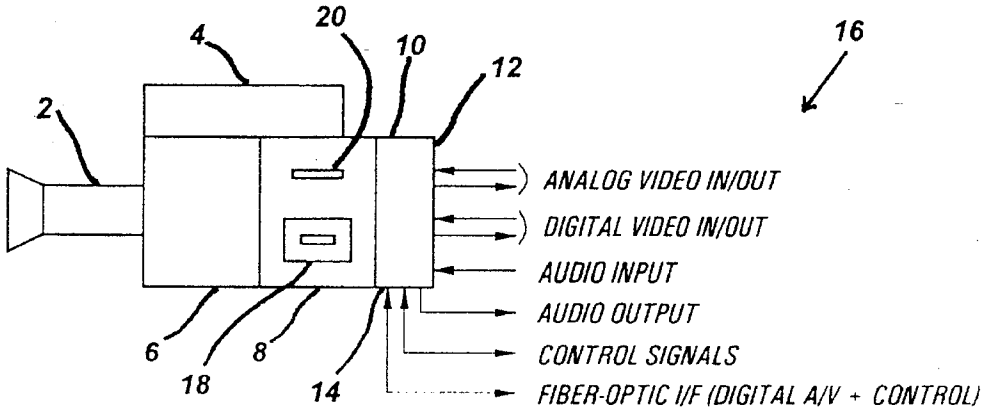


Figure 2

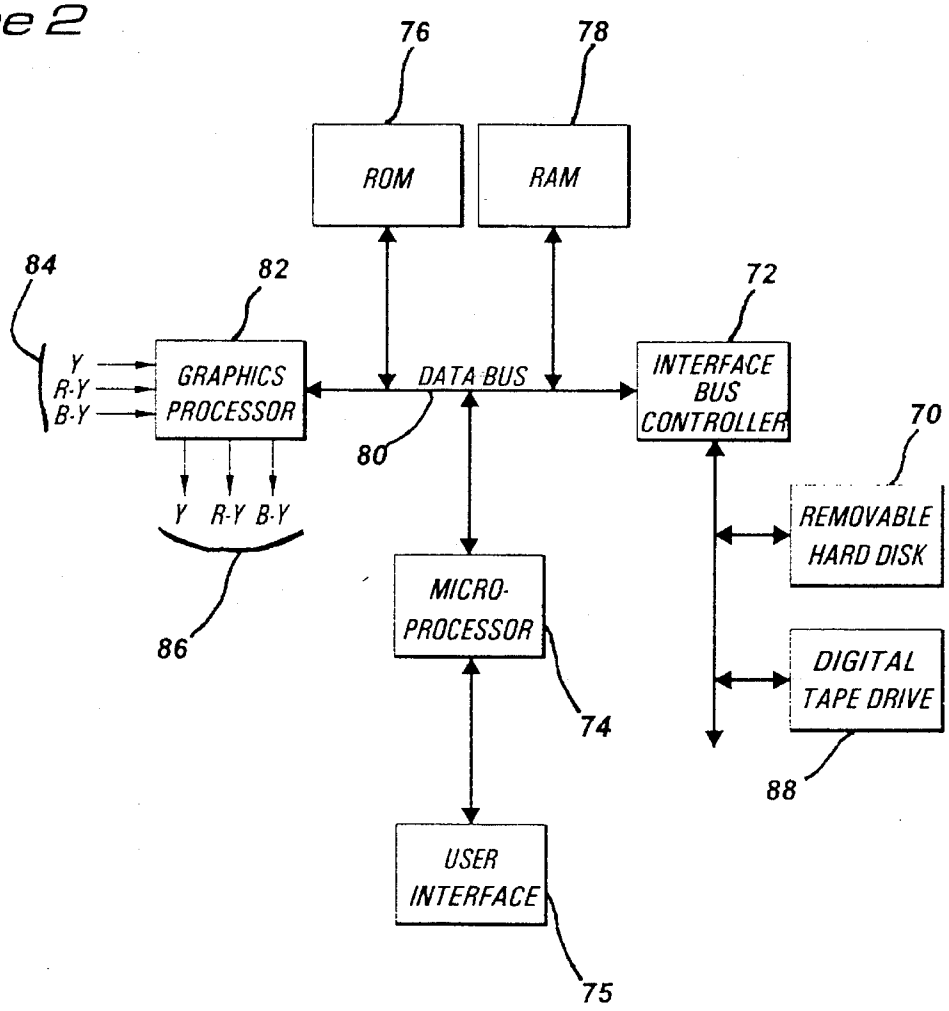


Figure 3

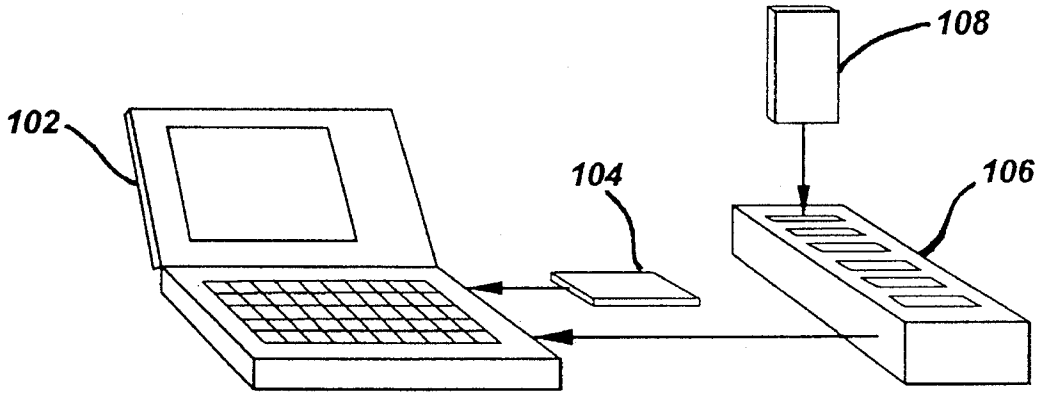
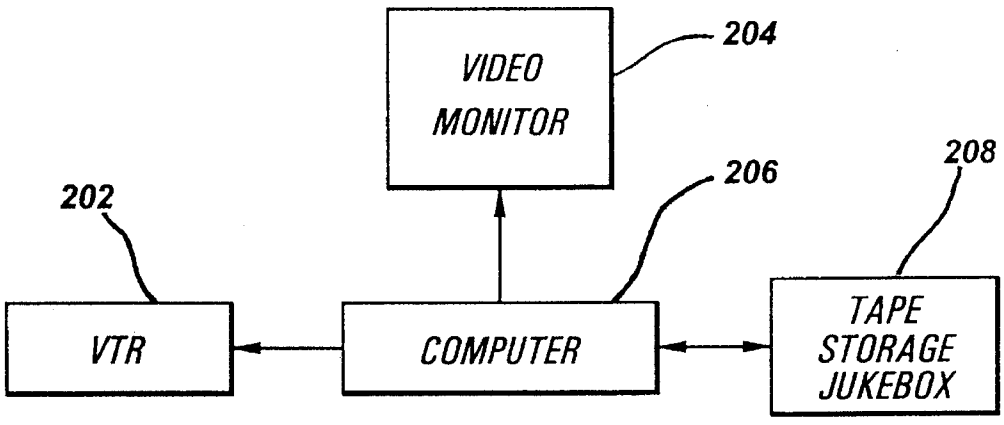


Figure 4



DUAL COMPRESSION FORMAT DIGITAL VIDEO PRODUCTION SYSTEM

REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of U.S. application Ser. No. 08/298,104, filed Aug. 30, 1994 and U.S. application Ser. No. 08/050,861, filed Apr. 21, 1993, now patented, U.S. Pat. No. 5,450,140.

FIELD OF THE INVENTION

This invention relates generally to video recording systems associated with the editing of program materials, and, more particularly, to a system that takes advantage of a PC-based platform for performing non-linear editing functions.

BACKGROUND OF THE INVENTION

Traditional video editing systems are generally divided into two categories: linear and non-linear. Linear editing systems are generally integrated with tape-based program storage, while non-linear editing systems are associated more closely with disk-based storage media, wherein random-access storage more easily may be implemented. The typical linear editing system is implemented with one of the many "broadcast quality" videotape recording formats. The choices for analog recorders include, among others, 1" C-format, Betacam, Betacam-SP, ¾" U-matic, U-matic-SP, S-VHS, and Hi-8. The choices for digital recorders include, among others, D-1, D-2, D-3, D-5, DCT, and Digital Betacam. Each of these recording formats is incompatible with any other format, and all require sophisticated system facilities, including synchronization systems, edit controllers, audio and video switchers and processors, digital video effects (DYE) systems, character generators, and other equipment. This, in turn, requires extensive physical plant facilities for electric power, air conditioning and air filtration, storage space, and maintenance equipment. Furthermore, large operational and maintenance staffs are required to keep the equipment in good working order. However, recording duration capacity for these types of videotape recorders ranges up to three hours or more, making them uniquely valuable for many applications, such as program distribution, archival storage, and as master program sources for mass duplication of videos for the home video market.

In contrast, non-linear systems are based on optical discs, or alternatively, on magnetic or magneto-optical disks. Because of the relatively high cost of these storage media when long-duration recording periods are required, such systems are relegated to use as off-line editing systems applied to the preparation of edit decision lists (EDLs) for use in edit suites incorporating linear editing systems. However, the rapid random-access features and editing ease are valuable for short programs.

As currently implemented by many manufacturers (such as AVID and videoCube), PC-based hard disk storage is very expensive. If equipped with 10 GB of storage capacity, the system, in practice, is utilized in a two-step process. First, the original unedited program material is digitized at a high data-compression ratio to provide representative pictures for use in an off-line editing environment, whereby the operator may develop an EDL. This EDL then is used to perform the required editing, using program materials that have been digitized and stored at much lower data-compression ratios. Because these two digitizing steps must be performed in real time, this is an expensive, time-consuming process which

requires well-trained and expensive operational and engineering personnel.

SUMMARY OF THE INVENTION

It is an object of the invention to integrate the most valuable features of linear and non-linear editing system approaches.

It is another object of the invention to provide capabilities for automatic unattended editing from edit decision lists developed on an off-line editing system.

It is yet another object of the invention to provide a PC-based digital video recorder for applications such as broadcast television playback, video duplication source-master playback, or other related applications.

A further object of the invention is to provide extended playback of 40 hours or more of digital video programming, for cable television or other uses.

The present invention achieves these and other objectives by providing a PC-based audio/video production system which addresses the problem of providing inexpensive alternatives to the large, expensive edit suites currently in common use. Digital program source materials, produced by specially modified cameras or other sources, provide data-compressed audio and video program materials in two formats having matched edit-time-code identification. A first format having a higher data-compression ratio and intended for use in an off-line editing system is used to develop an edit decision list, and a second format having a lower data-compression ratio is used in an on-line editing system for the production of a final representation of the program. As such, off-line editing decisions may be developed on a PC, including a portable PC, using removable storage media, and final representations of the programs may be implemented on a stationary-head or rotary-head digital-tape-based format, such as DAT, 6-mm or 8-mm.

By employing one of several new, small, inexpensive storage media such as PCMCIA-based disk drives, and by utilizing data-compression technology, the off-line editing capabilities are achieved in an economical system, with the digital-tape-based formats providing broadcast-quality required even for demanding applications. Recording duration capacity for these media is 60 to 120 minutes or longer for conventional NTSC or PAL video formats, and a natural extension to HDTV formats (with comparable program duration capacity) is achieved as commercial availability of storage media having higher recording densities becomes economically practical. Where compatibility to film materials is desirable, operation of the various system components at 24 frames-per-second is implemented.

A method of producing a final video program according to the invention therefore includes the steps of providing program source materials in first and second digital formats, the first format being characterized in having a higher data compression ratio than the second; recording the materials in the first and second formats, respectively, onto first and second removable storage media along with correlated edit-time-code information in each case; interfacing the first storage medium to an off-line video editing system to develop an edit decision list; interfacing the second storage medium to an on-line video editing system; transferring the edit decision list developed in conjunction with the off-line video editing system to the on-line video editing system; and editing the materials in the second formal on the second storage medium, in accordance with the edit decision list, to produce a final video program.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic drawing of a portable dual-format digital video recorder optionally implemented as part of a camcorder system;

FIG. **2** is a functional block diagram of a dual-format digital video recorder;

FIG. **3** is an oblique representation of an off-line digital video editing system implemented with a PC-based edit controller having provisions for accepting removable storage media; and

FIG. **4** is a block diagram of an on-line digital video editing system implemented with a PC-based edit controller having provisions for accepting removable storage media.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a portable dual-format digital video recorder according to the invention, optionally implemented as part of a camcorder system. A lens **2** and viewfinder **4** are mounted on the body of a camera frame. The usual optical-splitter, CCD sensors and driver circuitry, and digital signal processing circuitry are located at **6**, with optional battery-pack capability being shown at **10**. The various analog and digital output signals and any input audio, video, or control signals, all shown generally at **16**, are interfaced through appropriate connectors disposed on the rear-panel **12** and sub-panel **14**. Provisions are included as shown for the input of analog audio signals, and for the output of both analog and digital audio signals. Preferably fiber-optic cabling is employed as a signal-carrying medium.

The internal video recording facilities are comprised of two parts. First, a lower data-compression-ratio digital audio/video signal is recorded on a stationary-head or rotary-head digital data tape recorder (such as quarter-inch cartridge, half-inch cartridge, DAT, 6-mm or 8-mm) in the removable-tape transport **18**, intended for utilization in an off-line video editing system, described herein below. Simultaneously, a second digital audio/video signal having a higher data-compression ratio is recorded on a removable storage media unit **20**. This removable storage medium is intended for utilization in an off-line video editing system, also described herein below. In practice, this removable storage medium may be implemented by any of several well known technologies, such as magnetic or magneto-optical disks, optical discs, or semiconductor memory modules. The two signal recording media implemented in the two parts of the internal video recording facilities may record the audio and video signals in separated form, or alternatively may be implemented by any of several well-known systems for interleaved audio/video data, such as the audio/video interleave ("AVI") system of Microsoft Corporation, the "M-Power" technique offered by Hewlett-Packard, or other systems.

Examples of removable storage media include PCMCIA-based removable disk drives (currently available with capacities of 420 MBytes, and soon to be available with capacities as high as 1 GByte) and 8-mm. tape cassettes (currently available with capacity of 20 GB, and soon to be available with capacities as high as 80 GB). At a data-compression ratio of 50:1, 420 MBytes will store approximately 75 minutes of program material (in NTSC format using an image dimension in pixels of 320×240 for off-line editing), and at a data-compression ratio of 5:1, 20 GB also will store approximately 60 minutes of program material. When the newer 50 GB or 80 GB tapes become available, these tapes will be capable of storing either four hours of programming in NTSC or PAL format, or two hours in an HDTV format, making them practical for use in those applications currently allocated to linear editing equipment, as described above. Alternatively, using the currently available MPEG-2 data compression with a ratio of 20:1, a 20 GB tape will accommodate four hours of NTSC or PAL recording (or one hour of HDTV); an 80 GB tape will accommodate 16 hours of NTSC or PAL recording (or four hours for HDTV). Where compatibility to film materials is desirable, operation of the various system components at 24 frames-per-second is implemented.

FIG. **2** is a functional diagram of a storage-device-based digital recorder according to the invention, either employed in a video camera, or implemented separately in editing and production facilities. As shown, a removable hard disk drive **70** and a digital tape drive **88** are interfaced through an interface bus controller **72**. Such a system achieves data transfer rates of 10 MB/sec, and higher rates on these or other data storage devices, such as high-capacity removable memory modules, is anticipated. In practice, alternative methods of storage such as optical or magneto-optical drives could be utilized, preferably based on various interface bus standards such as SCSI-2 or PCMCIA. In all cases, however, in order to ensure compatibility with downstream editing facilities, both of the removable media for drives **70** and **88** should be recorded with identical or at least correlated edit-time-code information, so that edit lists developed from one storage medium will produce the same results when applied to the program material recorded simultaneously on the other storage medium.

Microprocessor **74**, through user interface provisions **75** (such as keyboards, touch-screens, etc.) controls the 64-bit or wider data bus **80**, which integrates the various components. Currently available microprocessors include the Alpha 21064 by Digital Equipment Corporation, and the MIPS R4400 by MIPS Technologies, Inc. Future implementations might rely on the already announced **P6** by Intel Corp. or the PowerPC 620. An alternative architecture may be implemented using multiple processors working in parallel to increase the effective frame rate. The PCI data bus, for example, is capable of sustained data transfer rates of 100 MB/sec. A ROM **76** is used for fixed program storage. The RAM **78** preferably has the capacity to function as a buffer, representing 25 seconds or more of live NTSC video in 4:2:2 format, to enable "hot-swapping" of removable media without interruption of the input video signal during recording or alternatively the output video signal during playback. Graphics processor **82** represents dedicated hardware which performs the various manipulations required to process input video signals **84** and to output the video signals **86**. Although shown as Y/R-Y/B-Y format, either the inputs or outputs, or both, may be configured in alternative formats, such as RGB, YIQ, YUV or other commonly used alternatives.

While a software-based implementation of the data compression is possible, a hardware-based implementation is preferred, with the system employing, for the tape-based drives, a data-compression ratio of 5:1 for conventional signals (NTSC/PAL) and a 10:1 data-compression ratio for HDTV signals. For the hard-disk drive, a data-compression ratio of 50:1 is preferably utilized. Examples of the many available options for this data compression function include the currently available Apple QuickTime system, fractal compression, MPEG-1 (for off-line applications) and Motion-JPEG (for on-line applications). In many applica-

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