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computer 33 in accordance with this edit decision list (e.g. a look-up table in software) that follows the synchronized time line that is common to the program sources. With reference to the block schematic diagram of the video encoder 37 illustrated in FIG. 7, the exact timing for the switching is determined by the synchronizing clock 45 that received sync input from the synchronization generator 31, which, in turn, may derive its synchronization from the reference subcarrier information (i.e. standard SCH timing signals), as illustrated in FIG. 2(*a*). Thus, the video input gating or switching 47 under exact timing control of the clock 45 selects color field I from video source 1, color field II from video source 2, color field III from video source 3, color field IV from video source 4, and so on. Control by computer 33 may not be required in this cyclic example to achieve a succession of video fields in the composite video signal 6, but is required to achieve non-cyclic, dynamically-controllable succession of video fields selected in arbitrary sequence, as shown in FIG. 3(*a*), from the video inputs.

Referring now to FIG. 8, there is shown a block schematic diagram of an interval encoder 37 that is arranged to place all of the header and digital data in the correct locations in each video field in the composite video signal 6. The header data must be issued according to the timeline which is the standard SMPTE timecode input 50 to the time code reader 51. This time code input is derived from a master controller such as computer 33 or from a master tape recorder, or the like. Thus at every new video field, the computer 39 is activated by the time code reader to supply control data 53 to the level shifting buffer 55 of the interval encoder 37. This buffer 5 changes the signal levels to video compatible levels and interposes the data 57 on the correct horizontal scan line or trace of the current video field. The timing for interposing the header and other digital data at proper video signal levels is under control of the timing generator 59 that supplies synchronizing pulses 61 derived from the current video field or, optionally, from an external timing signal in a manner similar to the operation of the video encoder previously described in connection with FIG. 7.

Referring now to FIG. 9, there is shown a block schematic diagram of the audio encoder 41 which is connected to receive the composite video signal (with header and digital data included) from the interval encoder 37. This encoder is similar in features and operation to the video and interval encoders previously described herein, and is configured generally to interpose the audio signal information in the current video field with the proper timing and signal levels. The audio encoder 41 accept (N) number of audio signal inputs (which may be correlated with N number of tiers of displayable programs) for processing and placement in the current video field according to either embodiment of the invention previously described. Converter 63 thus receives the audio inputs and the video timing signals from the timing clock 65 (derived from the current video field or from an external timing source) to supply the requisite audio signal information for the current video field. In the one embodiment of the present invention in which channels of audio signal samples sequentially follow the horizontal sync pulse, as previously described with reference to FIGS. 2(*b*) and 2(*d*), the converter 63 is configured in conventional manner to supply an audio sync pulse 22 followed by a sample pulse per individual audio signal channel for interposing 67 on substantially each of 262 horizontal scan lines of the current video field.

In the alternate embodiment of the present invention in which compressed audio signal data is included on a specific horizontal scan line, as previously described with reference to FIG. 1(*b*), the converter 63 is configured in conventional manner to sample and compress approximately 1/60 of a second of audio signal information from each audio input 61 for interposing 67 on, say, the tenth horizontal scan line, or other line or lines, of each video field in the video input 40 an assembled, high-speed stream of compressed audio samples, as later described herein.

As thus described herein, the present invention produces a composite video signal which includes a sequence of video fields assembled by cyclic or non-cyclic selection of selected, successive fields of multiple displayable programs. Header and other data and audio signal information are interposed on the video fields to provide program and field designations useful in detecting and re-assembling successive video fields, with associated audio signals, that are correlated with a selected displayable program. However, it should be noted that while certain classes of real-time programming (e.g. multiple camera angles of the same sports event) may not require editing or pre selection, classes of displayable program material such as tutorial or game-oriented products may require editing or pre selection functions in order to assemble an optimal, interactive displayable product. In this latter class of products, there may be a need to play multiple program sources simultaneously in synchronism, and to select certain sequences for encoding and decoding, as later described herein, to develop a subjectively acceptable sequence of scenes of arbitrary durations selected from the multiple number of program sources. In addition, for tutorial or game-oriented products, certain video field sequences may have to be locked out from subsequent selection by an interactive viewer. A listing of acceptable and locked-out sequences is thus compiled into the edit decision list, previously described, which imposes limitations upon the sequencing of video fields from multiple tiers of displayable programs that is controlled by computer 33.

With the video fields selected, the interactiveness of the interval codes is reviewed by decoding and viewing the results subjectively. An edit control list is compiled of the sequences that are correctly workable in acceptable sequences, and such edit control list forms the basis for a look-up table that resides in the computer 39 to impose limitations upon the interval coding that may be introduced into each designated program and video field designation. The audio signals which correlate with the multi-tier programs can be stored on separate tape tracks for synchronized introduction into the edited version of a master tape of the selectable video fields, and normal audio signals may also then be recorded on the master tape in accordance with NTSC and RS-170 standards for television signals.

Specifically, then, some displayable program material will be edited in the present invention in the manner similar to conventional video production. In addition, editing program material according to the present invention may require displaying the sequence of interleaved video fields with and without interval encoded interactions. The header data including interval codes thus provide the code information for the interactive recovery of the original tier information along a timeline. Thus, a master tape that stores a multi tier, interleaved composite signal of video fields will begin with a standard timecode (by Hours: Minutes: Seconds: Frames), and will continue with successive timecodes representative of every change in pattern or data, as illustrated in the following example:

00: 00: 00: 00-00: 01: 00: 00 =	normal blackburst signal;
00: 01: 00: 01-00: 01: 01: 00 =	Color logo be held for 1 minute;
00: 01: 02: 00-00: 02: 00: 00 =	copy protection and main data;
00: 02: 00: 01-**: **: **: ** =	tutorial or game program;

The duration of every timecode associated with a change in pattern or data may be stored in a database, down to the smallest duration (i.e. one field). Thus, the preceding examples identify four events by their start time code numbers and their ending timecode numbers, listing the changes with descriptions of the events.

It should be noted that the timecode may be used effectively for controlling operation of multi-tier interleaved program material. For example, the timecode for blackburst signal has no header data, and a decoder unit that is arranged to receive the program material will normally wait for a valid header. A selected first display screen may thus have a header that designates a logo as tier zero (0) which the playback decoder will hold or freeze on display while digital data in successive video fields (not for display) in the form of executable object code ma be downloaded to a decoder. The initial transfer or downloading of data may include an initialization routine for the decoder. Second and subsequent transfers may be of data and programs to determine how designated tiers and fields throughout the program may interact.

Referring now to FIG. 10(*a*), there is shown a block schematic diagram of one embodiment of decoder or playback apparatus 71 according to the present invention. Central processor 73 is connected to controllers 75 and to sync separator and system timing device 79, and to field store 81 and to the 8 bit shift register 83 at the output of video detector 85, and to the audio selector 87, and to the audio synthesizer 89. The central processor 73 is a Z-80 microprocessor with 8 kilobytes of RAM and 8 kilobytes of ROM. It also has I/O ports sufficient to accept input from the controllers 75 and to control the audio selector 87 and the sample-and-hold line 90 for the field store 79, and to accept download data from the 8-bit shift register 83. Video 91 in the form of composite NTSC signals from a standard video cassette recorder 93 (either in VHS, or BETA, or 8 mm, or other format) enters the decoder apparatus 71 through a jack so provided. The incoming video signal 91 is simultaneously applied to the input of the field store 79, the audio decoder 95, the video detector 85 and the sync separator and system timing device 77. The field store 79 captures on a field by-field basis the contents of video pictures that come off a VCR tape of the type described in connection with FIG. 4 and played through the VCR 93. Timing and control signals are provided to the field store 79 from the sync separator and timing system 77 in the form of 7.1 megahertz oscillations and vertical sync, and 30 hertz reference signals. Control is also provided from the central processor 73 to the field store 79 to control whether the field store shall currently sample a new video image or play back a previously sampled video image. The field store 79 thus operates in a sample mode or hold mode. In a sample mode it samples a new video signal, the timing of which is controlled by the 7.1 megahertz, and vertical sync and 30 hertz signals. In the hold mode, those same signals are used to play back a previously stored field at the same rate at which it was recorded.

The output of the field store 79 is applied to the video section of the RF modulator 97 which modulates the stored video field for reception on channel 3 or 4. This modulated signal 99 becomes input to a standard television set 101.

When the field store 79 operates in the hold mode, a previously-sample field is played back from the field store through the RF modulator 97 and into the television set 101, and the input 91 to the field store 79 during the hold and playback mode are ignored.

The input 91 from the VCR 93 is also applied to the sync separator and system timing block 77 which breaks out the synchronizing signals of the composite video signal 91 and makes them available for operation within the decoder 71. Thus, the vertical sync signal is applied to the field store 79, and the burst gate (which is a synchronizing pulse timed from the video input) is applied to the audio decoder 95, and a 60 hertz input is applied to the central processor 73. The 60 hertz signal applied to the central processor 73 gives the central processor a timing mark to designate when new fields of video occur so that the processor can make the decision whether to sample a new field or continue to hold a previously sampled field. The central processor 73 also uses the 3.6 megahertz signal that comes from the system timing block 77 as the basic system clock for the Z80 processor. The central processor 73 also relies upon the composite synchronizing signal from the sync separator block 77 in order to synchronize with the beginning of each horizontal scan line in a field.

The central processor 73 coordinates and handles the downloading of digital program data that may be stored on the tape. Such data ma be available at each horizontal scan line where digital data is present, and the composite sync provides an indication to the central processor 73 of the beginning of a scan line so that the central processor 73 can synchronize its download function.

The sync separator and timing system block 77 provides 14.3 megahertz and a burst gate signal to the audio decoder 95. The 14.3 megahertz is used for timing within the audio decoder in order to locate audio data that was previously encoded into the video portion of horizontal scan lines of various fields in a manner compatible with the NTSC signal standards. The burst gate signal is used to locate the beginning of each scan line which contains audio data. The sync separator and timing system block 77 provides an 89 kilohertz signal which acts as a data-byte-ready indicator to the central processor 73 for the downloading of data. This data byte ready signal indicates that 8 bits of downloadable data had been shifted into the shift register 83 and that a byte, or 8 bits of data, is now available to the central processor 73. The data is shifted into the shift register at the rate of 0.71 megahertz or 710 kilohertz, a signal which is also provided by the sync separator and system timing block 77. Thus, the video detector 85, which is basically a comparator, looks for video level above a certain threshold value. Video above that threshold value is taken as a binary 1 and video below that level is taken as a binary 0. The video detector 85 thus makes a decision based upon the luminence level of the video signal at a particular point on the scan line whether there is a 0 or a 1 binary value at that location. That value is then shifted into the 8-bit shift register 83 at each 710 kilohertz sample point. When 8 bits have been shifted in, an indication is supplied to the central processor 73 from the sync separator and timing system timing block 77 to indicate that 8 bits have been shifted in, and that the central processor 73 should accept the 8 bits of data to allow the cycle to begin again. There are two bytes of data accepted during each horizontal scan line.

The audio decoder 95 decodes audio which has been encoded into the video portion of each horizontal scan line. Multiple samples from various audio tracks may be so encoded on each horizontal scan according to one embodiment of the invention, and the audio decoder 95 will decode up to 4 audio tracks placed side by side at intervals of the 3.58 megahertz signal. The 4 tracks so decoded by the audio decoder are then applied to the audio selector 87 and the control lines 103 thereto from the central processor 73 determine which particular combination of the 4 audio tracks is to be combined to form one composite audio track. The selected audio track is then fed into an audio mixer 105. The audio mixer combines the decoded audio track with the output of a sound effects audio synthesizer 107 which is also under control of the central processor 73. The output of the sound-effects audio synthesizer 107 is mixed by the audio mixer with the combination of selected tracks to provide a mixed audio output which is then applied to the RF modulator 97 where (like the video) it is modulated up for reception on channels 3 or 4 as part of the RF signal 99 in the standard VHF television range of channels 3 or 4 for playback on a standard television set 101.

The controllers 75 represent a matrix of pushbuttons, including pushbuttons numbered 1-12, an action button and a freeze button. The controllers 75 encode the buttons in such a way that each button has a unique 4-bit binary code. These 4-bit binary codes are applied to the central processor 73 as operator inputs to control interaction with the displayable video fields. Of course, the particular sequence of video fields controlled by the operator using controllers 75 may also be recorded on a standard video tape recorder connected to receive the modulated video output 99 as a mode of preserving the individually-edited multi-tier program material.

All the schematic bloc circuits in FIG. 10(*a*) are of conventional design. For example, the field store circuit 79 is similar to the frame-freezing buffer circuit available in the commercial DX3 digital video cassette recorders produced by Toshiba Corporation, and the audio synthesizer 107 is a commercially available integrated circuit type AY3 8910 produced by General Instruments.

Referring now to FIG. 10(*b*), there is shown a block schematic diagram of the sync separator and system timing block 77 of FIG. 10(*a*). A standard integrated circuit 110 (type MC 1378 produced by Motorola Corporation) is connected through a capacitor 111 to receive the incoming video 91 at pin 24, for example, from the standard video cassette recorder 93 of FIG. 10(*a*). An external tank circuit 113 is connected between pins 32 and 33 to form a 14.3 megahertz oscillator (i.e. tuned to a frequency which is four times higher than the basic NTSC standard color-carrier frequency). This 14.3 megahertz signal is available on pin 35 to be amplified, divided and shaped as required and is applied to the audio decoder 95 of FIG. 10(*a*) In addition, the 14.3 megahertz signal is divided by divider 115 and shaped by pulse shaper 117 into a pulse of 5 microsecond width for application to pin 40 as the horizontal input timing pulse. This forms a phase locked loop that synchronizes the 14.3 megahertz signal with standard 63.5 microsecond horizontal scan lines. Thus, exactly 910 cycles of the 14.3 megahertz signal occurs in the interval of each horizontal scan line. With +5 volts applied to pin 1, the integrated circuit 110 is thus able to synchronize on incoming video 91 to separate out the video composite sync signal at pin 39 (applied to the central processor 73 of FIG. 10(*a*)), and the vertical sync signal at pin 30 (applied to the field store 79 of FIG. 10(*a*)), and the burst-gate signal at pin 5 (applied to the audio decoder 95 of FIG. 10(a)). Also, the 14.3 megahertz signal produced by the integrated circuit 110 is divided by 2 in divider 119 and shaped substantially to a sinewave in network 121 for application to the field store circuit 79 of FIG. 10(*a*) In addition, the 7.1 megahertz signal from divider 119 is further divided by 2 in divider 123 to provide the 3.58 megahertz signal that is applied as the basic clock signal to the central processor 73 of FIG. 10(*a*).

The vertical sync signal appears at pin 30 of the integrated circuit 110 approximately 60 times per second, and this signal is also applied to the central processor 73 of FIG. 10(*a*) to assure that changes in selected video fields can occur in synchronized, timely, manner. These vertical sync signals (and the divided-by two version available at the output of divider 125) are supplied to the field store 79 of FIG. 10(*a*) to assure synchronized field storing operation on the beginning of selected video field.

The 7.1 megahertz signal at the output of divider 119 is also divided by 10 in scale of-ten divider 127 to provide the 710 kilohertz output signal 131 that is supplied to the 8-bit shift register 83 of FIG. 10(*a*) as the bit-shifting clocking frequency for down loading data from incoming video signal 91, as previously described. In addition, the 710 kilohertz signal is further divided by 8 in the scale of-eight divider 133 to supply 89 kilohertz signal to the central processor 73 of FIG. (10)*a* as a synchronized indication that 8-bits of data have been shifted into this register 83 and are ready for downloading to the processor 73, as previously described herein. These dividers 127 and 129 may be scaler counters which are reset to zero by the horizontal sync signal at the output of divider 115. All frequencies described herein ar referred to by nominal values, but it should be understood that exact multiple values are actually present in the operation of the present invention.

Referring now to FIG. 10(*c*), there is shown a block schematic diagram of the audio decoder 95 of FIG. 10(*a*). This circuit includes 8 flip-flops 137-151 and a conventional analog switch 153 (for example, type 40HC66 integrated circuit). In operation, the flip flops 137, 139, 141, 143, 145, 147 are initially cleared to the zero state. The 14.3 megahertz signal previously described is applied to flip-flop 149 which divides the frequency by two for application to flip flop 151 which again divides the frequency by two for application as a 3.58 megahertz signal 152 to the clock inputs of flip-flops 141, 143, 145 and 147. These latter four flip flops are configured as a shift register of the type in which data applied to the D input 155 of flip flop 141 is sequentially transferred to the next flip flop in succession at the leading edge of each applied clock signal 152. It should be noted that since the D input 157 of flip-flop 137 is connected to receive +5 volts, that flip-flop 137 also triggers a '1' output 161 in response to the leading edge of the burst gate signal 159 that is applied to the clock input of flip-flop 137. The '1' output 161 from flip-flop 137 transfers to the D input of flip flop 139 and also deactuates its 'clear' input 163. The next video signal 165 of sufficient level to be detected as a '1' (i.e. detecting video white level), and applied to the preset input of flip flop 139, sets that flip flop. This, in turn, supplies a '1' output to D input of the first flip flop 141 in the shift register configuration.

In addition, the combination of flip flop 37 being set and flip flop 139 being reset provides two low-enable signals to the gate 167, the output of which is inverted and provides a preset to flip flops 149 and 151. These flip flops are configured as a divide-by-4 counter. Thus, the combination of flip flop 137 being set and flip flop 133 being reset has the effect of holding flip-flops 149 and 151 at a count of 3 during the time between when the leading edge of the burst gate appears and when video white level is detected. As soon as the video white level is detected, the very next cycle of 14.3 megahertz signal 169 resets both flip flops 149 and 151 from their 3 count value to a 0 count equivalent value. This provides a '1' pulse that is clocked into flip flop 141. This causes a '1' output from flip flop 141 which is supplied to flip flop 137. The clearing of flip flop 137, in turn, cause flip flop 133 to be cleared, thus removing the '1' input to the D input of flip flop 141 as the single value that will be gated into the shift register comprising flip flops 141-147. Since the clocks of flip flop 141-147 are supplied by the output of flip flop 151 (i.e. the last stage of the divide by 4-counter), the net effect is that '1' is shifted into flip flop 141 and through the succeeding flip flops 143, 145 and 147 at the 3.58 megahertz rate.

The output of each of those flip flops in turn presents the '1' signal to the four inputs 172 of the four stages of analog switch 153. The inputs 173 to the analog switch are also connected to the video in line 175 so that when each stage in succession is turned on, each of the outputs seizes a sample of the video input for 280 nanoseconds sample width. The samples are stored in the capacitors 177 which are connected to the respective audio track outputs 179. The sample-and-hold effect of the switches 153 and capacitors 177 per audio track allows the recovery of the audio signals from those samples at the specific locations immediately following detection of the video white level, as shown in FIG. 2(*d*).

Referring now to FIG. 10(*d*), there is shown a block diagram of the audio selector 87 which is connected to receive the four audio-track outputs 179 from the audio decoder 172 of FIG. 10(*c*). Under control of the central processor 73, any combination of the four control lines 181 that lead into the analog switch 183 of conventional integrated circuit configuration (for example, type 4066) may be enabled or disabled to pass any combination of audio track 1-4 through the switch 183 to constitute the selected audio tracks for application to the audio mixer 105 of FIG. 10(*a*).

Referring now to FIGS. 11(*a*) and (*b*) there are shown graphs of the vertical and horizontal sync pulses which are the bases for operation of the compressed audio embodiment of the present invention. In operation the compression and expansion of the audio signals is controlled with respect to timing signals derived from the video fields in which it is inserted, or from which it is retrieved. Thus, as illustrated, the audio signals in the time domain of the vertical sync pulse interval FIG. 11(*a*) is compressed to fit within the time domain of the horizontal sync pulse interval FIG. 11(*b*). The video circuitry preceding the audio compression encoder recovers the color subcarrier and creates a master clock of 14.3 megahertz. A frequency at half the master clock frequency, or 7.16 megahertz and a frequency of one 637th of the master clock frequency are derived from the master clock. As illustrated in the block schematic diagram of an audio encoder shown in FIG. 12, a color lock and sync separator circuit 191 of conventional design extracts horizontal and vertical timing signals 193, 195 from the video input 6. The start bits 197 constitute a full "white" level video signal for a logical '1' and the next bit is a "black" level video signal for a logical '0'. The master clock frequency is divided by 637 and by 2 to provide the control frequencies 199 and 201, along with horizontal line count 203, to the clocking selection logic 205.

An analog shift register 207 of conventional design (for example, type CCD 321B integrated circuit produced by Fairchild Semiconductor Co.) is normally operable as a delay line to delay a line of video for possible restoration or replacement of a "dropped out" line of video in a video cassette recorder, or the like. However, according to this embodiment of the present invention, audio signal in the time span of the duration of one video field is compressed in the analog shift register 207 into the time span of one horizontal scan or trace of a video field. In such a conventional analog shift register 207, there are two 455-sample registers, and one such register can be clocked at 7.16 megahertz to receive or produce 455 samples in the time interval of one horizontal scan. The resulting audio compression ratio of 318.5 is selected because 375 samples can be clocked in at 1/637the of the master clock frequency in about 53 microseconds, or about the usable time interval of one horizontal scan. Thus, the audio input 209 can be clocked into the shift register 207 at about 22477.5 hertz (i.e. about 11 kilohertz bandwidth), commencing with the start bits 197, for 375 successive samples. A quick burst of 80 clock pulses fills the 455-sample register and produces the first audio sample at the output 211 for placement in the video signal in a manner similar to that which was previously described in connection with FIGS. 5-9. Specifically, when the selected horizontal scan line of the next video field starts and the horizontal blanking is completed, 377 samples are shifted out of the shift register 207 into the video signal at the 7.16 megahertzrate. This process can be repeated to add more channels of audio to additional horizontal scan lines, with the '1'-'0' start bits at the beginning of each such audio/video scan line. Thus, the audio information is only placed on selected horizontal scan lines in video field lines that are reserved for signal information. Also, using a pair of similar analog shift registers can provide two audio channels of "good" quality for recovery as stereo signal channels.

Referring now to FIG. 13, there is shown a block schematic diagram of a decoder according to an embodiment of the present invention. Specifically, similar conventional circuits operate in the manner previously described to derive the required timing signals from the video input 43 (with compressed audio) for application to the clocking selection logic 206. Also, the video input 43 (with compressed audio) is applied to the analog shift register 208 which is controlled by the clocking selection register 206 to fill the register with the compressed audio samples, commencing with the '1-'0' start bits and continuing for one horizontal scan interval, and thereafter to clock out the stored samples at the rate of 22477.5 hertz into conventional filter and amplifier **215** to provide the real-time audio output **217**.

I claim:

1. A method of formatting a composite video signal for selectably displaying the fields of at least three displayable programs, the method of comprising the steps of:

forming a first video signal for displaying a first field of a first one of the plurality of displayable programs;

forming a second video signal for displaying a second field of a second one of the plurality of displayable programs after said first video signal;

forming a third video signal for displaying a third field of a third one of the plurality of displayable programs after said second video signal;

forming a fourth video signal for displaying a subsequent field of one of the plurality of displayable programs after said third video signal; and

recurringly forming successive video signals for selectably displaying subsequent fields of said plurality of displayable programs.

2. A method of formatting a composite video signal for selectably displaying the fields of at least three displayable programs, the method comprising the steps of:

forming a first video signal for displaying a first field of a first one of the plurality of displayable programs;

forming a second video signal for displaying a second field of a second one of the plurality of displayable programs after said first video signal;

forming a third video signal for displaying a subsequent field of said first displayable program after said second video signal;

forming a fourth video signal for displaying a subsequent field of said second displayable program after said third video signal;

forming a fifth video signal for displaying a third field of a third one of the plurality of displayable programs after said second video signal;

interposing said fifth video signal after said second video signal and before said third video signal;

forming a sixth video signal for displaying a subsequent field of said third program after said fourth video signal;

interposing said sixth video signal after said fourth video signal, and

recurringly forming successive video signals for displaying subsequent fields of said plurality of displayable programs.

3. The method according to claim **2** wherein in each of the steps of forming, data representative of the program and field is included in each of said first and second and third and fourth video signals for individually identifying such video signals.

4. A method of formatting a composite video signal for selectably displaying the fields of at least three displayable programs, the method comprising the steps of:

forming a first video signal for displaying a first field of a first one of the plurality of displayable programs;

forming a second video signal for displaying a second field of a second one of the plurality of displayable programs after said first video signal;

forming a third video signal for displaying a subsequent field of said first displayable program after said second video signal, said subsequent field appearing after an arbitrary number of successive fields of said first program;

wherein in the step of forming a fourth video forming a fourth video signal for displaying a subsequent field of said second displayable program after said third video signal, said subsequent field appearing after an arbitrary number of successive fields of said second program; and

recurringly forming successive video signals for displaying subsequent fields of said plurality of displayable programs.

5. A method of formatting video signals for displaying successive fields of a plurality of displayable programs, the method comprising the steps of;

assembling a plurality of horizontal traces of video information for selectably displaying successive fields of the plurality of displayable programs; and

interposing audio signal information associated with each of the plurality of displayable programs on selected horizontal traces of said video information in successive fields of each of the displayable programs.

6. The method according to claim **5** wherein in the step of interposing, the audio signal information associated with each of the plurality of displayable programs is interposed on selected horizontal traces of video information in individual sampled-signal channels.

7. The method according to claim **5** for formatting video signals for displaying successive fields of a plurality of selectable programs wherein in the step of assembling, horizontal traces of video information are assembled in recurring succession for selectably displaying fields of the plurality of programs;

and including the step of interposing coded signal information representative of program and field designations on selected horizontal traces of video information.

8. The method according to claim **7** wherein in the step of interposing, the coded signal information is interposed upon selected ones of the twelfth through twentieth horizontal traces of video information.

9. The method of translating a succession of video signal information for displaying selectable video fields of different ones of a plurality of displayable programs, comprising the steps of;

detecting selected video signal information in the succession thereof for displaying subsequent video fields of a selected one of the plurality of displayable programs;

storing the detected video signal information for displaying one video field of the selected one program; and

updating the stored video signal information with detected subsequent video signal information for displaying a subsequent video field of the selected one program.

10. The method according to claim **9** wherein in the step of updating, the stored video signal information is updated with subsequent video signal information detected after the interval of at least two subsequent video fields for displaying the corresponding subsequent video field of the selected one program.

11. The method according to claim **9** for translating a succession of video signal information for displaying subsequent video fields in which the video signal information includes coded signals representative of program and field designations, and in which in the step of detecting, the coded signals are sensed for program

designations corresponding to the selected one program, and for field designations corresponding to subsequent video fields of the selected program in the succession of video signal information.

12. The method according to claim 9 in which each of the video fields includes audio signal information for all of the plurality of displayable programs, the method comprising the additional step of;

detecting the audio signal information associated at least with the selected displayable program of successive video fields; and

forming an audio output from the detected audio signal information in the successive video fields of the selected displayable program.

13. The method according to claim 12 comprising the additional step of;

segregating the audio signal information in each video field for a selected displayable program to produce an audio output associated with successive video fields of the selected displayable program.

14. Apparatus for forming multi-program composite video display signal from the video display signals from at least three sources of displayable programs, the apparatus comprising;

switch means having an output and having inputs coupled to receive the video signals from each of the sources for displaying subsequent fields of the individual displayable programs, said switch means being operable in at least three operating states for selecting in each operating state a video signal for displaying a field of the displayable program from one of said sources; and

control means coupled to control the operating state of the switch means for altering the operating state thereof to couple said output to each of said inputs in selected succession to receive at each selected input the video signal for displaying one field of a displayable program from the source coupled to such selected input for producing at said output a composite video signal which includes a succession of interleaved selected video signals from separate ones of said sources, each such video signal for displaying one field of one displayable program.

15. Apparatus as in claim 14 wherein;

said control means cyclically alters the operating state of the switch means to couple the output thereof in sequence to each of the inputs thereof for producing at said output a composite video signal having successively interleaved video signals, each for displaying one field of one displayable program from one of said source, in cyclic succession.

16. Apparatus for selectively displaying video images from a composite multi-program video signal including a sequence of video field information for displaying selectable video fields of a plurality of displayable programs, the apparatus comprising:

means coupled to receive the composite video signal for segregating the selectable video fields associated with one of the plurality of displayable programs;

buffer means coupled to receive the segregated video fields to store video field information for displaying a selected video field;

signalling means coupled to the buffer means for producing a video output therefrom capable of continuously displaying a selected video field of a selected one of the plurality of displayable programs; and

circuit means coupled to the buffer means for successively and selectively storing therein successive segregated video field information associated with selected video fields of said selected one of the plurality of displayable programs.

17. Apparatus as in claim 16 wherein said composite video signal includes cyclic iteration of successive video fields from the plural number of displayable programs; and

said means selects each said plural number video field in the sequence thereof for displaying the selected program therefrom.

18. Apparatus as in claim 16 in which said composite video signal includes coded signals representative of program and video field designations, and wherein said circuit means is responsive to the coded signals for identifying selected video fields in the sequence thereof for selectively storing successive video fields in the buffer means.

19. Apparatus for selectively displaying video images from a composite multi-program video signal including a sequence of video field information for displaying selectable video fields of a plurality of displayable programs, wherein the video field information in the sequence includes horizontal trace signals and audio information on the horizontal trace signals, the apparatus comprising:

means coupled to receive the composite video signal for segregating the selectable video fields associated with one of the plurality of displayable programs;

buffer means coupled to receive the segregated video fields to store video field information for displaying a selected video field;

signalling means coupled to the buffer means for producing a video output therefrom capable of continuously displaying a selected video field of a selected one of the plurality of displayable programs;

circuit means coupled to the buffer means for successively and selectively storing therein successive segregated video field information associated with selected video fields of said selected one of the plurality of displayable programs; and

detector means responsive to audio information on the horizontal trace signals for producing an audio output associated with the selected video fields of the selected displayable program.

20. Apparatus as in claim 19 wherein said audio information includes samples of audio signals associated with each of the plurality of displayable programs, and said detector means includes sample selector means for segregating successive samples associated with a displayable program appearing on each horizontal trace signal to produce said audio output associated with the selected displayable program.

21. Apparatus for producing a composite video signal for displaying successive fields of a displayable program, the apparatus comprising;

means producing a plurality of horizontal traces of video field information including white video reference pulse following a horizontal synchronizing pulse for displaying successive video fields of the displayable program; and

circuit means coupled to said means for interposing audio signal information within sample intervals immediately following the white video reference pulse on selected horizontal traces of said video field information in successive video fields of the displayable program.

22. Apparatus as in claim 21 for producing a composite video signal for displaying successive fields of a plural number of displayable programs in which each video field includes a plurality of horizontal traces, and wherein;

said circuit means interposes audio signal information for each of the plural number of displayable programs within distinct sample intervals immediately following the white video reference pulse on selected horizontal traces of said video field information.

23. Apparatus as in claim 22 wherein said circuit means introduces said audio signal information within said sample intervals associated with each of said plural number of displayable programs as sample-amplitude audio signals upon selected horizontal traces of the video field information.

* * * * *

US005113493A

United States Patent [19]

Crosby

[11] Patent Number: 5,113,493

[45] Date of Patent: May 12, 1992

[54] FULL SPEED ANIMATION SYSTEM FOR LOW-SPEED COMPUTERS AND METHOD

[75] Inventor: C. Scott Crosby, Greer, S.C.

[73] Assignee: Liberty Life Insurance Co., Greenville, S.C.

[21] Appl. No.: 48,553

[22] Filed: May 11, 1987

[51] Int. Cl.[5] G06F 3/14

[52] U.S. Cl. 395/152; 340/725; 340/728

[58] Field of Search 364/518, 521; 340/725, 340/701, 703, 709, 724, 726, 747; 358/343

[56] References Cited

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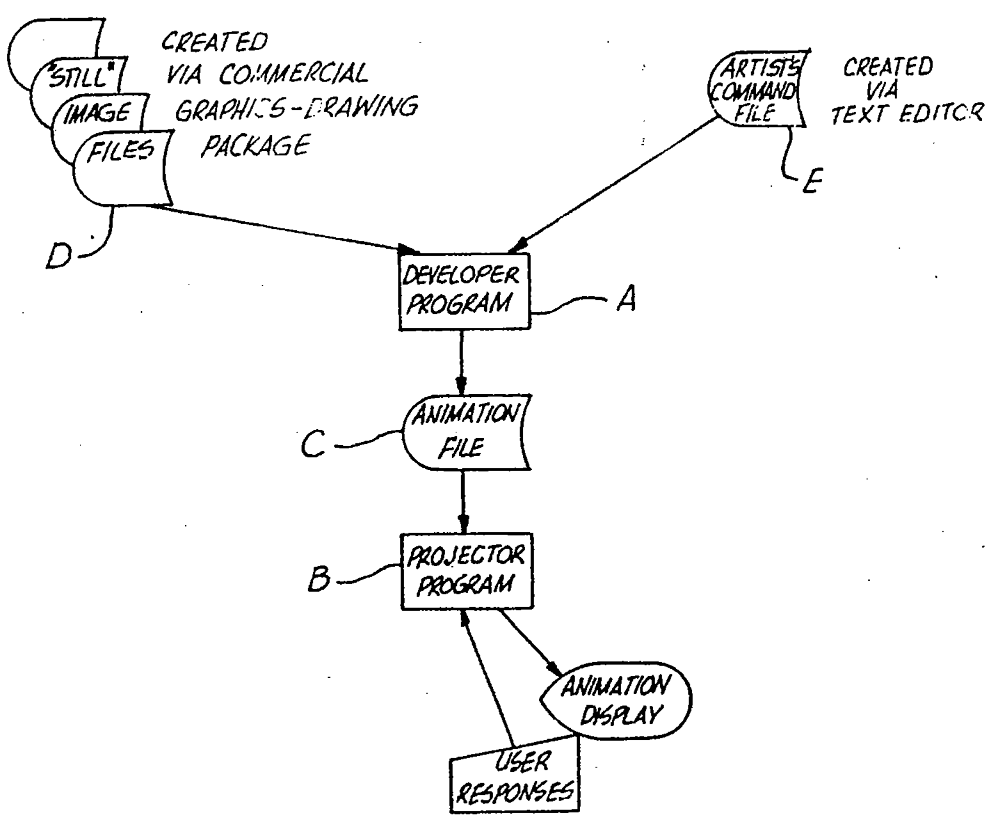
Primary Examiner—David L. Clark
Attorney, Agent, or Firm—Cort Flint

[57] ABSTRACT

Graphics display systems are used to display animated images, generated from a sequence of images (D) developed by an artist, and projected using a conditional replacement technique, in a manner as directed by a series of commands (E), given to the program by the artist. The method works for systems of any resolution and number of colors. To facilitate the process is broken into two steps, development (A) and projection (B). This eliminates all activities from the actual projection effort that do not directly contribute to it, enabling faster operation. In combination with the storage and display techniques, which only note any changes from one image to the next, this allows true animation displays not normally attainable with given equipment.

47 Claims, 13 Drawing Sheets



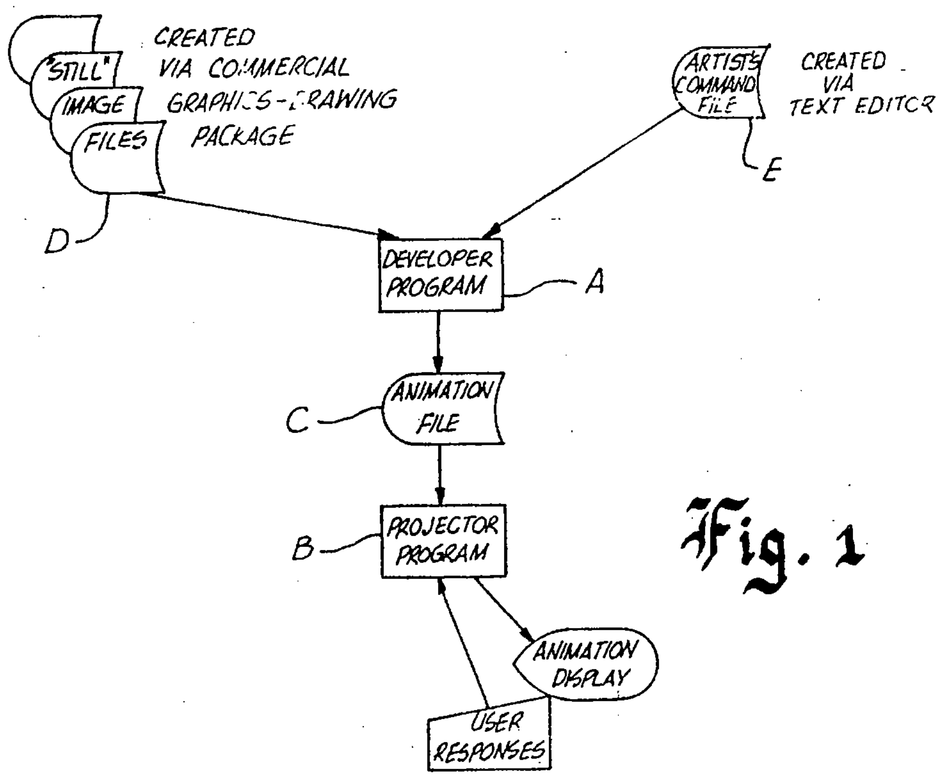

CREATED
VIA COMMERCIAL
GRAPHICS-DRAWING
PACKAGE
"STILL"
IMAGE
FILES
D
ARTIST'S
COMMAND
FILE
CREATED
VIA
TEXT EDITOR
E
DEVELOPER
PROGRAM
A
ANIMATION
FILE
C
PROJECTOR
PROGRAM
B
ANIMATION
DISPLAY
USER
RESPONSES

Fig. 1

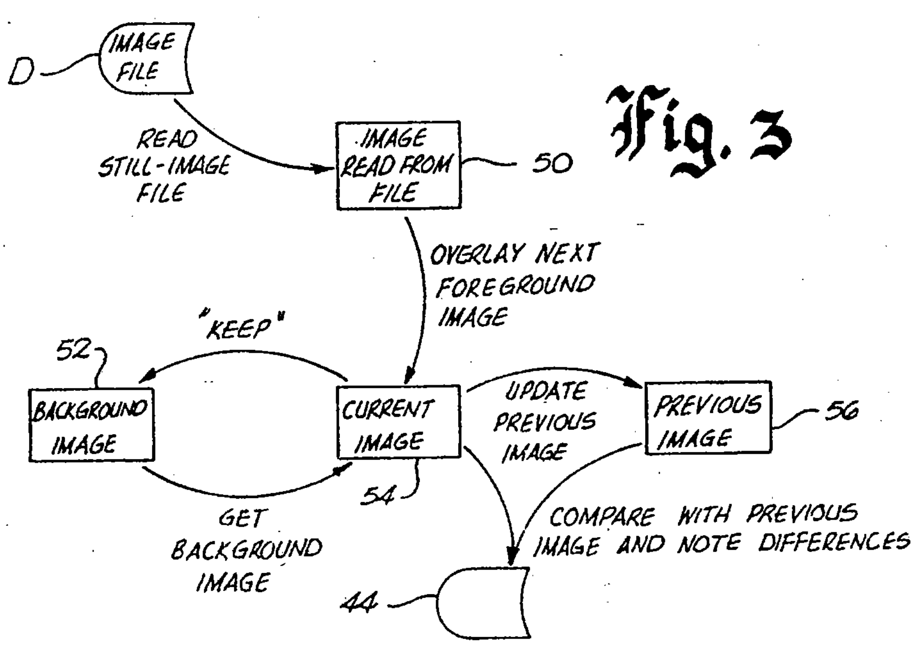
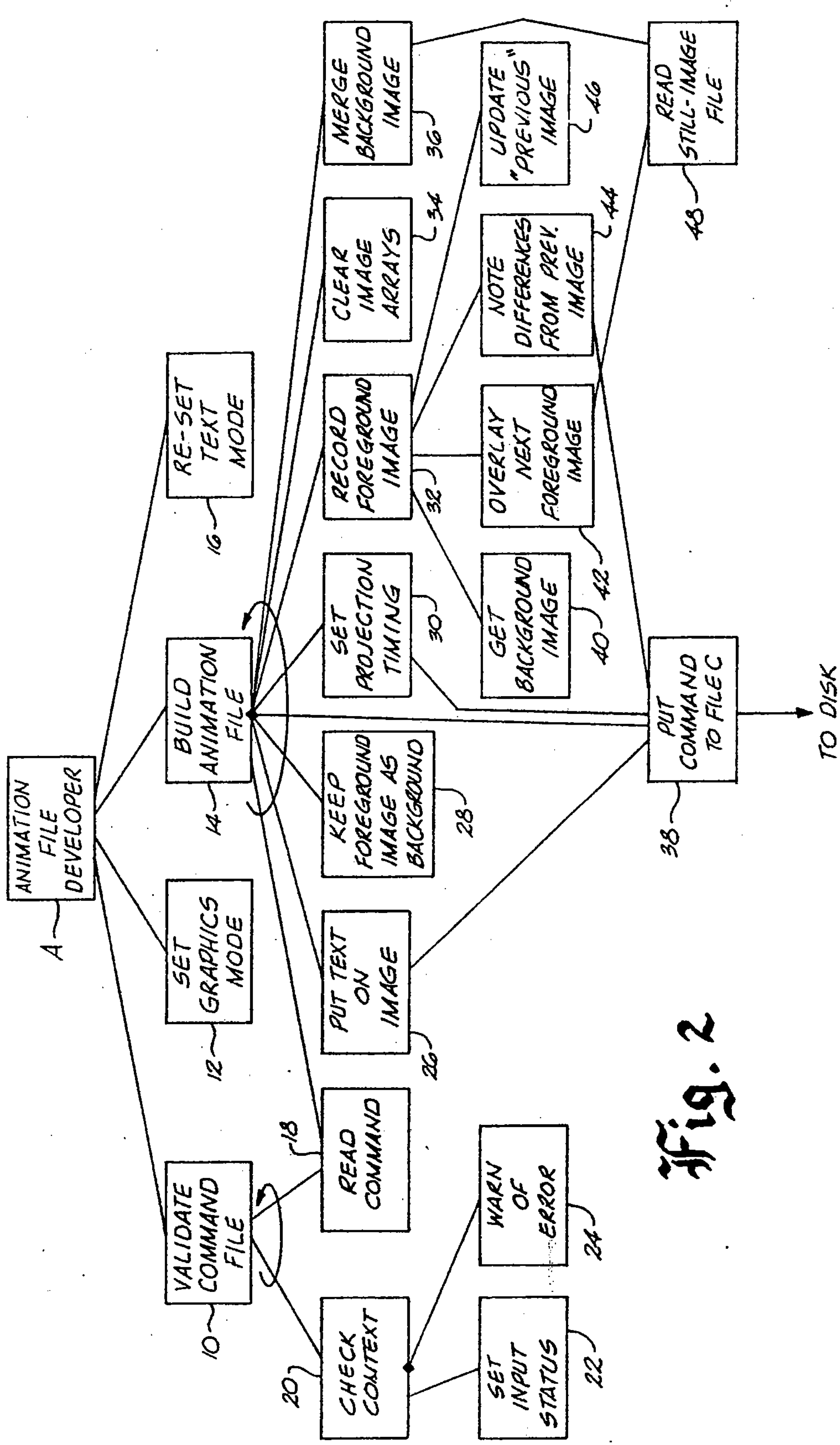


IMAGE
FILE
D
READ
STILL-IMAGE
FILE
IMAGE
READ FROM
FILE
50
OVERLAY NEXT
FOREGROUND
IMAGE
"KEEP"
52
BACKGROUND
IMAGE
CURRENT
IMAGE
54
UPDATE
PREVIOUS
IMAGE
PREVIOUS
IMAGE
56
GET
BACKGROUND
IMAGE
COMPARE WITH PREVIOUS
IMAGE AND NOTE DIFFERENCES
44

Fig. 3



ANIMATION FILE DEVELOPER
A
VALIDATE COMMAND FILE
10
SET GRAPHICS MODE
12
BUILD ANIMATION FILE
14
RE-SET TEXT MODE
16
READ COMMAND
18
CHECK CONTEXT
20
SET INPUT STATUS
22
WARN OF ERROR
24
PUT TEXT ON IMAGE
26
KEEP FOREGROUND IMAGE AS BACKGROUND
28
SET PROJECTION TIMING
30
RECORD FOREGROUND IMAGE
32
CLEAR IMAGE ARRAYS
34
MERGE BACKGROUND IMAGE
36
PUT COMMAND TO FILE C
38
TO DISK
GET BACKGROUND IMAGE
40
OVERLAY NEXT FOREGROUND IMAGE
42
NOTE DIFFERENCES FROM PREV. IMAGE
44
UPDATE "PREVIOUS" IMAGE
46
READ STILL-IMAGE FILE
48

Fig. 2

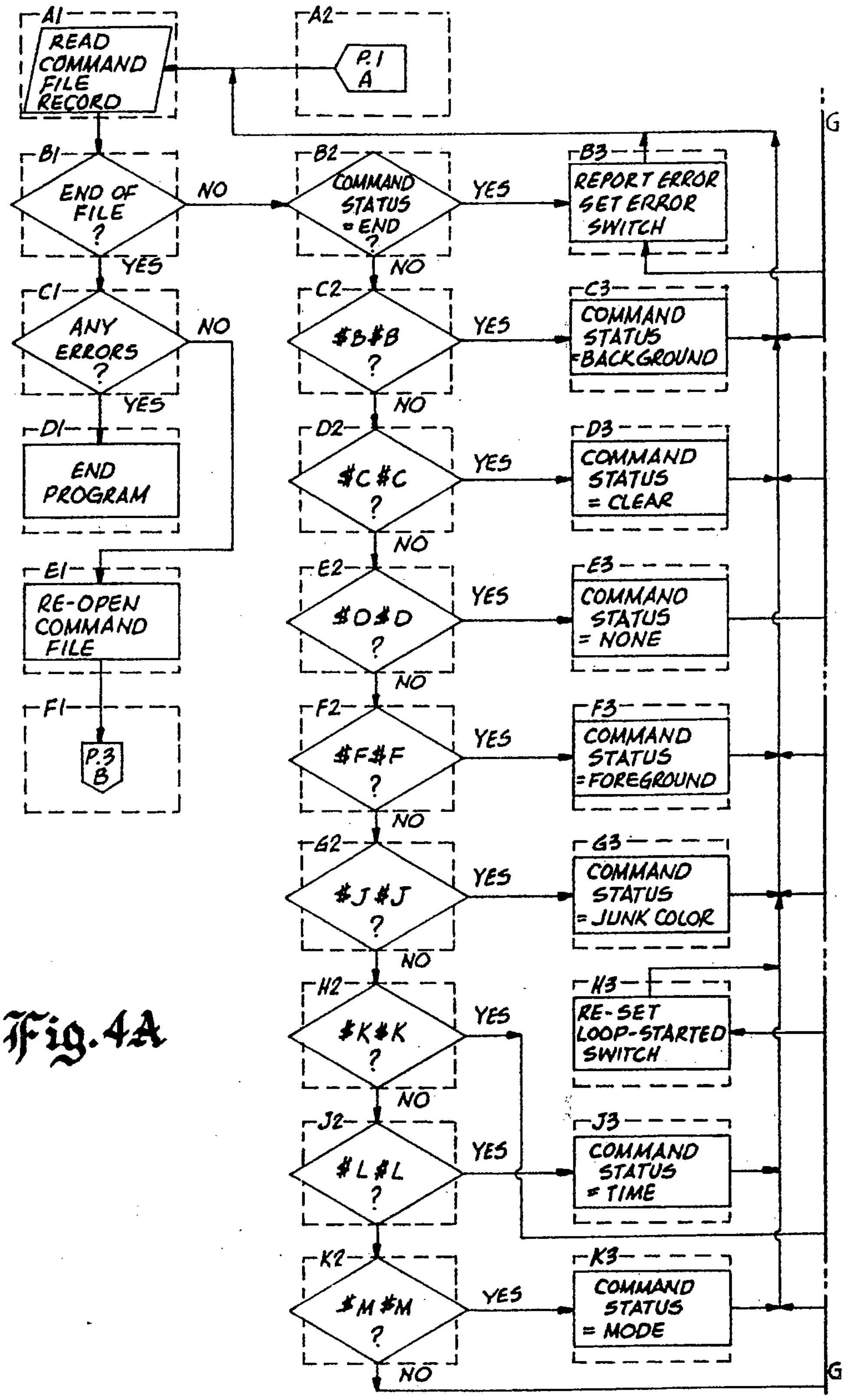
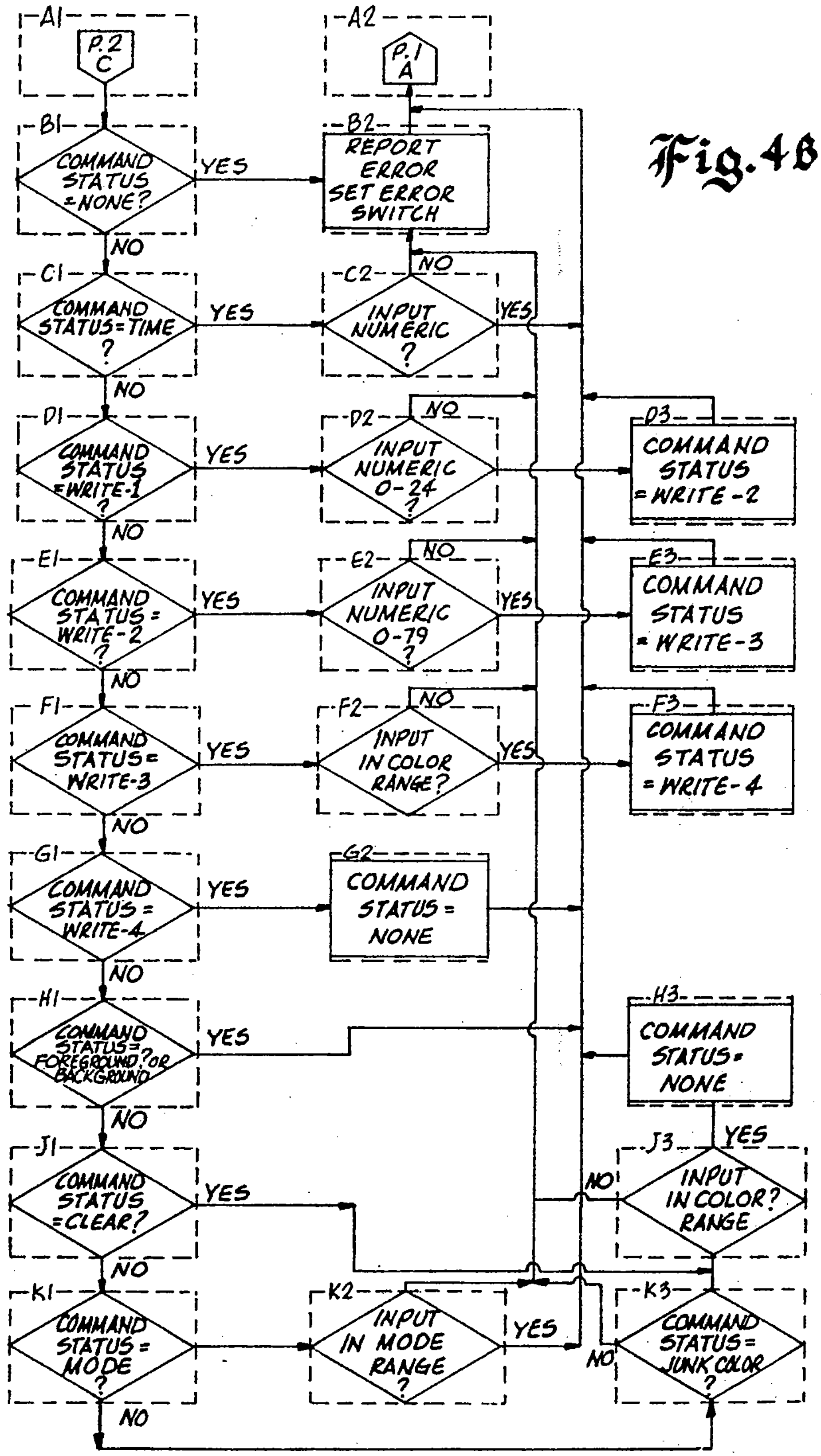

A1
READ COMMAND FILE RECORD
A2
P.1 A
B1
END OF FILE ?
NO
B2
COMMAND STATUS = END ?
YES
B3
REPORT ERROR SET ERROR SWITCH
YES
NO
C1
ANY ERRORS ?
NO
C2
BB ?
YES
C3
COMMAND STATUS =BACKGROUND
YES
NO
D1
END PROGRAM
D2
CC ?
YES
D3
COMMAND STATUS = CLEAR
NO
E1
RE-OPEN COMMAND FILE
E2
DD ?
YES
E3
COMMAND STATUS = NONE
NO
F1
P.3 B
F2
FF ?
YES
F3
COMMAND STATUS =FOREGROUND
NO
G2
JJ ?
YES
G3
COMMAND STATUS = JUNK COLOR
NO
H2
KK ?
YES
H3
RE-SET LOOP-STARTED SWITCH
NO
J2
LL ?
YES
J3
COMMAND STATUS = TIME
K2
MM ?
YES
K3
COMMAND STATUS = MODE
NO
G
G

Fig.4A

Fig. 4B


A1
P.2 C
A2
P.1 A
B1
COMMAND STATUS =NONE?
YES
B2
REPORT ERROR SET ERROR SWITCH
NO
C1
COMMAND STATUS=TIME ?
C2
INPUT NUMERIC ?
D1
COMMAND STATUS =WRITE-1 ?
D2
INPUT NUMERIC 0-24 ?
D3
COMMAND STATUS =WRITE-2
E1
COMMAND STATUS = WRITE-2 ?
E2
INPUT NUMERIC 0-79 ?
E3
COMMAND STATUS = WRITE-3
F1
COMMAND STATUS= WRITE-3
F2
INPUT IN COLOR RANGE?
F3
COMMAND STATUS =WRITE-4
G1
COMMAND STATUS = WRITE-4
G2
COMMAND STATUS = NONE
H1
COMMAND STATUS= FOREGROUND ?OR BACKGROUND
H3
COMMAND STATUS= NONE
J1
COMMAND STATUS =CLEAR?
J3
INPUT IN COLOR? RANGE
K1
COMMAND STATUS = MODE ?
K2
INPUT IN MODE RANGE ?
K3
COMMAND STATUS= JUNK COLOR ?

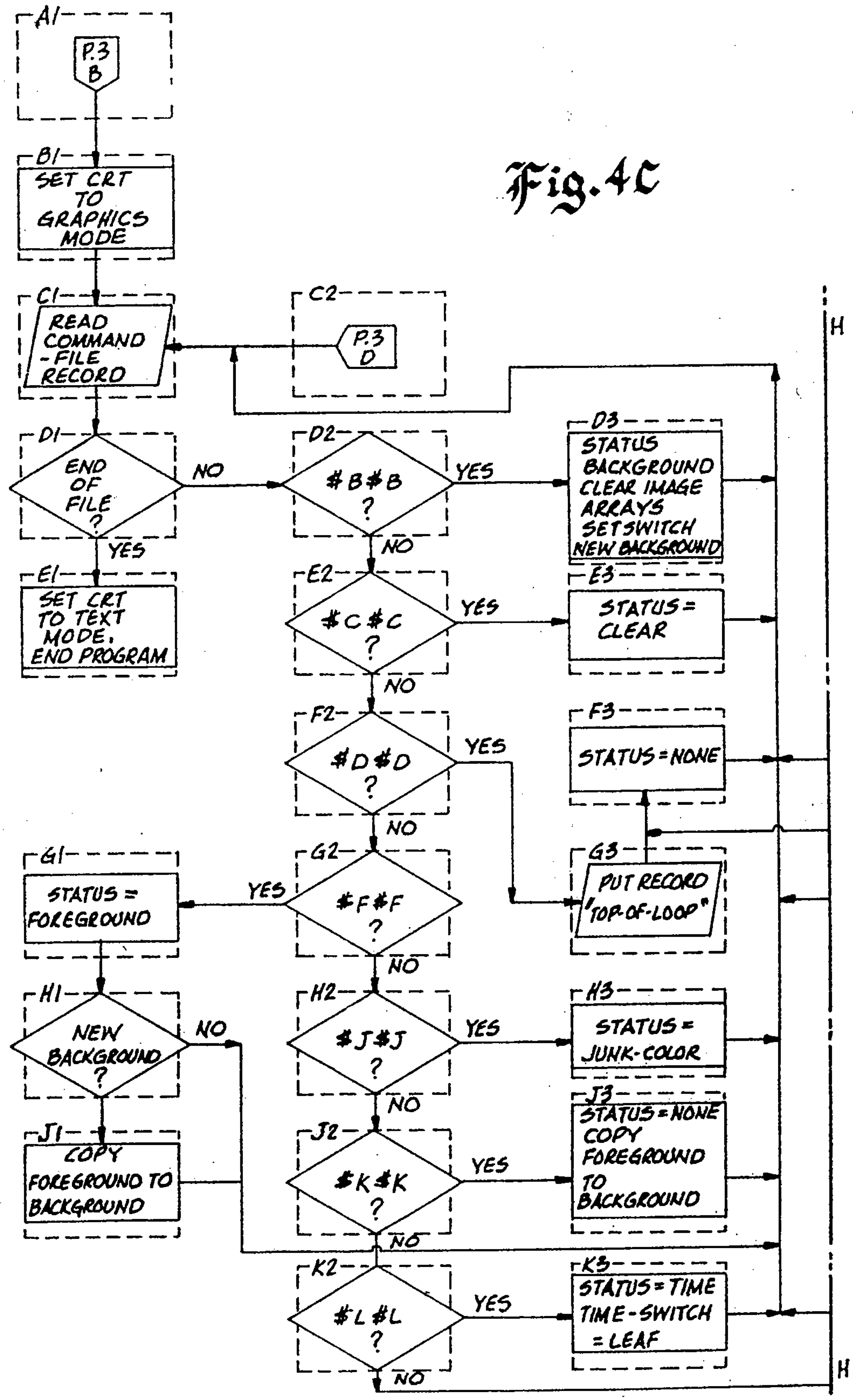
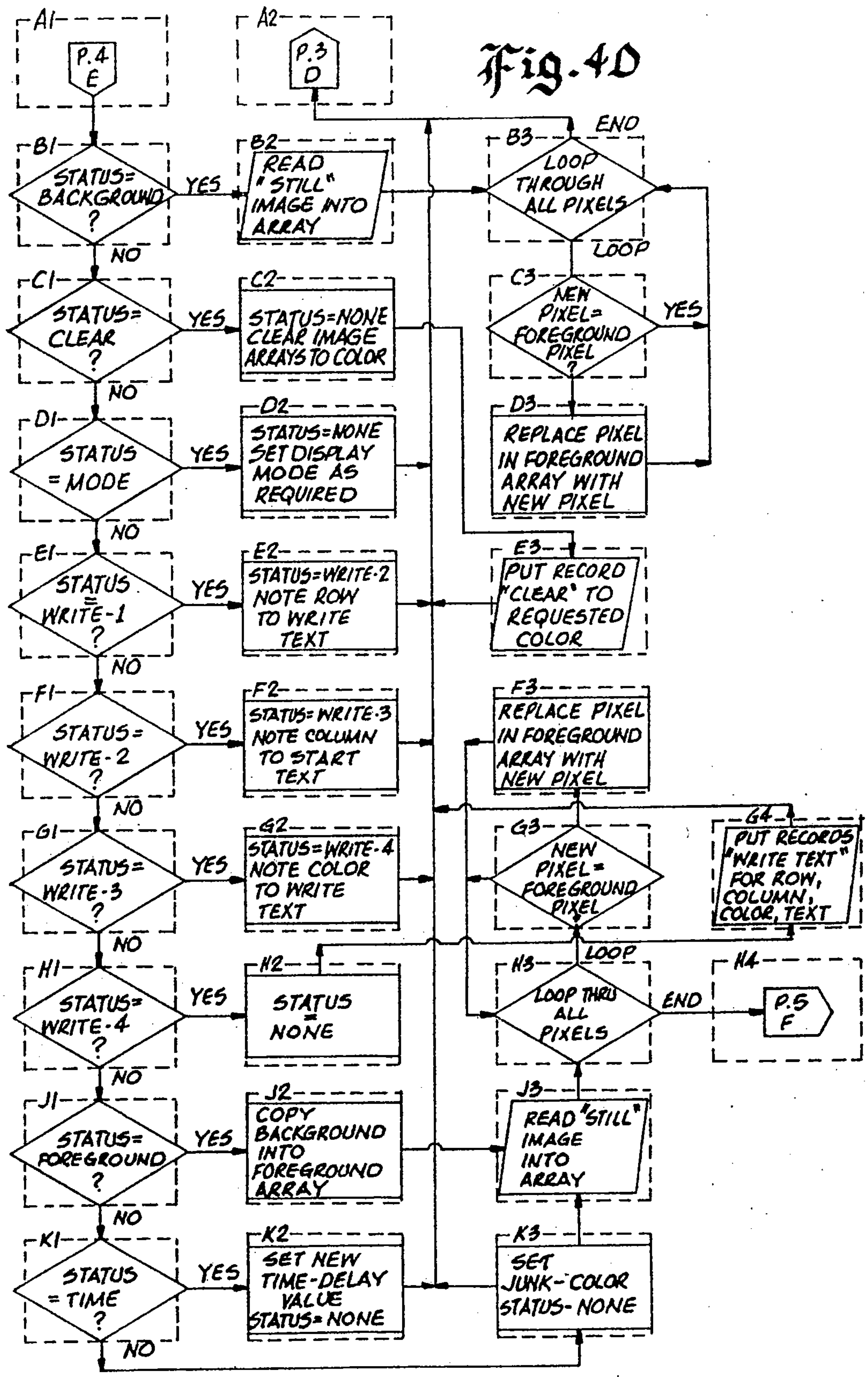

A1
P.3 B
B1
SET CRT TO GRAPHICS MODE
C1
READ COMMAND -FILE RECORD
C2
P.3 D
D1
END OF FILE ?
NO
YES
E1
SET CRT TO TEXT MODE, END PROGRAM
D2
#B#B ?
YES
D3
STATUS BACKGROUND CLEAR IMAGE ARRAYS SET SWITCH NEW BACKGROUND
E2
#C#C ?
E3
STATUS = CLEAR
F2
#D#D ?
F3
STATUS = NONE
G1
STATUS = FOREGROUND
G2
#F#F ?
G3
PUT RECORD "TOP-OF-LOOP"
H1
NEW BACKGROUND ?
H2
#J#J ?
H3
STATUS = JUNK-COLOR
J1
COPY FOREGROUND TO BACKGROUND
J2
#K#K ?
J3
STATUS = NONE COPY FOREGROUND TO BACKGROUND
K2
#L#L ?
K3
STATUS = TIME TIME-SWITCH = LEAF
H

Fig.4C

Fig. 4D


A1
P.4 E
A2
P.3 D
B1
STATUS= BACKGROUND ?
YES
NO
B2
READ "STILL" IMAGE INTO ARRAY
B3
LOOP THROUGH ALL PIXELS
END
LOOP
C1
STATUS= CLEAR ?
C2
STATUS=NONE CLEAR IMAGE ARRAYS TO COLOR
C3
NEW PIXEL= FOREGROUND PIXEL ?
D1
STATUS =MODE
D2
STATUS=NONE SET DISPLAY MODE AS REQUIRED
D3
REPLACE PIXEL IN FOREGROUND ARRAY WITH NEW PIXEL
E1
STATUS = WRITE-1 ?
E2
STATUS=WRITE-2 NOTE ROW TO WRITE TEXT
E3
PUT RECORD "CLEAR" TO REQUESTED COLOR
F1
STATUS= WRITE-2 ?
F2
STATUS=WRITE-3 NOTE COLUMN TO START TEXT
F3
REPLACE PIXEL IN FOREGROUND ARRAY WITH NEW PIXEL
G1
STATUS= WRITE-3 ?
G2
STATUS=WRITE-4 NOTE COLOR TO WRITE TEXT
G3
NEW PIXEL= FOREGROUND PIXEL
G4
PUT RECORDS "WRITE TEXT" FOR ROW, COLUMN, COLOR, TEXT
H1
STATUS= WRITE-4 ?
H2
STATUS = NONE
H3
LOOP THRU ALL PIXELS
H4
P.5 F
J1
STATUS= FOREGROUND ?
J2
COPY BACKGROUND INTO FOREGROUND ARRAY
J3
READ "STILL" IMAGE INTO ARRAY
K1
STATUS = TIME ?
K2
SET NEW TIME-DELAY VALUE STATUS= NONE
K3
SET JUNK-COLOR STATUS- NONE

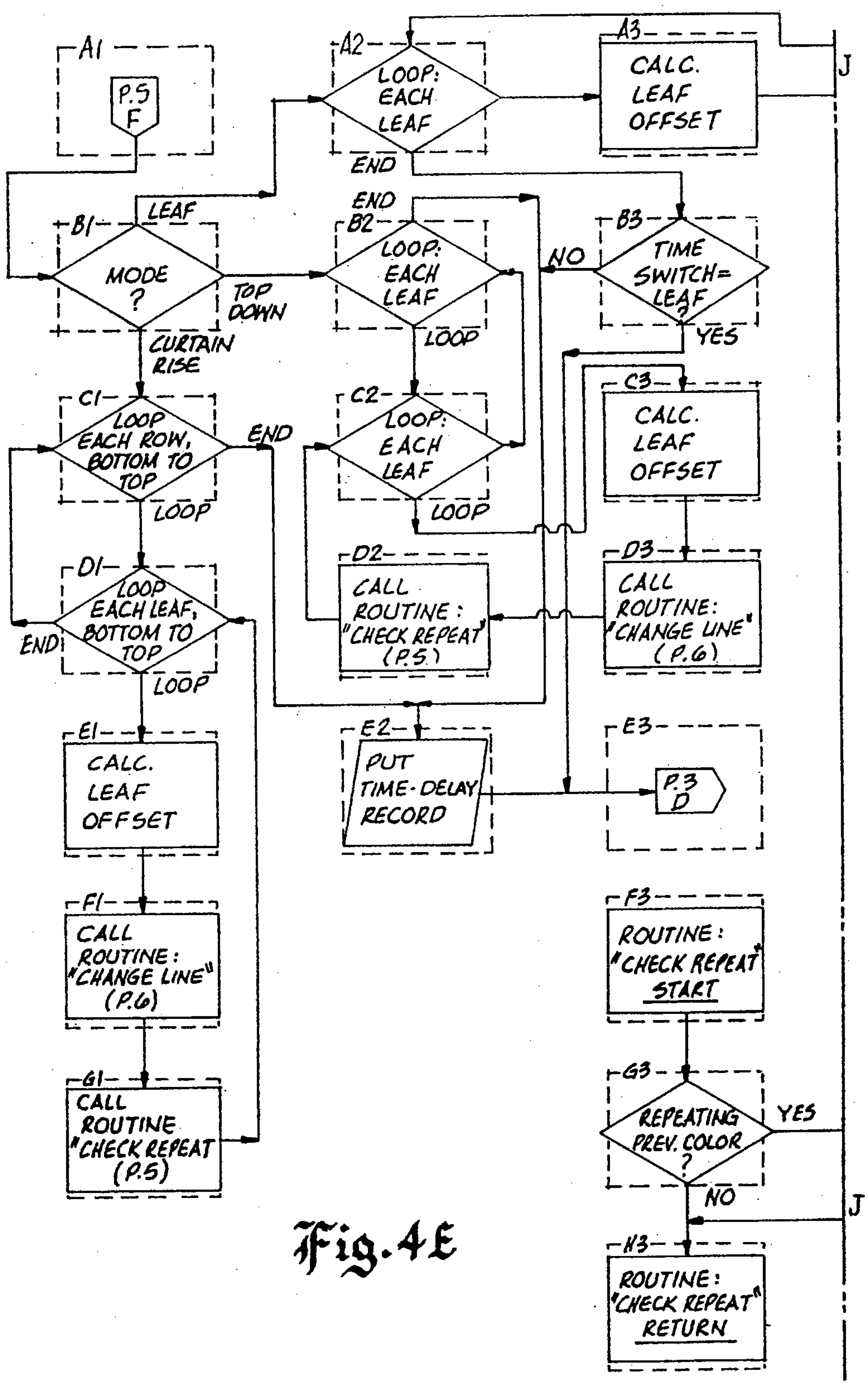

A1
P.5 F
A2
LOOP: EACH LEAF
END
A3
CALC. LEAF OFFSET
J
B1
LEAF
MODE ?
TOP DOWN
CURTAIN RISE
END
B2
LOOP: EACH LEAF
LOOP
NO
B3
TIME SWITCH= LEAF ?
YES
C1
LOOP EACH ROW, BOTTOM TO TOP
LOOP
END
C2
LOOP: EACH LEAF
LOOP
C3
CALC. LEAF OFFSET
D1
LOOP EACH LEAF, BOTTOM TO TOP
END
LOOP
D2
CALL ROUTINE: "CHECK REPEAT" (P.5)
D3
CALL ROUTINE: "CHANGE LINE" (P.6)
E1
CALC. LEAF OFFSET
E2
PUT TIME-DELAY RECORD
E3
P.3 D
F1
CALL ROUTINE: "CHANGE LINE" (P.6)
F3
ROUTINE: "CHECK REPEAT" START
G1
CALL ROUTINE "CHECK REPEAT (P.5)
G3
REPEATING PREV. COLOR ?
YES
NO
J
H3
ROUTINE: "CHECK REPEAT" RETURN

Fig. 4E

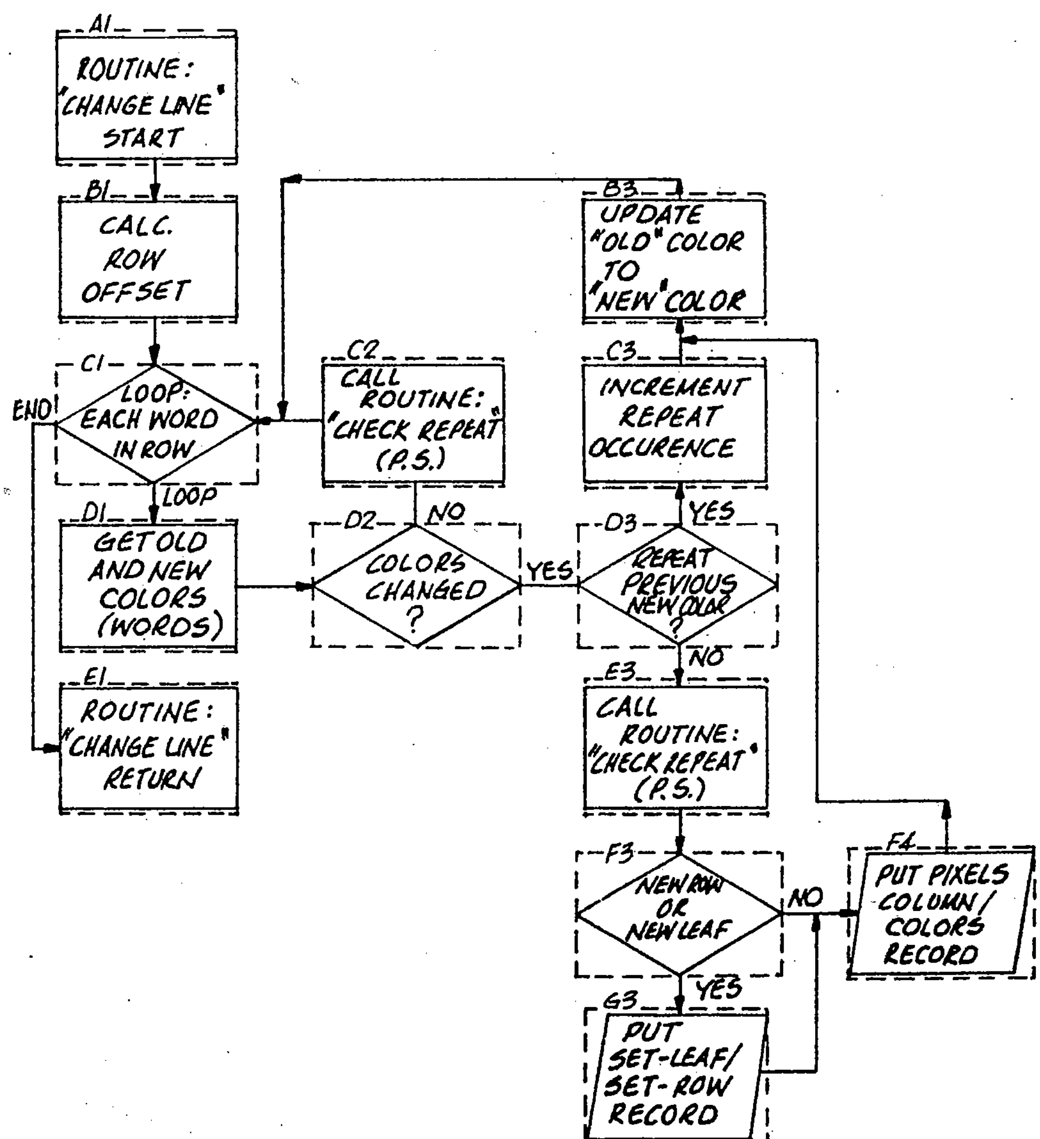

A1
ROUTINE: "CHANGE LINE" START
B1
CALC. ROW OFFSET
C1
LOOP: EACH WORD IN ROW
END
LOOP
D1
GET OLD AND NEW COLORS (WORDS)
E1
ROUTINE: "CHANGE LINE" RETURN
C2
CALL ROUTINE: "CHECK REPEAT" (P.S.)
NO
D2
COLORS CHANGED ?
YES
B3
UPDATE "OLD" COLOR TO "NEW" COLOR
C3
INCREMENT REPEAT OCCURENCE
YES
D3
REPEAT PREVIOUS NEW COLOR ?
NO
E3
CALL ROUTINE: "CHECK REPEAT" (P.S.)
F3
NEW ROW OR NEW LEAF
NO
YES
F4
PUT PIXELS COLUMN/ COLORS RECORD
G3
PUT SET-LEAF/ SET-ROW RECORD

Fig. 4F

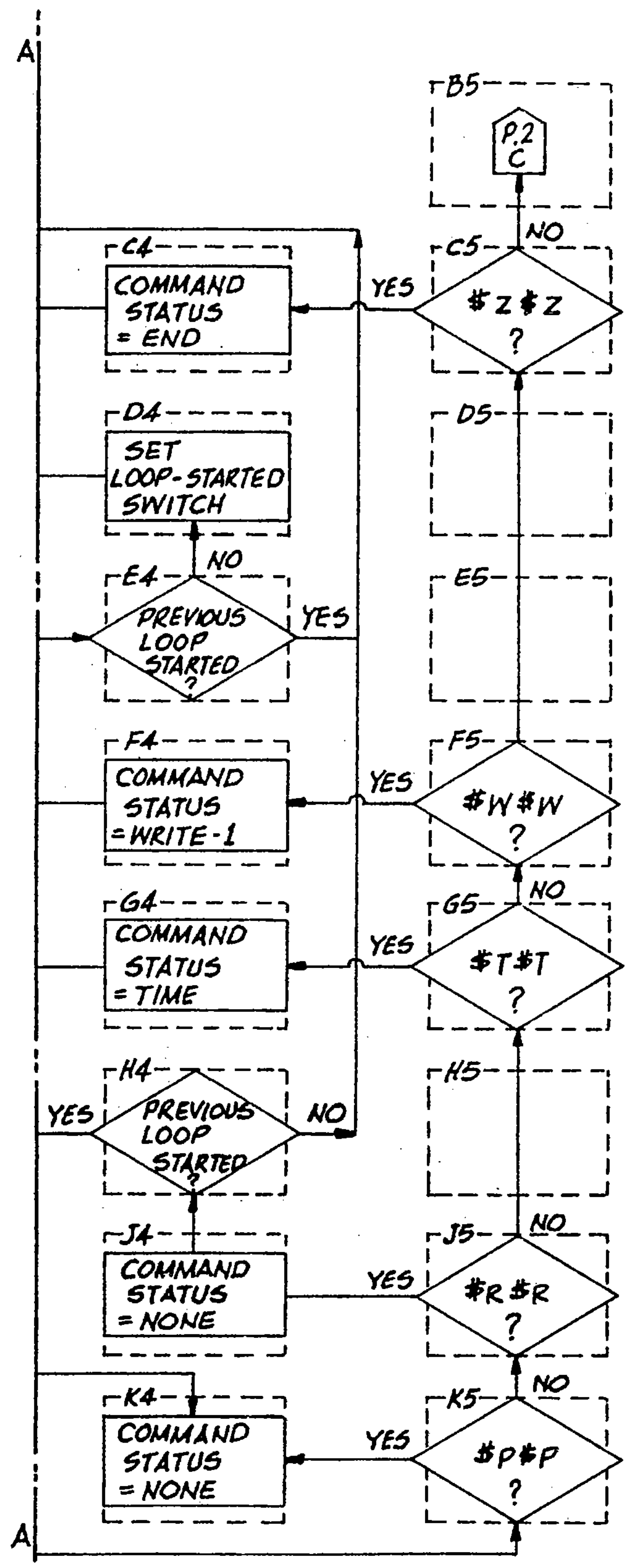
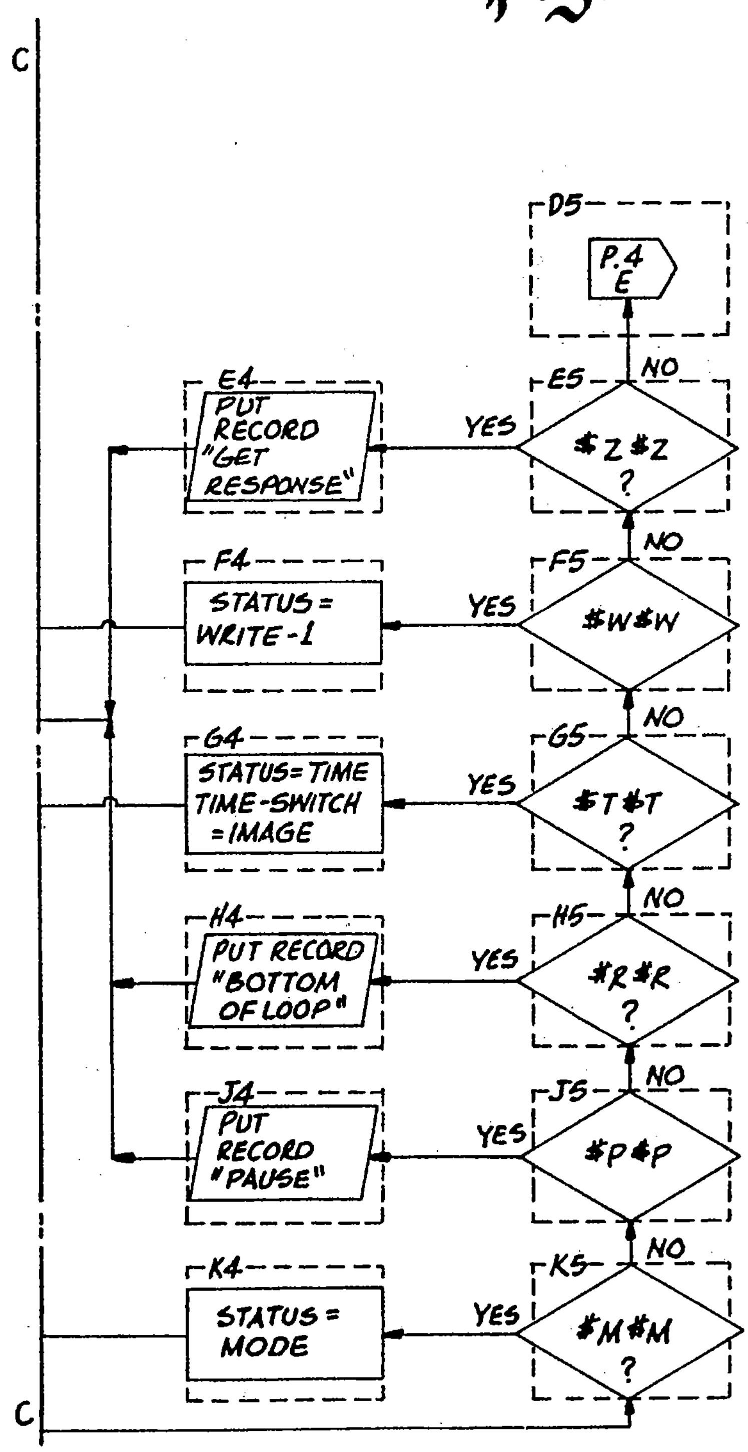

A
B5
P.2 C
NO
C4
COMMAND STATUS = END
YES
C5
#Z#Z ?
D4
SET LOOP-STARTED SWITCH
D5
NO
E4
PREVIOUS LOOP STARTED ?
YES
E5
F4
COMMAND STATUS = WRITE-1
YES
F5
#W#W ?
NO
G4
COMMAND STATUS = TIME
YES
G5
#T#T ?
H4
YES
PREVIOUS LOOP STARTED ?
NO
H5
J4
COMMAND STATUS = NONE
YES
J5
NO
#R#R ?
NO
K4
COMMAND STATUS = NONE
YES
K5
#P#P ?
A

Fig.4 G

Fig. 4h


C
D5
P.4 E
E4
PUT RECORD "GET RESPONSE"
E5
YES
NO
ZZ ?
F4
STATUS = WRITE-1
F5
YES
NO
WW
G4
STATUS= TIME TIME-SWITCH = IMAGE
G5
YES
NO
TT ?
H4
PUT RECORD "BOTTOM OF LOOP"
H5
YES
NO
RR ?
J4
PUT RECORD "PAUSE"
J5
YES
NO
PP
K4
STATUS = MODE
K5
YES
NO
MM ?
C

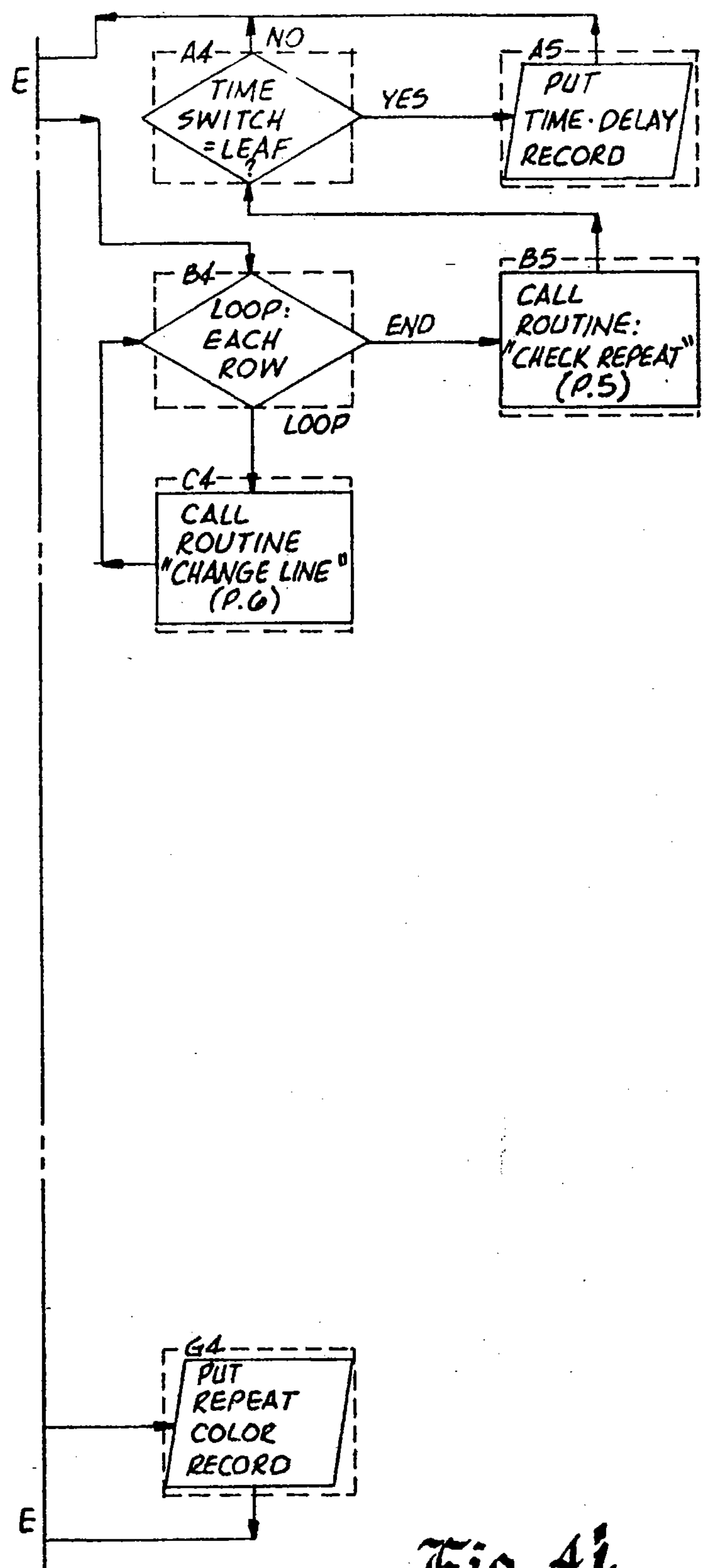

E
A4
NO
TIME SWITCH =LEAF ?
YES
A5
PUT TIME·DELAY RECORD
B4
LOOP: EACH ROW
END
LOOP
B5
CALL ROUTINE: "CHECK REPEAT" (P.5)
C4
CALL ROUTINE "CHANGE LINE" (P.6)
G4
PUT REPEAT COLOR RECORD
E

Fig. 4i

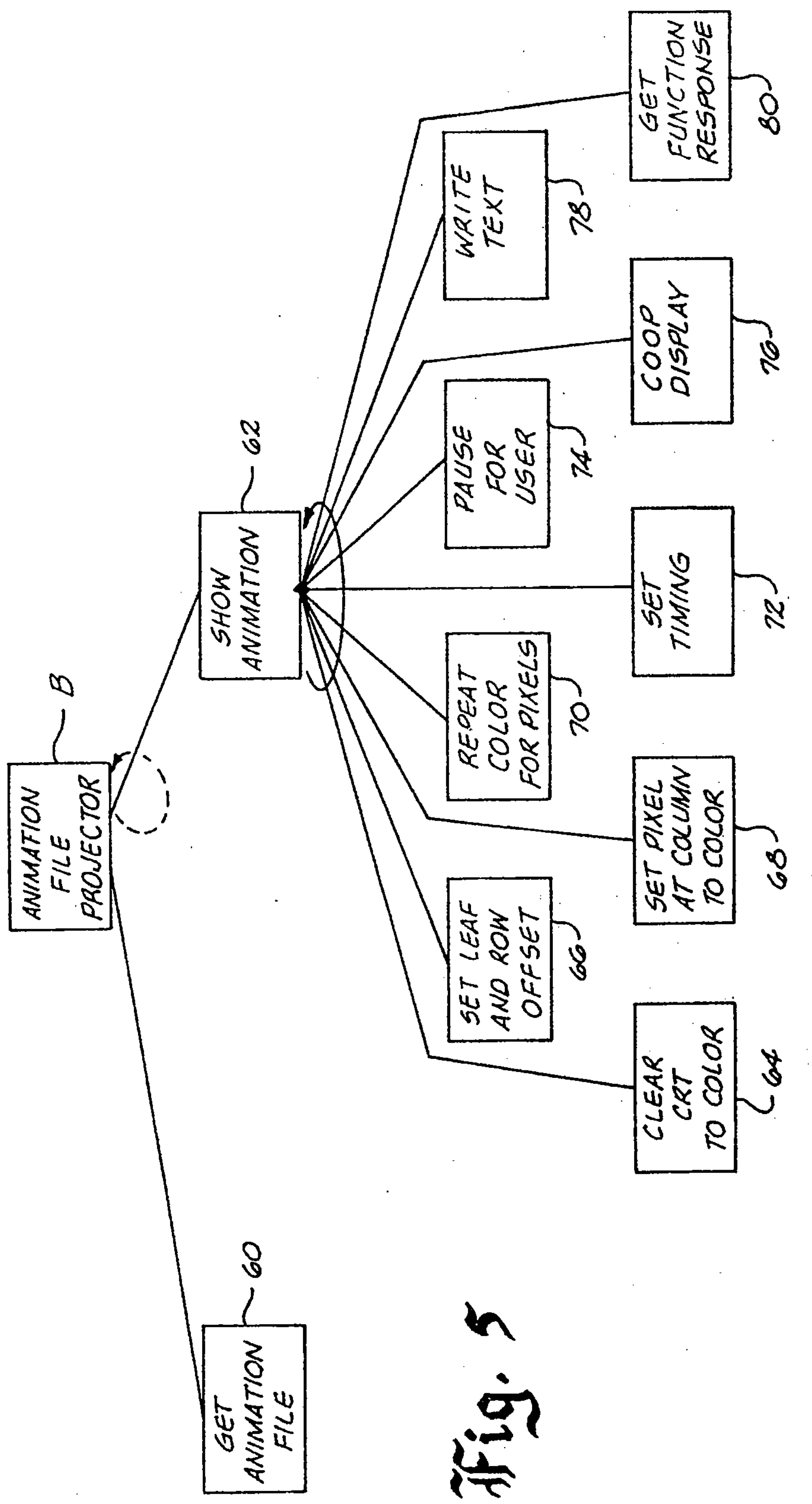

ANIMATION FILE PROJECTOR
B
GET ANIMATION FILE
60
SHOW ANIMATION
62
CLEAR CRT TO COLOR
64
SET LEAF AND ROW OFFSET
66
SET PIXEL AT COLUMN TO COLOR
68
REPEAT COLOR FOR PIXELS
70
SET TIMING
72
PAUSE FOR USER
74
COOP DISPLAY
76
WRITE TEXT
78
GET FUNCTION RESPONSE
80

Fig. 5

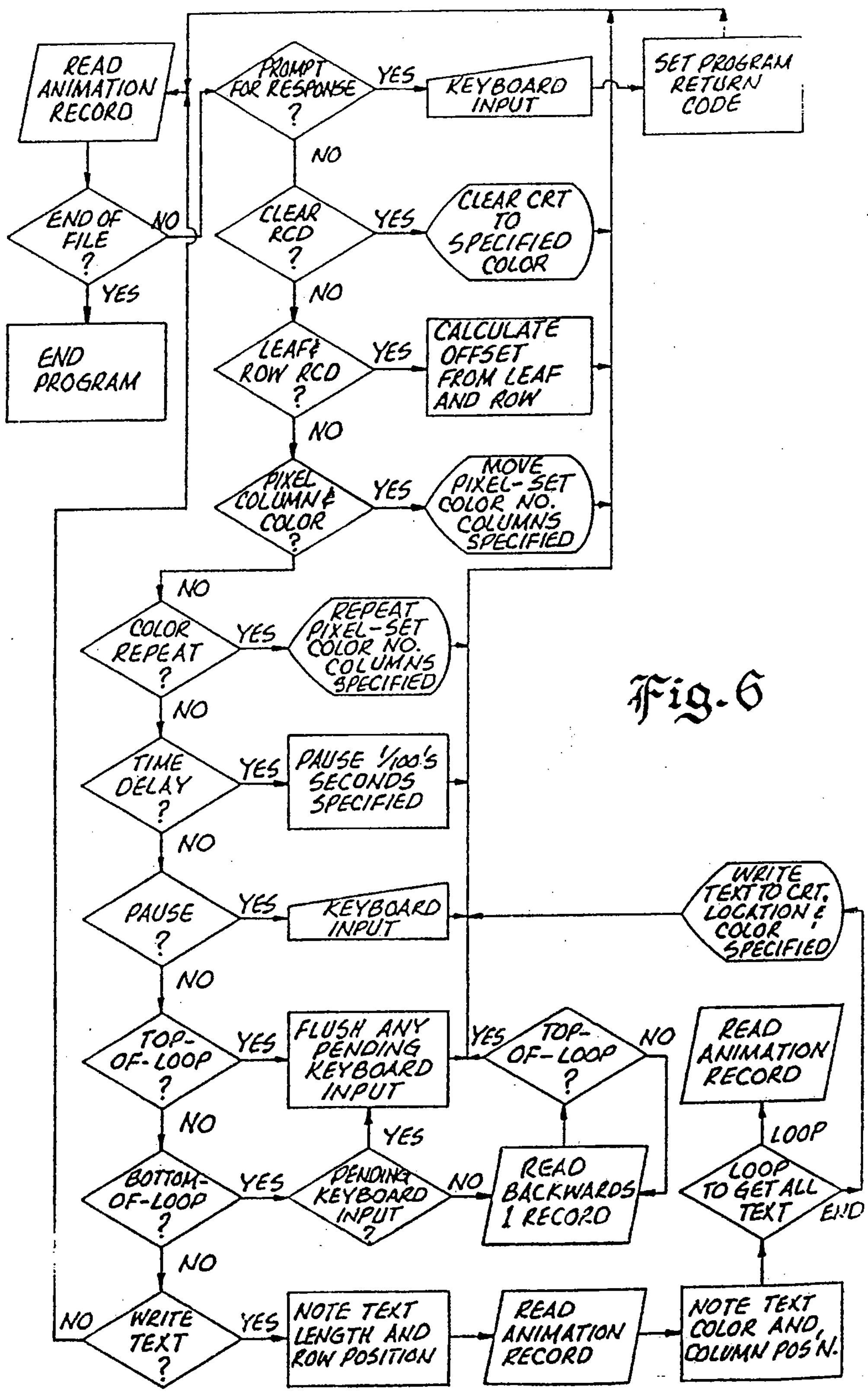

READ ANIMATION RECORD
END OF FILE ?
NO
YES
END PROGRAM
PROMPT FOR RESPONSE ?
YES
KEYBOARD INPUT
SET PROGRAM RETURN CODE
NO
CLEAR RCD ?
YES
CLEAR CRT TO SPECIFIED COLOR
NO
LEAF & ROW RCD ?
YES
CALCULATE OFFSET FROM LEAF AND ROW
NO
PIXEL COLUMN & COLOR ?
YES
MOVE PIXEL-SET COLOR NO. COLUMNS SPECIFIED
NO
COLOR REPEAT ?
YES
REPEAT PIXEL-SET COLOR NO. COLUMNS SPECIFIED
NO
TIME DELAY ?
YES
PAUSE 1/100's SECONDS SPECIFIED
NO
PAUSE ?
YES
KEYBOARD INPUT
WRITE TEXT TO CRT, LOCATION & COLOR SPECIFIED
NO
TOP-OF-LOOP ?
YES
FLUSH ANY PENDING KEYBOARD INPUT
YES
TOP-OF-LOOP ?
NO
READ ANIMATION RECORD
NO
BOTTOM-OF-LOOP ?
YES
PENDING KEYBOARD INPUT ?
YES
NO
READ BACKWARDS 1 RECORD
LOOP
LOOP TO GET ALL TEXT
END
NO
NO
WRITE TEXT ?
YES
NOTE TEXT LENGTH AND ROW POSITION
READ ANIMATION RECORD
NOTE TEXT COLOR AND, COLUMN POS'N.

Fig. 6

FULL SPEED ANIMATION SYSTEM FOR LOW-SPEED COMPUTERS AND METHOD

BACKGROUND OF THE INVENTION

The present invention is directed to a full speed animated graphic display specifically designed for a CRT of a personal computer where computer speed is not normally suitable for displaying true animation graphics. The speed of most personal computers allows complete change of the display about twice per second. For true animation, thirty complete changes of display are needed. Also of prime concern is the ability of the artist to use the system to build new animation scripts, without further intervention by the programmer. The animation scripts require control of the background (the still part of the picture at any given instant) and the foreground (the moving part at any instant), clearing the screen, repeating part of a script, display timing, pauses, and other factors.

The invention is suitable for bit-mapped graphic displays having images in which a large part of the image is static, with only a limited amount of movement. As the percentage of the image that is dynamic increases, the invention becomes progressively unsuitable, due to limitations on the computer's ability to maintain a visually acceptable speed of operation. The invention is applicable only to memory-mapped graphics, where a given pixel on the graphics screen in represented in a given memory location in computer memory (RAM). Depending on the number of colors available, each pixel may typically require one byte, a half-byte, two bits, one bit, or some other unit of storage.

U.S. Pat. No. 3,937,878 (Judice) discloses a bi-level (two color) graphics display system primarily concerned with a dithering process which produces grayscale images. Typically, bi-leveled systems are on/off and do not have the capability for gray tones. In Judice, each display cell is given a dither threshold value. If the signal of any given picture element is greater than the dither threshold value, then that cell is turned on. Otherwise, it is left off. As a result of this dithering process, various shades of gray appear in the reproduced image. The technique is applied to images received from a video camera. In contrast, the present invention is useful with any number of colors. The present invention separates the image development and projection processes. The artist controls the development and projection via a command file and combinations of still images he has created. Judice's technique of dithering is not applicable to the present invention. The present invention treats each color as distinct and unrelated to any other. Pixel colors and animation are produced by replacement of pixel color values rather than from threshold values.

Accordingly, an object of the invention is to provide a method and programming of computer functions on a personal computer to provide true, full-speed animated displays on a CRT.

Another object of the invention is to provide for a full-speed simulated visual display for a personal computer comprising a developer program for developing an animation file and a projector program for projecting the animated file wherein only the projector program may be run during display for fast operation and full speed animation.

Still another object of the invention is to provide a simulated visual display for a personal computer wherein a different animation script may be created by inputting a new series of still image files in accordance with commands and parameters specified by an artist and without intervention by the programmer.

SUMMARY OF THE INVENTION

Input to the system consists of two parts. The first part is a set of still images developed by the artist, each of which is in its own file. As with standard movie film, each still image is slightly altered from the previous image. The second input to the system is a single file, the command file. Here the artist designates images as background or foreground, as well as other commands such as are given below. Part of the significance of background versus foreground is the ability to overlay multiple images. Overlay is controlled through designating an image as background or foreground: background images are overlayed by foreground images. Also included in overlay logic is a designation of a "junk" color, which is not meant to be displayed, but rather to be ignored, allowing the background to "show through". This same technique (using a junk color) enables the use of multiple backgrounds (overlaid) as well. The result is a very powerful display technique capable of complex imaging at visually acceptable display speeds. The system has a single output, the displayed animation on a computer graphics screen. The system consists of two programs, the development and projection programs. These are analagous in function to the development and projection of photographic film. The developer program uses the two inputs already described to create an animation file. When read by the projection program, this animation file directs the operation of the projection program, in order to produce the desired animation as an end result. The two steps can be run at different times, places, and computers, meaning that to view the animation, only the projection program is run, using the respective records of the animation file.

DESCRIPTION OF THE DRAWINGS

The construction designed to carry out the invention will hereinafter be described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown and wherein:

FIG. 1 is a system diagram, describing the relationship of programs and files;

FIG. 2 is a structure chart for the developer program named in FIG. 1;

FIG. 3 is a structure chart describing the image-storage areas used by the development program.

FIGS. 4A, 4G and 4B illustrate a flowchart for a validation subroutine of the developer program which validates the artist's command file;

FIGS. 4C, 4H, 4D, 4E and 4J illustrate flowcharts of the main part of the developer program which create the animation file;

FIG. 4F illustrates a flowchart for a subroutine of the main part of the developer program which records the differences in pixels of the display by comparing previous and current still image files;

FIG. 5 is a structure chart for the projector program named in FIG. 1; and

FIG. 6 is a flowchart for the projector program named in FIG. 1;

DESCRIPTION OF A PREFERRED EMBODIMENT

The full-speed animation system for low-speed computers is comprised of a "developer program" A, "projector program" B, and structure of an "animation file" C outputted by the developer program as input for the projector program.

Use of the system begins with the running of developer program A, after individual "still-image files" D have been created and an artist's "command file" E has been written using any conventional text editor. Individual still image files D are created by the artist and are input into the computer by a suitable free form entry pad device such as a "Penpad" device manufactured by Pencepts, Inc. of Waltham, Mass. Program execution begins with the validation of the command file. Typically, a command (e.g., FF) sets the command status to a specific state, which then is used to select the proper edit for subsequent inputted data values. This is a simple and fairly standard parsing technique.

The validation routine (FIGS. 4A, 4G and 4B) reports any errors found. If there are errors, program execution terminates, and no animation-file development occurs. If command file E is valid, then, development of animation file C commences, guided by command file E. Still image file D consist of a number of still images each of which is a file. Command file E consists of two types of records, command records and parameter records. Animation file C consists of a number of individual pixel records, text records, and projection records which will be more fully described.

The structure chart shown in FIG. 2 describes the developer program. The overall purpose of the developer program, as shown, is to develop animation file C. This operation is broken down into four component parts: "validate the command file" 10; "set graphics mode" 12; "build animation file" 14; and "reset text mode" 16.

Validating the command file routine 10 (FIGS. 4A and 4B) refers to command file E written by the artist, which controls and directs the operation of both the developer and projector programs. This function is broken into two parts, reading a record from the command file 18, and checking its context 20. In turn, checking the context sets the input status 22 and produces an error message, if necessary. Setting the input status is used for the aforementioned context checking, in subsequent records.

Setting the graphics mode routine 12 and resetting the text mode routine 16 function at the basic machine level, performing the specific function in each case (FIG. 4C and 4H).

Building the animation file routine 14 (FIG. 4C, 4H 4D, 4E, 4J and 4F) occurs based on the contents of the artist's action is initiated and record made. These include: putting text on the image 26; keeping the foreground as background 28; setting timing and other projection controls 30; recording the foreground image 32; clearing the image arrays 34; and merging the background image 36.

Putting text on the image 26 involves writing the appropriate commands E to animation file C, as shown, to place text on the image, in the position and color as instructed by the artist's command file.

Keeping the foreground as background 28 is an operation limited to the developer program. The function exists to provide the artist with greater flexibility in his development of an animation display. Normally, building up a background (via a set of overlaid images) does not cause any screen display to occur; rather the first occurance of a foreground image (which overlays the background image) produces changes on the CRT screen. If, however, the artist wishes the build-up of the background to be visibly evident, then he would start by designating the desired images as foreground. Then when the image build-up is complete, he would give the command to "keep" the "foreground" image (FIG. 3) as a "background", to be subsequently overlaid by the new foreground images.

Projection controls, such as timing, display repetition, and user input are recorded in the function, "set projection timing" 30.

The function "record foreground image" 32 includes four operations (FIG. 2): "get background image" 40, "overlay next foreground image" 42, "note differences from previous images" 44, and "update previous images" 46. The description of "record foreground image" begins with an explanation of the developer program's internal data storage. Four matrices (or arrays) 50, 52, 54, 56 act as screen image storage areas for use by the development program (see FIG. 3).

Matrix 50, "image read from file", contains the current foreground image, ready for use. A separate routine has read the image file D and performed any necessary translations to produce the image matrix.

Matrix 52, "background image", is built through the developer program function, "merge background image" 36, or through the "keep foreground as background" function 28 (see FIG. 2).

Matrix 56, "previous image", contains the previous image that was built up prior to beginning the current image. In effect, the "current" image becomes the "previous" image when completed. The previous image is initialized to be empty at the beginning of operation.

Matrix 54, "current image", is the center of activity. First, the background image is copied into the current image matrix ("get background image", FIG. 2). Second, the new foreground image is overlayed from matrix 50 ("overlay next foreground image", FIG. 2). Third, matrix 54 (the current image) is compared to matrix 56 (the previous image), "note differences from previous image" 44 and "put command to file" 38. The differences are recorded using the record types described on page 16 and 17: type 2, set leaf and row; type 3, set pixel column and color; type 4 repeat previous color for number of times specified. Fourth, matrix 54 is copied into matrix 56 ("update previous image", FIG. 2).

Additional functions under "build animation file" 14 (FIG. 2) include "clear image arrays" 34, which clears all image storage matrices 50, 52, 54, and 56 (FIG. 3).

The function "merge background image" 36 is used to build up the background image matrix, by overlaying multiple images in a manner described by the artist. In this way, images which the artist drew on separate occasions may be combined (overlayed) in a specific manner.

The command file E includes two types of records, command records and parameter records. All command records are in the format of nn, where "n" is a letter. Parameters, if any, are entered on subsequent line(s). Animation may be based on files which are intended for

640×400, 16-color boards. Files also may be converted for use on 640×200, 2-color CGA boards. CGA allows two colors: one is black and the other may be any of the 16 listed below. Sample colors are:

0 = Black
1 = Blue
2 = Green
3 = Cyan
4 = Red
5 = Magenta
6 = Brown
7 = White
8 = Grey
9 = Light Blue
10 = Light Green
11 = Light Cyan
12 = Light Red
13 = Light Magenta
14 = Yellow
15 = Bright White

Example of Artist Commands

An example of the commands available for use by the artist in the inputted command file E follow ("*"=changes appear on screen only for these commands):

```
$n$n
 B - background file name(s) follow: if more
     than one file is listed, they are overlaid
 C - * clear the screen to the desired color
 D - top of loop (see $R$R)
 F - * foreground file(s) follow: if more than
     one file is listed, they are shown in
     succession (on background)
 J - "junk color" - consider the specified
     color as the null color, that does not
     overlay other colors (the default is black)
 K - keep the current foreground image as the
     background
 L - timing-delay that follows occurs after
     every LEAF (as compared with $T$T): this
     is useful only for $M$M of O
 M - display method:
     0 = normal interleave (fastest)
     1 = top-down
     2 = bottom-up (curtain rise)
 P - beep, wait for user to press key (pause)
 R - bottom of loop (see $D$D): if key has
     been pressed, continue (drop out of loop
     else, go back up to top ($D$D), and re-
     show
 T - timing-delay changed to amount that
     follows (in 1/100ths seconds) (default is 0)
 W - * write text - four lines follow:
     1: row, 0 . . . 24
     2: column, 0 . . . 79
     3: attribute: background and foreground
     colors
     4: text to display (max = 80 characters;
     1 line)
 Z - beep, wait for user to press any key, and
     end the projector program with return-code
     set to a standard value that may be tested
     in the batch file after the program ends:
     $Z$Z must be the last line in a command
     file if it is used
```

Other commands may be added, for special conditions relating to the use of specific hardware, and other reasons.

Example Command File

Lists of sequential commands in a file, as might actually be written by an artist, may look like the following:

MM	CC
1	0
CC	TT
0	4
FF	MM
DA2	2
KK	BB
DD	$PORT
MM	FF
1	H04
TT	MM
20	0
FF	FF
DA21	H03
DA22	H02
MM	H01
2	HO
FF	H1
DA23	H2
TT	H3
300	H6
FF	H7
DA2	H8
RR	H9

Based on the artists' commands and the corresponding parameters, still-image files D are used to construct the animation file C. FIGS. 4A, 4G and 4B illustrate a flow chart for the validation subroutine which validates the artist's command file E described previously. The subroutine reads the command records to determine if they contain valid command. The parameter records are read to determine if a parameter is specified where required depending on commands. An example of individual commands and their operation is as follows (FIGS. 4A, 4B, 4C, 4D, 4E, 4F, 4G, 4H and 4J):

BB: Sets the command status to indicate that the subsequent still-image file name(s) are to be used to build up the background image (FIG. 4C.D3). For each still-image file, the still image is read into an array (FIG. 4D.B2), which array is then compared pixel by pixel to the current background array. For any pixel for which the new array is not set to the junk color (that is, the color which is basically a "place holder", and which does not overlay other colors), the background array is updated with the value of the corresponding pixel color value from the new array (FIG. 4D.D3). Note that for this operation (i.e. while status is "background") the foreground array is actually used to build the background, then copied to the background array later. This allows a greater range of possible operations by the developer (notably, the KK command).

CC: Clears the arrays (FIG. 4D.C2), puts animation file record: "clear" to color specified (FIG. 4D.E3).

DD: Writes animation file record: "top-of-loop" (FIG. 4C.G3).

FF: If a background was being built, move it to the background array 52 (FIG.** 4C.J1). For each foreground file listed (FIG. 4D.J1); copy background array into current image array 54 (FIG. 4D.J2) and read the specified foreground still-image file into its array 50 (FIG. 4D.J3). For each pixel, if the still-image pixel in the foreground array is not the junk-color (FIG. 4D.G3), put the pixel's color-value into the current image array 54 (i.e. replacing and thus overlaying the background FIG. 4D.F3). The new current image array is now built. The previous image array has been moved to 56. Depending on the display mode (top-down, curtain-rise, or normal), for the proper order (FIG. 4E.B1), compare each pixel-set of the previous and current foreground images (a pixel-set may be one or more pixels; and pixel-set size is typically the word-size of the particular computer used to maximize the speed of operation FIG. 4F.D2). If pixel-sets of the current image are the same color as the previous pixel-set but are different from the previous image: run the "repeat" color routine if a repeat-previous color status exists, end it, and write the repeat record to the file, FIG. 4F.C2). Take no other action if the current and previous are the same, because unchanged pixel-sets are ignored. If the pixel sets of the current and previous image are different and the pixel-set has the same value as the previous pixel-set of the current image examined (FIG. 4F.D3), increment the repeat occurence value (FIG. 4F.C3), or if the pixel value is new (FIG. 4F.D3), run the "repeat" routine described above (FIG. 4F.E3). If the row or leaf values have changed (FIG. 4F.F3), put a record with the current leaf and row values (FIG. 4F.G3). Put a record with the pixel-set's column and color (FIG. 4F.F4). Update the "old" pixel-set value to the "new" one (FIG. 4F.B3). Put the proper time-delay value record (FIG. 4E.A5 or —.E2)

JJ: Set new "junk color" value (FIG. 4DK3); the junk color is the color which, if it occurs in the overlaying image, does not get transferred; the existing color on the overlayed image remains unchanged.

KK: Copy the foreground array image to the background (FIG. 4C.J3); allows a background to "fade" in or out, and the changing of part of an image from dynamic to static.

LL: Let the timing delay occur after every leaf of an image, rather than after every image (See TT) (FIG. 4C.K3). Use the timing delay inputted (FIG. 4D.K2).

MM: Set display mode (FIG. 4D.D2): normal, which is fastest, displays each leaf of an interleaved image in sequence; top-down, which starts image changes at the top, working down; curtain-rise, the opposite of top-down, gives the impression of a rising curtain.

PP: Put a "pause" record (FIG. 4C.J4), which will cause the projector program to "beep" and wait for a key to be pressed to continue.

RR: Put record: "bottom of loop" (FIG. 4C.H4); working with a "top of loop" record, will cause the projector to repeat an animation sequence until stopped.

TT: Let the timing delay occur after every image, rather than after every leaf (see LL) (FIG. 4C.G4); use the timing delay inputted (FIG. 4D.K2).

WW: Put records "write text" (FIG. 4D.G4) noting row (FIG. 4D. E2), column (FIG. 4D.F2), color (FIG. 4D.G2), and text (FIG. 4D.H2)

ZZ : Put a record "get response" (FIG. 4C.E4).

The structure of amimation file C is optimized to incur the greatest efficiency of storage for the most commonly used record types (such as the set-pixel type). Types used infrequently (such as the loop-control types) may be less efficient, or special cases may be used (such as with text storage for the Write-text type). Minimizing storage size and speed work hand-in-hand to produce faster storage access; this goal, and that of a high speed display, were the criteria for the file structure design.

Animation file C is made up of four-byte records. The first byte describes the record type, except in the case of the text records used by the "write-text" record type. Since the length of the text is given in the first write-text record, enough text records are read to obtain that much text. Thus, the record-type is eliminated as unnecessary for text records, minimizing the file size.

Depending on the first byte indicator, the other contents of a record will vary. Some types will use all three bytes, some may use only two or one, and some may use none. Further optimization is possible, through the grouping of records into super-records that take advantage of the natural buffering techniques of the computer to be used. Thus, all the records of the animation file may be read into the computer memory at first or may be read in large groups of "super" records depending on the file size and computer memory size. This reduces pauses and jerks in the animated display caused by reading the records intermittently simultaneously with the animated display. When using "super" records, the records may be divided into any suitable number. It is not desirable to divide the file in such a manner that empty files will be read. For examle, reading a thousand records at a time as a "super" record when the file only contains twelve hundred records would result in reading eight hundred empty records. In one example, an animation display consisted of an animation file having seventy five thousand records. In this case, "super" records were utilized containing ten thousand records each.

Other considerations may include file input during the animation display. If the file size is kept within the limit of what may be entirely read into main memory, then all input can be accomplished prior to the animation display, eliminating undesirable pauses due to file access. This is also a significant reason for designing the file structure so as to minimize the size of the file. In cases where delays during the animation display area not important, reduction of file access time is still desirable.

The file structure allows enhancements and additions to be made, based on the requirements of specific hardware and for other reasons.

Example of Animated File Structure

The following is an example of the structure for animation file C created and outputted by developer program A, for use by an input to projector program B.

Animation file record types, and their record layouts (records are four (4) bytes in length, the "type" designation is the first byte of each record):

1. Clear CRT to requested color
   Clear color = 2 bytes
   (unused) = 1 byte
2. Set leaf (for interleaved displays) and row values
   Leaf = 1 byte
   Row = 2 bytes
3. Set pixel-set at column specified, to color specified
   Column = 1 byte (for images greater than 225 columns, a multiplicative factor is used)
   Color = 2 bytes
4. Repeat previous color, number of times specified
   Repeat count = 2 bytes

-continued

(Unused) = 1 byte

5. Change time delay to amount specified
Delay amount = 2 bytes (100th of a second)
To slow down the image display, this command sets the delay-size which occurs between successive images
(Unused) = 1 byte
6. Top of a loop:
No parameters: works with type 7
7. Bottom of a loop:
No parameters, works with type 6. Loop is repeated until a key is pressed.
8. Write text to CRT: Crosses multiple records:
Record (1) - number of characters to display = 1 byte; and row on which to display text = 2 bytes.
Record (2) - column in which to start text display = 1 byte; and color of text = 2 bytes.
Record (3) and beyond contain text, four characters per record (i.e. no record type): enough records are used to hold complete text as defined by number of characters in record (1).
9. Pause, wait for user to press key to continue, no parameters.
10. Get Function-key response from user no parameters, optionally used at end of display: waits for user response. Based on response, program exits with a return code that can be used to determine subsequent course of action.

The structure chart shown in FIG. 5 describes projector program B. The projector function is broken into two parts, "get animation file" 60, and "show animation" 62. Normally, the entire animation file C is read into the high-speed internal computer memory prior to showing the animation, to eliminate pauses in the motion due to access of slow-speed storage devices. The file is then used to control the action of projector program B, showing the desired animation. The various functions control the image screen display and acting on user-input as follows:

"Clear CRT to color" 64 clears the entire image screen, changing all pixels to a single specified color.

"Set leaf and row offset" 66 causes certain locational calculations to occur. These calculations need not occur for every pixel-set, but the values will be used in the calculation of the location of every pixel-set.

"Set pixel at column to color" 68 calculates the location and color of a pixel-set, and causes that pixel-set change to occur. The calculation is based upon the column specified and the offset calculated for "set leaf and row offset" 66.

"Repeat color for pixel-sets" 70 uses the same color as the previously set pixel-set for a number of pixel-sets that immediately follow it in the image storage. The number (count) is specified in the "repeat" record.

"Set timing" 72 causes a pause of the specified length to occur.

"Pause for user" 74 causes the animation projection to stop, until a key is pressed by the person viewing the display.

"Loop display" 76 causes the previous portion of the file to be searched for the loop "top" record, from which point the animation display will continue. However, if a key is pressed, the looping will not occur.

"Write text" 78 causes the specified text to written to the image, at the location and in the color specified.

"Get function response" 80 allows the viewer to type a specific key, indicating the choice among several options as to how to continue.

Referring now in more detail to FIG. 6, a flow chart of the projector program is given wherein the steps in column 2 of the flow chart determine the record type from the animation file. Columns 3, 4, and 5 of the flow chart determine the actions to be taken based on the type record determined. The projector program's operation begins with the accessing of animation file C created by developer program A. After each record is read (FIG. 6.A1), it is first examined for record type. Depending on record type the following operations may be prepared.

Clear record: clears the CRT to the color specified on the record (FIG. 6.B3).

Leaf & Row record: the "offset", a numeric value used elsewhere, is calculated from the leaf (for interleaved displays) and row values (FIG. 6.C3); this method of calculating an offset minimizes the number of calculations required for determining each pixel-set's position, to improve the speed of the animation display.

Pixel Column & Color: the pixel-set (see definition in developer program detailed description) color is placed on the CRT location calculated by adding the offset and the column (FIG. 6.D3).

Color Repeat: using the previous pixel-set's color, it is repeated for the number of times specified, over subsequent pixel-sets (FIG. 6.E3): this takes advantage of the high speed of certain repetitive computer instructions, and reduces the size of the animation file.

Time Delay: delays the animation display, for the specified number of hundredths of a second (FIG. 6.F3); this allows the same animation file to be shown on computers of different speeds, by limiting the number of images displayed per second;

Pause: waits for any keyboard input as a signal to continue (FIG. 6.G3);

Top-of-loop: flushes any waiting keyboard input, in preparation for the Bottom-of-loop record (FIG. 6.H3);

Bottom of loop: checks for waiting keyboard input (FIG. 6.J3); if any exists, it is flushed (FIG. 6.H3), and execution continues with the next record; if no keyboard input is waiting, the animation file is read backwards (FIG. 6.J4) until a Top-of-loop record is found;

Write-text: the text length and row are noted (FIG. 6.K3), the next record is read (FIG. 6.K4), from which the text color and column position are obtained (FIG. 6.K5); then, depending on the text length noted in the previous record, enough records are read (at four characters per record) (FIG. 6.H5) to obtain the complete text (FIG. 6.J5); the text is then written to the CRT, at the specified row, column, and color (FIG. 6.G5); and

Prompt-for-response: waits for input from the keyboard; based on the key entered, a particular return-code is set when the program ends, so tht it may be tested for conditional subsequent operation (FIG. 6.A4).

Thus, it can be seen that an advantageous computer system can be had in accordance with the invention for projecting an animated display on a bit-mapped display screen of a computer.

The system includes still image file D containing a set of serial still images having prescribed image differences from one another. Artist command file E contains command records and parameter records for developing the still image file.

Developer program A develops the still image files into animation file C in accordance with the commands and parameters of the artist command file.

Projector program B reads the animation file and projects the animation file to change the display screen and produce the animated display. Developer program A includes means 32 for comparing said image files and determining the pixel color changes from a current and a previous image file until each of the image files of the set has been compared. Means 38 is provided for making a set pixel record containing the different pixel colors between the serial still image files in the set. Developer program A includes means for creating a repeat pixel record for repeating the color of a previously set pixel for a number of pixels that immediately follow it in the image.

Animation file records have a size of four bytes and the first byte of the records specifies the record type so that the structure of the animation file is optimized for the greatest storage efficiency and speed. Text records 26 include a first record specifying the type of record and number of characters to be displayed in the text, a second record specifying the location, and three or more subsequent records containing said characters of the text.

In a preferred embodiment, still image files include foreground image files and background image files. Developer program A includes means for storing a background image 52, overlaying a foreground image onto said background image 42 to create a current foreground image 54, comparing said current foreground image to a previous foreground image 44, and developing set pixel records containing the differences in the colors of said pixels in a manner that the pixels in said current foreground image which are different replace the color of the pixels in the previous foreground image sequentially in the animated display.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

What is claimed is:

1. A method of producing an animated display on a bit-mapped display screen of a personal computer system and the like comprising:

(a) creating a set of successive serial still images which successively make up said animated display wherein each next successive still image contains slight differences from the previous still image;

(b) creating individual still image files which contain binary digit data for each of said successive still images in said set and storing said still image files in a computer accessible memory;

(c) inputting an artist's command file written in a computer programming language into said computer which contains commands and command parameters for processing said still image data files, and executing said artist command file in said computer as a stored computer program;

(d) developing an animation data file by processing said still image files in response to said commands and command parameters of said artist's command file to generate in said animation data file a plurality of set-pixel records containing binary digit data which represents the differences in pixels between said successive still image files and sets pixel colors at prescribed pixel locations in accordance with said differences between said successive still images, and a plurality of projection records containing binary digit data for timing and sequencing said pixel color changes for projecting said set-pixel records of said animation data file on said display screen in a prescribed sequence;

(e) storing said animation data file in computer accessible memory; and

(f) reading said animation data file and changing said locations and colors of pixels to produce said animated display in accordance with said animation data file.

2. The method of claim 1 including:

(a) developing said set-pixel records in said animation data file by comparing a current still image file to a previous still image file and recording the changes in the colors of the pixels in said set-pixel record; and

(b) comparing each said still image file of said set as in step (a) wherein the current image file, once compared, becomes the next previous image file until all said still image files in said set are compared and a set-pixel record made.

3. The method of claim 1 including:

(a) designating a number of said still image files as background files which are static in said animated display and a number of said still image files as foreground files which are dynamic in said animated display; and

(b) overlaying a first foreground image file on a background image file to produce a previous image file;

(c) overlaying a second foreground image file on said background image file to produce a current image file; and

(d) comparing said current image file to said previous image file and putting the differences in pixel colors between said respective images in said set-pixel record; and

(e) repeating steps (b)-(d) until the series of said foreground images have been compared and the pixel color changes put in said set-pixel records.

4. The method of claim 1 including developing said animation data file by developing animation file records having a fixed size of four bytes optimized for compactness, data content and command content, to efficiently utilize machine memory providing a rate of pixel change which produces animation.

5. The method of claim 4 comprising assigning the first byte of said records as the type of record, and specifying the parameter in the other bytes.

6. The method of claim 1 including developing said animation data file by designating said still image files either as background image files or foreground image files and projecting said background image files in a non-changing manner while projecting said foreground image files in a changing manner to produce animated display.

7. The method of claim 6 including building a background by reading each background image file into a background array, comparing a previous background array, pixel by pixel, to a current background array, updating the previous background array by replacing the pixel colors in the previous background array with the colors which are different in the current background array.

8. The method of claim 7 including:

(a) copying said background into a foreground array;

(b) reading a foreground image file into said foreground array and designating said array as a current foreground array;
(c) comparing the pixel colors of the current foreground array to a previous foreground array: and
(d) repeating steps (b) and (c) until all the foreground image files have been read and compared and the changes in pixel colors put in said set-pixel records.

9. The method of claim 8 including:
(a) developing a pixel repeat record if the pixels at consecutive memory locations of the compared foreground arrays are to be changed to the same color; specifying the number of repetitions of said pixels in said pixel repeat record; repeating the same color as said pixel in the previous location, and starting said repetition at a location immediately following said previous location.

10. The method of claim 8 wherein said pixels of said foreground arrays are compared in pixel sets of two or more pixels.

11. The method of claim 10 including writing repeat pixel color records for consecutive pixel sets which are the same in said current foreground array and writing new set-pixel records for the pixel-sets that are different.

12. The method of claim 6 including designating one of said colors in the computer system as a junk color, creating said background images on said junk color, building up said background array by overlaying successive background images, determining the changes in pixel colors of successive images, replacing the color of said pixels in a previous background with the colors in a current background image, and keeping the pixel color of said previous background image where the color in the current background image is said junk color.

13. The method of claim 6 including designating a plurality of background images as foreground images in said command file, keeping said foreground images as background, and displaying said foreground images to produce a visibly evident dynamic background during display.

14. The method of claim 1 including reading said animation data file into memory prior to initiating said animated display.

15. The method of claim 14 including grouping a number of said set-pixel records into record groups and reading said animation data file by intermittently reading said record groups so that pauses which disrupt the normal motion of the animation due to file accessing are minimized.

16. The method of claim 1 including developing an animation data file which contains text records containing prescribed location and characters for text.

17. The method of claim 16 wherein developing said text records include specifying the record type in a first record and placing the text characters in one or more subsequent records.

18. The method of claim 17 wherein developing said text records includes indicating in a first record that the record and a prescribed number of subsequent records are text type records and developing the subsequent records to include said text until a prescribed number of text characters are recorded as specified by said first record.

19. The method of claim 18 including developing said first record to indicate text record type, number of characters to display, and the row on which to begin text display, developing a second record specifying the column in which to start the text display and the color of the text, and developing at least a third record containing only the text characters.

20. The method of claim 16 including developing projector command records in said animation data file which contain commands for controlling the projection of said pixel records and text records in said display.

21. The method of claim 20 including projecting said set-pixel and text records in loops from top to bottom.

22. The method of claim 21 including clearing said display screen prior to beginning said animation display to a prescribed color.

23. The method of claim 20 including controlling the amount of time delay between successive images.

24. The method of claim 20 including developing a pause command which creates a pause in said animation display for entry into said computer of user commands entered by a viewer of said animated display.

25. A method for producing an animated display on a bit-mapped display screen of a programmable computer system having a personal computer comprising the steps:
(a) initially storing in a computer accessible memory an animation data file which includes a plurality of set-pixel records containing binary digit data which sets pixel color changes at prescribed pixel locations on said display screen in accordance with prescribed differences between successive still images of said animated display, text records containing binary digit data specifying textural characters at prescribed colors and locations in said display, and a plurality of projection records containing binary digit data for timing and sequencing said pixel color changes for projecting said set-pixel records and said text records of said animation data file on said display screen in a prescribed sequence;
(b) inputting said animation data file to a projector program in said computer which reads said set-pixel records, text records, and projection records; and
(c) reading said animation data file in said computer to repeatedly and sequentially change individual prescribed pixels of an existing display to produce said animated display in accordance with said animation data file records.

26. The method of claim 25 including setting said pixels by setting the color and location of said pixels.

27. The method of claim 26 including setting said pixels by sets of pixels and repeating the color a plurality of specified times over subsequently specified pixel sets to reduce the size of the animation data file and increase the speed of the animated display.

28. The method of claim 25 including projecting a prescribed number of said animation file records per second on said display screen.

29. The method of claim 25 including momentarily interrupting said animated display for keyboard input by the viewer of user commands.

30. The method of claim 25 including projecting said pixel and text records in a loop from the top to the bottom of said display screen.

31. The method of claim 25 including storing and projecting said animation file records in files consisting of four bytes and specifying the type of record in the first byte of said records.

32. The method of claim 25 including changing the colors of said pixels in an interleaving manner to speed up said display.

33. A method of operating a personal computing system having a personal computer to produce an animated display on a bit-mapped display screen of the computing system comprising:

(a) creating a set of serial still images having prescribed changes from one another:

(b) storing said still images in the form of binary digit data corresponding to individual serial still image files in a computer accessible memory;

(c) inputting an artist's command file in a computer programming language into said computer containing commands and parameters for developing said still image files, and executing said artist command file in said computer as a stored computer program;

(d) developing said still image files in said computer by building and comparing a current composite image which includes a plurality of current still images with a previous composite image which includes a plurality of previous still images in accordance with the commands and parameters of said artist's command file and making set-pixel records of the differences in color between the pixels of said current and previous composite images:

(e) updating and converting the current composite image to a previous composite image and building the next current composite image as a new current image and repeating step (d) until all of the still images in said set have been composed and compared sequentially:

(f) creating an animation data file which includes said set-pixel records containing binary digit information corresponding to pixel change instructions: and

(g) inputting said animation data file into a projector program in said computer which changes the pixel colors on said display screen and produces said animated display in accordance with said animation data file.

34. The method of claim 33 wherein said projector system reads said set-pixel records of said animation data file sequentially and changes only the pixels on the display screen which are different from the preceding image in accordance with said pixel change instruction of said animation file.

35. The method of claim 34 wherein said artist's command file includes command records which contain commands which the developer system follows and parameter records which specify perameters for the commands.

36. The method of claim 34 wherein said animation files data consist of a series of animation file records which are fixed in size and include four operable bytes of information to standardize operation of said projector program to improve speed and minimize storage for more rapid deployment of the animated display.

37. A system for projecting an animated display on a bit-mapped display screen of a computer system having a personal computer comprising:

(a) a set of still image files containing serial still images having prescribed successive image changes from one another;

(b) an artist command file for storage in said computer written in a computer programming language containing command records and parameter records for developing the still image files:

(c) a developer program for developing said still image files into an animation data file which includes set pixel records containing binary digit data corresponding to pixel changes between successive still image files and text records containing binary digit data specifying textural characters in said display developed in accordance with said commands and parameters of said artist command file: and

(d) a projector program for reading said animation data file and changing the pixel colors on said display screen to produce said animated display in accordance with said animation data file.

38. The system of claim 37 wherein said developer program includes means for comparing said still image files and determining the pixel color changes from a previous and to a current image file and means for making set-pixel records containing the changes of said pixel colors for said files in said set.

39. The system of claim 38 wherein said developer program includes means for creating a repeat pixel record for repeating the color of a previous pixel for a number of pixels that immediately follow it in said image file.

40. The system of claim 38 wherein said still image file includes foreground image files and background image files; and said developer program includes developer means for storing a background image. overlaying a foreground image onto said background image to create said current foreground image. comparing said current foreground image to said previous foreground image, and developing set-pixel records containing the differences in the colors of said pixels so that the pixels in the projected animation which are different will be changed.

41. The system of claim 40 wherein said developer further includes means for overlaying a plurality of said background images to develope said background image.

42. The system of claim 40 wherein said development program includes developer means for overlaying a foreground image onto said background image and keeping said overlayed image as the new background image.

43. The system of claim 37 wherein said animation file records have a fixed size of four bytes and the first byte of said records indicates a type of record so that the structure of the animation data file is optimized for the greatest storage efficiency and speed.

44. The system of claim 37 wherein said set pixel record files contain the location and color of the pixels of said display.

45. The system of claim 37 wherein said text records include a first record specifying the type of record and number of characters to be displayed in the text, a second record specifying the location, and three or more subsequent records containing said characters of said text.

46. A system for projecting an animated display onto a bit-mapped display screen of a computer comprising:

(a) an animation data file containing a series of set pixel records containing binary digit data which sets pixel color changes at prescribed pixel locations on said display screen in accordance with prescribed differences between successive still images which comprise said animated display displayed on said display screen, and a plurality of projection records containing binary digit data which controls the timing and repetition of said set pixel records: and

(b) a projector program for sequentially reading said set pixel records of said animation data file in said computer and for projecting said pixel color changes to repeatedly change an existing display screen to produce an animated display in accordance with said animation data file.

47. The system of claim 45 wherein said animation data file includes text records containing the color and position of text characters to be displayed on said display screen with said pixel records so that said projector program produces said animated display with text in said color and at said position at a specified time.

* * * * *

US005339413A

United States Patent [19]

Koval et al.

[11] **Patent Number: 5,339,413**

[45] **Date of Patent: Aug. 16, 1994**

[54] **DATA STREAM PROTOCOL FOR MULTIMEDIA DATA STREAMING DATA PROCESSING SYSTEM**

[75] Inventors: **Michael J. Koval; William W. Lawton,** both of Boca Raton; **John G. Tyler,** Boynton Beach; **Scott L. Winters,** Plantation, all of Fla.

[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[21] Appl. No.: **934,069**

[22] Filed: **Aug. 21, 1992**

[51] **Int. Cl.**[5] **G06F 13/00**

[52] **U.S. Cl.** **395/650;** 364/DIG. 1; 364/239.1; 364/239.7; 364/281.7

[58] **Field of Search** 395/154, 650, 250

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,251,209 10/1993 Jurkevich et al. 370/82

5,297,249 3/1994 Bernstein et al. 364/DIG. 1

Primary Examiner—Thomas M. Heckler

Attorney, Agent, or Firm—Bernard D. Bogdon

[57] **ABSTRACT**

A data stream is created for moving data from a source to a target in accordance with a stream protocol defined by controlling stream protocol control blocks (SPCBs) created from a predefined source SPCB and a predefined target SPCB. The controlling SPCBs include information establishing a plurality of data buffers that are used to efficiently stream or transfer data on a real-time basis. The controlling SPCBs are formed by a process of negotiation in which differences between the source and target SPCBs are reconciled in accordance with rules of negotiation. Once the data stream is created, it is then started by the application program and data is streamed until an end of stream is reached.

18 Claims, 16 Drawing Sheets

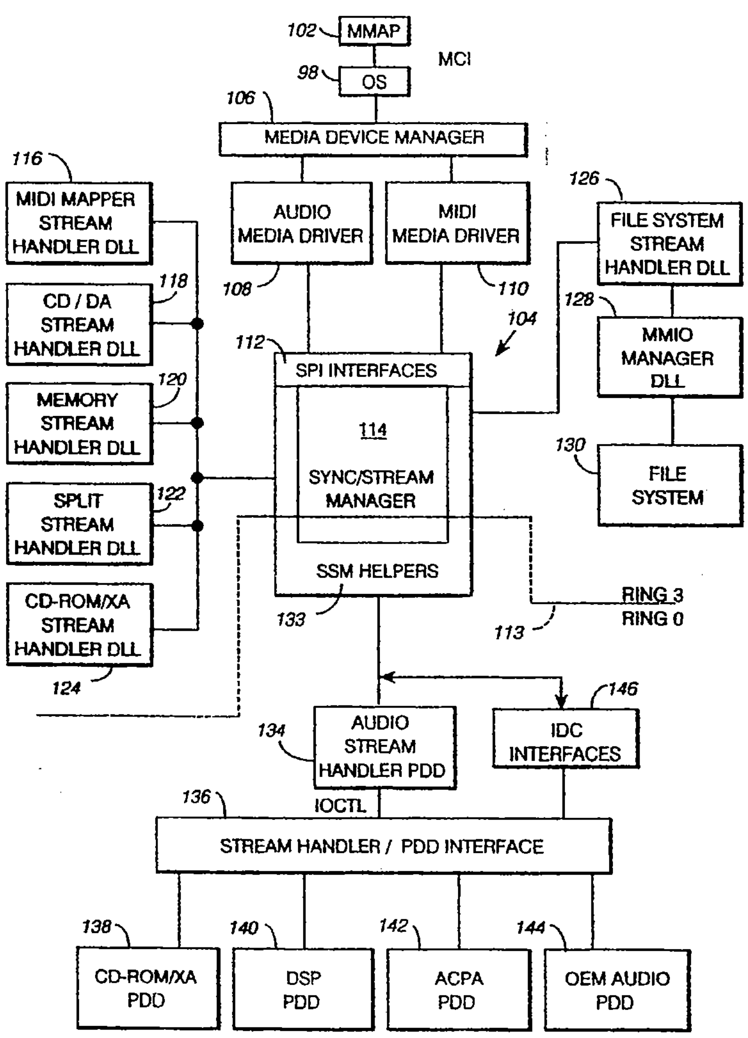


FIG. 1

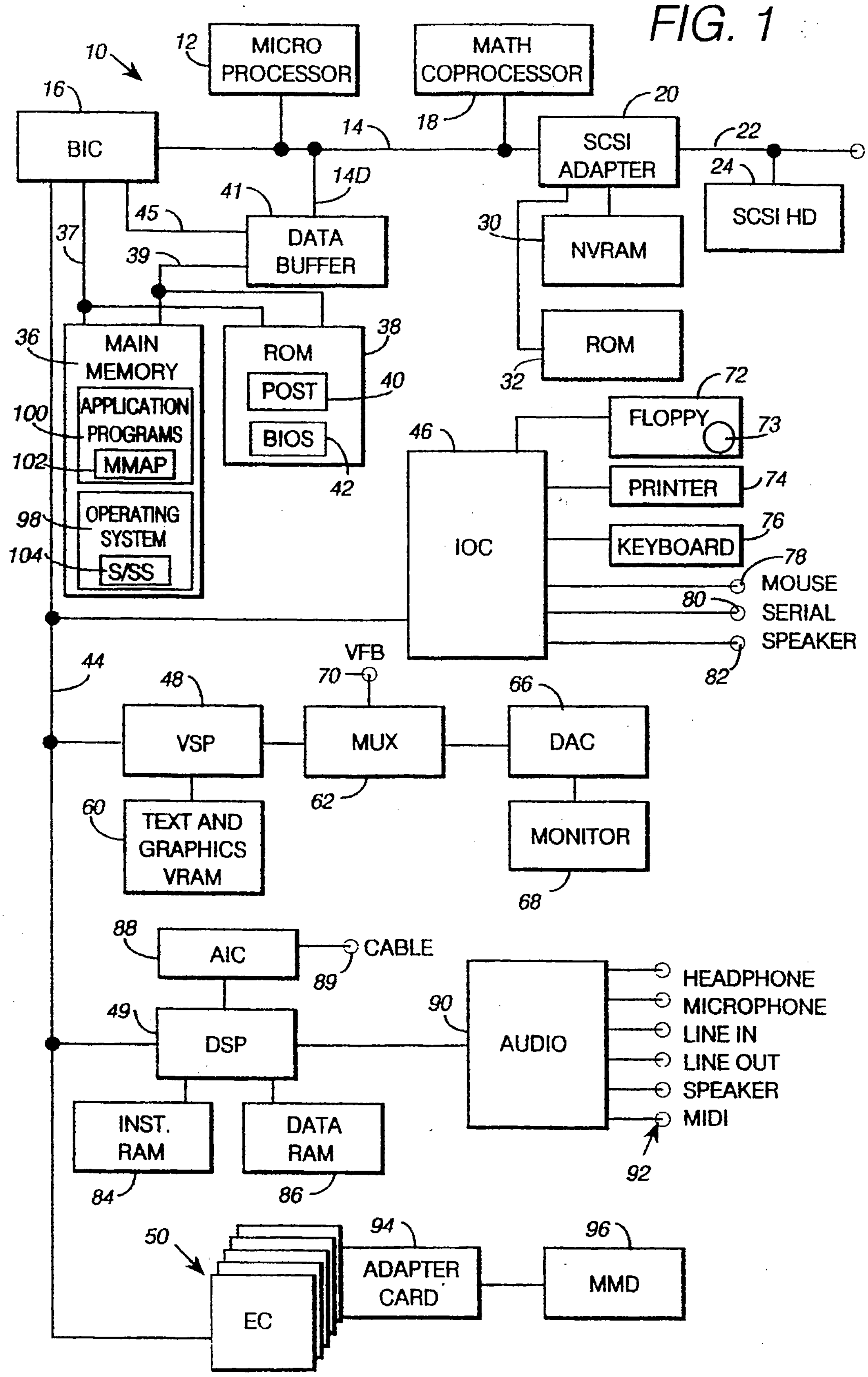

10
12
MICRO PROCESSOR
MATH COPROCESSOR
16
BIC
14
18
20
SCSI ADAPTER
22
24
SCSI HD
14D
41
45
DATA BUFFER
37
39
30
NVRAM
ROM
32
36
MAIN MEMORY
APPLICATION PROGRAMS
MMAP
OPERATING SYSTEM
S/SS
100
102
98
104
38
ROM
POST
40
BIOS
42
46
IOC
72
FLOPPY
73
PRINTER
74
KEYBOARD
76
78
MOUSE
80
SERIAL
SPEAKER
82
44
48
VSP
VFB
70
MUX
66
DAC
62
60
TEXT AND GRAPHICS VRAM
MONITOR
68
88
AIC
CABLE
89
49
DSP
90
AUDIO
HEADPHONE
MICROPHONE
LINE IN
LINE OUT
SPEAKER
MIDI
92
INST. RAM
84
DATA RAM
86
50
EC
94
ADAPTER CARD
96
MMD

FIG. 2

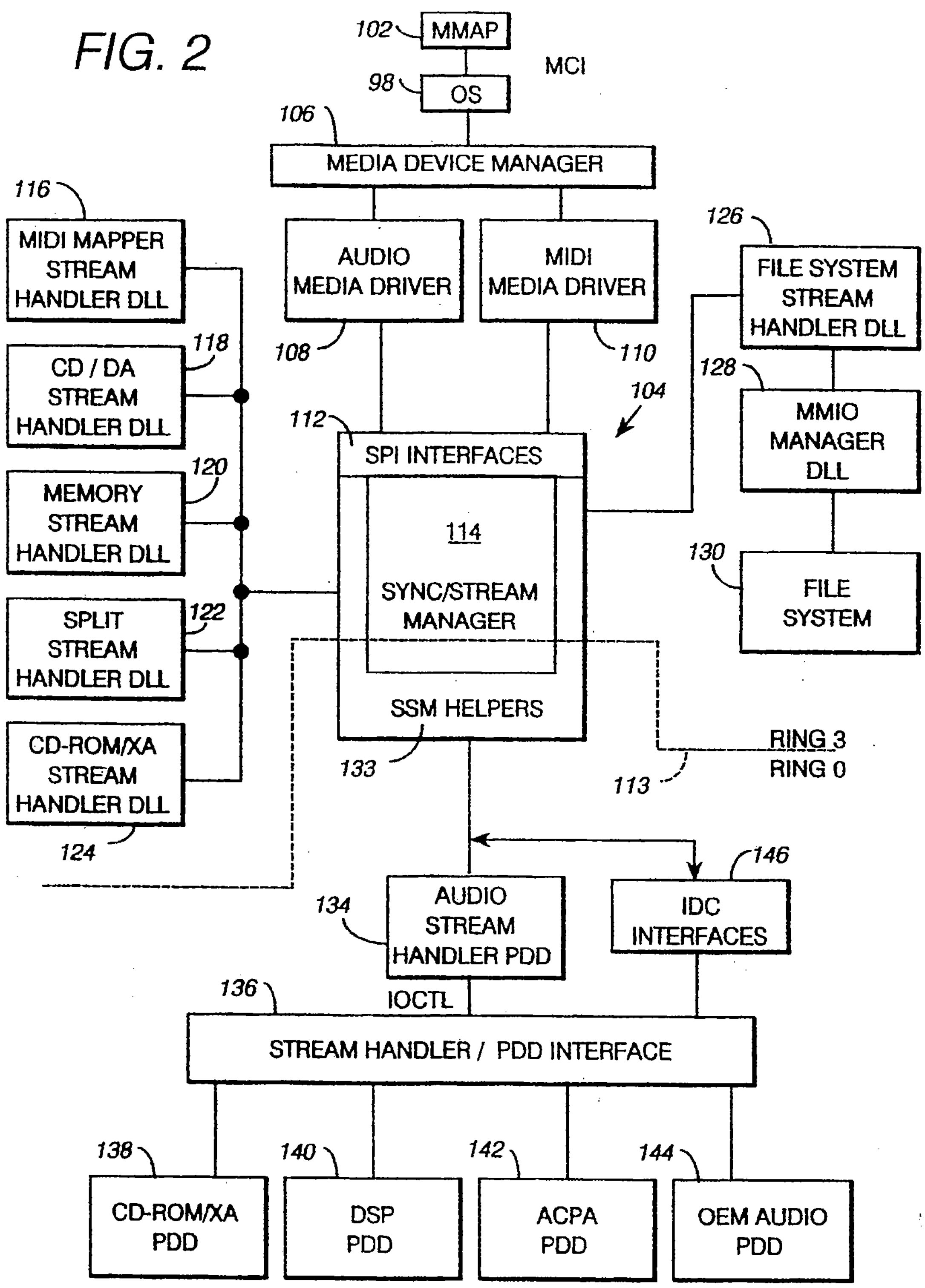

102
MMAP
MCI
98
OS
106
MEDIA DEVICE MANAGER
116
MIDI MAPPER STREAM HANDLER DLL
AUDIO MEDIA DRIVER
MIDI MEDIA DRIVER
126
FILE SYSTEM STREAM HANDLER DLL
118
CD / DA STREAM HANDLER DLL
108
110
104
128
MMIO MANAGER DLL
112
SPI INTERFACES
120
MEMORY STREAM HANDLER DLL
114
SYNC/STREAM MANAGER
130
FILE SYSTEM
122
SPLIT STREAM HANDLER DLL
SSM HELPERS
CD-ROM/XA STREAM HANDLER DLL
133
113
RING 3
RING 0
124
146
134
AUDIO STREAM HANDLER PDD
IDC INTERFACES
136
IOCTL
STREAM HANDLER / PDD INTERFACE
138
140
142
144
CD-ROM/XA PDD
DSP PDD
ACPA PDD
OEM AUDIO PDD

FIG. 3

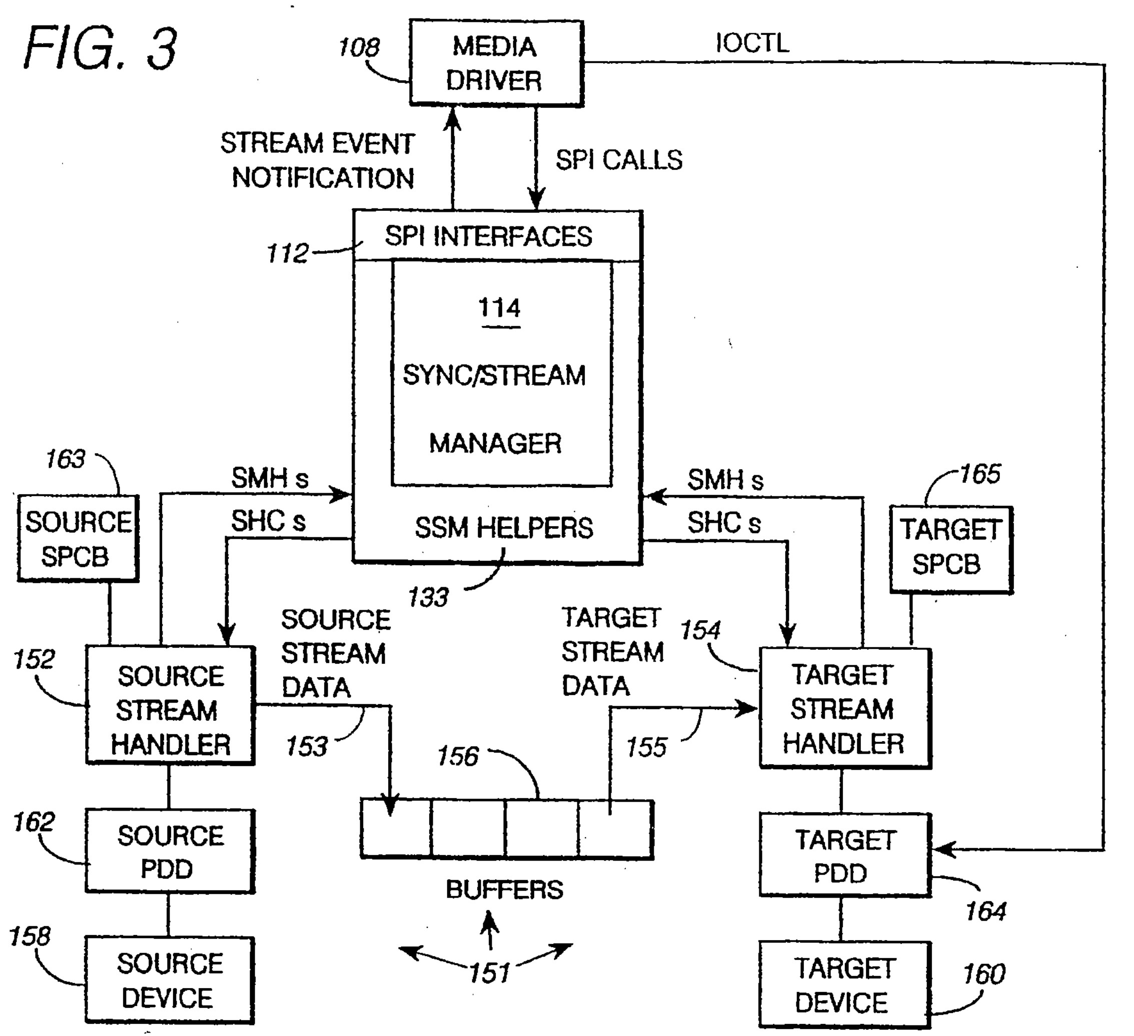

MEDIA DRIVER
108
IOCTL
STREAM EVENT NOTIFICATION
SPI CALLS
SPI INTERFACES
112
114
SYNC/STREAM MANAGER
SSM HELPERS
133
SMH s
SHC s
SMH s
SHC s
163
SOURCE SPCB
165
TARGET SPCB
SOURCE STREAM DATA
TARGET STREAM DATA
152
SOURCE STREAM HANDLER
154
TARGET STREAM HANDLER
153
156
155
BUFFERS
151
162
SOURCE PDD
TARGET PDD
164
158
SOURCE DEVICE
TARGET DEVICE
160

FIG. 4

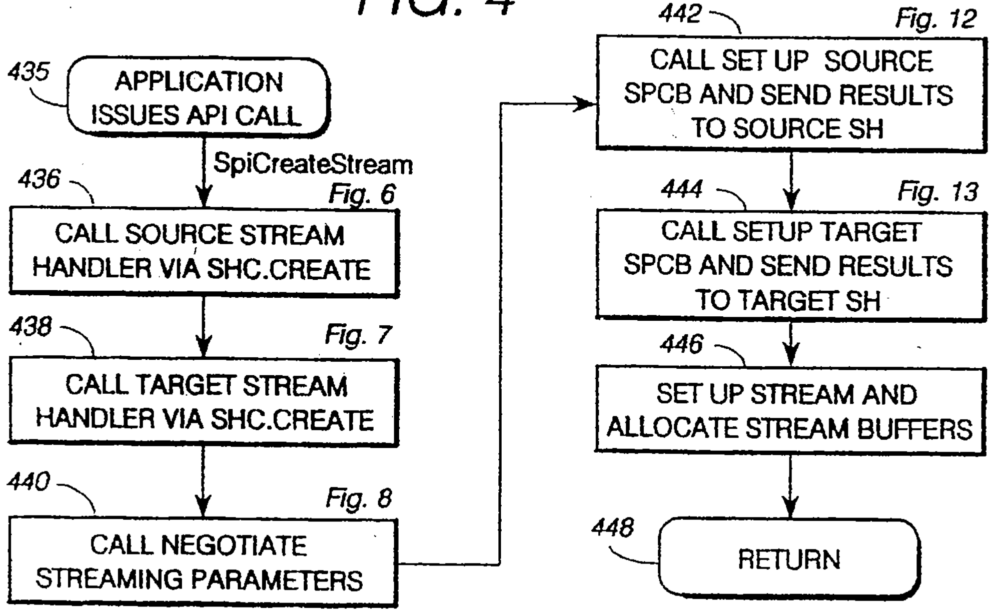

435
APPLICATION ISSUES API CALL
SpiCreateStream
436
Fig. 6
CALL SOURCE STREAM HANDLER VIA SHC.CREATE
438
Fig. 7
CALL TARGET STREAM HANDLER VIA SHC.CREATE
440
Fig. 8
CALL NEGOTIATE STREAMING PARAMETERS
442
Fig. 12
CALL SET UP SOURCE SPCB AND SEND RESULTS TO SOURCE SH
444
Fig. 13
CALL SETUP TARGET SPCB AND SEND RESULTS TO TARGET SH
446
SET UP STREAM AND ALLOCATE STREAM BUFFERS
448
RETURN

FIG.5

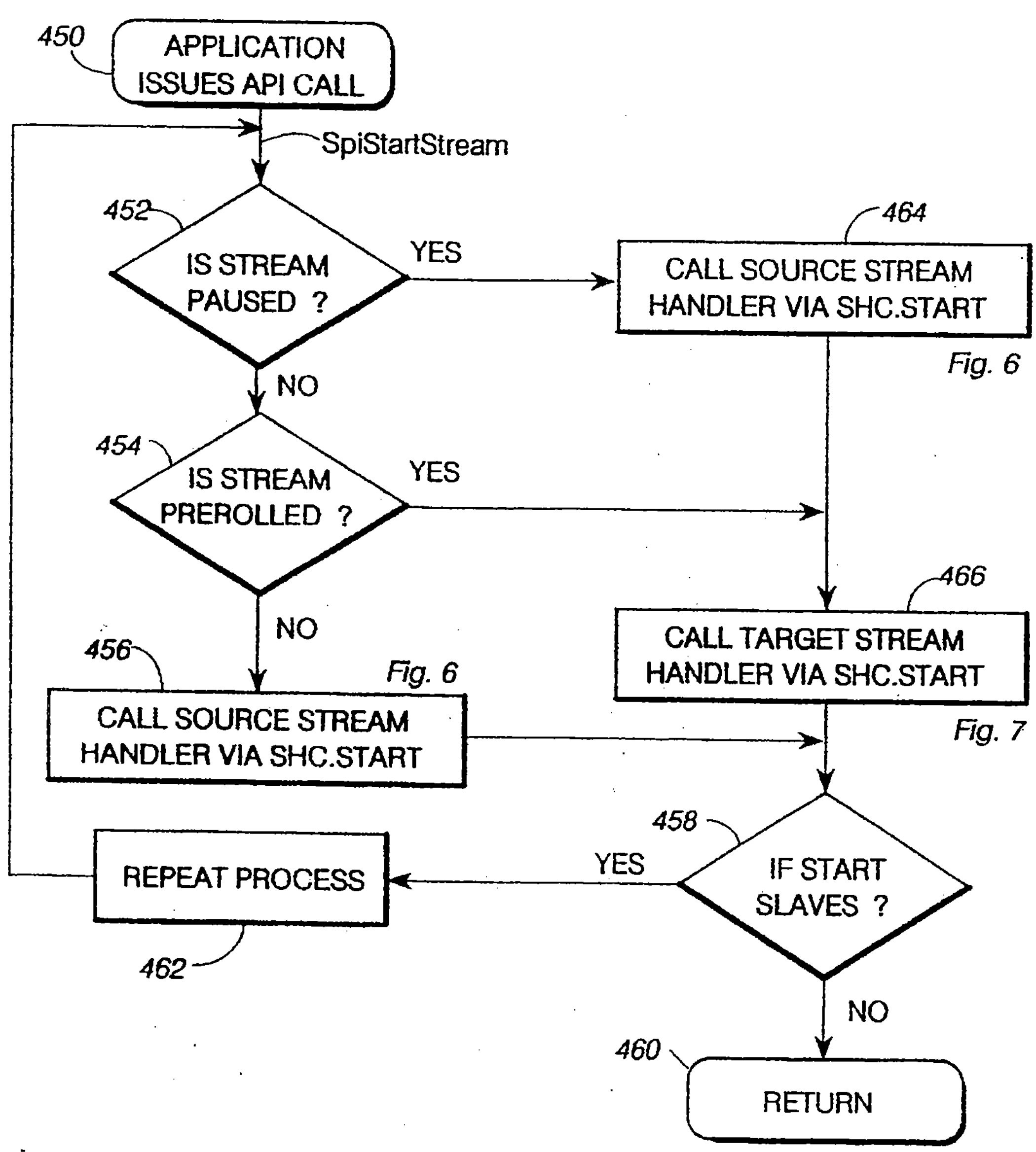

450
APPLICATION ISSUES API CALL
SpiStartStream
452
IS STREAM PAUSED ?
YES
NO
464
CALL SOURCE STREAM HANDLER VIA SHC.START
Fig. 6
454
IS STREAM PREROLLED ?
YES
NO
466
CALL TARGET STREAM HANDLER VIA SHC.START
Fig. 7
456
CALL SOURCE STREAM HANDLER VIA SHC.START
Fig. 6
458
IF START SLAVES ?
YES
REPEAT PROCESS
462
NO
460
RETURN

FIG. 6

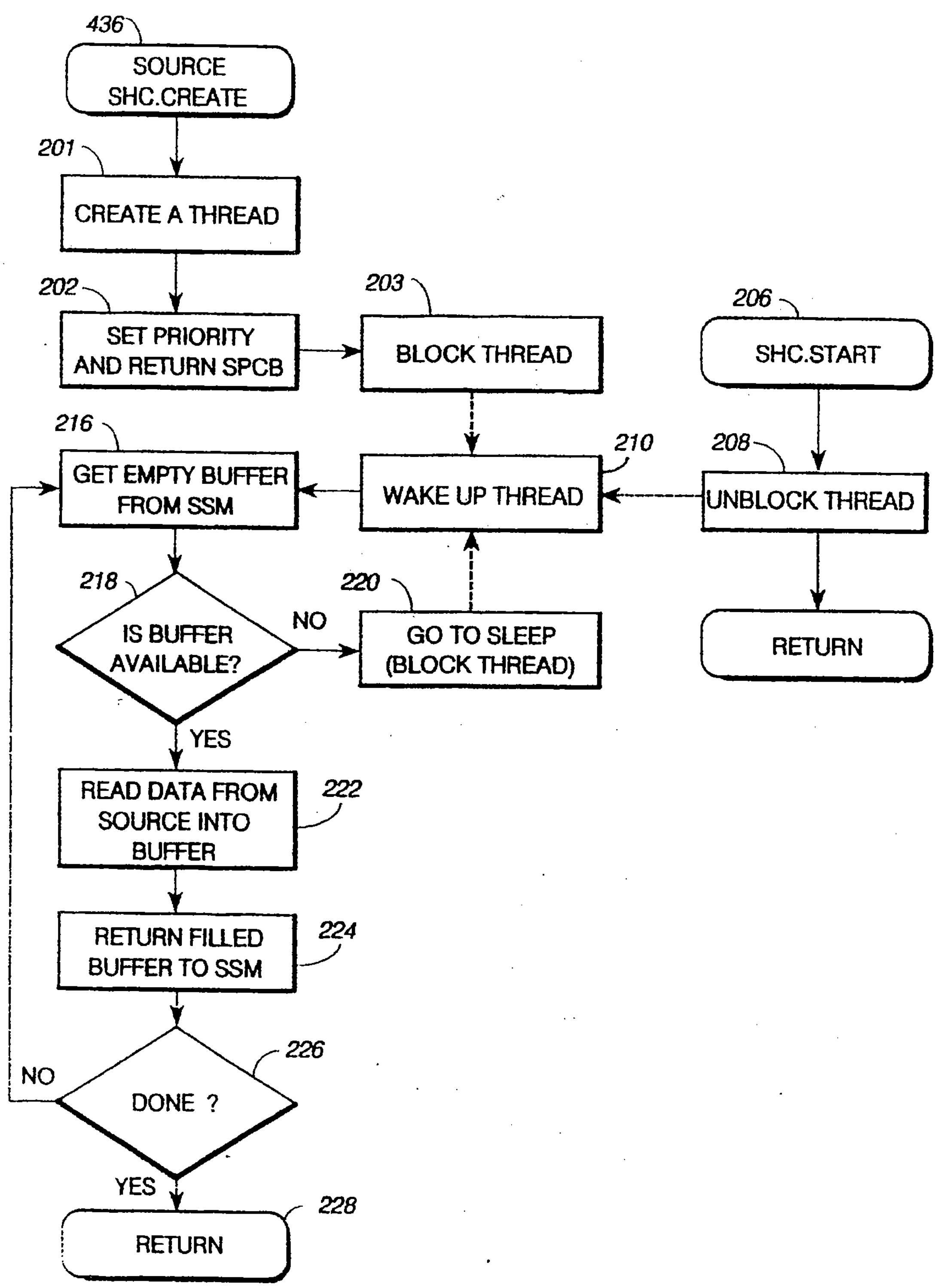

436
SOURCE SHC.CREATE
201
CREATE A THREAD
202
SET PRIORITY AND RETURN SPCB
203
BLOCK THREAD
206
SHC.START
216
GET EMPTY BUFFER FROM SSM
WAKE UP THREAD
210
208
UNBLOCK THREAD
218
IS BUFFER AVAILABLE?
NO
220
GO TO SLEEP (BLOCK THREAD)
RETURN
YES
READ DATA FROM SOURCE INTO BUFFER
222
RETURN FILLED BUFFER TO SSM
224
NO
DONE ?
226
YES
RETURN
228

FIG. 7

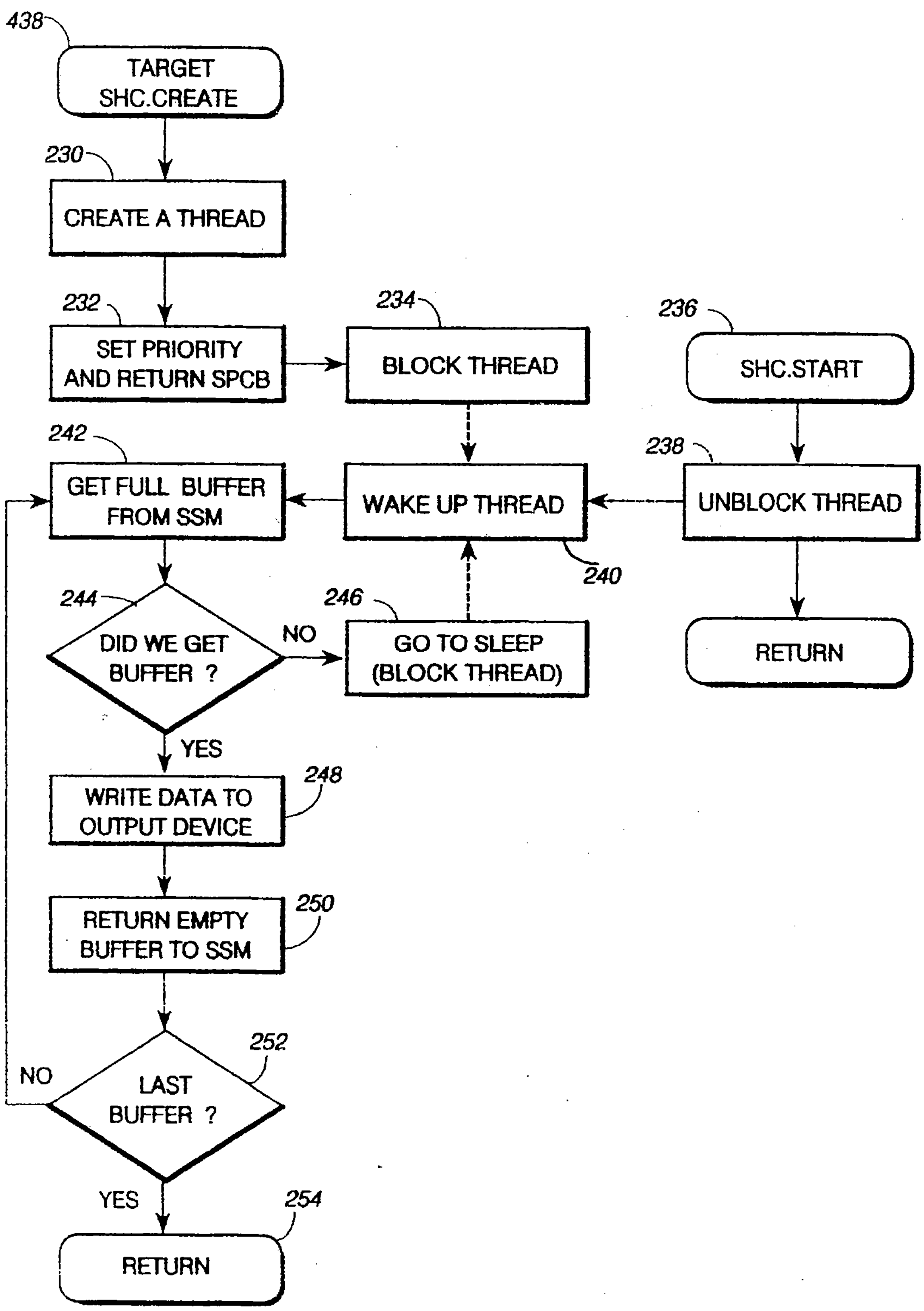

438
TARGET SHC.CREATE
230
CREATE A THREAD
232
SET PRIORITY AND RETURN SPCB
234
BLOCK THREAD
236
SHC.START
242
GET FULL BUFFER FROM SSM
WAKE UP THREAD
238
UNBLOCK THREAD
240
244
DID WE GET BUFFER ?
NO
246
GO TO SLEEP (BLOCK THREAD)
RETURN
YES
248
WRITE DATA TO OUTPUT DEVICE
250
RETURN EMPTY BUFFER TO SSM
252
NO
LAST BUFFER ?
YES
254
RETURN

FIG. 8

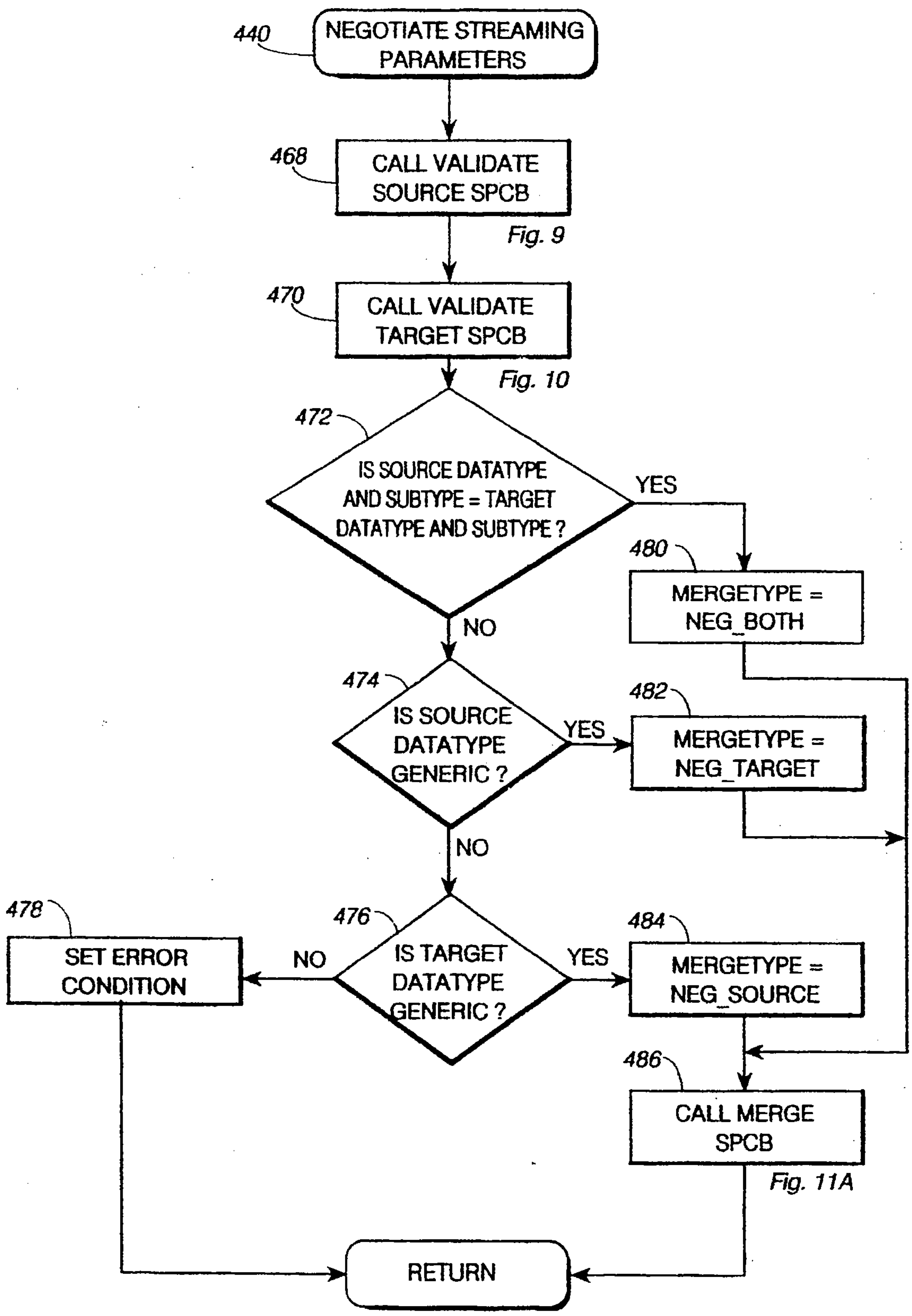

440
NEGOTIATE STREAMING PARAMETERS
468
CALL VALIDATE SOURCE SPCB
Fig. 9
470
CALL VALIDATE TARGET SPCB
Fig. 10
472
IS SOURCE DATATYPE AND SUBTYPE = TARGET DATATYPE AND SUBTYPE ?
YES
480
MERGETYPE = NEG_BOTH
NO
474
IS SOURCE DATATYPE GENERIC ?
YES
482
MERGETYPE = NEG_TARGET
NO
478
SET ERROR CONDITION
NO
476
IS TARGET DATATYPE GENERIC ?
YES
484
MERGETYPE = NEG_SOURCE
486
CALL MERGE SPCB
Fig. 11A
RETURN

FIG. 9

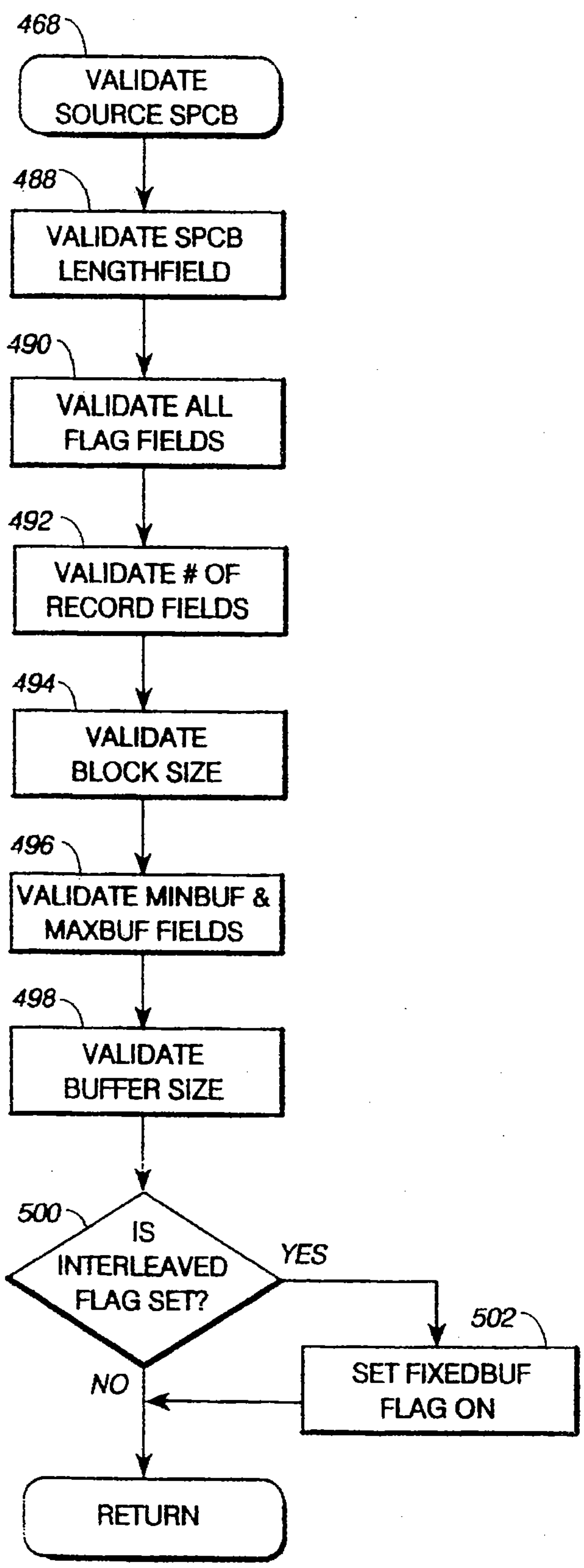

468
VALIDATE SOURCE SPCB
488
VALIDATE SPCB LENGTHFIELD
490
VALIDATE ALL FLAG FIELDS
492
VALIDATE # OF RECORD FIELDS
494
VALIDATE BLOCK SIZE
496
VALIDATE MINBUF & MAXBUF FIELDS
498
VALIDATE BUFFER SIZE
500
IS INTERLEAVED FLAG SET?
YES
502
SET FIXEDBUF FLAG ON
NO
RETURN

FIG. 10

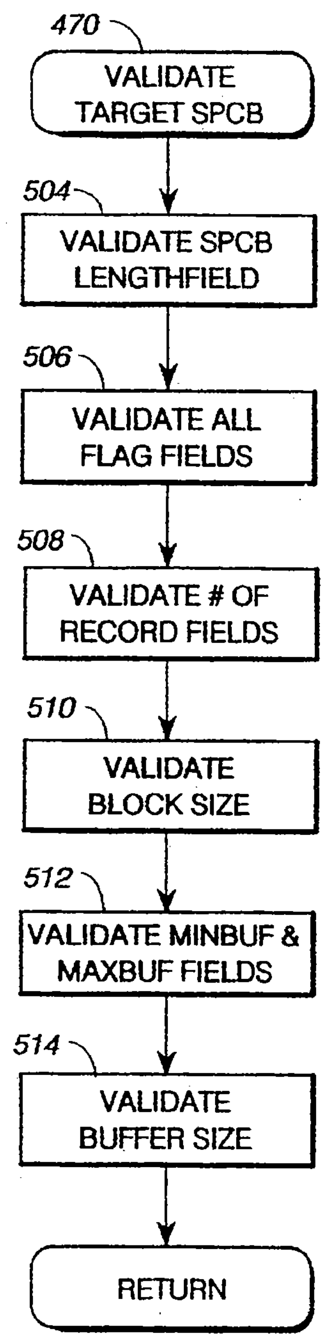

470
VALIDATE TARGET SPCB
504
VALIDATE SPCB LENGTHFIELD
506
VALIDATE ALL FLAG FIELDS
508
VALIDATE # OF RECORD FIELDS
510
VALIDATE BLOCK SIZE
512
VALIDATE MINBUF & MAXBUF FIELDS
514
VALIDATE BUFFER SIZE
RETURN

FIG. 11A

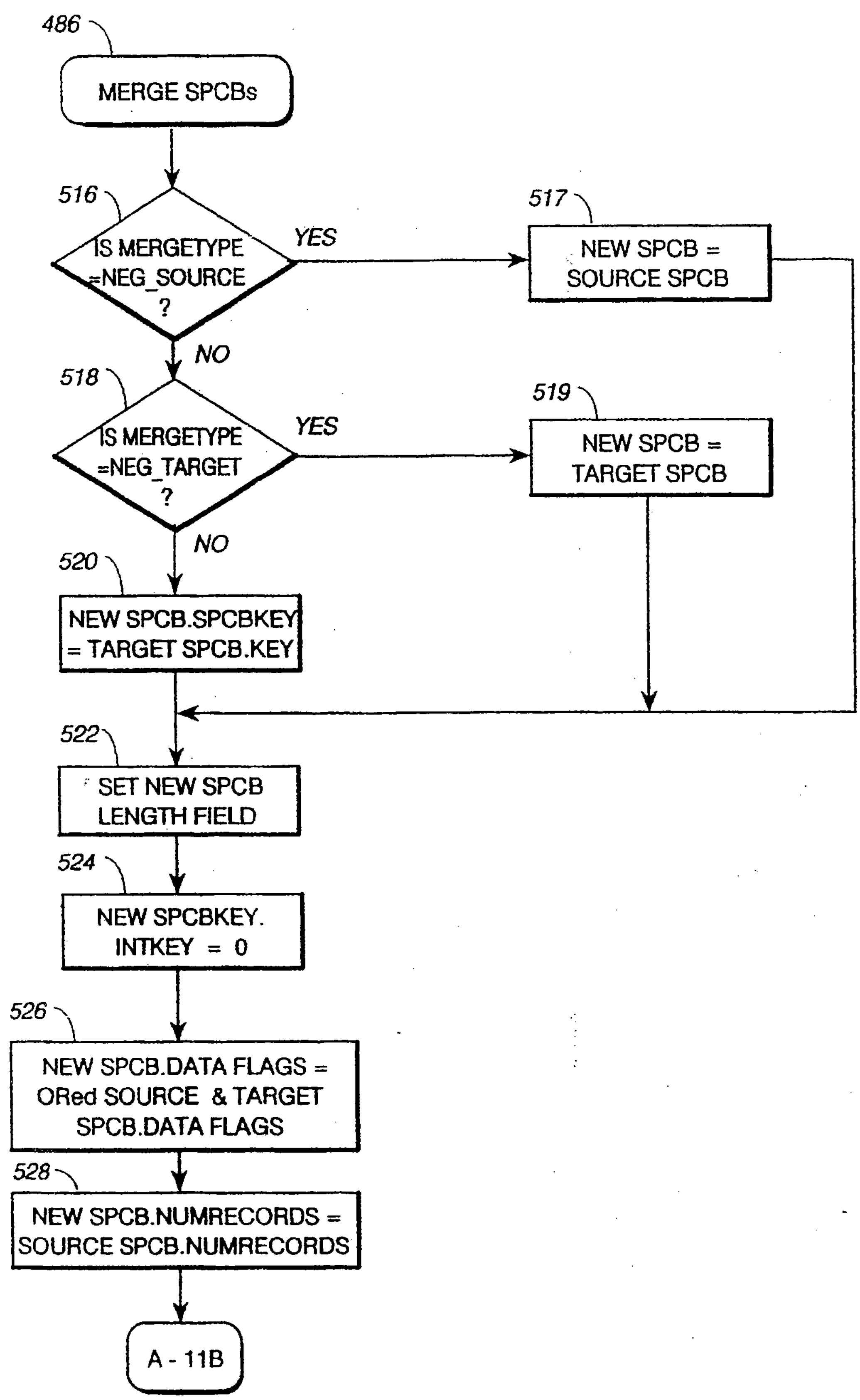

486
MERGE SPCBs
516
IS MERGETYPE =NEG_SOURCE ?
YES
517
NEW SPCB = SOURCE SPCB
NO
518
IS MERGETYPE =NEG_TARGET ?
YES
519
NEW SPCB = TARGET SPCB
NO
520
NEW SPCB.SPCBKEY = TARGET SPCB.KEY
522
SET NEW SPCB LENGTH FIELD
524
NEW SPCBKEY. INTKEY = 0
526
NEW SPCB.DATA FLAGS = ORed SOURCE & TARGET SPCB.DATA FLAGS
528
NEW SPCB.NUMRECORDS = SOURCE SPCB.NUMRECORDS
A - 11B

FIG. 11B

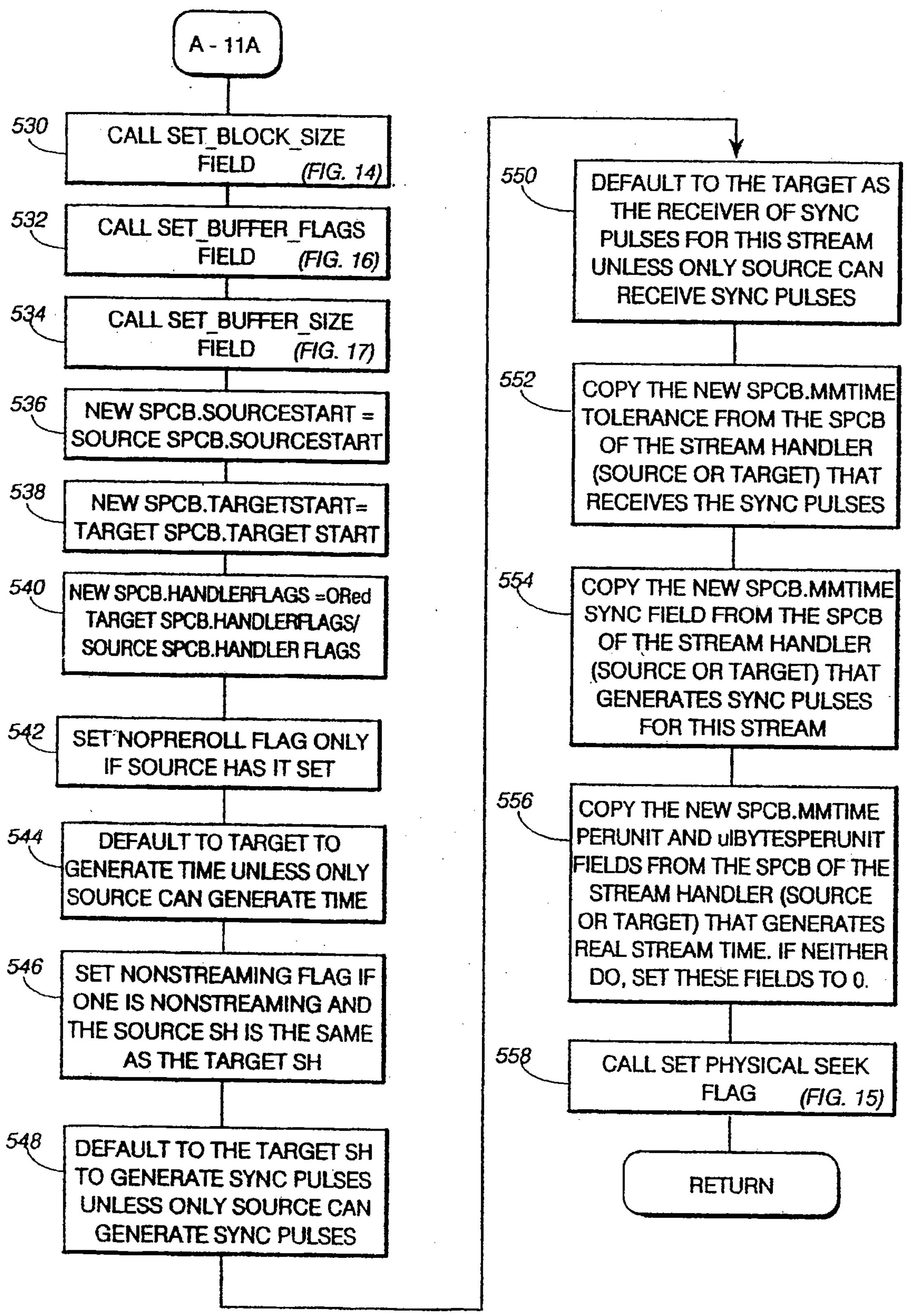

A - 11A
530
CALL SET_BLOCK_SIZE FIELD (FIG. 14)
532
CALL SET_BUFFER_FLAGS FIELD (FIG. 16)
534
CALL SET_BUFFER_SIZE FIELD (FIG. 17)
536
NEW SPCB.SOURCESTART = SOURCE SPCB.SOURCESTART
538
NEW SPCB.TARGETSTART= TARGET SPCB.TARGET START
540
NEW SPCB.HANDLERFLAGS =ORed TARGET SPCB.HANDLERFLAGS/ SOURCE SPCB.HANDLER FLAGS
542
SET NOPREROLL FLAG ONLY IF SOURCE HAS IT SET
544
DEFAULT TO TARGET TO GENERATE TIME UNLESS ONLY SOURCE CAN GENERATE TIME
546
SET NONSTREAMING FLAG IF ONE IS NONSTREAMING AND THE SOURCE SH IS THE SAME AS THE TARGET SH
548
DEFAULT TO THE TARGET SH TO GENERATE SYNC PULSES UNLESS ONLY SOURCE CAN GENERATE SYNC PULSES
550
DEFAULT TO THE TARGET AS THE RECEIVER OF SYNC PULSES FOR THIS STREAM UNLESS ONLY SOURCE CAN RECEIVE SYNC PULSES
552
COPY THE NEW SPCB.MMTIME TOLERANCE FROM THE SPCB OF THE STREAM HANDLER (SOURCE OR TARGET) THAT RECEIVES THE SYNC PULSES
554
COPY THE NEW SPCB.MMTIME SYNC FIELD FROM THE SPCB OF THE STREAM HANDLER (SOURCE OR TARGET) THAT GENERATES SYNC PULSES FOR THIS STREAM
556
COPY THE NEW SPCB.MMTIME PERUNIT AND ulBYTESPERUNIT FIELDS FROM THE SPCB OF THE STREAM HANDLER (SOURCE OR TARGET) THAT GENERATES REAL STREAM TIME. IF NEITHER DO, SET THESE FIELDS TO 0.
558
CALL SET PHYSICAL SEEK FLAG (FIG. 15)
RETURN

FIG. 12

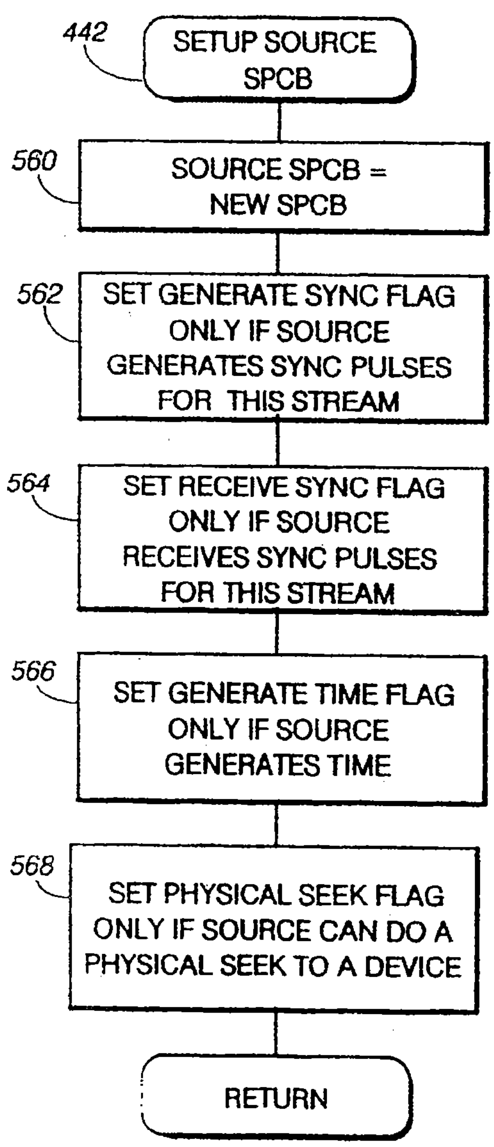
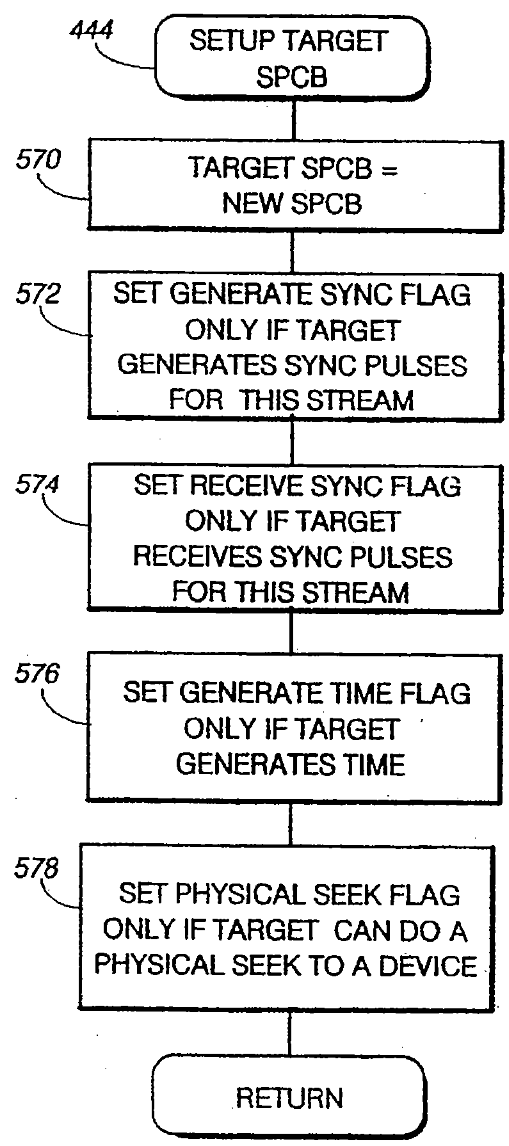

442
SETUP SOURCE SPCB
560
SOURCE SPCB = NEW SPCB
562
SET GENERATE SYNC FLAG ONLY IF SOURCE GENERATES SYNC PULSES FOR THIS STREAM
564
SET RECEIVE SYNC FLAG ONLY IF SOURCE RECEIVES SYNC PULSES FOR THIS STREAM
566
SET GENERATE TIME FLAG ONLY IF SOURCE GENERATES TIME
568
SET PHYSICAL SEEK FLAG ONLY IF SOURCE CAN DO A PHYSICAL SEEK TO A DEVICE
RETURN

FIG. 13


444
SETUP TARGET SPCB
570
TARGET SPCB = NEW SPCB
572
SET GENERATE SYNC FLAG ONLY IF TARGET GENERATES SYNC PULSES FOR THIS STREAM
574
SET RECEIVE SYNC FLAG ONLY IF TARGET RECEIVES SYNC PULSES FOR THIS STREAM
576
SET GENERATE TIME FLAG ONLY IF TARGET GENERATES TIME
578
SET PHYSICAL SEEK FLAG ONLY IF TARGET CAN DO A PHYSICAL SEEK TO A DEVICE
RETURN

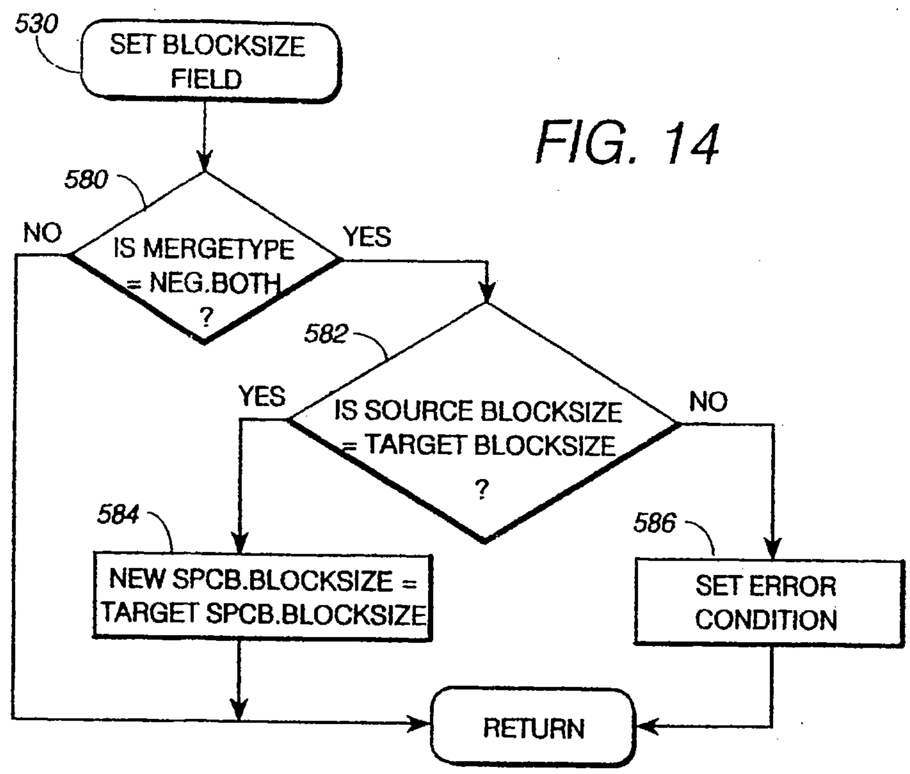

530
SET BLOCKSIZE FIELD
580
IS MERGETYPE = NEG.BOTH ?
NO
YES
582
IS SOURCE BLOCKSIZE = TARGET BLOCKSIZE ?
YES
NO
584
NEW SPCB.BLOCKSIZE = TARGET SPCB.BLOCKSIZE
586
SET ERROR CONDITION
RETURN

FIG. 14

FIG. 15

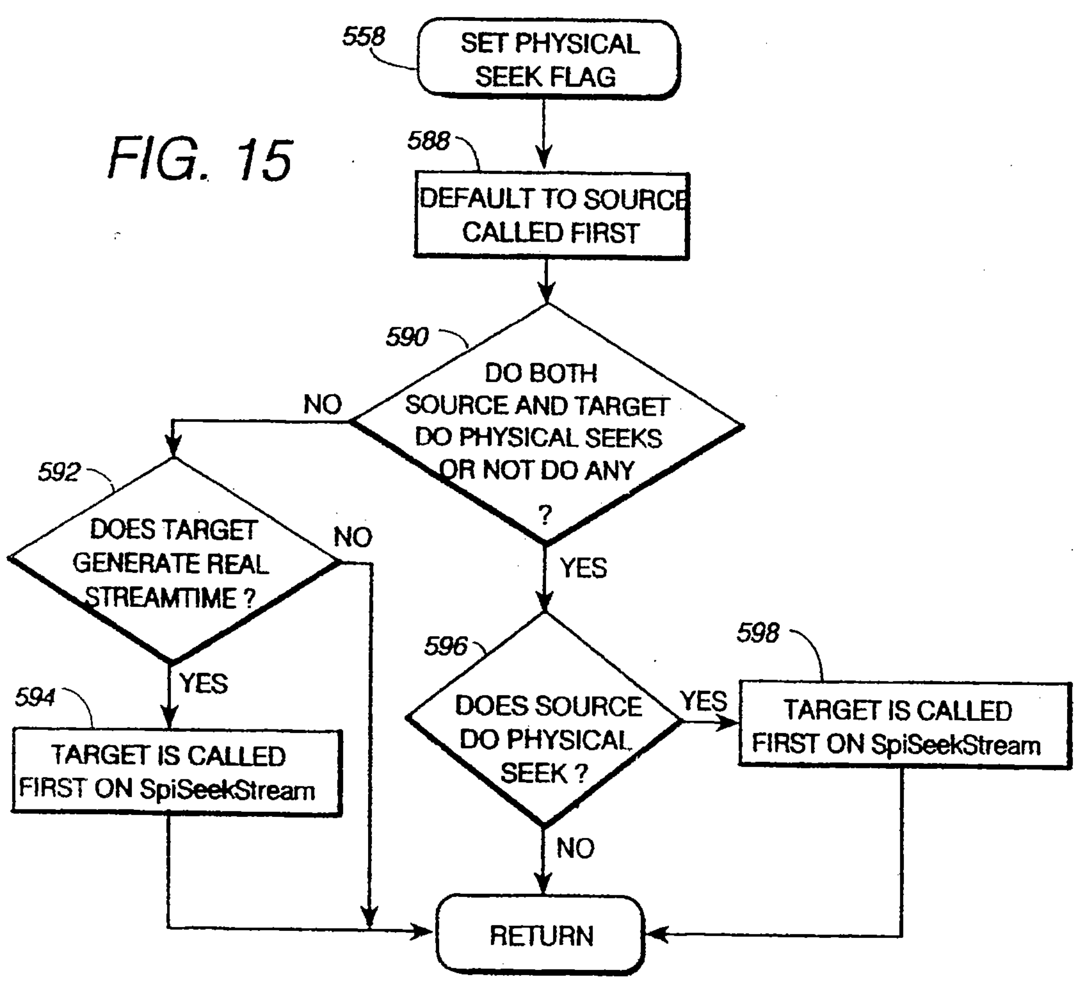

558
SET PHYSICAL SEEK FLAG
588
DEFAULT TO SOURCE CALLED FIRST
590
DO BOTH SOURCE AND TARGET DO PHYSICAL SEEKS OR NOT DO ANY ?
NO
YES
592
DOES TARGET GENERATE REAL STREAMTIME ?
NO
YES
594
TARGET IS CALLED FIRST ON SpiSeekStream
596
DOES SOURCE DO PHYSICAL SEEK ?
YES
NO
598
TARGET IS CALLED FIRST ON SpiSeekStream
RETURN

FIG. 16

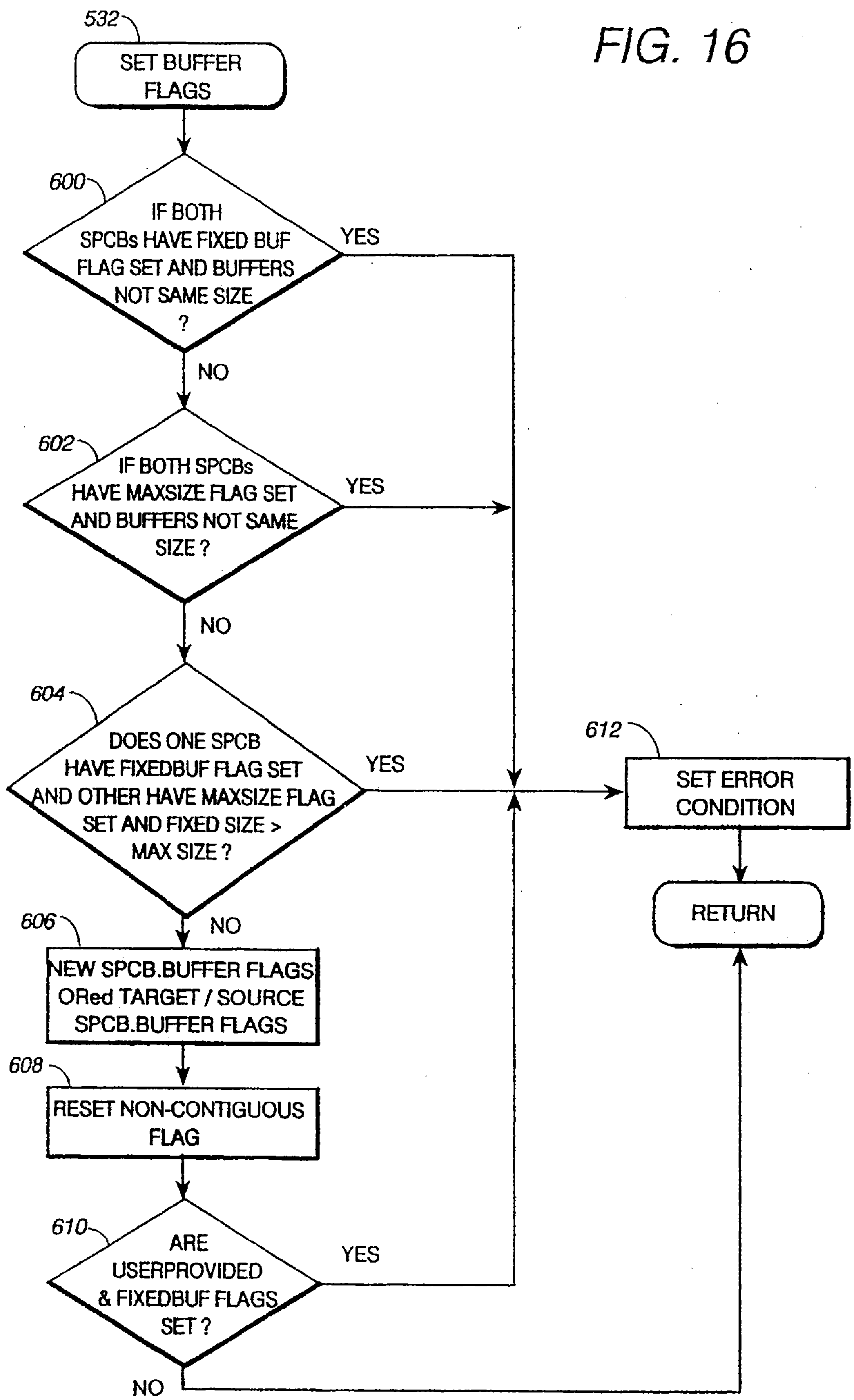

532
SET BUFFER FLAGS
600
IF BOTH SPCBs HAVE FIXED BUF FLAG SET AND BUFFERS NOT SAME SIZE ?
YES
NO
602
IF BOTH SPCBs HAVE MAXSIZE FLAG SET AND BUFFERS NOT SAME SIZE ?
YES
NO
604
DOES ONE SPCB HAVE FIXEDBUF FLAG SET AND OTHER HAVE MAXSIZE FLAG SET AND FIXED SIZE > MAX SIZE ?
YES
NO
606
NEW SPCB.BUFFER FLAGS ORed TARGET / SOURCE SPCB.BUFFER FLAGS
608
RESET NON-CONTIGUOUS FLAG
610
ARE USERPROVIDED & FIXEDBUF FLAGS SET ?
YES
NO
612
SET ERROR CONDITION
RETURN

FIG. 17A

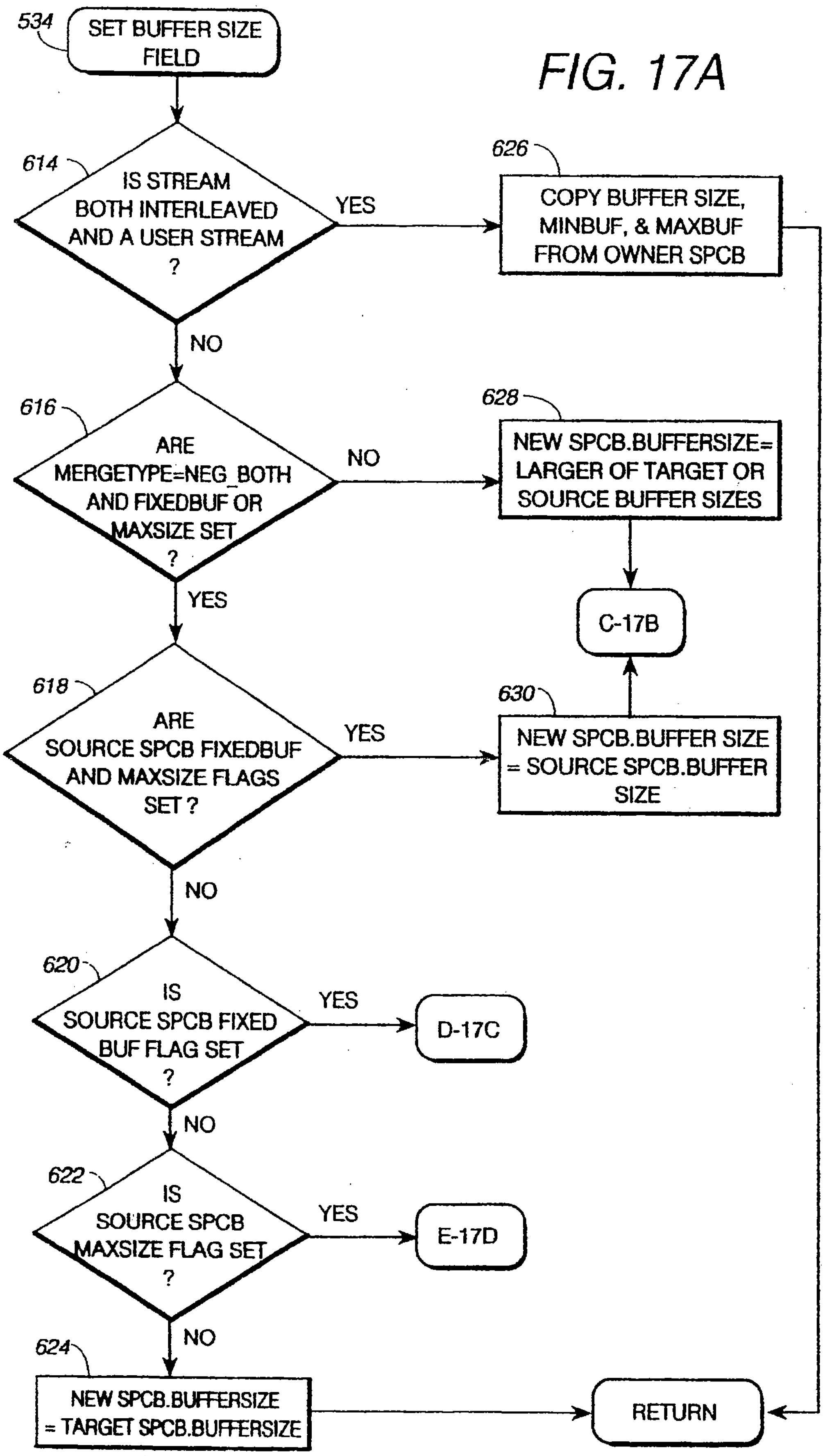

534
SET BUFFER SIZE FIELD
614
IS STREAM BOTH INTERLEAVED AND A USER STREAM ?
YES
626
COPY BUFFER SIZE, MINBUF, & MAXBUF FROM OWNER SPCB
NO
616
ARE MERGETYPE=NEG_BOTH AND FIXEDBUF OR MAXSIZE SET ?
NO
628
NEW SPCB.BUFFERSIZE= LARGER OF TARGET OR SOURCE BUFFER SIZES
YES
C-17B
618
ARE SOURCE SPCB FIXEDBUF AND MAXSIZE FLAGS SET ?
YES
630
NEW SPCB.BUFFER SIZE = SOURCE SPCB.BUFFER SIZE
NO
620
IS SOURCE SPCB FIXED BUF FLAG SET ?
YES
D-17C
NO
622
IS SOURCE SPCB MAXSIZE FLAG SET ?
YES
E-17D
NO
624
NEW SPCB.BUFFERSIZE = TARGET SPCB.BUFFERSIZE
RETURN

FIG. 17B

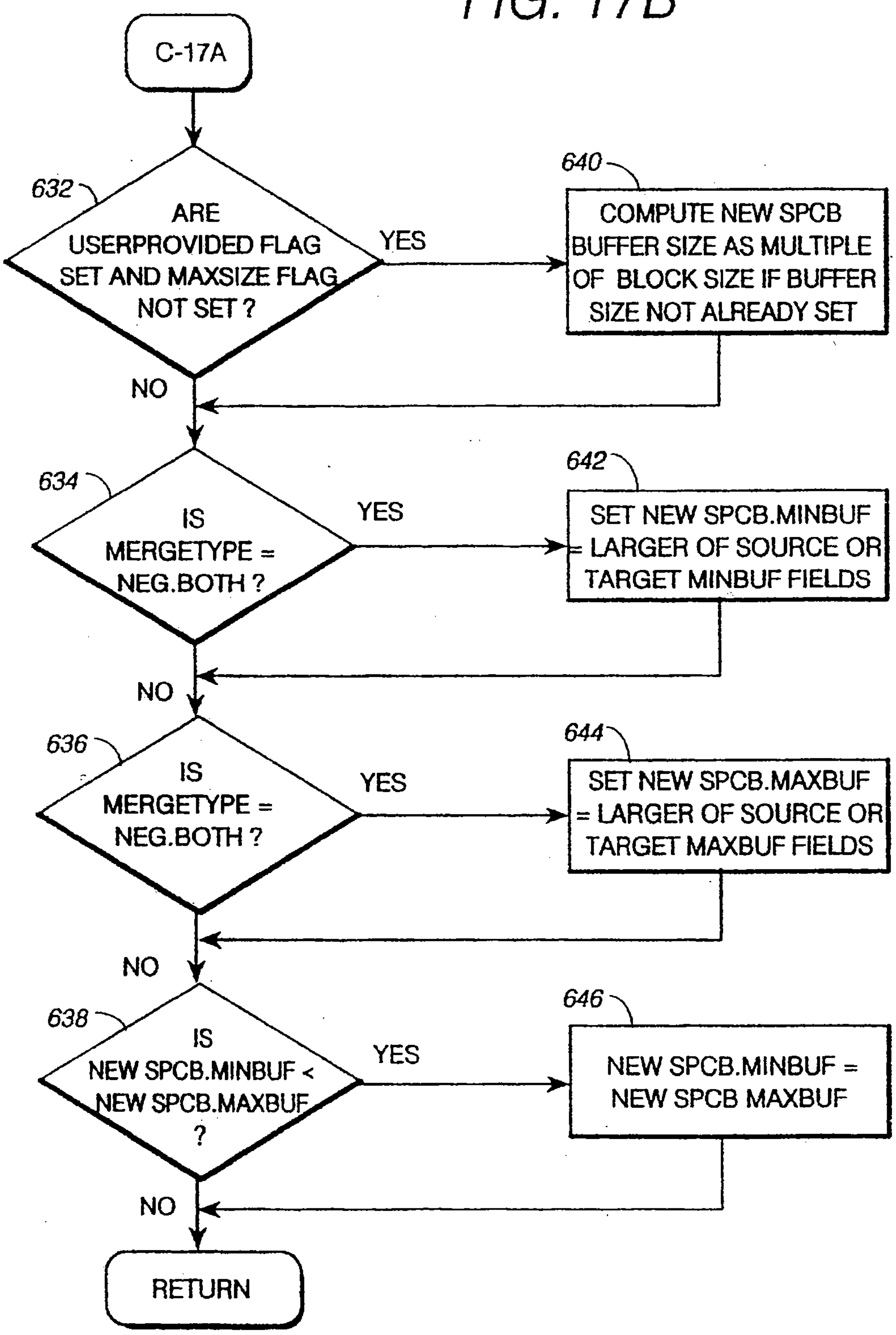

C-17A
632
ARE USERPROVIDED FLAG SET AND MAXSIZE FLAG NOT SET ?
YES
640
COMPUTE NEW SPCB BUFFER SIZE AS MULTIPLE OF BLOCK SIZE IF BUFFER SIZE NOT ALREADY SET
NO
634
IS MERGETYPE = NEG.BOTH ?
YES
642
SET NEW SPCB.MINBUF = LARGER OF SOURCE OR TARGET MINBUF FIELDS
NO
636
IS MERGETYPE = NEG.BOTH ?
YES
644
SET NEW SPCB.MAXBUF = LARGER OF SOURCE OR TARGET MAXBUF FIELDS
NO
638
IS NEW SPCB.MINBUF < NEW SPCB.MAXBUF ?
YES
646
NEW SPCB.MINBUF = NEW SPCB MAXBUF
NO
RETURN

FIG. 17C

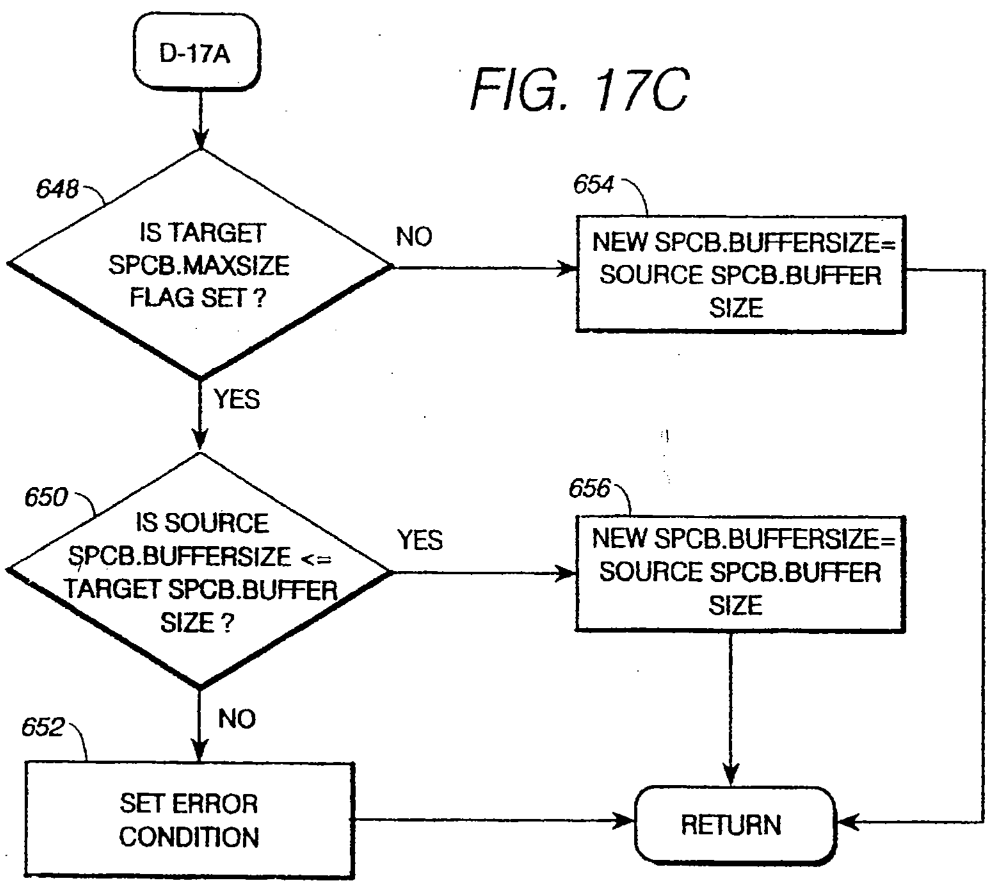
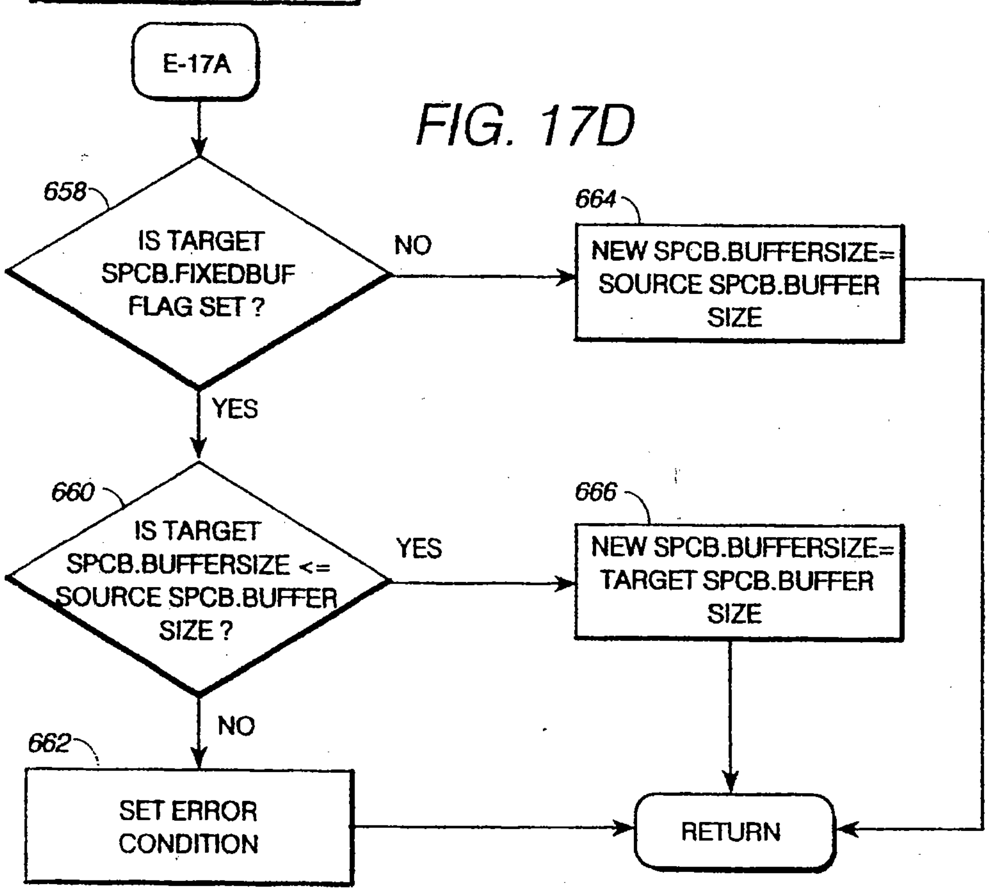


FIG. 17D



DATA STREAM PROTOCOL FOR MULTIMEDIA DATA STREAMING DATA PROCESSING SYSTEM

RELATED APPLICATIONS

The following applications, which are assigned to the same assignee of this application and are hereby incorporated herein by reference, are related:

(1) "PERSONAL COMPUTER WITH GENERALIZED DATA STREAMING APPARATUS FOR MULTIMEDIA DEVICES" Ser. No. 07/816,517, filed Dec. 31, 1991, by C.A. Dinallo et al, abandoned; and

(2) "SYNCHRONIZATION TECHNIQUES FOR MULTIMEDIA DATA STREAMS", Ser. No. 07/815,652, filed Dec. 31, 1991, by M.J. Koval et al.

BACKGROUND OF THE INVENTION

A multimedia data processing system is designed to present various multimedia materials in various combinations of text, graphics, video, image, animation, sound, etc. Such a system is a combination of hardware and software. The hardware includes a personal computer to which various multimedia devices can be attached. The hardware runs under the control of an operating system and multimedia application programs.

Multimedia applications impose heavy demands on the operating system to move large amounts of data from device to device, from system memory to a device, or vice-versa, in a continuous, real-time manner. Multimedia systems must support a flexible yet consistent means for transporting these large data objects, and control this activity accurately in real time. Adding new multimedia devices and data types should require minimal, if any, new system extension code. The total real memory requirements at run time must be minimized, so that system performance is not degraded. Also, support for complex data types and devices that manipulate interleaved data objects, must be provided. Finally, it must be possible to implement each multimedia data transport control means at the most appropriate system privilege level. Operating system extensions that support multimedia data types and devices must provide the ability to control the many different multimedia I/O devices and to transport, or stream, large multimedia data objects within real-time constraints.

Multimedia applications control the input and output of large amounts of data, including the continual display of bitmaps, output of digitized audio waveforms or MIDI audio sequences, input of digitized audio from an analog microphone or line source, etc. Applications control the data flow in the context of a real-time clock: certain events under program control occur at explicitly defined points in time, and these points are defined very accurately (e.g., in milliseconds).

Given only OS/2 control program services such as DOS calls, or similar services in other operating systems such as AIX or UNIX, controlling the level of function at the application programming interface requires highly complex, device-specific, data transport control modules. Even if such modules are created, there is no guarantee that the threads controlling each I/O operation would execute within their required time intervals. To address this problem, the application needs to add sophisticated semaphore logic and make the I/O control threads time critical. The nature of multitasking operating systems, combined with the high data throughput load common to multimedia applications, will at times prevent data from being delivered to the destination device within the allotted time interval. Failing to meet these real-time requirements results in visible or audible defects in the multimedia presentation.

A system solution for controlling many heterogeneous, multimedia hardware devices requires consistent support for widely divergent data types and real-time-dependent system response capabilities. The system must provide the capability to manage different device specific and data type specific behaviors in a generalized, consistent, device and data type independent interface. The ability of applications to readily control (i.e. tune) these behaviors, where necessary, is also a key requirement. The invention is directed to a multimedia data streaming protocol which overcomes the above difficulties meets the above criteria and objectives set forth hereinafter.

SUMMARY OF THE INVENTION

One of the objects of the invention is to provide an improved multimedia data streaming protocol by means of which the ability to control many heterogeneous multimedia hardware devices is accomplished using minimum system resources and at the same time provides for all the data specific controls needed through a device independent interface.

Another object of the invention is to establish a stream protocol for a specific stream, as such stream is created, from a plurality of predefined stream protocol control blocks (SPCBs) that contain information from which the specific stream protocol can be derived.

Still another object of the invention is to create a controlling SPCB from source and target SPCBs by a process of negotiation.

Another object of the invention is to handle a SPCB so as to allow dynamic protocol binding to occur when a stream handler is loaded thus relieving the stream handler from having such control blocks included with a dynamic link library (DLL) or physical device driver (PDD).

A still further object of the invention is to provide additional protocol flexibility by allowing an application program to query, install and deinstall a SPCB at run time to fine tune the protocol to the specific operating environment that currently exists on the system.

A further object of the invention is to provide a stream protocol system in which new data types can be added and supported at run time without changing stream handlers.

A further object of the invention is to provide an SPCB which enables data stream buffers to be created, allocated, locked, and unlocked without any intervention by applications or other higher level software entities.

Still another object is to provide an improved SPCB which controls the size of and how many stream buffers are allocated, the number of buffers allowed to remain free during streaming to control for data transfer latencies (i.e., the "high water mark") and the number of buffers which are always in use during streaming (i.e., the "low water mark").

Briefly, in accordance with the invention, a data stream is created for moving data from a source to a target in accordance with a stream protocol defined by controlling SPCBs created from a predefined source handler SPCB and a predefined target handler SPCB.

The controlling SPCBs include information establishing a plurality of data buffers that are used to efficiently stream or transfer data in real-time.

DRAWINGS

Other objects and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a block diagram of a data processing system embodying the invention;

FIG. 2 is a block diagram of sync/stream subsystem architecture embodied in the system shown in FIG. 1;

FIG. 3 is a block diagram illustrating a generalized model of data streaming;

FIG. 4 is a flow chart illustrating steps for creating a data stream;

FIG. 5 is a flow chart illustrating steps for starting stream operations;

FIG. 6 is a flow chart illustrating source handling steps for creating and operating a data stream;

FIG. 7 is a flow chart illustrating target handling steps for creating and operating a data stream;

FIG. 8 is a flow chart of a routine for negotiating streaming parameters;

FIG. 9 is a flow chart of a routine for validating a source SPCB;

FIG. 10 is a flow chart of a routine for validating a target SPCB;

FIGS. 11A and 11B are a flow chart of a routine for merging SPCBs;

FIG. 12 is a flow chart of a routine to setup a source SPCB;

FIG. 13 is a flow chart of a routine to setup a target SPCB;

FIG. 14 is a flow chart of a routine to set a blocksize field;

FIG. 15 is a flow chart of a routine to set a physical seek flag;

FIG. 16 is a flow chart of a routine to set buffer flags; and

FIGS. 17A-17D are a flow chart of a routine for setting a buffer size field.

DETAILED DESCRIPTION

MULTIMEDIA SYSTEM

Referring now to the drawings, and first to FIG. 1, there is shown an exemplary data processing system comprising a personal computer 10 operable under a multitasking operating system such as OS/2 Version 2.0, to execute application programs. Computer 10 comprises a microprocessor 12 connected to a local bus 14 which, in turn, is connected to a bus interface controller (BIC) 16, a math coprocessor 18, and a small computer system interface (SCSI) adapter 20. Microprocessor 12 is preferably one of the family of 80xxx microprocessors, such as an 80386 or a 80486 microprocessor, and local bus 14 includes conventional data, address, and control lines conforming to the architecture of such processor. Adapter 20 is also connected to a SCSI bus 22 which is connected to a SCSI hard drive (HD) 24 designated as the C:drive, the bus also being connectable to other SCSI devices (not shown). Adapter 20 is also connected to a non-volatile random access memory (NVRAM) 30 and to a read only memory (ROM) 32.

BIC 16 performs two primary functions, one being that of a memory controller for accessing a main memory 36 and a ROM 38. Main memory 16 is a dynamic random access memory (RAM) that stores data and programs for execution by microprocessor 12 and math coprocessor 18. ROM 38 stores a POST program 40 and a BIOS 42. POST program 40 performs a standard power-on, self-test of the system when computer 10 is started by turning the power on or by a keyboard reset. An address and control bus 37 connects BIC 16 with memory 36 and ROM 38. A data bus 39 connects memory 36 and ROM 38 with a data buffer 41 that is further connected to data bus 14D of bus 14. Control lines 45 interconnect BIC 16 and data buffer 41.

The other primary function of BIC 16 is to interface between bus 14 and an I/O bus 44 designed in conformance with Micro Channel (MC) architecture. Bus 44 is further connected to an input/output controller (IOC) 46, a video signal processor (VSP) 48, a digital signal processor (DSP) 49, and a plurality of expansion connectors (EC) or slots 50. VSP 48 is further connected to a video RAM (VRAM) 60 and a multiplexor (MUX) 62. VRAM 60 stores text and graphic information for controlling what appears on the screen of a monitor 68. MUX 62 is further connected to a digital to analog converter (DAC) 68 and to a connector or terminal 70 that is connectable to a video feature bus (VFB). DAC 66 is connected to monitor 68 that provides a conventional output screen or display for viewing by a user.

IOC 46 controls operation of plurality of I/O devices including a floppy disc drive 72 designated as the A:-drive, a printer 74, and a keyboard 76. Drive 72 comprises a controller (not shown) and a removable floppy disc or diskette 73. IOC 46 also is connected to a mouse connector 78, a serial port connector 80, and a speaker connector 82 which allow various optional devices to be connected into the system.

DSP 49 is further connected to an instruction RAM 84, a data RAM 96, an analog interface controller (AIC) 88, and an audio controller (90). RAMs 84 and 86 respectively hold instructions and data used by DSP 49 for processing signals. Audio controller 90 controls various audio inputs and outputs and is connected to a plurality of connectors 92 by which various devices can be connected to the system. Such devices include a headphone, a microphone, a speaker, a musical instrument digitizing interface (MIDI), and devices requiring audio line-in and line-out functions. Various other multimedia devices (MMD) 96 can be also attached to the system through an EC 50 and adapter card 94.

Memory 36 stores various programs for execution in the system, which programs include application programs 100, including multimedia application programs (MMAP) 102, and an operating system 98 having extensions thereto including a sync/stream sub-system (S/SS) 104. It is to be noted that while FIG. 1 illustrates an exemplary multimedia system, the operating system is general purpose and is designed to run or control data processing systems having configurations that are different from the one shown in FIG. 1. The invention is embodied primarily in S/SS 104 and its interaction with operating system 100, which will now be described.

SYNC/STREAM SUB-SYSTEM

Referring to FIG. 2, multimedia application programs (MMAP) 102 execute at a layer above operating system (OS) 98 and communicate through multimedia control interface (MCI) by sending MCI commands for controlling devices in the multimedia environment. Some of the basic commands are pause, play, record, resume, seek, save, set, stop, etc. Such commands are routed by the operating system 98 to a media device manager (MDM) 106. The application programing model for MMAPs is a logical extension of the OS/2 Presentation Manager programming model, incorporating both object oriented messaging constructs and procedural (call and return) programming interfaces. The MCI provides a view to application developers and users similar to that of a video and audio home entertainment system. Operations are performed by controlling the media information processors known as media devices. Media devices are internal or external hardware devices, or software libraries that perform a defined set of operations by manipulating lower-level hardware components and system software functions. Multiple media devices may be included in a scenario, and allocated and controlled as a group for the purpose of synchronized playback.

Multimedia applications must control two aspects of real time system behavior, the transfer of large amounts of data from one device to another and the synchronization of events that are related. Events under the control of the program must be perceived to be under the direct control of the user, and the underlying system functions facilitate and ensure that these events occur in a predictable, real-time manner. Multimedia application authors write programs that operate on a real-time clock basis, rather than an approximate clock that could allow events to occur within windows of probability.

The MCI has two levels of dynamic link libraries (DLLs) comprising MDM 106 and media drivers including an audio media driver 108 and a MIDI media driver 110. MDM 106 provides resource management for media devices. It resolves contention for access to media devices and provides an application developer a view of resources that is independent of hardware. The media drivers are dynamic link libraries that implement the functionality of media devices. Media drivers invoke the services of hardware devices or software to implement their functionality. The media drivers do not directly control the hardware devices. Instead, they pass commands to S/SS 104 through a stream programming interface (SPI) 112 to a sync/stream manager (SSM) 114 which controls synchronization and streaming activities. SSM 114 performs two primary functions, the first being to control data streaming to provide continuous, real-time data streaming the inventive aspects of which are the subject of the above-identified related application (1). The second primary function involves synchronizing data streams and the details of such function are covered by the above-identified related application (2).

Stream handlers are required at both the system kernel level and the application level. Some data streams are best controlled by a direct connection between a stream handler and the physical device driver at a Ring 0 privilege level Such stream handler communicates with the PDD using a common interface based on OS/2 Interdevice Driver Communication (IDC). Other data streams are not associated with a data source or target that can be mapped to a specific physical device and can be controlled at a Ring 3 privilege level by a DLL. Dotted line 113 generally indicates which items operate at the different privilege levels. Within SSM 114, some routines operate at one level and other routines operate at the other level, as appropriate to the task at hand.

Each stream handler is programmable and is capable of streaming according to stream protocols. A "stream handler" is a set of code that handles either source or target specific actions for a device class specific data stream (i.e. audio or video). The stream handler is data type independent. It can be either a DLL or a PDD and interfaces with the Sync/Stream manager as well as a device driver or the file system of the operating system.

From the perspective of SSM 114, all stream handlers have similar responsibilities. Each handler is designed to be the source or target for one or more data streams where each data stream moves data independently. Manager 114 is responsible for connecting a stream source to an appropriate stream target, for maintaining data flow, and for cleaning up the various resources when the stream has ended. Further, the stream handlers are not device dependent modules. Although each stream handler supports streaming data of specific predefined types, data is passed from one handler to the next without any knowledge of hardware behavior. Also, audio stream handler 134 can communicate with any compatible audio device PDD in a completely hardware independent manner. To be compatible, the PDD must conform to the IDC interface as well as to the standard audio device driver interface IOCTL. Thus as shown, stream manager 114 interacts with a plurality of stream handler dynamic link libraries (DLL) 116–126 which respectively are MIDI mapper, CD/DA, memory, split stream, CD-ROM/XA, and file system, stream handlers. File system stream handler DLL 128 calls a multimedia I/O (MMIO) manager for accessing a file system 130.

Stream manager 114 also interacts through stream manager helpers 133 with an audio stream handler physical device driver (PDD) 134 that selectively accesses physical devices through a stream handler/PDD interface 136 and a plurality of PDDs 138–144. Stream manager 114 can also interact with interface 136 through inter-device communication (IDC) interfaces 146.

DATA STREAM MODEL

FIG. 3 is a generalized model of data streaming operations. Each complete data stream comprises six elements: a source data object or device, a source stream handler, a target stream handler, stream protocol, stream buffers, and a target data object or device. The stream protocol includes a controlling, negotiated stream protocol control block (SPCB) associated with each handler. FIG. 3 shows generally a single data stream 151 and how data flows or is transported under the control of stream manager 114, source and target stream handlers 152 and 154, and SPCBs 163 and 165. A plurality of stream buffers 156 are allocated in memory for use in streaming. Buffers 156 are filled with stream data from a source device 158 and are emptied of stream data by transmitting the data to a target device 160. Data stream 151 comprises two paths, a source stream data path 153 and a target stream data path 155. The data path for the source stream data is from source 158, through source PDD 162, and through stream handler 152 to buffers 156. The data path for the target stream data 155 is from buffers 156, through target stream handler 154, through target PDD 164, and to target device 160. Source stream handler 152 actuates a source PDD 162 which in turn controls operation of the source device. Target stream handler 154 actuates a target PDD 164 which controls target device 160. The general objective is for the source stream handler 152 to fill at least two of stream buffers 156 before the target device is started, and, once the target device has started, to thereafter keep ahead of the target device by filling buffers **156** until the complete source data has been transferred. After the buffers are filled, the target stream handler can then obtain target data therefrom and transfer it to the target device.

Media driver **108** interacts with SPI interface **112** by sending SPI functions or calls and receiving stream event notifications. Manager **114** interprets the SPI calls and in response thereto performs the desired functions by interacting with the stream handlers by sending system helper commands SHCs to the handlers and receiving stream manager helpers SMH calls from the handlers. Media driver **108** can also directly control PDD **164** by issuing control functions defined by standard IOCTL commands. The principal SPI calls related to the invention are SpiCreateSream and SpiStartStream which respectively setup up the desired stream(s) and then start the data streaming. Should there be plural streams that must be synchronized, a SpiEnableSync call is made, as more fully discussed in the related application (2).

When a MultiMedia application determines that data will be streamed between devices, then it issues a SpiCreateStream call, which results in the stream being created. The caller specifies source and target stream handler IDs, source and target device specific information, and the stream data type. With reference to FIG. 4, when an application program issues an SpiCreateStream call in step **435**, control passes to sync/stream manager **114** which in step **436** calls the source stream handler using the handler command SHC.CREATE. Then, the target stream handler is called using SHC.CREATE in step **438**. Step **440** negotiates the streaming parameters which include buffer numbers and size, data stream type, maximum number of records per buffer, minimum number of buffers needed to maintain a constant data stream, number of empty buffers needed to start source stream handler, number of full buffers needed to start target stream handler, etc. Step **442** calls a routine to create source SPCB **163** and then informs the source stream handler of the stream parameters. Step **444** calls a routine to create target SPCB **165** and informs then target stream handler of the stream parameters. Step **446** sets up the stream, and dynamically allocates stream buffers **156** and locks such buffers in memory so the buffers cannot be paged out. The dynamic allocation of memory during stream creation (at create time) prevents the need to perform allocations of physical memory when the stream is active, which could result in disrupting the data flow and affecting the real-time performance of the system. Step **448** returns to the application.

During steps **436** and **438**, SSM **114** notifies each of the two stream handlers **152** and **154** that a stream is being created, and each stream handler returns a valid SPCB to SSM **114**. Then, SSM **114** negotiates the parameters of the stream and notifies (i.e., return the negotiated SPCB to the handler) the handlers by a SHC_NEGOTIATE_RESULT call to each handler. Negotiation consists of determining which SPCB parameters both stream handlers can mutually accept. The stream handlers then program or set themselves to operate in accordance with such streaming parameters. Further details of stream creation and starting, and of the negotiations are discussed hereinafter.

Typically, SSM **114** allocates buffers for the stream, but it is possible to use application buffers directly. A SPCBBUF_USERPROVIDED flag in the SPCB indicates whether to use provided buffers or to allocate buffers. This is useful for streaming to or from the memory stream handler. In a split stream situation, a particular stream may not allocate its own buffers, but use the buffers of another stream. In other words, share buffers. This is useful for interleaved data that comes from one source but goes to more than one destination.

For SSM **114** allocated buffers, stream buffer allocation is done during stream creation. The numbers of buffers to allocate is taken from the "negotiated" SPCB. The buffers are allocated and then locked so that they will not be paged out to disk. The buffers are unlocked and freed upon an SpiDestroyStream request. These buffers are available at ring **3** in the process linear space and ring **0** in global linear system memory. SSM **114** provides GDT selectors to allow ring **0** stream handlers to access the buffer memory. The stream handler can assume that SSM **114** manages the GDT selectors used.

Both handlers **152** and **154** (source and target) share access to the buffers allocated by the stream manager. Note that if the minimum buffer space (specified in the SPCB) is not available, the stream creation will fail. The allocation of memory at create time prevents the need to perform allocations of physical memory when the stream is active, which could result in disruption of data flow affecting the real-time performance of the stream. Therefore, it is advantageous to allow SSM **114** to allocate buffers and lock them at stream creation time instead of providing buffers to SSM **114** that probably can not be locked at stream creation time, but locked at stream run time.

Referring to FIG. **5**, after the data stream has been created, the application program can start data streaming by issuing astart streaming call SpiStartStream in step **450**. In response to such call, control passes to manager **114**. SSM **114** executes a SpiStartStream routine which first checks in step **452** to see if the stream is paused. A stream is "paused" when data is kept in the stream buffers and the stream is blocked. If the stream is not paused, step **454** determines if the stream is prerolled. If not, step **456** calls the source stream handler with the command SHC.START to unblock the source thread. Then step **458** checks to see if the stream is a slave stream in a sync group. If not, step **460** returns to the application program. If so, step **462** branches back to step **452** to repeat process for each slave stream. If step **452** answers "yes", step **464** calls the source stream handler with a SHC.START command to unblock the source stream thread and then makes a call in step **466** to unblock the target stream handler thread. Step **466** also follows a "yes" result from **454**. Step **458** then follows step **466**. When both handler threads are unblocked, streaming commences.

FIG. **6** illustrates what happens when the SHC.CREATE command is executed by a DLL source stream handler **152**. First, step **201** creates a thread under the OS which will be controlled by the multitasking features of the OS. Step **202** assigns a priority level to the thread as appropriate to the task to be performed and returns a valid SPCB to the SSM for use in negotiation, then the source handler thread is blocked on a semaphore in step **203** and the source handler goes to "sleep". The priority level may be used to control the rate at which the OS dispatches and executes the thread. If discontinuities arise, priority levels may be adjusted. It is to be noted that in accordance with the standard operation of OS/2, the threads are treated as individual tasks, and control returns to the OS when the threads are blocked, when calls are made, when returns are made, etc. This allows the operating system to execute other tasks in the system and to return to the streaming threads, on a multitasking basis.

In response to a start stream call being made in the application program, manager **114** sends (via steps **436** and **438**—FIG. 4) SHC.START commands first to the source thread handler and then to the target stream handler. The source stream handler needs to be started first to fill stream buffers before the target handler can use the data being transferred thereto. In response to receiving such command in step **206** (FIG. 6), the source stream handler in step **208** unblocks the source thread. In response to being unblocked or awakened in step **210**, source thread then requests, in step **216**, an empty buffer from manager **114**. If an empty buffer is not available, as determined in step **218**, step **220** then blocks the thread again. If an empty buffer is available, then step **222** reads data from the source device and fills the buffer. Step **224** then returns the filled buffer to manager **114**. Step **226** decides if any more buffers need filling. If so, a branch is made back to step **216** and a loop is formed from steps **216-226** which loop is broken when step **226** decides no more buffers need filling. Then, the thread is blocked. Once the streaming operation has been started, the buffer filling process repeats until the end of the source file is reached at which point the source thread quiesces.

FIG. 7 illustrates operating the DLL target stream handler **154** at ring 3 privilege level. Target stream handler **154** receives from manager **114** an SHC.CREATE command to create a target data stream. A target stream thread is created in step **230**. The stream handler then assigns a priority to the thread, returns a valid target SPCB in step **232**, and blocks the target thread on a semaphore in step **234**. When the target thread is awakened by manager **114** issuing a SHC.START command in step **236**, the target thread is unblocked in step **238** to awaken the thread in step **240**. Step **242** attempts to get a full buffer from the data stream. Step **244** checks to see if a buffer is obtained, and, if not, step **246** blocks the target thread. If a full buffer is obtained, step **248** writes the data in the buffer to the target device and then returns an empty buffer in step **250** to manager **114**. Step **252** checks to see if the buffer is the last buffer in the data stream i.e. has the end of stream (EOS) been reached. If not, a branch is made back to step **242** to repeat the process of getting a full buffer. The loop repeats until the end of stream is detected, whereupon step **244** returns to the application.

STREAM PROTOCOL

To ensure that the data being processed streams in a continuous manner, each controlling SPCB (**163** and **165**) associated with the stream is set up to contain information used to allocate the buffers. (i.e., the number of buffers, the buffer size, and values indicating when to start the stream handlers). This information is important because dependent on the type of data being streamed, the amount and size of buffers must be optimum to ensure that continuous streaming of data occurs, and at the same time, ensure that the system resources are not over used (e.g. allocate more memory than is actually needed). Along with the allocation of memory, the values used to start the stream handlers ensure that enough buffers are filled by the source stream handler so that the target stream handler can be started and assured that there is enough data buffered up to allow real-time data streaming to occur.

The stream protocol defines several key operational parameters that control the behavior of a data stream. The application can query, install or deinstall a specific SPCB from a stream handler. Each stream handler supports one or more stream protocols. An SPCB is uniquely identified by a SPCB key. One field of an SPCB key allows the stream handler to have multiple SPCB's installed for the same data type. This field can be used by an application to specify which SPCB, for any data type, it wants to use. Each application in the system could define a different SPCB for the same data type. The application can modify a stream protocol by installing a new SPCB and deinstalling the old SPCB.

The fields and parameters in an SPCB are:

1. SPCB Length—(SPCBLEN) Length of SPCB structure.

2. SPCB Key—(SPCBKEY) Data stream type and internal key. The internal key is used to differentiate between multiple SPCB's of the same data stream type. This field specifies:
   - a. Data type (DATATYPE),e.g. waveform or MIDI.
   - b. Data subtype (DATASUBTYPE), e.g. 16-bit stereo PCM.
   - c. Internal key (INTKEY). This is used to differentiate between plural SPCBs of the same data type and subtype.

3. Data Flags—(DATAFLAGS) Attributes of the data type. (i.e. specifies whether data or time cue points and seeking are supported by this data type). The data flags are:
   - a. SPCBDATA_CUETIME—indicates the data type can support time cuepoint events.
   - b. SPCBDATA_CUEDATA—indicates data type can support data cuepoint events.
   - c. SPCBDATA_NOSEEK—indicates seeking cannot be done on the data type.

4. Number of Records—(NUMREQ) Maximum number of records per buffer. (This is only valid for split streams).

5. Data Block Size—(BLOCKSIZE) A block is an atomic piece of data. For example, for digital audio data type PCM stereo at a 44.1 KB sampling rate, the block size is four bytes.

6. Data Buffer Size—(BUFSIZE) Size of buffer to be used while streaming. Maximum buffer size is 64 KB.

7. Minimum Number of Buffers—(MINBUF) Minimum number of buffers needed to maintain a constant data stream.

8. Maximum Number of Buffers—(MAXBUF) For normal streams, this means the number of buffers that will be allocated for the stream. For user provided buffer streaming, this means the number of buffers that the SSM **114** can queue up for a consumer. This can be used by a source stream handler that gives the same set of buffers to the SSM **114** repeatedly. If the number of buffers is set to the number of buffers in the set minus one, the source stream handler is able to detect when the target stream has consumed a buffer and the buffer can be reused. The set of allocated buffers is an ordered set and each buffer is used in the same order each time.

9. Source Start Number—(SRCSTART) Number of empty buffers required to start the source stream handler. The value should be at least a big as the maximum number of buffers that would be requested by the source stream handler.

10. Target Start Number—(TGTSTART) Number of full buffers required to start the target stream handler. This value should be at least as large as the maximum number of buffers that would be requested by the target stream handler. Usually, a target will require at least two buffers at the start of streaming.

11. Buffer Flags—(BUFFLAGS) Buffer attributes (i.e. user provided buffers, fixed block size, interleaved data type, maximum buffer size). The buffer flags are:

a. SPCBBUF_USERPROVIDED—User provides buffers for streaming. SSM will not allocate buffers but will attempt to lock user provided buffers or copy the data to locked buffers. Using this flag affects streaming performance. Only a source stream handler can set the flag. The flag is mutually exclusive with an interleaved flag and a fixedbuf flag cannot be used with this flag set.

b. SPCBBUF_FIXEDBUF—The buffer size for this stream handler must be a particular fixed size for the particular data type. The flag cannot be used with the userprovided flag. The interleaved flag (split stream) implies a fixedbuf flag.

c. SPCBBUF_NONCONTIGUOUS—Each data buffer is allocated contiguously in physical memory unless both stream handlers set this flag. The flag allows the system flexibility in allocating memory.

d. SPCBBUF_INTERLEAVED—Indicates the stream is a split stream having an input stream of one data type which is split into plural streams of individual data types. Only the source stream handler can set this flag. It is mutually exclusive-with the userprovided flag. The fixedbuf flag cannot be used when this flag is set.

e. SPCBBUF_MAXSIZE—Indicates a data buffer size field contains the maximum size buffer that this stream handler can handle.

f. SPCBBUF_16MEG—Stream buffers may be allocated above a 16 MB address for use by device driver supporting greater than 16 MB addresses.

12. Handler Flags—(HANDFLAGS) Stream handler flags (i.e. handler can receive sync pulses, use SSM **114** timer as master, non-streaming handler (NULL handler)). The flags are:

a. SPCBHAND_GENSYNC—This stream handler can generate sync pulses.

b. SPCBHAND_RCVSYNC—This stream handler can receive sync pulses.

c. SPCBHAND_NONSTREAM—This stream handler is a non-streaming handler which can participate in synchronization but does not stream.

d. SPCBHAND_GENTIME—The stream handler can keep track of real stream time which is done by keeping track of how much data is transferred to the target device.

e. SPCBHAND_NOPREROLL—A recording stream cannot preroll its device. Prerolling is the process by which a source handler initially fills a predetermined number of buffers before starting the target stream.

f. SPCBHAND_NOSYNC—This stream can be in a sync group but does not receive or generate sync pulses.

g. SPCBHAND_PHYS_SEEK—This stream handler does a seek to a physical device.

13. Resync Tolerance—(MMTIMETOLERANCE) Resync tolerance value. It is used to determine whether to send a sync pulse to this specific slave stream handler, if it is a slave.

14. Sync Pulse Granularity—(MMTIMESYNC) Used to save sync pulse generation granularity if this stream handler is a master, but can't generate its own sync pulse.

15. Bytes Per Unit of time—(BYTESPERUNIT) This is used to do seeks on linear data that is not compressed or of variable length. Also used for SHC_GETTIME queries in a stream handler.

16. MMTIME Per Unit—(MMTIMEPERUNIT) The amount of MMTIME each unit represents. This is also used for the seek and gettime functions of a stream handler. MMTIME is expressed in integer values of time units of a predetermined amount, e.g. 1/3000th of a second.

Except for the SPCB length and SPCB key fields, all of the above fields are subject to negotiation and can be changed to create the source and target controlling SPCBs.

When the system is initially configured, a system file called SPI.INI is created which contains a list of stream handlers and device drivers. Such file also contains predefined SPCBs for each of the handlers. The file can be accessed to return a list of stream handler names. The file can then be accessed using a handler name to return a stream handler ID and, at the same time, dynamically bind (i.e., install) the SPCB(s) associated with a stream handler. The file can also be used to determine which data types a given stream handler can process.

STREAM PROTOCOL NEGOTIATION

As previously indicated relative to FIG. 4, the stream handlers stored in the system have predefined SPCBs which are accessed during stream creation and are used during stream protocol negotiation to create a negotiated SPCB. The negotiated SPCB is then copied to create source SPCB **163** and target SPCB **165** (FIG. 3). These latter SPCBs are returned to the respective handlers and are the SPCBs that are actually used to control the data streaming. The predefined SPCBs are not used to directly control data streaming. In response to creating the controlling SPCBs, the-source and target handlers look at information in such SPCBs and adjust themselves (the handlers) to perform the functions in accordance with the values of the parameters set forth in the SPCBs. The following are rules used during stream protocol negotiation to create the negotiated SPCB:

1. The following handler flags are set On in the negotiated SPCB for the stream handler that should perform the function indicated by the flag. Either the source or the target negotiated SPCB contains these set bit flags:

a. SPCBHAND_GENSYNC
b. SPCBHAND_RCVSYNC
c. SPCBHAND_GENTIME
d. SPCBHAND_PHYS_SEEK

2. A generic data type matches any other data type during negotiation. This is useful for stream handlers like the file system stream handler which is a generic data type that can be a source for almost any data type. In contrast, a audio stream handler has a plurality of control blocks specifying audio data types having different attributes such as 44K sampling rate, 20K sampling rate, MIDI, etc.

3. If neither of the SPCB key data types are generic then both the data type and subtype fields must match or an error will occur. The internal key field is not used

during negotiation. An internal key of 0 is returned from negotiation.

4. The block size default to one byte if not specified. The source and target block size fields must match or the negotiation fails.

5. The data buffer size must be an integral multiple of block size.

6. The negotiation fails if one stream handler has a fixed buffer size SPCBBUF_FIXEDBUF greater than the maximum buffer size SPCBBUF_MAXSIZE of the other.

7. Both handlers must not have fixed buffer sizes (SPCBBUF_FIXEDBUF) of different lengths.

8. Both handlers must not have maximum buffer sizes SPCBBUF_MAXSIZE of different lengths.

9. Negotiation defaults to a fixed buffer size SPCBBUF_FIXEDBUF. Otherwise, the buffer size is set to the greater of the two SPCB buffer sizes but not less than the maximum buffer size SPCBBUF_MAXSIZE if one is specified.

10. If no special conditions (SPCBBUF_USERPROVIDED, SPCBBUF_FIXEDBUF, SPCBBUF_MAXSIZE) are specified, the largest buffer size is the one that is used for the stream creation.

11. For user provided buffers, the buffer size is set to the maximum buffer size or to the largest buffers possible rounded to a multiple of block size.

12. For split streams, the negotiated SPCB must have a maximum number of records per buffer greater than 0. The source SPCB supplies this value and the target SPCB does not. The target SPCB must always be 0.

13. The maximum and minimum number of buffers must be greater than 0.

14. The largest minimum number of buffers value is used.

15. The largest maximum number of buffers value is used.

16. SSM **114** attempts to allocate the maximum number of stream buffers requested. If it is unable to allocate this amount of space, but is able to allocate the minimum needed, the stream is created. Otherwise, the stream creation is rejected.

17. The number of EMPTY buffers required to start the source is always taken from the source SPCB.

18. The number of FULL buffers required to start the target is always taken from the target SPCB.

19. For SpiGetTime requests, each handler must specify whether it can receive these requests and return real-time information. It can do this by specifying the SPCBHAND_GENTIME flag. For negotiation, the target stream handler is the default provider of this information unless only the source can provide this information.

20. The Bytes Per Unit and MMTIME Per Unit are set from the stream handler that handles the real-time requests per the previous statement.

21. For sync pulses, each handler must specify whether it can send or receive sync pulses. It can do this by specifying the SPCBHAND_GENSYNC or SPCBHAND_RCVSYNC flag. For negotiation, the target stream handler is the default generator/receiver of sync pulses unless only the source can generate/receive sync pulses.

22. The sync tolerance is only valid for handlers that set the SPCBHAND_RCVSYNC.

23. The sync pulse granularity is only valid for handlers that set the SPCBHAND_GENSYNC. Any undefined bit in any bit flag of the stream protocol must be set to zero.

24. The SPCBHAND_PHYS_SEEK flag is used to specify if a stream handler does a physical device seek when called. SSM **114** uses this information to determine which stream handler should be called. The handler that does a physical device seek will be called first. Otherwise, the stream handler that specified SPCBHAND_GENTIME is called first.

25. Any reserved fields are set to NULL.

26. Any undefined bit in any bit flag of the stream protocol must be set to 0.

The negotiation process is illustrated in more detail in FIGS. **8–17C**. Referring to FIG. **8**, when the negotiate parameters routine is called in step **440**, step **468** first validates the source SPCB by calling a routine described below with reference to FIG. **9**. Validation is a process for preventing the use of erroneous data wherein each data item is compared with allowable values and ranges and only those items within such values and ranges can be used. Step **470** then validates the target SPCB as described relative to FIG. **10**. Step **472** then decides by accessing the datatype and subtype fields in the source and target SPCBS whether the source datatype and subtype are the same as those of the target. If not, step **474** decides if the source datatype is generic. If the source datatype is not generic, step **476** decides if the target datatype is generic. If it is not, step **478** sets an error condition and a return is made to the caller. If steps **472**, **474**, and **476** result in positive determinations, steps **480**, **482**, and **484** respectively set the mergetype to NEG_BOTH, NEG_TARGET, and NEG_SOURCE. Step **486** follows completion of any of steps **480**, **482**, and **484** and calls the merge SPCB routine which merges data from the target SPCB and the source SPCB and produces a resultant negotiated SPCB. Afterwards, a return is made to the caller.

As shown in FIG. **9**, the validate source SPCB routine first validates the SPCB length field in step **488**. This is followed by steps **490**, **492**, **494**, **496**, and **498** which respectively validate all flag fields, the number of record fields, block size, minbuf and maxbuf fields, and buffer size fields. Step **500** then looks at the interleaved flag to see if it is set. If the interleaved flag is not set, a return is made but if such flag is set, step **502** sets or turns on the fixedbuf flag before returning. The target SPCB validation process is shown in FIG. **10** and performs steps **504–514** to validate the listed target SPCB fields in a manner similar to steps **488–498** for validating source SPCB fields.

With reference to FIGS. **11A** and **11B**, information from the source and target SPCBs is merged to form the new or negotiated SPCB in the following manner. First, step **516** decides if the mergetype has been set to NEG_SOURCE. If not, step **518** decides if the mergetype has been set to NEG_TARGET. If not, the conclusion is reached that the mergetype is NEG_BOTH and step **520** then sets the new SPCB.KEY to equal the target SPCB.KEY. If step **516** results in a positive determination, step **517** sets the new SPCB to equal the source SPCB. That is, the source SPCB is copied to create a new SPCB having fields that are may be later changed during the negotiation process. If step **518** results in a positive determination, step **519** initially sets the new SPCB to be the same as the target SPCB. Step **522** follows completion either of steps **517**, **519** or **520** and it sets the length field of the new SPCB in accordance with how many bytes are contained therein.

Step 524 then sets the new SPCBKEY.INTKEY (internal key) to zero. Step 526 then merges or sets the new SPCB.DATA flags to equal the logical ORing of the corresponding flags of the source and target SPCBs. Step 528 then sets the number of records field in the new SPCB to be the same as the number of record in the source SPCB. The bottom box in FIG. 11A is a drawing connector indicating the process continues through box A in FIG. 11B. Steps 530, 532 and 534 sequentially call the set block size field, set the buffer flags field, and set the buffer size fields, routines that are discussed below with reference to FIGS. 14, 16 and 17.

Steps 536 and 538 set the new SPCB.SOURCESTART and SPCB.TARGETSTART fields in accordance with the contents of the source and target SPCBs. Step 540 then merges the handler flags by setting the new SPCB.HANDLERFLAGS in accordance with logically ORing the corresponding fields of the source and target SPCBs. Step 542 sets on the NOPREROLL flag only if the source has it set. Step 544 defaults to the target to generate time unless only the source can generate time. In step 546, the nonstreaming flag is set if one handler is nonstreaming and the source stream handler is the same as the target stream handler. Step 548 defaults to the target stream handler to generate sync pulses unless only the source can generate sync pulses. Step 550 defaults to the target stream handler as the receiver of sync pulses for the data stream unless only the source stream handler can receive sync pulses.

Step 552 copies the new SPCB.MMTIME tolerance from the stream handler of the source or target which handler receives the sync pulses. Step 554 copies the new SPCB.MMTIME sync field from the stream handler of the source or target which handler generates the sync pulses for the stream. Step 556 copies the new SPCB.MMTIMEPERUNIT and BYTESPERUNIT fields from the stream handler of the source or target which handler generates real stream time. If neither handlers generate such time, these fields are set to zero. Finally, step 558 calls the set physical seek flag routine (discussed relative to FIG. 15) and then a return is made to the caller.

Referring to FIG. 12, when the setup source SPCB routine is called, step 560 sets the source SPCB to equal the new SPCB. Step 562 sets the generate sync flag only if the source generates time. The receive sync flag is set in step 564 only if the source receives sync pulses for the stream, and the generate time flag is set in step 566 only if the source generates time. Finally, step 568 sets the physical seek flag only if the source can do a physical seek to a device, and then control returns to the caller. FIG. 13 illustrates steps 570–578 which perform functions for the target SPCB similar to those functions done in steps 560–568 for the source SPCB.

When the set blocksize routine is called at 530, see FIG. 14, step 580 determines if the mergetype is set to NEG_BOTH. If not, a return is made to the caller and the BLOCKSIZE value defaults to the value initially placed or copied in the new SPCB. If the mergetype is NEG_BOTH, step 582 then decides if the source blocksize is equal to the target blocksize. If the two block sizes are the same, the new SPCB.BLOCKSIZE is set in step 584 from the target blocksize field. If the two block sizes are not the same, then step 586 sets an error condition and a return is made to the caller.

FIG. 15 shows the set physical seek flag routine 558 in which step 588 sets the SSM to a default condition in which the source handler is called first when the source need to do a physical seek. Step 590 determines if both the source and target perform physical seeks or if neither one does. If neither such condition is met, indicating that one or the other does a physical seek, step 592 decides if the target generates real stream time. If so, step 594 sets up condition so the target is called first on SpiSeekStream call. If the decision of step 592 is negative, or after step 594, a return is made. If step 590 results in a positive determination, step 596 decides if the source does a physical seek. If so, step 598 sets upon conditions so that the target is called first on SpiSeekStream. A return is made after steps 596 or 598.

As shown in FIG. 16, upon calling set buffer flag routine 532, step 600 determines if both SPCBs have the fixed buf flags set and if the buffers are not the same size. If step 600 results in a NO decision, step 602 sees if both SPCBs have the maxsize flags set and if the buffers are not the same size. If step 602 produces a negative result, step 604 then determines if one SPCB has the fixedbuf flag set and if the other SPCB has maxsize flag set and the fixed size is set to the max size. If the result from step 604 is a NO, then step 606 sets the new SPCB buffer flags equal to the logical ORing of the target and source SPCB.BUFFER flags. Next, step 608 resets the noncontiguous flag and step 610 determines if the userprovided and the fixedbuf flags are set. If not, a return is made. If the results from any of steps 600, 602, 604, or 610 are positive, step 612 sets an error condition before returning to the caller.

Referring to FIG. 17A, the set buffer size field routine 534 begins with step 614 which decides if the stream is both interleaved and a user stream. If so, step 626 copies the buffer size, minbuf and maxbuf fields from the owner SPCB into the new SPCB and then returns. If step 614 produces negative results, step 616 decides if the mergetype is set to NEG_BOTH and if the fixedbuf or maxsize flags are set. If so, step 618 decides if the source SPCB fixedbuf and maxsize flags are set. If they are not set, step 620 checks to see if the source SPCB fixedbuf flag is set. If it is not set, step 622 checks to see if the source SPCB maxsize flag is set. If it is not set, step 624 sets the new SPCB.BUFFERSIZE from the target SPCB buffersize field and a return follows. If step 616 results in a negative determination, step 628 then sets the new SPCB buffersize field to the lager buffer size in either of the corresponding fields of the source or target SPCBs. If step 618 results in a positive determination, step 630 sets the buffer size field of the new SPCB in accordance with the setting of the source SPCB buffer size field. Following either steps 630 or 628, step 632 (FIG. 17B) is performed. Positive determinations from steps 620 and 622 causes steps 648 (FIG. 17C) and step 658 (FIG. 17D) to be performed.

Referring to FIG. 17B, step 632 decides if the user provided flag is set and the maxsize flag is not set. If both conditions are true, step 640 computes the new SPCB buffer size as a multiple of the block size if the buffer size is not already set. Step 634 sees if the mergetype is set to NEG.BOTH. If so, step 642 sets the new SPCB minbuf field to be the larger of the source or target minbuf fields. Step 636 sees if the mergetype is set to NEG.BOTH. If so, step 644 sets the new SPCB maxbuf field to be the larger of the source or target maxbuf fields. Step 638 then checks to see if the minbuf field of the new SPCB is less than its maxbuf field and if so, step 646 then sets the minbuf field of the new SPCB to equal the maxbuf field thereof. Negative determinations from steps 632-638 simply causes the illustrated succeeding steps to be performed.

When step 648 in FIG. 17C occurs, the target SPCB.MAXSIZE flag is checked to see if it is set. If it is not set, step 654 then sets the new SPCB buffer size to equal the buffer size in the source SPCB and a return is made. If step 648 results in a positive determination, step 650 checks to see if the source SPCB buffersize is equal to or less than the buffer size of the target SPCB. If so, step 656 sets the new SPCB buffersize field to equal the source SPCB.BUFFERSIZE, before returning. If step 650 results in a NO, step 652 sets an error condition prior to returning.

Step 658 (FIG. 17D) decides if the target SPCB fixedbuf flag is set. If it is set, step 660 then determines if the buffersize in the target SPCB is equal to or less than the buffer size in the source SPCB. If so, step 686 sets the buffersize of the new SPCB to equal the buffer size in the target SPCB. If the result of step 660 is NO, step 662 sets an error condition prior to returning. If step 658 produces a negative result, step 664 then sets the buffer size of the new SPCB to equal the buffer size in the source SPCB.

It should be apparent to those skilled in the art that many changes can be made in the details and arrangements of steps and parts without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a multimedia data processing system comprising a personal computer having processor and a storage system, said storage system including a memory for storing at least one multimedia application program and a multitasking operating system for execution by said processor, data streaming apparatus operable under said operating system and said application program for streaming data from a source device to a target device in accordance with a streaming protocol, said apparatus comprising:

a plurality of programmable stream handlers stored in said storage system and including at least one source stream handler and at least one target stream handler;

a plurality of predefined streaming protocol control blocks (SPCBs) stored in said storage system and including a first SPCB for said source stream handler and a second SPCB for said target stream handler;

each of said predefined SPCBs containing a plurality of fields for storing stream protocol parameters including data type, number of buffers needed to maintain continuous streaming of data, and size of buffers;

said source stream handler comprising a callable first routine for creating a source thread as a task under said operating system and blocking such source thread, and a callable second routine for unblocking said source thread and streaming data from said source device to said buffers;

said target stream handler comprising a callable third routine for creating a target thread as a task under said operating system and blocking such target thread, and a callable fourth routine for unblocking said target thread and streaming data from said buffers to said target device;

and stream manager means operable in response to execution of a stream create call instruction in said application program, to create a data stream by calling said first routine and said third routine to set up source and target threads as multitask threads under said operating system and block on such threads,

creating a negotiated source SPCB and a negotiated target SPCB by negotiating differences between said first and second SPCBs, said negotiated source SPCB and said negotiated target SPCB defining a negotiated streaming protocol mutually acceptable to both said source handler and said target handler,

and dynamically allocating in said memory a plurality of buffers for said data stream in accordance with said streaming protocol defined in said negotiated source and target SPCBs.

2. A multimedia data processing system in accordance with claim 1 wherein:

said stream manager means is operable in response to execution of a start stream call in said application program, to call said second and fourth routines to initiate data streaming and transfer data in accordance with said negotiated streaming protocol.

3. A multimedia data processing system in accordance with claim 2 wherein said stream protocol parameters include a plurality of buffer attribute flags, a plurality of data attribute flags, and a plurality of stream handler flags.

4. A multimedia data processing system in accordance with claim 3 wherein:

said stream manager means is operative to produce said negotiated SPCBs by selecting parameters from said first and second SPCBs in accordance with predefined rules of negotiation.

5. A multimedia data processing system in accordance with claim 4 wherein said data type parameters in said first and second SPCBs may be specified as a generic data type or as a specific data type, and said data type parameters in said negotiated SPCBs are set in accordance with said rules of negotiation to a generic type when either one of said first or second SPCBs specifies a generic data type and to a specific data type when both of said first and second SPCBs specify the same specific data type.

6. A multimedia data processing system in accordance with claim 5 wherein said system manager means produces an error indication when said first and second SPCBs specify different specific data types.

7. A multimedia data processing system in accordance with claim 4 wherein said data attribute flags indicate whether data or time cue points and seeking are supported by data type set forth in said negotiated SPCBs.

8. A multimedia data processing system in accordance with claim 7 wherein a SPCBHAND_PHYS_SEEK flag is used to specify if a stream handler does a physical device seek when called, said stream manager means being operative to first call such stream handler when said SPCBHAND_PHYS_SEEK flag is set.

9. A multimedia data processing system in accordance with claim 4 wherein said stream handler flags indicate whether each stream handler can participate in synchronization by receiving or generating sync pulses, or without streaming.

10. A multimedia data processing system in accordance with claim 8 wherein for sync pulses, each handler must specify whether it can send or receive sync pulses by setting SPCBHAND_GENSYNC and

SPCBHAND_RCVSYNC flags, and in accordance with said rules of negotiation said target stream handler is set as a default generator/receiver of sync pulses unless only the source can generate/receive sync pulses.

11. A multimedia data processing system in accordance with claim **4** wherein said buffer attribute flags indicate user provided buffers, fixed block size, interleaved data type, and maximum buffer size.

12. A multimedia data processing system in accordance with claim **4** wherein said negotiated SPCBs contain size of buffer parameters that are set to the greater one of the size of buffer parameters contained in said first SPCB and said second SPCB.

13. A multimedia data processing system in accordance with claim 4 wherein said fields in said negotiated source SPCB include a field for specifying a maximum number of records per buffer which field is obtained for split streams from said first SPCB and is a value greater than 0.

14. A multimedia data processing system in accordance with claim **4** wherein said negotiated SPCBs include fields specifying the number of empty buffers required to start said source thread which number is always taken from said first SPCB, and said negotiated SPCBs further include fields specifying the number of full buffers required to start said target thread which number is always taken from said second SPCB.

15. A multimedia data processing system in accordance with claim **2** wherein:

said stream manager means is further operable in response to execution of said start stream call to call said second routine to fill a plurality of buffers with data from said source device, and to thereafter call said fourth routine to empty such filled buffers, said second routine and said fourth routine being thereafter operable to run both threads to alternately fill buffers with data and write data from said buffers until an end of data stream is reached.

16. A multimedia data processing system in accordance with claim **15** wherein said source handlers are operative to initially block said threads after said threads have been set up, and to thereafter unblock said threads in response to said start stream call thereby allowing said threads to transfer said data through said buffers.

17. A multimedia data processing system in accordance with claim **16** wherein said stream manager means controls use of said buffers by said threads whereby said stream manager means provides empty buffers to said source thread for filling with data from said source device, receives filled buffers from said source thread, provides filled buffers to said target thread for writing data therefrom to said target device, and receives empty buffers from said target thread.

18. A multimedia data processing system in accordance with claim **2** wherein said memory is a paged memory;

and said apparatus includes means operative after said buffers have been allocated to lock said buffers in said memory to prevent said buffers from being paged out while data streaming is occurring.

* * * * *

US005434678A

United States Patent [19]

Abecassis

[11] Patent Number: 5,434,678

[45] Date of Patent: Jul. 18, 1995

[54] SEAMLESS TRANSMISSION OF NON-SEQUENTIAL VIDEO SEGMENTS

[76] Inventor: Max Abecassis, 19020 NE. 20 Ave., Miami, Fla. 33179

[21] Appl. No.: 2,998

[22] Filed: Jan. 11, 1993

[51] Int. Cl.[6] H04N 5/781

[52] U.S. Cl. 358/342; 358/335; 358/311

[58] Field of Search 358/342, 335, 310, 311; 360/13; 348/7, 8

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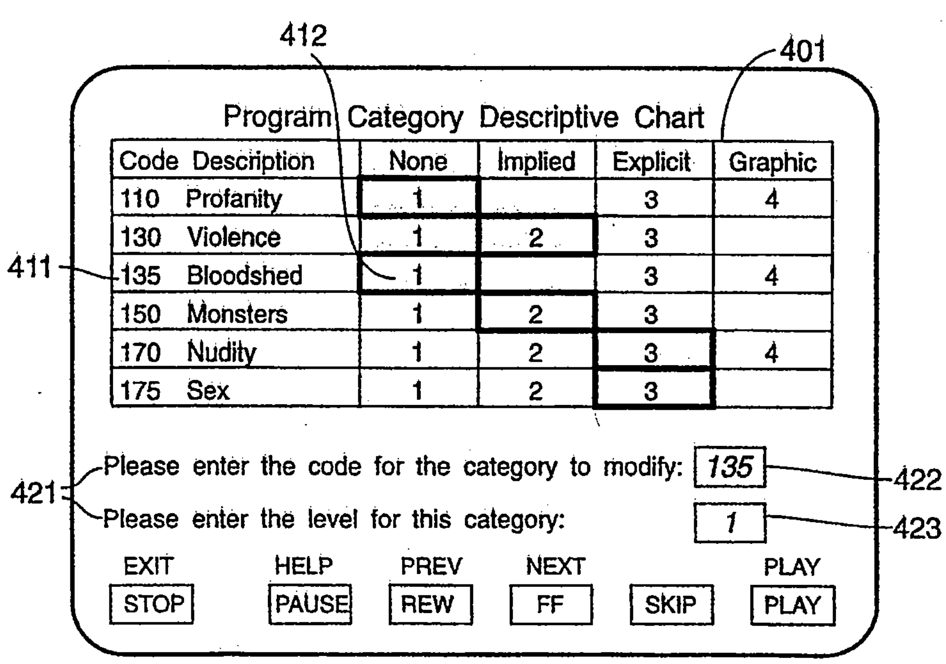
Primary Examiner—Tommy P. Chin
Assistant Examiner—Robert Chevalier

[57] ABSTRACT

This invention relates to a video system comprising integrated random access video technologies and video software architectures for the automated selective retrieval of non-sequentially stored parallel, transitional, and overlapping video segments from a single variable content program source, responsive to a viewer's preestablished video content preferences. Embodiments of the video system permit the automatic transmission of the selected segments from a variable content program as a seamless continuous and harmonious video program, and the transmission of the selected segments from an interactive video game further responsive to the logic of the interactive video game. The viewer's video content preferences being stored in the video system, and/or in a compact portable memory device that facilitates the automatic configuration of a second video system. The system's controls also provide an editor of a variable content program the capability for efficiently previewing automatically selected video segments to permit the editor to indicate the inclusion of the selected segments in the program to be viewed by a viewer. The system further integrates fiber optic communications capabilities and the read/write laser disc player capabilities to facilitate the downloading of a variable content program from a source remote to the system.

19 Claims, 11 Drawing Sheets



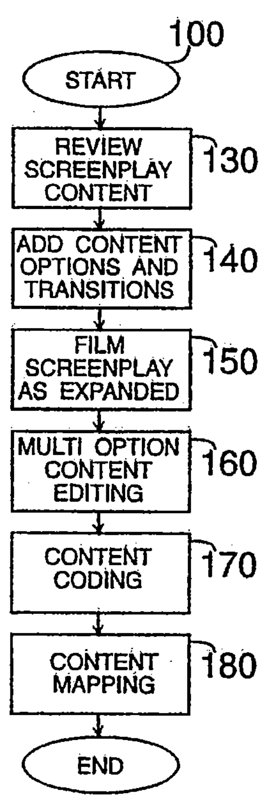

100
START
REVIEW SCREENPLAY CONTENT
130
ADD CONTENT OPTIONS AND TRANSITIONS
140
FILM SCREENPLAY AS EXPANDED
150
MULTI OPTION CONTENT EDITING
160
CONTENT CODING
170
CONTENT MAPPING
180
END

FIG. 1

Video Segment Category Descriptive Structure

210

211 Code Description	None	Implied	Explicit	Graphic
110 Profanity	1	2	3	4
212 130 Violence	1	2	3	4
135 Bloodshed	1	2	3	4
150 Monsters	1	2	3	4
170 Nudity	1	2	3	4
175 Sex	1	2	3	4

219

FIG. 2A

Video Segment Element Descriptive Structure

220

221 Code Description	None	Minimal	Expanded	Extensive
210 Character	1	2	3	4
222 220 Location	1	2	3	4
230 Time	1	2	3	4
340 Detail	1	2	3	4
420 Expertise	1	2	3	4

FIG. 2B

Video Segment Inclusion Descriptive Structure

230

231 Code Description	Highlight	Summary	Condensed	Detailed
610 Inclusion	1	2	3	4

FIG. 2C

Video Segment Generalized Descriptive Structure

240

241				
G	PG	PG-13	R	NC-17

249

Symbols MPAA Trademark

FIG. 2D

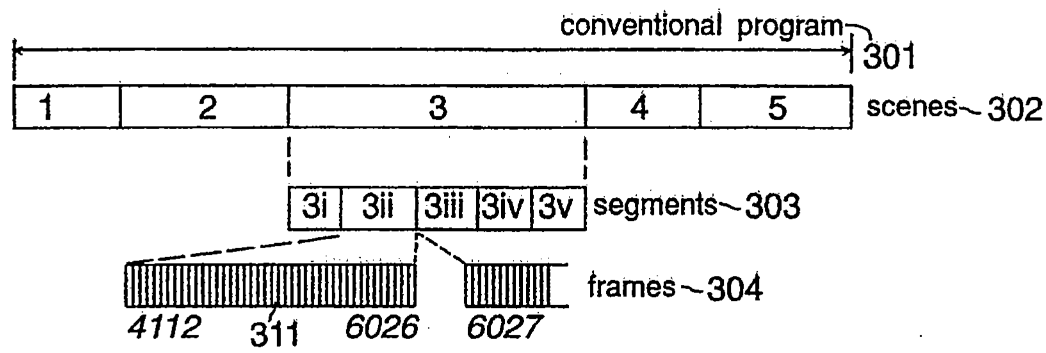


FIG. 3A

Code Description	None	Implied	Explicit	Graphic
135 Bloodshed			3	

319

FIG. 3B

Code Description	None	Implied	Explicit	Graphic
135 Bloodshed	1			

329

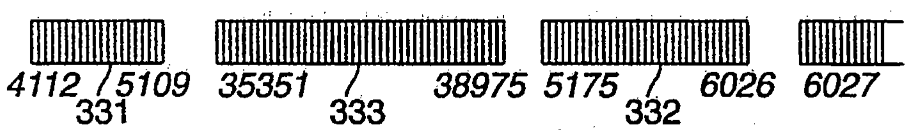


FIG. 3C

Code Description	None	Implied	Explicit	Graphic
135 Bloodshed				4

339

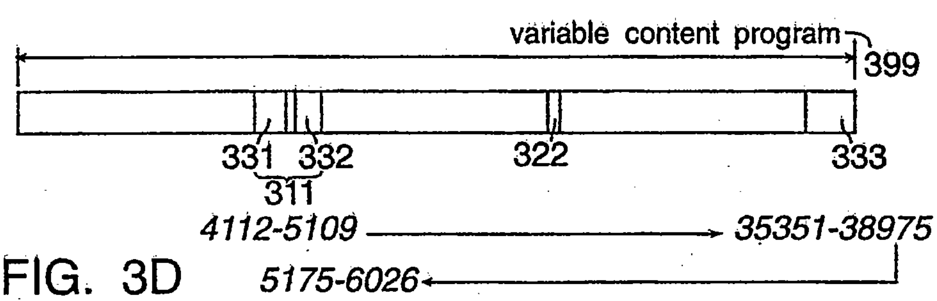


FIG. 3D

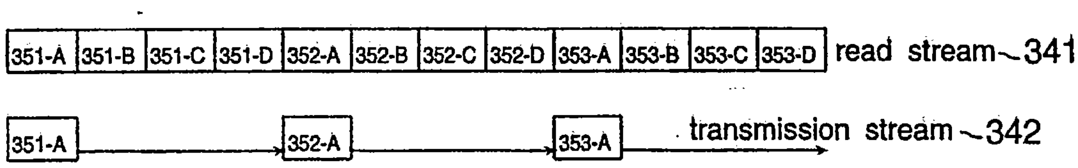


FIG. 3E

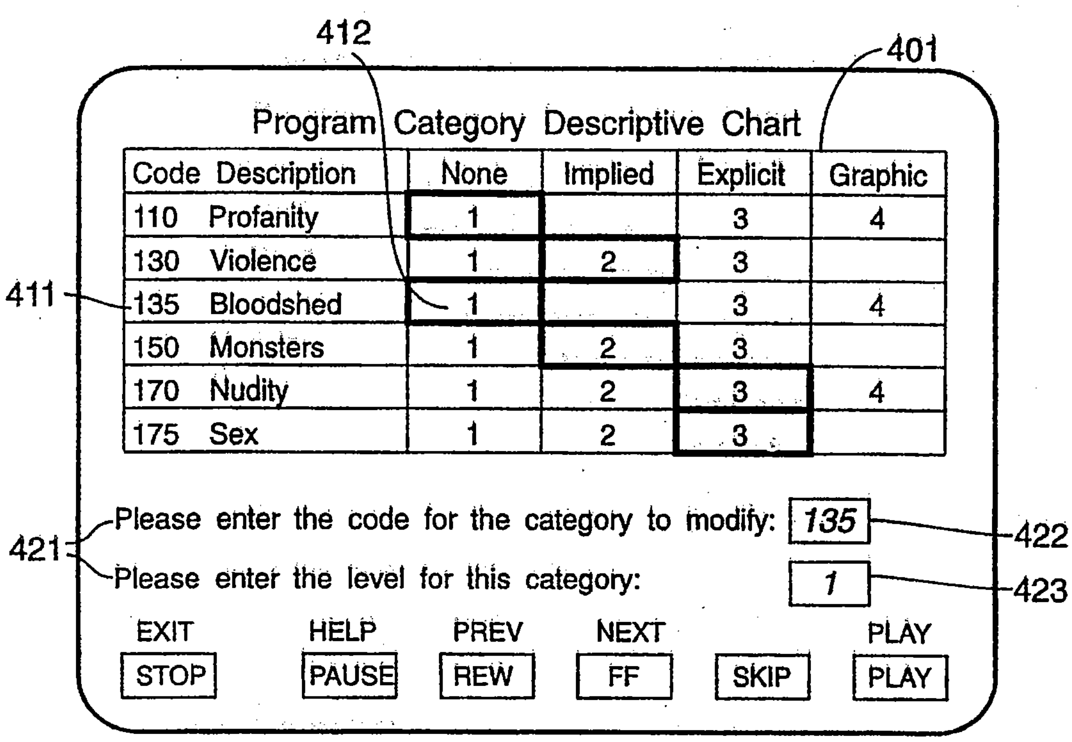

412
401
Program Category Descriptive Chart
Code Description
None
Implied
Explicit
Graphic
110 Profanity 1 3 4
130 Violence 1 2 3
411
135 Bloodshed 1 3 4
150 Monsters 1 2 3
170 Nudity 1 2 3 4
175 Sex 1 2 3
421
Please enter the code for the category to modify: 135
422
Please enter the level for this category: 1
423
EXIT
HELP
PREV
NEXT
PLAY
STOP
PAUSE
REW
FF
SKIP
PLAY

FIG. 4

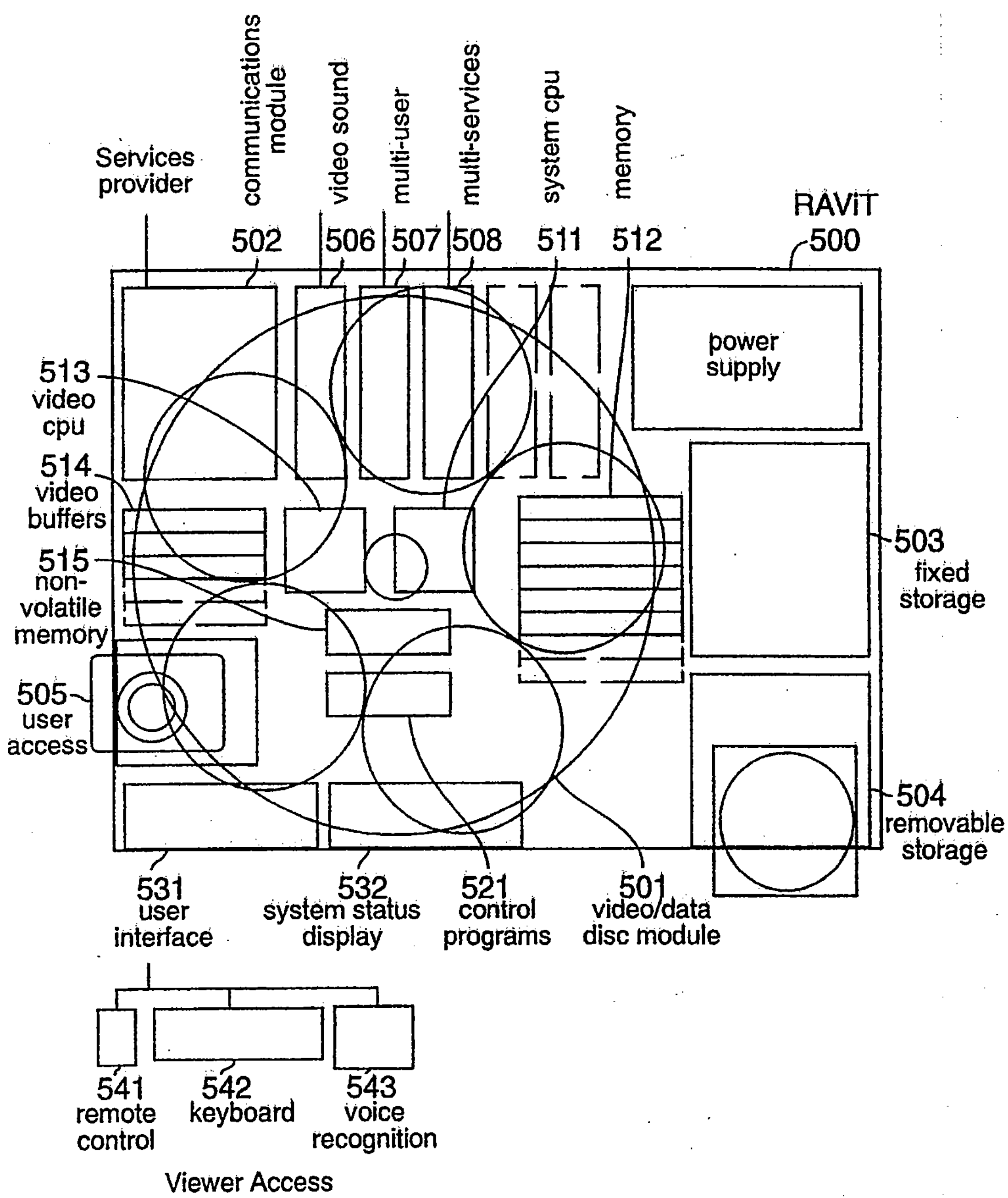

Services provider
communications module
video sound
multi-user
multi-services
system cpu
memory
RAVIT
500
502
506
507
508
511
512
513 video cpu
514 video buffers
515 non-volatile memory
505 user access
power supply
503 fixed storage
504 removable storage
531 user interface
532 system status display
521 control programs
501 video/data disc module
541 remote control
542 keyboard
543 voice recognition
Viewer Access

FIG. 5

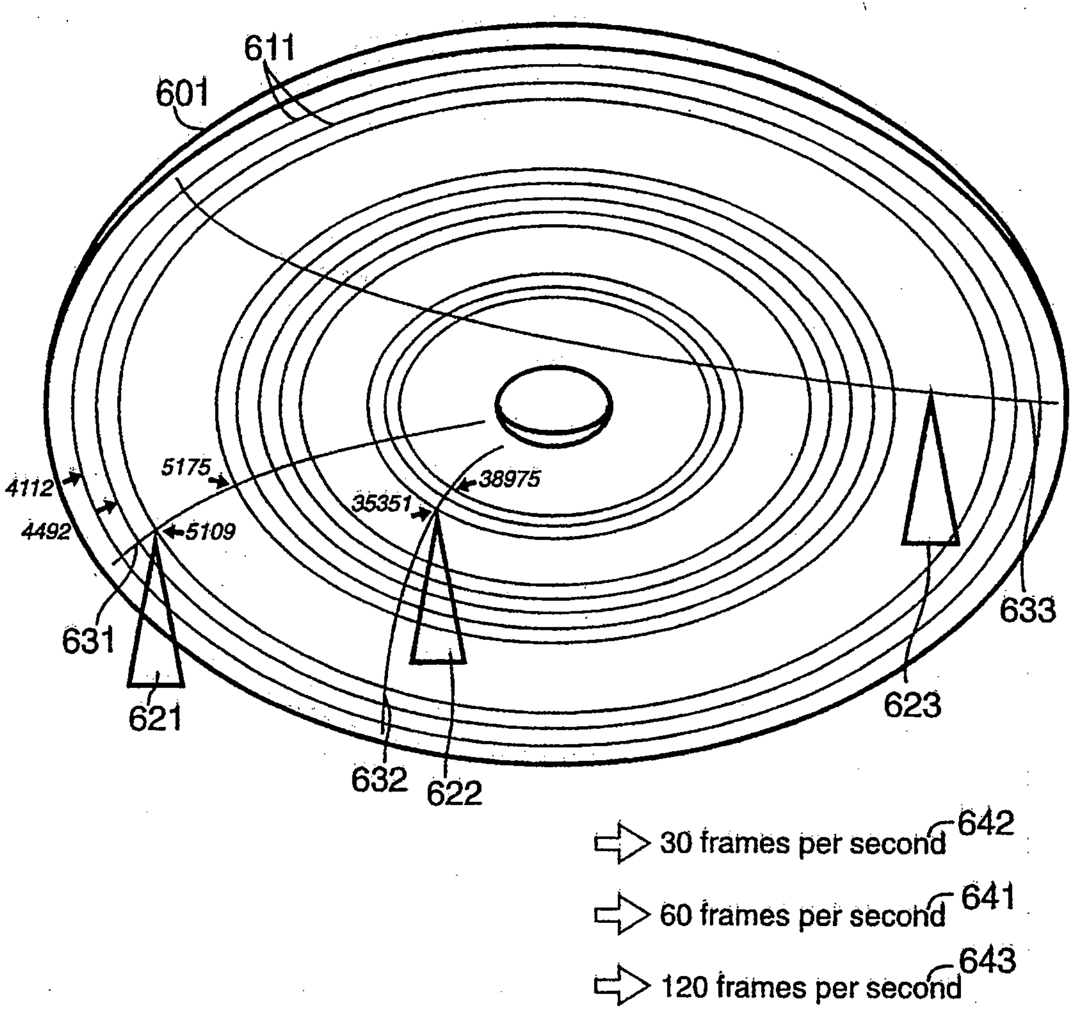

611
601
4112
4492
5175
5109
35351
38975
631
621
632
622
623
633
30 frames per second 642
60 frames per second 641
120 frames per second 643

FIG. 6

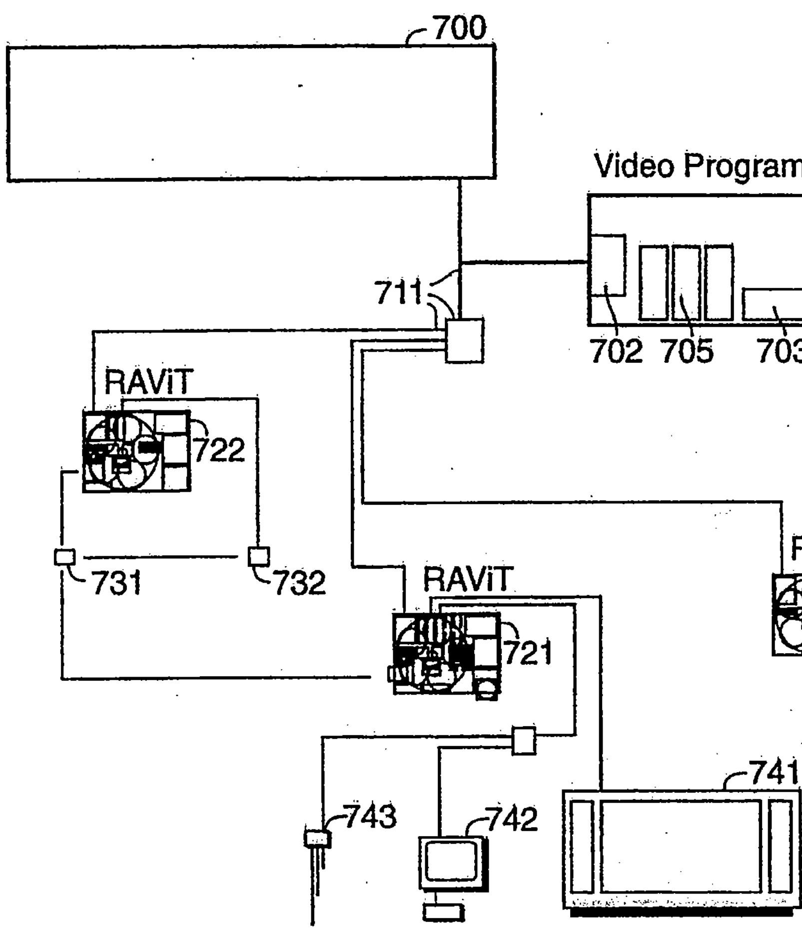

700
Video Program Provider
700
711
702
705
703
704
701
RAViT
722
731
732
RAViT
721
RAViT
723
741
743
742

FIG. 7

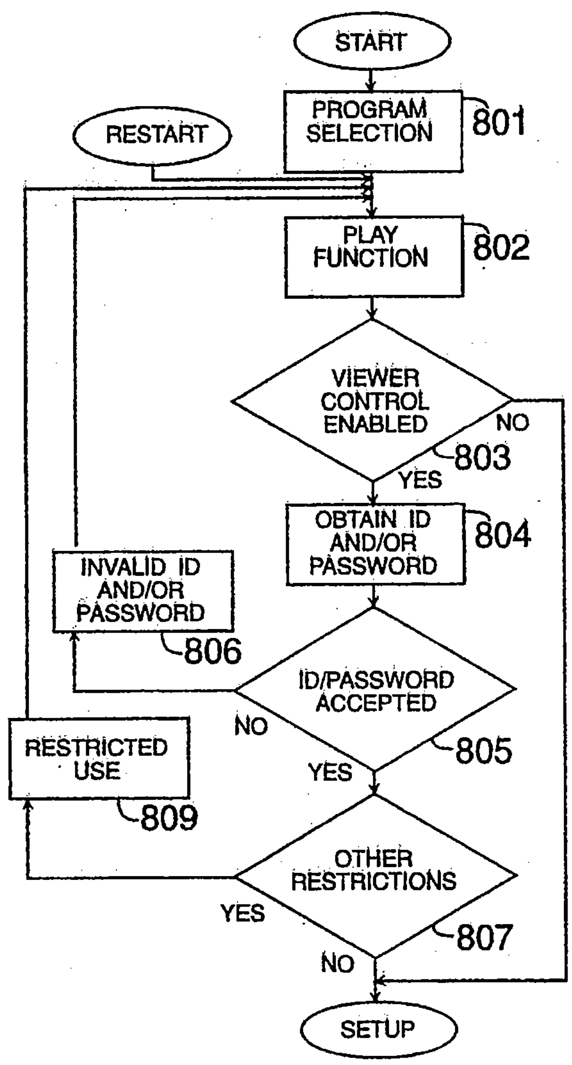

START
PROGRAM SELECTION
801
RESTART
PLAY FUNCTION
802
VIEWER CONTROL ENABLED
NO
803
YES
OBTAIN ID AND/OR PASSWORD
804
INVALID ID AND/OR PASSWORD
806
ID/PASSWORD ACCEPTED
NO
805
YES
RESTRICTED USE
809
OTHER RESTRICTIONS
YES
807
NO
SETUP

FIG. 8A

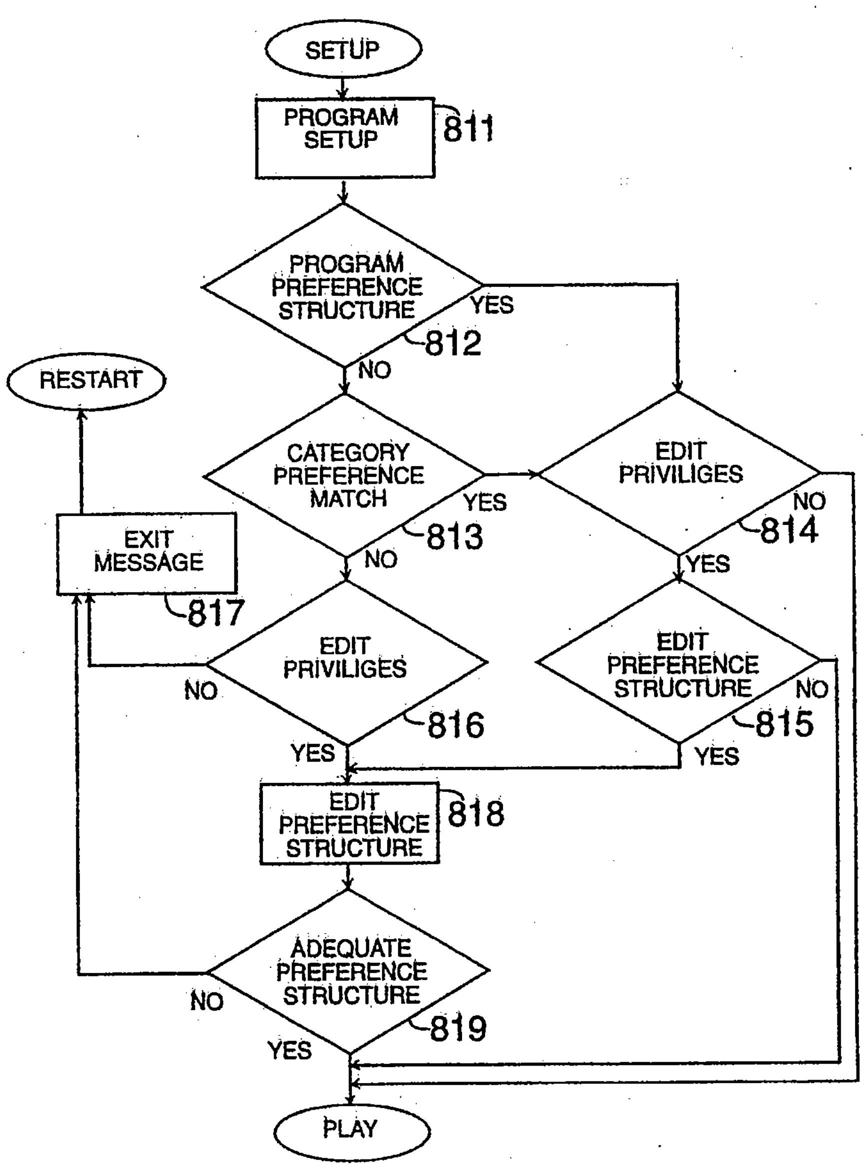

SETUP
PROGRAM SETUP
811
PROGRAM PREFERENCE STRUCTURE
YES
812
NO
RESTART
CATEGORY PREFERENCE MATCH
YES
813
NO
EDIT PRIVILIGES
NO
814
YES
EXIT MESSAGE
817
EDIT PRIVILIGES
NO
816
YES
EDIT PREFERENCE STRUCTURE
NO
815
YES
EDIT PREFERENCE STRUCTURE
818
ADEQUATE PREFERENCE STRUCTURE
NO
819
YES
PLAY

FIG. 8B

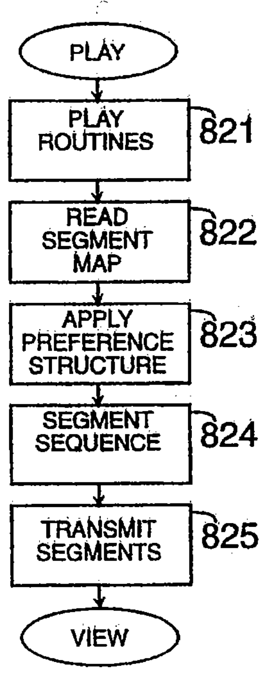

PLAY
PLAY ROUTINES
821
READ SEGMENT MAP
822
APPLY PREFERENCE STRUCTURE
823
SEGMENT SEQUENCE
824
TRANSMIT SEGMENTS
825
VIEW

FIG. 8C

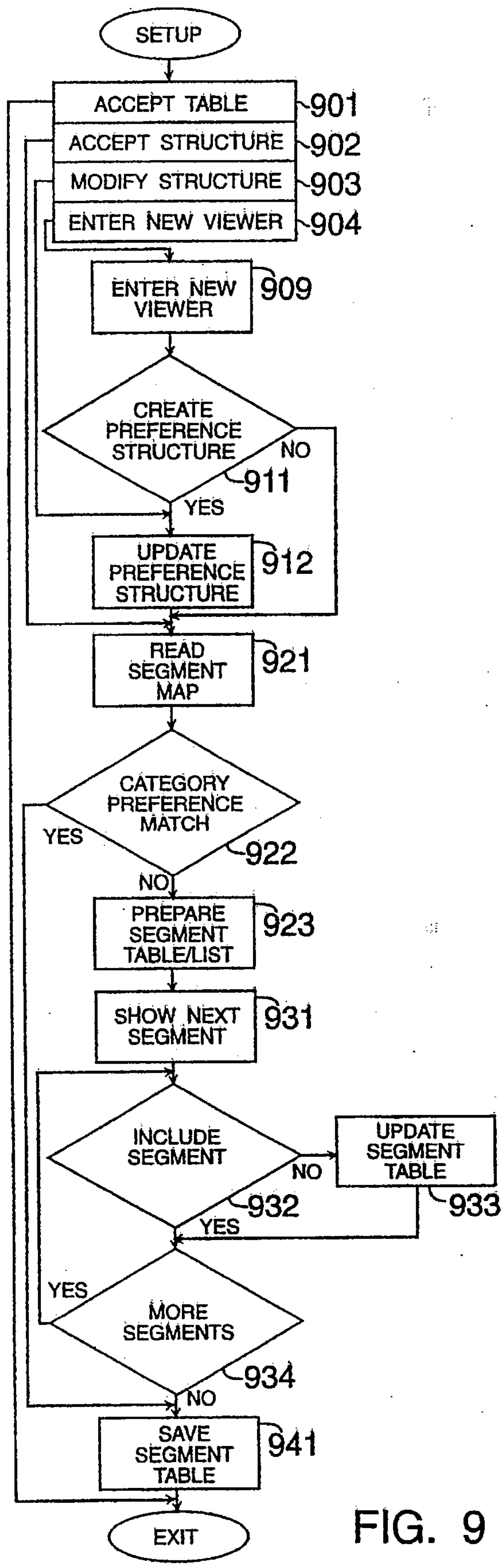

SETUP
ACCEPT TABLE
901
ACCEPT STRUCTURE
902
MODIFY STRUCTURE
903
ENTER NEW VIEWER
904
ENTER NEW VIEWER
909
CREATE PREFERENCE STRUCTURE
NO
911
YES
UPDATE PREFERENCE STRUCTURE
912
READ SEGMENT MAP
921
CATEGORY PREFERENCE MATCH
YES
922
NO
PREPARE SEGMENT TABLE/LIST
923
SHOW NEXT SEGMENT
931
INCLUDE SEGMENT
NO
UPDATE SEGMENT TABLE
932
933
YES
YES
MORE SEGMENTS
934
NO
SAVE SEGMENT TABLE
941
EXIT

FIG. 9

SEAMLESS TRANSMISSION OF NON-SEQUENTIAL VIDEO SEGMENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a video device for the automated selective retrieval of non-sequentially-stored video segments of a video program, from a single video program source, responsive to a viewer's preestablished video content preferences, and the transmission of the selected segments as a seamless video program.

2. Description of the Prior Art

Conventional memory storage devices, as for example, laser disc players and computer hard disks, when accessing or transferring data randomly located on the device's memory storage unit, the read/write functions of the device must wait for the proper positioning of the read/write head from one location to another location. This operation usually referred to as the average access time and measured in microseconds is one of the primary determinants of a random access device's performance capabilities.

In full motion picture applications a device's capabilities are also critical in terms of transfer rates and storage capacity. A typical motion picture runs at 30 frames per second. In digital terms, reasonable quality video, such as may be obtained from a VCR tape, requires approximately 1.5 megabytes per second, or a total of 10,800 megabytes for a two hour film. While the application of compression technologies reduces the storage requirements, this is offset by the greater requirements of high definition television (HDTV).

As a result of the storage capacity, transfer rates, and average access times, laser optical technology has proven its costs effectiveness in full motion picture applications. State of the art laser video disc systems, such as for example Pioneer's VDR-V1000, incorporates separate optical heads for recording and erasing, and provides an average access time of 0.3 seconds. While in most applications a 0.3 seconds average access time can be accommodated, this proves not be the case when a continuous seamless retrieval of random frame sequences from a single video source is required. A 0.3 average access time translates into a gap of 0.3 seconds (approximately 9 frames) each time a non-sequential frame needs to be retrieved. Where the viewing of a motion picture requires a significant number of such random accesses, the repeated gaps represent a significant failing.

Various data and video read and read/write architectures, such as those comprising: i) a single head; ii) multiple heads, in which each head operates on a different source surface; iii) multiple heads operating in one surface, in which each set of heads moves over the surface as a single unit; and iv) multiple heads, in which each head's movement over the shared surface and function is independent of the operation of the other heads; provide different average access time and transfer rate capabilities.

For example, the patent to Takemura et al., U.S. Pat. No. 4,744,070, discloses a tracking method for an optical disc in which two laser spots irradiate two adjoining slants of a V-shape groove. Since the laser spots movement over the disc surface are in unison, the shortcomings of access time gaps are not resolved.

With respect to the objects of the present invention, the shortcomings of the prior art known to the applicant are not limited to the hardware architecture. From the outset, film production has and continues to be directed at the eventual production of a unique linear sequence of frames.

In the creation of motion picture, producers and artists often surrender the exercise of creative expression to the inherent constraints of an unique linear sequence of frames, generally accepted norms, marketing objectives, and the censoring influence of the Motion Picture Association of America, Inc. rating system. In general, the resulting compromise inevitably provides for scenes, content, or artistic expression, which either exceeds or fails to satisfy individual viewer preferences. Too often, gains made in the exercise of creative expression result in the loss of potential audience. To that extent, recently a number of films are issued in an U.S. version, and a more explicit European version.

Viewers that are attracted by the general subject matter of a motion picture, and, on the basis of the MPAA's motion picture rating system, elect to view the motion picture are subjected to material in the program they would not have selected for their own viewing. In a 1989 poll conducted by the Associated Press, 824 of the respondents felt that movies contained too much violence, 804 found too much profanity, and 724 complained of too much nudity.

A number of editing systems in the prior art have attempted to address these issues. For example, the patent to Von Kohorn, U.S. Pat. No. 4,520,404, discloses a remote recording and editing system, whose functions include the activation or deactivation of a television receiver and a recording apparatus by the transmission of control or editing command signals, generated from a central station where an operator monitors a broadcast transmission. Similarly, the patent to Chard, U.S. Pat. No. 4,605,964 discloses a television controller that utilizes coding for identifying and automatically deleting undesirable sound and visual event broadcast with a program. The patent to Olivo, Jr., U.S. Pat. No. 4,888,796, discloses a screening device capable of automatically disabling the TV or video receiving device in response to the receiver's recognition of a non-interfering material content signal co-transmitted with the program signals. However, even the aggregation of Von Kohorn, Chard, and Olivo, fails to suggest a video software/hardware architecture wherein the disabling of segments of the program material does not produce dead segments.

The patent to Vogel, U.S. Pat. No. 4,930,160, addresses the resulting dead segments in the transmission by providing a facility for displaying alternative material during the dead segments. The alternative material selected during censorship periods can originate from a remote source, for example, another television broadcast, or locally, for example, from a video disc or tape player. However, Vogel and the prior art known to the applicant, do not provide a system that creates, from a single source, an automatically edited, seamlessly continuous program in which edited out segments are replaced with other parts of the same program responsive to a viewer's preestablished video content preferences.

The patent to Bohrman, U.S. Pat. No. 5,109,482, discloses and is titled "Interactive Video Control System for Displaying User-Selectable Clips". In Bohrman, it is the viewer that, with precise knowledge of the contents of the video segments of a program, interactively creates an arrangement of the viewer selected segments. In other words the segments are not automatically selected and arranged responsive to a viewer's preestablished content preferences. Additionally, Bohrman fails to address the problems associated with the laser disc player's average access times.

A number of other interactive systems in the prior art provide viewers the means to participate, and thereby affect, the program's story lines or plot. The patent to Best, U.S. Pat. No. 4,569,026, discloses a video entertainment system where human viewers conduct simulated voice conversations with screen actors or cartoon characters in a branching story game shown on a television screen. As opposed to passive systems, the essence of interactive video systems is a viewer's participation. In interactive systems, at frequent points, the system's continued operation is dependent on the viewer's response.

In electronic games, of which Sega's CD ROM System for Genesis is an example, the access time of approximately one second results in noticeable pauses in the action, the effect of which is also mitigated by the interactive nature of the software. As a result of their interactivity, these systems can accept significantly slow random access times.

Further, as electronic games have been principally directed at children, or contain primitive subject matter, they have not dealt with issues raised by the more complex adult forms of expression inherent in contemporary motion picture films. While electronic games provide setup editing capabilities (selection of: level of difficulty, character, weapons, etc.), they do not provide censoring editing capabilities. This is clearly evidenced in the discussion, marketing, and development of video games dealing with material generally deemed not suitable for children. Given the random access capability of CD-based systems, it is surprising that when dealing with adult subject matter, the inherent limitations of conventional films and the MPAA's rating system have been adopted by forthcoming CD based video games.

Thus the prior art known to the applicant has failed to show an integrated software and hardware architecture that provides for the automated selective retrieval of non-sequentially stored video segments of a program, from a single program source, responsive to a viewer's preestablished viewing preferences, and the transmission of the selected segments as a seamless video program.

SUMMARY OF THE INVENTION

These and other shortcomings of the prior art are overcome by the various features of the present invention which are directed to a seamless transmission of non-sequential video segments. For purposes of the present invention, various terms or nomenclature used in the art are defined as follows:

The term "viewer" as used herein is meant to include and be interchangeable with the words "player" (when referring to a person), subscriber, and "user". That is, the term "viewer" ought to be understood in the general sense of a person passively viewing a video, interactively playing a video game, retrieving video from a video provider, and/or actively using multi-media.

The terms "video" and "video program" are interchangeable and refer to any video image regardless of the source, motion, or technology implemented. A "video" comprises images found in full motion picture programs and films, in interactive electronic games, and in video produced by multimedia systems. Unless otherwise qualified to mean a computer software program, the term "program" is interchangeable and may be replaced with the word "video". While a particular feature may be detailed with respect to a specified viewing, gaming, or computing application, it is intended herein to apply the teachings of the present invention broadly and harmoniously across the different classes of applications that generate a video output.

The terms "variable content program" and "variable content game" refer to a specific video program characterized by a greater variety of possible logical content sequences that result from the additional segments provided for that purpose. The term "content" referring principally to the form of expression rather than the story-line. Where initially produced as a variable content program, the video utilizes parallel, transitional, and overlapping segments to provide viewing of a program's story-line/interactive action at different levels of forms of expression.

The term "video content preferences" refers to a viewer's preferences as to the "content" of a video. "Video content preferences", specifically and principally, although not exclusively, refers to a viewer's preestablished and clearly defined preferences as to the manner or form (e.g. explicitness) in which a story/game is presented, and the absence of undesirable matter (e.g. profanity) in the story/game. In the broadest sense the term "video content preferences" further includes "video programming preferences", which refers exclusively to a viewer's preferences as to specific programs/games (e.g. Sega's "Sherlock Holmes Consulting Detective"), types of programs/games (e.g. interactive video detective games), or broad subject matter (e.g. mysteries). In contrast to the prior art "video-on-demand" systems which are responsive to a viewer's "video programming preferences"; a more inclusive "content-on-demand" system as per the teachings of the present invention is responsive to a viewer's "video content preferences".

The term "seamless" is intended in the sense that the transmission of sequential and non-sequential frames is undiscernible to the eye, and not in the sense of the natural video seams that result in the intended changes from one scene to another, from one camera angle to the other, or from one gaming sequence to the other. In a seamless transmission of a variable content motion picture a constant video frame transmission rate is maintained, whether the frames are sequential or non-sequential.

The terms "B-ISDN", specifically referring to a broadband integrated services digital network, and "fiber optic", specifically referring to a network comprising fiber optic cable, refer to any "communications" means, private or public, capable of transmitting video from a remote video source to a viewer. In the broadest sense these terms further comprise satellite communications.

Where not clearly and unambiguously inconsistent with the context, these and other terms defined herein are to be understood in the broadest possible sense that is consistent with the definitions.

Accordingly, in view of the shortcomings of the prior art, it is an object of the present invention to provide a device comprising integrated random access video technologies and video software architectures that furnishes a viewer the automated selective retrieval of non-sequentially stored, parallel, transitional, and overlapping video segments from a single variable content program source, responsive to the viewer's preestablished video content preferences, and transmits the selected segments as a logical, seamless, and continuous video program.

It is another object of the invention to provide an interactive video game system comprising interactive video game software, variable content game, and a program segment map defining segments of the variable content game, furnishing a player of the interactive video game the automatic and logical selection of video segments responsive to the application of the player's video content preferences to the program segment map, and responsive to the logic of the interactive video game software.

It is yet another object of the present invention to provide a device that furnishes a previewer of a variable content program the capability for efficiently previewing automatically selected segments from the program, responsive to a viewer's preestablished preferences, to permit the previewer to indicate the inclusion of the selected segments in the program to be viewed by the viewer.

It is yet another object of the present invention that a viewer's video content preferences be stored in a portable memory device.

It is yet another object of the present invention to integrate fiber optic communications capabilities and read/write laser disc player capabilities within a single device to facilitate the downloading of a motion picture program from a source remote to the device.

It is yet other objects of the present invention to provide a variety of reading architectures that produce a seamless reading of sequential and non-sequential segments of a variable content program from a single video source.

Briefly these and other objects of the invention are accomplished by means of the random access video technologies detailed herein in combination with the teachings herein of a variable content program.

Unlike traditional film media that permits a program format with only a single sequence of frames, random access video technologies make possible a variable content program format that is characterized by a variety of possible logical sequences of video frames. In a variable content program the artist and program producer are challenged to create greater variety in the form of expression, and utilize parallel, transitional, and overlapping segments to provide viewing of a program at that level of expression, content, detail, and length, that is consistent with a variety of viewer preferences.

In contrast to interactive motion pictures, and full motion video games, in a variable content program it is principally the form of expression that is the object of alternate frame sequences, rather than the story-line. In a variable content program, each of the significant scenes and actions can be implicitly expressed, as found for example in a "PG" rated film, explicitly expressed, as found for example in an "R" rated film, and graphically expressed, as found for example in an "NC-17" rated film. As a result, unlike motion pictures which are packaged as a single sequence of frames, the U.S. version, the European version, the edited-for-TV version, the "XXX" version, and the version addressing each viewer's particular tastes and preferences, reside harmoniously within a single variable content motion picture.

The present invention details a number of random access video technologies that permit the retrieval, in a logical order, of the non-sequential segments that comprise a variable content program without altering the transmission of the required frames per second. An embodiment of a video system as per the present invention, permits the automatic transmission of the selected segments from a variable content program as a seamless continuous and harmonious video program responsive to a viewer's preestablished video content preferences. In a second embodiment, segments from an interactive video game are selected responsive to the logic of the interactive video game software and the player's video content preferences.

In a laser disc video system, random access video technologies principally comprising: multiple independently simultaneously controlled reading units, video buffer, and media architecture, permit, in one embodiment, during the read operation of one of the reading units of the video information contained in a program source, the repositioning of a second one of the reading units to the next required non-sequential position in the program source. The resulting synchronization effectively eliminating the gaps that would result from a single reading unit's average access time. That is, pauses, gaps, dead frames, and fill-ins, are eliminated in the playing of non-sequential video segment stored in a single program source.

To achieve the automated selection of only those segments consistent with a viewer's preestablished viewing preferences, each program segment in a variable content program is defined by and is associated with a content descriptive structure that provides specific and detailed information as to each segment's subject matter, level of detail, and form of expression. The segments definitions of a program further comprises a first and last frame identifier, and beginning frame identifiers of the next logical segments. The segments definitions are organized into a program segment map.

A random access device as per the present invention provides each viewer the opportunity to preestablish both any number of generalized, personalized video content preferences, and program/event specific content preferences, identifying the viewing preferences in each of a number of content categories. By analyzing a viewer's preestablished video content preferences as they relate to a program's segment map, the random access device gains the information to automatically exclude segments of the variable content program containing material which the viewer does not wish to view, and to transmit as a logical seamless transparently harmonious and continuous program only those sequential or non-sequential scenes or segments of the program whose content and form of expression are consistent with the viewer's preestablished video content preferences. The playing of a variable content program does not require that the viewer preview the contents of the segments of the program, and does not require viewer intervention during the viewing of the program.

Thus, the present invention while challenging the video program producer to fully exercise the freedom of expression, provides for the automated, seamless transmission of non-sequential video segments containing that level of artistic expression that is consistent with a viewer's preestablished video content preferences. The present invention, effectively harmonizing what are regarded in the popular press as conflicting objectives, provides an unparalleled opportunity for "freedom of expression and freedom from expression" (C).

These and other features, advantages, and objects of the present invention, are more easily recited and are apparent in the context of the detailed description of the invention, accompanying drawings, and appended claims, that follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow chart summarizing the steps of producing a variable content program as per the present invention;

FIGS. 2A, 2B, 2C, and 2D, are illustrations of video segment descriptive structures as per the present invention;

FIGS. 3A, 3B, 3C, are diagrams of three versions of a video segment and corresponding descriptive structures, each segment a variation of the other as per the present invention;

FIG. 3D is a diagram representation of a variable content program showing the non-sequential arrangement of segments as per the present invention;

FIG. 3E is a diagram representation of a variable content program reading stream and transmission stream as per the present invention;

FIG. 4 is a sample video content preference selection screen as per the present invention;

FIG. 5 is a schematic diagram of a random access video technology device comprising fiber optic communications and variable content laser disc capabilities as per the present invention;

FIG. 6 is a schematic detail of a laser disc module's multiple reading units architecture as per the present invention;

FIG. 7 is a schematic diagram a video program provider and subscriber network architecture as per the present invention;

FIGS. 8A, 8B, and 8C, are flow charts summarizing the process of playing a variable content program as per the present invention; and

FIG. 9 is a flow chart summarizing the process of previewing flagged segments as per the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The steps in the production of a variable content program are Summarized with respect to the simplified flow chart of FIG. 1. Each scene or fragment of a scene on a video script is reviewed 130 according to an appropriate segment descriptive structure, as for example detailed with respect to FIGS. 2A–D. A screenwriter now has the freedom to expand the scenes by adding parallel, overlapping, and transitional segments, to cover a wider descriptive range 140 without the concern for the limitations inherent in first generation program formats. A successful filming 150 of this variable content architecture is a function of the skill of director(s), actors, animators, programmers, etc. to provide for parallel and transitional segments with the required transparent harmony.

In contrast to the editing of first generation motion pictures that require producing a unique linear sequence of segments, editing of this program format requires a parallel, non-sequential, logical arrangement of segments 160. A segment assigned a category descriptor may be congruent in one or more frames with a segment assigned a different category descriptor. Where necessary, a video segment is associated with more than one audio segment, and corresponding separate voice and video category descriptors are provided. The editing of a variable content program is significantly distinguished from the editing of an interactive motion picture is that in the latter the editing is concerned with a branching story-line, while editing in the former is principally concerned with optional forms of expression of the same story-line.

The complexity of a variable content program/game is only limited by the requirements, desires, skill, and hardware/software available to the program editor. To that extent, it is intended that the editing functions, in particular, be assisted by integrated computerized editing resources. With respect to the computer assisted editing, the teachings of the patents to Bohrman, previously cited, and to Kroon et al., U.S. Pat. No. 4,449,198, are by reference incorporated herein. It should be appreciated that the art of program editing under this new format is intended to significantly transfer censorship, and time-constrained editing decision making from the producer/editor to the viewer.

As each segment is defined, the beginning frame and end frame in each of the relevant segments is identified, the segment content is assigned a category descriptor, and logical entry and exit references are assigned 170. The resulting segment definition is mapped 180 and the required user interface produced. The program segment map, any user interface routines particular to the program, and player control codes, if required, are provided with the information comprising the programs video and sound.

FIGS. 2A, 2B, and 2C illustrate examples of generalized descriptive structures that are utilized to review the contents of each segment contained in a given program, and to assign the appropriate segment content descriptors. Specifically, FIG. 2A illustrates a descriptive structure 210 implementing a descriptive scale 211 that mirrors the current rating system utilized by the MPAA (Motion Picture Association of America, Inc.). The MPAA's "Voluntary Movie Rating System" comprises the symbols "G", "PG", "PG-13", "R", and "NC-17" and the corresponding legends, which are trademarked/pending by the MPAA.

The descriptive structure, further includes, in this example, a number of categories 212 of conventional concern in the popular culture. Each number in the matrix 219 in the chart represents the particular descriptor for a given category that can be assigned to a specific scene or segment. For example, a scene of an old western style barroom brawl might be assigned a 130-4 (graphic violence). While the absence of an element is presumed, unless otherwise indicated, as an example, the absence of bloodshed is assigned a 135-1 (no bloodshed).

The contents of a segment are further coded on the basis of a number of other considerations. FIG. 2B is an example of an element descriptive structure 220 utilized to analyze the development 221 of a number of elements 222 such as character, location, time, degree of detail, and the level of expertise appropriate for the segment. In a similar manner, an individualized, tailored, and descriptive structure may be provided for any one category or group of categories. For example, FIG. 2C illustrates a descriptive structure 230 utilized to classify segments according to a level of inclusion 231. Such a structure is appropriate, for example, in coding a news report.

Additionally, or alternatively, a video segment descriptive structure, as shown in FIG. 2D, is implemented that incorporates the MPAA's movie rating system. Under this video segment generalized descriptive structure 240, segment definitions are assigned a descriptor (rating) 249 from a descriptive scale 241 incorporating the MPAA rating symbols 249, or any other available analogous rating system. Determination of each segment's rating symbol being similar to the manner in which the MPAA rating system is applied to a motion picture. While this rating scale 241 may be implemented in conjunction with categories, as detailed with respect to FIGS. 2A, and 2B, a simplified embodiment is not concerned with identifying the category, instead, the segment definition comprises frame information and a simple descriptor (rating).

It is noted that FIGS. 2A–2D are examples of an overall framework for segment analysis, the actual descriptive structures and level of complexity utilized may be highly tailored by the producer of a program to reflect the specific content of a program without being limited by the structures which will be widely accepted, constitute a standard, and found to be generally utilized in other works. Each program producer is offered the flexibility within the overall architecture of this descriptive structure to determine and include only those categories that are relevant to a particular program, and to add categories as the producer requires. Similarly, the producer is offered some flexibility in determining the labelling of the descriptive scale.

Meeting the objectives of being able to provide both a standardized set of descriptive structures that permits the automatic application of a viewer's preestablished preferences to a variety of programs, and provides the producer of the program the flexibility described above, are accomplished for example by assigning unique classification codes to each set of preestablished standardized categories, and by reserving a range of classification codes that are recognized by the system as requiring additional selection by the viewer.

FIG. 3A illustrates an example of a conventional motion picture program in which the segments are arranged as a unique sequential arrangement of frames. In a variable content program adaptation of the conventional motion picture, the various scenes 302 of the program are, according to an evaluation of the contents of the scenes, divided into appropriate segments 303. Each segment is identified with a beginning and ending frame and comprises any number of frames 304. In this example, scene three is divided into four segments, in which segment 3ii 311 begins at frame 4112 and ends at frame 6026. The next segment, 3iii, begins at frame 6027. Segment 3ii, which in a conventional motion picture contributes to an "R" rating for the program, includes frames depicting explicit bloodshed. The content of segment 3ii 311 is indicated by the numeral 3 in the appropriate cell 319 of that segment's descriptive structure.

Referring now to FIG. 3B, to provide for the option of editing-out the explicit bloodshed in a variable content program, the program segment map includes an additional segment definition 321 beginning at frame 4112 and ending at frame 5205. The end of this segment 321 is linked to a new transitional segment 322 beginning at frame 35205 and ending at 35350, the end of which is linked to frame 6027. In this fashion, frames are omitted and added to provide a continuous transparent edited version of any segment. This frame sequence 321/322 is associated with the corresponding segment content descriptive structure 329 to indicate the absence of bloodshed. In all other respects the segments 321/322 are equivalent to the original segment 311. For first generation programs, the editing-out works in a like manner except that the transitional segment 322 is not available to make the seamless transmission from frame 5205 to 6027 transparent.

To provide for the option to include a graphic level of bloodshed, the program segment map includes an additional segment definition. Referring to FIG. 3C, in this case, only 66 frames of the "first" segment 311 are "ignored", and new segment definitions 331 and 332 are created, to accommodate the graphic bloodshed included in an additional segment 333 beginning at frame 35351 and ending at frame 38975. This frame sequence 331/333/332 is associated with an appropriate segment content descriptive structure 339. In this manner, parallel and transitional segments provide a descriptive selection mix ranging from a segment combination excluding bloodshed 321/322 to a segment combination including graphic bloodshed 331/333/332, as well as the segment combination including explicit bloodshed 311. As a result, the particular scene of which these segments are a part can be viewed at any of the three content levels for that category.

A scene can include subject matter of more than one category. In such cases, overlapping segments and transitional segments are provided to permit viewing of one subject matter at one descriptive level and viewing of another subject matter at another level.

Referring now to FIG. 3D, the location of the net additional frames that result from the additional segments 322/333 cause some frames to be non-sequentially placed in the variable content program 399. Ignoring the frame numbers of segment 322, FIG. 3D is illustrated to diagrammatically emphasize the resulting sequential and non-sequential random-like arrangement of video segments in a variable content program. This is shown for example, in the segment combination 331/333/332 depicting explicit bloodshed and the corresponding non-sequential frame sequence.

The segments combinations shown comprising the segment definitions together with the corresponding descriptors comprise a program segment map. A program segment map causes, for example, the retrieval of the segment combination beginning at frames 4112–5109, followed by frames 353514–38975, and ending with frames 5175–6026 in response to the application of a viewer's program content preferences to the program segment map.

In an actual feature length variable content motion picture the significant additional segment/frames are arranged responsive to the particular random access hardware architecture implemented. For example, FIG. 3E, illustrates an arrangement in which the reading unit reading stream 341 comprises alternating frames from four separate segments and is read at an effective rate of 120 frames per second. The processing architecture selecting the desired segment from the read stream 341 to generate a transmission stream 342 of the desired frames 351A–353A at a rate of 30 frames per second. This and other architectures are detailed later on with respect to FIG. 6.

A system embodying the teachings of the variable content program provides each viewer the opportunity to define a personalized video content preferences. The content preferences identifies each viewer's preferences in a range of video content categories. The architectures of a viewer's content preferences and that of the segment content descriptive structures are interrelated.

As is detailed below, the preferences are established prior to transmission of the program to the receiver, so that during the transmission of the program viewer intervention is not required.

FIG. 4 illustrates a program's categories descriptive chart 401 that merges the various descriptive structures of the segments of a program. For example, the category bloodshed 411 indicates that the program offers options to omit the viewing of bloodshed, or include explicit or graphic segments in the viewing of the program. In this example, depicted by bold boxes is the viewer selected level for each category. The viewer in this case has elected to omit bloodshed 412 in his/her viewing of the program. In this particular screen design, viewers indicate their selections by following the entry requests 421, and pressing the appropriate numeric keys on the player's remote control unit to indicate the category they wish to access 422 and the viewing level for the category 423.

In simplified terms, any segment with a descriptive level higher (abstract) than the viewer-selected level for a given category is not included in the program produced for the viewer. The segment selected for viewing (a descriptive level equal to or next lowest) provides the next segment beginning frame information, skipping over parallel segments of a lower rating than the viewed segment.

While the teaching above are detailed principally in terms of a variable content motion picture movie, clearly the teachings are applicable to any video program. Specifically, interactive video games utilizing full motion video segments can also benefit from providing the viewer/player of the game the option to preestablish video content preferences in addition to the gaming options which may be included in the video game software. As in a variable content program, in a interactive variable content video game, the video segments shown are consistent with the player's video content preferences.

The preferred hardware architecture of a video system that embodies the teachings of, and delivers the benefits of, the variable content program is referred to herein as a Random Access Video Technology system ("RAViT") (C), and is specifically detailed with respect to FIG. 5. Referring to FIG. 5 a preferred configuration of a RAViT 500 device principally comprises the following primary modules and sub-systems: i) random access laser video/data disc module 501; ii) communications module 502; iii) fixed memory sub-system 503; iv) removable memory sub-system 504; v) compact portable memory sub-system 505; vi) external video/sound input/output support module 506; vii) multi-user modules 507; and viii) multi-services modules 508.

A fixed memory sub-system 503 refers to any nonvolatile memory storage device principally utilized to randomly read/write and store significant quantities of information. An example of a present fixed memory storage sub-system is a personal computer hard disk drive, currently generally installed in 80–240 MB capacities.

A removable memory sub-system 504 refers to any nonvolatile memory storage device principally utilized to transport information to and from two similarly equipped devices. Examples of present removable memory storage sub-systems are personal computer floppy disk drives 1.2 MB, micro floppy disk drives 1.4/2.8 MB, backup tape drives 60–240 MB, and removable hard disks 20–80 MB. The random access laser disc module 501 is another example of a removable memory storage sub-system.

A compact portable memory sub-system 505 is principally distinguished from a removable memory sub-systems 504 in the size of the media and the greater variety of memory storage technologies that are generally implemented. Nonetheless, some of the removable memory storage media such as for example, the micro floppy disk, are also considered compact portable memory media. With present technology, compact portable memory media is available in dimensions similar to conventional credit cards. Examples of compact portable memory are: laser read/write cards, in which at least one surface of the card permits a laser to read/write information; electronic cards, in which the information is stored in electronic components; and magnetic cards embodying magnetic storage technology, of which a credit card is an example. Other examples of compact portable media are electronic cartridges commonly utilized in electronic video game systems.

Clearly, a variety of memory devices are available utilizing technologies and combinations of technologies to suit particular performance requirements. The above classifications of the memory devices are directed at bringing attention to functional capabilities of RAViT rather than to a particular technology. The classifications are not intended to restrict a device to a particular classification, limit the selection of devices which may be implemented, or to limit the function of the particular device implemented.

From a marketing standpoint, it is also preferred that RAViT additionally "play" other laser media, such as for example current laser discs, CDs, CDGs, photo CDs, and interactive programs and games, in a conventional manner. This being diagrammatically shown in FIG. 5 as the five circles inside the representation of the laser disc unit 501. In this context, it is also noted that the multimedia capabilities in RAViT in combination with its ability to extract video/sound/data from these sources offers the user sophisticated CD-ROM like capabilities and interactive full motion video gaming capabilities. As to the latter, RAViT's hardware configuration detailed herein is significantly more capable than interactive CD-based video games such as for example Sega's CD ROM System for Genesis.

In a preferred embodiment, RAViT is a fully integrated viewing/gaming/computing video system. To that extent and given the other teachings that follow herein, RAViT's laser disc module will operate at the required rotational rate to accommodate differences in software rpm requirements. This being analogous to the different available speeds in a record player.

The external video/sound input/output support module 506 supports video/sound/data transmission to the primary video display system comprising for example a monitor/television, stereo system, and keyboard/voice recognition-response, Additionally, the input/output module supports video/sound input from local sources such as for example VCR's, video cameras, and videophones. The construction of the external support module follows the conventional practices of consumer electronic products as for example: laser disc players, VCRs, and personal computers.

Multi-user modules 507 principally support separate controlled independent access by other users of RAViT's processing, video, and communications resources. A multi-user operating system such as for example a version of Unix or Windows NT, manage the multi-user environment. The construction of multi-user modules following established networking technology and responsive to the operating system implemented.

Multi-services modules **508** provide a host of services, such as for example residential security, and appliance operation management. The operation of the module being principally a software application running under the multi-user operating system implemented. The construction of the particular multiservice module being responsive to the particular application. Example of a primitive multi-service module is a fax/modem pc card.

RAViT further comprises computing elements and video processing elements readily found in multimedia devices and video electronic systems such as for example and not limitation: i) microprocessor **511**; ii) memory units **512**; iii) video processor **513**; and iv) video buffers **514**.

RAViT's user control interface **531** includes communications to the buttons and keys located on the cabinet of the device, and to the associated control devices **541-2-3**. The keys, buttons, and switches, conventionally found in consumer electronic devices and deemed advantageous to the operation of RAViT are implemented. These controls are further augmented by the following keys/functions: segment skipping control, preferences control, segment mapping control, and system menu control. The user control interface **531** additionally supports infrared remote control units **541**, as for example infrared numeric control pad, and infrared keyboard; wire connected control units **542**, as for example cable connected computer keyboards, mouses, and game controllers; and voice recognition units **543**.

The keyboard, as in a personal computer implementation, facilitates system setup, keyword retrieval, and system functions requiring the entry of alpha characters. Since a preferred configuration of RAViT comprises significant multimedia capabilities, a keyboard is advantageous. A keyboard connector used to connect a standard AT keyboard or a dedicated keyboard is supplied. Alternatively, an infrared-based keyboard is implemented. Further, given the computing and storage capabilities of RAViT, a voice response sub-system option accommodating minimally the few commands, such as play, stop, mute, sound, skip, required to control the basic operation of the laser disc module can additionally be provided.

Implemented in RAViT is a digital system status display sub-system **532**, which provides visual feedback and system status information.

RAViT's control programs that manage RAViT's resources, and the retrieval and processing of data and video information, reside in dedicated chips **521**. Alternatively, the control programs are stored in mass memory devices **503** from installed software, in removable memory media **504**, or in a compact portable memory device **505**.

A variable content program not only comprises variable content video/sound information, but also comprises a corresponding program segment map, user interfaces, program routines, and system control codes. In an interactive variable content video game, the video game software also comprises a variable content program. The terms "program segment map" and the term "data", where not inconsistent with the context, are to be understood to comprise the program segment map, user interfaces, program routines, system control codes, and gaming software (where applicable). Wherever the terms "variable content program" are found, and the context permits, they are to be understood to comprise all the video/sound and "program segment map" elements.

In a preferred laser disc implementation, the entire variable content program (video/sound and program segment map) is provided in a video/data disc in a format similar to that required by the video images contained in the disc. Alternatively, the data is provided in the video/data disc in a different format from that of the video format, such as for example in digital photomagnetic or magnetic formats. In this respect the teachings of the patent to Smith, U.S. Pat. No. 4,872,151, are by reference herein incorporated. In a second alternative, the data is separately provided by a removable memory media **504**, a compact portable memory device **505**, or downloaded by means of the communications interface **502**.

A RAViT simply configured and comprising a laser disc module **501** and for example a micro floppy disk drive **504** provides editing out benefits for the existing library of motion picture laser discs. In this configuration, the micro floppy disk provides the program segment map, user interface and other control programs particular to the motion picture, and stores a viewer's video content preferences. While the resulting program suffers, as does edited-for-television programs, from the lack of transitional, parallel, and overlapping segments, this technique provides an immediate library of full motion pictures to which the teachings of the present invention is applied.

Upon a playing of a program, the control program causes the reading of the program's identifier from the program source **501**, searches the mass memory fixed storage device **503** for a corresponding viewer preferences, or applicable generic preferences, and upon viewer confirmation applies the stored viewer preferences to the program segment map.

With respect to control programs, scheduling routines, viewer preferences, program segment map, and other principally software elements, it is noted that these may be separately or jointly stored in any one of RAViT's various firmware/hardware memory devices. For example, the viewer preferences are stored in non-volatile resident memory **515**, in the memory of the fixed or removable memory sub-system **503/504**, a user's optical read/write access card or electronic memory card **505**, or from the respective read/write video/-data laser disc **501**. In an interactive video game application, data in general, and game software in particular, for example, may be downloaded to the hard disk, reserving subsequent access of the laser disc for video/-sound retrieval.

Generally, the control programs **521** generate a segment table reflecting the application of the viewer's preferences to the video program's content map. The segment table provides the control program's segment scheduling routines the information to cause the automated logical selection of sequential and non-sequential segments of the video program responsive to program segment map, the viewer's preferences, and the logic of the gaming software where applicable. The processing of the control programs being principally a function of the system cpu **511** and system RAM **512**.

RAViT's video random access retrieval architecture principally comprising the video/data laser disc module **501**, video cpu **513**, video buffers **514** and processing capabilities, provides for the retrieval and transmission of selected sequential and non-sequential video segments stored in the disc. In terms of the integration of laser disc and processing capabilities and the retrieval of non-sequential video frames, the teachings of the patent to Blanton et al, U.S. Pat. No. 4,873,585, which details a system comprising a video disc player for storing and retrieving video frames, and a control computer for accessing particular sequences of stored frames on the video disc, are by reference incorporated herein, and are relied upon to detail the core operation and construction of a laser-based random access system. With respect to laser read/write units and read/write laser discs, the prior art teachings of laser disc players, such as for example Pioneer's Rewritable Videodisc Recorder VDR-V1000, and the teachings of the patent to Matsubayashi, U.S. Pat. No. 5,132,953, are by reference incorporated herein.

RAViT's laser disc module **501** comprises laser disc technology distinguished principally in the cooperative operation, responsive to the instructions of the segment scheduler, of the multiple read/write laser units to produce a continuous transmission of non-sequential video segments. In a laser-based random access multiple read/write architecture, each read/write unit assembly and operation is principally equivalent to corresponding laser-based assemblies found in the prior art, in which a laser beam reads and reproduces memory signals from a disc.

Referring now to FIG. **6**, the principal elements of a laser-based random access multiple read/write units architecture as per the present invention are illustrated. FIG. **6** shows a laser disc **601** having therein, in a laser readable format, sufficient recording area **611** to store a variable content program. The recording area **611** of the laser disc **601** is shown as substantially concentric tracks lying in a single plane. Alternatively, the recording area comprises a multitude of quasi-concentric tracks forming one or multiple spiral tracks. Additionally, tracks can be provided in one or more planes on each side of the laser disc, as well as on both sides of the disc.

Referring now to FIG. **6** in conjunction with FIGS. **3C** and **3D**, in a preferred embodiment of reading non-sequential video segments from a single video source, a first reading unit **621** is directed by the segment scheduler to retrieve video information corresponding to the desired frames **4112–5109** of a first, or current, video segment from a video source. Concurrently with the first reading unit **621** reading the information from the first segment, a second reading unit **622** is positioned, according to the program segment map and the segment scheduler, to preread within one revolution of the disc beginning frame information of a next non-sequential segment from the same video source.

In this example, the next non-sequential segment begins at frame **35351**. Concurrently with the first reading unit reading **621** the current segment, the second reading unit **622** is caused to preread into a video buffer (**514** FIG. **5**) that portion of the next non-sequential segment beginning at frame **35351** necessary to provide a seamless transition from the first reading unit reading of the current segment ending at frame **5109** to the second reading unit reading of the next non-sequential segment beginning at frame **35351**. The video buffer, thus containing the segment information necessary to provide a synchronized, seamless transition from the first segment to the second segment without any gaps in the transmission of the retrieved video segments as a continuous video program.

Concurrently with the second reading unit **622** reading the next non-sequential segment, now a current segment, the first reading unit **621** is repositioned to begin prereading of a next non-sequential segment beginning at frame **5175**. By the time the second reading unit **622** completes reading the current segment at frame **38975**, the first reading unit **621** has preread frame **5175**. The process, analogous to a relay race, repeating itself until the last desired segment has been read.

In an interactive video game application, a multiple reading unit architecture is advantageously utilized to additionally provide faster video responses to the user/-player's actions. Briefly, while a first reading unit **621** is reading a first video segment, frames **4112–5109**, a second reading unit **622** is positioned to read a second segment beginning at frame **35351**. The positioning of said second unit **622** being responsive to the option being presented to the player during the reading of the first segment which may require reading the second segment rather than continuing reading the first segment or reading the next sequential segment. Alternatively, the second reading unit provides overlay images in synchronization with the images retrieved by the first reading unit.

Each reading units's movement over the disc surface is over a designated radial segment such that the movement of each reading unit over the recorded radius of the disc is not impaired by the movement of a different reading unit. In this fashion, the movement of the first reading unit **621** over its radial segment **631** does not intersect the movement of the second reading unit **622** over its radial segment **632**.

It is noted that the reading unit's travel need not be limited to the radial segments. A positioning system providing for the positioning of the reading unit at any point over the recording media, provides the reading unit the potential to precisely intercept the beginning of a segment/frame at a precisely defined moment. This being represented in FIG. **6** as the juncture of a radial segment **631** and the beginning of frame **5175**. In this fashion the requirement of prereading into a video buffer can be reduced if not eliminated.

FIG. **6** also shows a third reading unit **623**. While a simple variable content motion picture application does not require more than two reading units, the third reading unit **623** is illustrated principally to emphasize that a multiple-read architecture is not limited to two reading units **621–622**, and is available for more demanding interactive variable content game applications. Further, as illustrated, a reading unit's movements over the recorded surface need not be confined to a particular quadrant, side of the surface, or radius of the surface. In the illustration the third reading unit's **623** movement over the recorded surface is permitted over the recorded diameter **633** of the surface.

Additionally or alternatively, the information is recorded on the laser disc in a manner that, either through placement or duplication of frames, anticipates the desired and possible position of a reading unit. In this case, even if the movement of the reading units are confined to radial segments, the requirement of a video buffer is for this purpose eliminated. This also being represented in FIG. **6** as the various junctures of the radial segments and the beginning of the frames.

Specifically, in this architecture, concurrently with a first reading unit **621** reading a current segment from a single video source, a second reading unit 622 is positioned to be able to intercept and read the beginning of a next non-sequential segment, in this example frame 35351, at that instant that the first reading unit 622 completes reading the current segment at the end of frame 5109. At that the first reading unit 621 completes reading frame 5109, the second reading unit begins reading frame 35351, thereby in combination with the first reading unit causing a seamless transition from the reading of the current segment to reading of the next non-sequential segment.

In the next stage, concurrently with the second reading unit 622 reading the beginning of the next non-sequential segment at frame 35351, now a current segment, repositioning the first reading unit 621 to be able to intercept and read the beginning of a next non-sequential segment, frame 5175 at that instant that the second reading unit completes reading the current segment at frame 38975. The process continuing until all the required segments are read.

Still additionally, or alternatively, the rotational speed of the disc platter is set sufficiently high to permit the reading unit to read into buffers sufficient video information to provide the same reading unit sufficient time for repositioning and begin reading the next non-sequential segment before the video information in the buffer is exhausted. This would in certain applications eliminate the need for multiple reading units.

Specifically, in the reading of non-sequential video segments from a single video source, a single video source 601 is caused to rotate at a sufficiently high rate 641, in this example 60 frames per second or 3,600 rpm 641, i.e. twice the rate of 30 frame per second 642, to permit a reading unit 621 to both read and preread an amount of a current segment (frames 4412–5109) into a video buffer sufficient for the reading unit 621 to be repositioned to read the beginning of a next non-sequential segment, frame 35351, before the preread amount in said video buffer is exhausted. In this example, prereading frames 4498–5109 provides the reading unit 621 sufficient time to be repositioned to read a next non-sequential segment, frames 35351–38975. Concurrently with the repositioning of the reading unit, the video buffer provides the last preread frames 4498–5109 to cause a seamless transition from the reading of the current segment, frames 4112–5109, to the reading of the next non-sequential segment, frames 35351–38975. The process continuing until all the required segments are read.

In this architecture, the reading unit prereads into the buffer only in advance of a next non-sequential segment, or continually prereads into the video buffer as the video information in the buffer is depleted.

A variation of this technique particularly applicable to interactive video game applications is detailed with respect to FIG. 3E. In this example, previously summarized, a read stream comprises alternating frames from a number of different video segments. The number of different video segments resulting from the attainable effective transfer rates of the system. For example if the video application requires a transfer rate of 30 frames per second, and video compression techniques, rotational speed, and/or reading capability of the system can achieve an effective transfer rate of 120 frames per second, than four different video segments can be read "concurrently" by a single reading unit. In such an architecture, the frame arrangement comprises a reading stream 341 of alternating frames from four separate segments A–D and is read at an effective rate of 120 frames per second. The processing architecture selects the desired segment A,B,C, or D from the read stream 341 to generate a transmission stream 342, at a rate of 30 frames per second, of the desired frames 351A–353A, 351B–353B, 351C–353C, or 351D–353D.

To further detail, and with respect to FIG. 6, a single video source 601 is caused to rotate at a sufficiently high rate, for example 60 frames per second 641 or 120 frames per second 643 to permit a reading unit 621 to read at multiples of the 30 frames per second rate required to transmit a single one of a plurality of video segments (A–D). Referring once more to FIG. 3E, the frames being intermittently arranged as a reading stream 341 in the video source. As the reading unit is caused to read the reading stream 341; a video processor (513 FIG. 5) extracts from the reading stream 341 a transmission stream 342 representing a single one of the plurality of video segments.

In this fashion a single reading unit can provide instantaneous shifting among a number of different segments. In an interactive video game application, shifting among a number of different video segments can be instantaneously achieved in response to a players interaction with the game's software logic.

To enhance the simulation of each video stream, a windowing technique, such as shown in the previously cited patent to Blanton et al., in which only a portion of each frame is displayed, is applied to each frame in one or more of the video streams to enhance the simulation of movement within a multi-dimensional space and to provide composite images of greater complexity.

These and other variations in the particular number and arrangement of the reading units, video buffer, and frame arrangement configuration that is implemented in a RAViT is a function of the complexity of the video/-data, and cost/performance constraints. It is also intended that the teachings of the various configurations shown herein and in the cited art may be combined responsive to the particular application. Clearly, with technology continuously achieving greater storage capacity in smaller, faster, and more cost effective storage devices, there is no apparent limitation to the complexity of the variable content program that can be commercially executed.

The description above has for simplicity been detailed with respect to a reading unit. It is to be understood that a reading unit herein comprises both reading and writing capabilities operationally independent of the operation of another read/write unit in the system's architecture. Additionally, a read/write unit need not be limited to a particular current architecture, enhancements to the construction of the reading unit itself, such as for example multiple tracking mirrors/beam splitters, are contemplated to produce faster access times and transfer rates. Further, the multiple read/write architecture detailed need not be limited to a laser disc system. In an alternate embodiment, a hard disk drive is modified as per the teachings above detailed to significantly increase transfer rates and lower average access times. Clearly, at present, in a hard disk embodiment the read/write units are magnetic read/write heads.

Generally, the viewing of a variable content program is intended to be hardware independent. That is, a variety of hardware, firmware, and software architectures are possible either locally or remotely accessible by the viewer that provide the benefits of a variable content program. In particular, a random access device's read/-

buffer architecture, modified as per the present invention, is intended to be implemented in a variety of mass memory devices. Embodiments of the read/buffer architecture detailed herein is not intended to be limited to any particular available recording medium and recording format technologies. The teachings of the present invention are applicable to a number of random access technologies such as, for example, and not limitation, fixed and removable magnetic, optical, or photomagnetic media, and digital or analog recording formats. Any combination of existing or forthcoming media, format, and compression memory technologies may advantageously incorporate the teachings herein detailed.

In general, parts, sub-assemblies, and components of a RAViT are of conventional characteristics and are freely substituted by like functioning elements and components. For example, and not limitation, while fiber optic-based communications are preferred, copper phone lines and coaxial cable-based communications are considered, albeit less capable nonetheless, functional equivalents. Additionally, a certain degree of redundancy of components is illustrated in FIG. 5 to schematically show and detail significant functions. Clearly, redundant components in general, and redundant electronic components in particular, are intended to be eliminated in a preferred embodiment. For example, in a number of configurations a removable memory subsystem and a compact memory sub-system are both required. In a general sense, one is the functional equivalent of the other. In a preferred embodiment, for example, a removable memory sub-system is eliminated, and the compact memory sub-system performs the functions that are associated with it. In general, where cost effective, components are designed to serve a combination of functions.

Further, the configuration of RAViT's various modules, components, and sub-systems, are intended to offer flexibility analogous to that found in a personal computer. Specifically with respect to the multi-user capabilities, a RAViT may be configured, for example, with more than one laser disc module. Whether inside the primary cabinet or in a mating or sister cabinet. Responsive to user friendliness, a more advanced wireless plug and play communications and power motherboard and cabinet design is preferred. The motherboard and cabinet permitting the replacement of, for example, the power supply just as easily as a battery is replaced in a portable personal computer. In a preferred embodiment of RAViT, every component and sub-system is replaced without resorting to screwdrivers and the need to unplug and plug communications and power cables.

While an embodiment of the present invention is detailed above with respect to a random access video laser disc device physically accessible by the viewer, variations are also possible. For example, the laser disc device need not be physically located near the television set. The patent to Fenwick et al. U.S. Pat. No. 4,947,244, by reference incorporated herein, discloses remote video distribution systems such as may be found in a hotel, wherein the viewer is provided remote controlled access to video resources. Fiber optic communications easily permit the required transfer rates between a device, or any alternative memory device, and a viewer's receiver/television.

As shown by the hardware configuration detailed with respect to FIG. 5, RAViT is equally adept at retrieving full motion video from a resident program storage device or remotely from a network-based service provider. A B-ISDN interface, an internal or external modem, or a dedicated communications line, such as for example a coaxial cable, provides RAViT communications capabilities with providers of programming and other on-line services. These other services comprising, for example, banking, security, shopping, instructional, and educational services.

With respect to video-on-demand, and video networks, the teachings of the patents to Monslow, U.S. Pat. No. 4,995,078, to Way, U.S. Pat. No. 4,891,694, and to Walter, U.S. Pat. No. 4,506,387, are by reference incorporated herein. These patents teach a variety of land line and fiber optic transmission of programs embodying varying degrees of viewer capabilities in the selection of programs. While the prior art does not teach transmission of a variable content program, a reading of said art will assist the reader interested in obtaining a more detailed disclosure of the hardware of such systems than is necessary to provide here.

FIG. 7 is a simplified schematic diagram a video program provider and subscriber network architecture as per the present invention. Participants in a B-ISDN 711, as per the present invention, comprise any number of video program providers 700 and any number of subscribers 721. As in a communications network, each participant is able to transfer and retrieve video/data transmissions from any other participant. Each participant obtaining a hardware configuration consistent with their desire and their financial means.

The particular configuration of each subscriber's video system's 721/722/723 storage, memory, processing, and communication capabilities is responsive to, but is not necessarily limited by, the minimum requirements of the particular service provider. A RAViT configuration, such as detailed with respect to FIG. 5, provides the required video program storage, processing, and communications architecture.

The video system of a participant who wishes to serve as a video program provider 700 is functionally equivalent to the RAViT device previously detailed, differing only in that the respective resources are appropriately scaled and modified to simultaneously access a variety of programs, and service a number of subscribers.

A video provider system 700 comprises: i) mass storage random access memory devices 701 for storing a plurality of variable content programs, and a plurality of program segment maps each defining segments of a corresponding video program; ii) communications linkages 702 to the B-ISDN for establishing communications with a plurality of participating subscriber video systems (RAViTs) 721/722/723; iii) processing hardware/software 703 for retrieving from participating subscriber video system a subscriber's video content preferences, and for automatically selecting, for each of the participating subscribers, variable content program/program segment map, and/or segments, from a programbase, comprising a plurality of variable content programs and corresponding program segment maps, responsive to the application of the corresponding one of the subscriber's video content preferences to the programbase; iv) random access devices 704 for retrieving for each participating subscriber the corresponding selected variable content programs and/or video segments; and v) transmission architecture 705 for transmitting, to each participating subscriber video system, the corresponding retrieved selections. Simply stated, an on-line variable content program provider provides each viewer content-on-demand.

In a preferred embodiment, in response to a subscriber 721 request of one or more variable content program(s) from a video provider 700, the entire variable content program including all the parallel, overlapping, and transitional segments is provided via the fiber optic network 711. Alternatively, the program is provided to the subscriber in the form that results from the execution of the viewer's video content preferences, i.e. a logical seamless sequence of only those segments that are consistent with the viewer preferences are transmitted in a real-time or a non real-time format over the network 711.

Where the subscriber 721 remains on-line with the video provider 700 during the transmission of the video and utilizes the hardware resources of the video provider, a RAViT comprising principally communications capabilities without significant local storage, processing, or memory, is adequate. In such an architecture the viewer preferences are retained by the video provider.

Retrieving video from a remote video provider permits subscribers to efficiently obtain from an extensive programbase a program to be viewed at the time of their choosing, over which they exercise complete control as to the subject matter, form of expression, and other elements comprising the program. Further, the resulting program need not comprise or result from a single variable content program in a programbase. A program may result from the automated selection of a variety of segments/programs from the programbase.

In a video provider, the implementation of the multiple read head architecture provides for the simultaneous retrieval of several versions of a program from a single program source to satisfy simultaneously the particular viewing requirements of several subscribers. A multiple read head architecture reduces, for example, the number of copies of a program that the on-line video provider requires. Alternatively, where cost effective, a variable content program may be entirely or partially stored in RAM.

It is also important to note that the novel combination of an external fiber optic based communications module and a multiple read/write units laser disc module, provides a RAViT configuration capable of efficiently downloading significant amounts of full motion video to be viewed, played with, or processed at the subscriber's leisure. In such a RAViT the downloading of, for example, a feature length motion picture, an interactive video game, or a series of lectures can be achieved with unprecedented speed.

The previously shown capacity to read/write the viewer preferences from/to a compact portable memory device 731 provides a viewer the means to automatically configure a RAViT that had not previously learned the viewer's video content preferences (dumb RAViT).

Referring once more to FIG. 7, in anticipation of the desire to efficiently utilize a dumb RAViT, a viewer instructs the smart RAViT 721 to download to a compact portable memory device 731 the desired viewer preferences and program request routines. To automatically configure and retrieve programming consistent with the preferences and program request routines, the viewer provides the prepared compact portable memory device 731 to the dumb RAViT 722, or to an accessory device 732 in communication with the dumb RAViT 722. The compact portable memory device 731 automatically configuring the dumb RAViT without necessarily downloading the viewer preferences other than to volatile memory. The operation being similar to moving a game cartridge from a first game player to a second game player.

In this context, programming request routines automate the retrieval of desired programming from a programming services provider 700 accessible to a RAViT 722. In this fashion, for example, a travelling executive can automatically configure each days new hotel room RAViT to retrieve videophone messages, the day's news in a format and for topics preestablished by the executive, followed by a menu of recently released films that the executive has not seen. The operation being analogous to inserting an access card in a hotel room door.

Alternatively, a similar automated configuration is performed by means of line-based external communications capabilities 711 available to both the dumb RAViT 722 and the smart RAViT 721.

As indicated with respect to FIG. 5, and represented in FIG. 7, multi-user and multi-services modules support separate controlled independent access by other users of RAViT's processing, video, and communications resources. In addition to the primary video display system 741 supported by RAViT 721, the multi-user module and multi-services module installed in this example support a separate monitor/keyboard 742 access to RAViT's 721 resources, and cooperatively supports the operation of a security system 743.

Before proceeding with a detailed description of the steps of utilizing a variable content video disc on RAViT, it is important to appreciate that in general following the initial setup of RAViT with a viewer preferences, a subsequent viewing of a variable content program conforming to the standard structure only requires the pressing of a play key. Following the pressing of the play key, RAViT automatically initiates playing of the video program without the necessity of any further viewer interaction or instructions. In other words, in a standardized descriptive structure architecture, once RAViT initially learns the viewer's preferences, it does not require any more of the viewer than, for example, a conventional laser disc player. Similarly in the playing of an interactive variable content game, once RAViT initially learns the viewer/player preferences, the gaming interaction proceeds transparently of the video editing functions. It is intended that a single viewer preferences serve both gaming and viewing applications. Optionally, the viewer may establish separate viewing preferences for each of the classes (e.g. gaming, viewing, computing) of video programs.

The steps comprising the method of viewing a variable content program on a RAViT are detailed with respect to the flow chart of FIGS. 8A, 8B, and 8C. Beginning at step 801, the viewer selects and retrieves the desired program consistent with the architecture of the particular RAViT hardware implementation. Upon selection of the play function 802, RAViT's software, firmware, and hardware processing capabilities ("processor") issue a command to read the viewer control setup to ascertain if viewer control is enabled 803. If enabled, RAViT's handshaking routines request viewer identification and, if required, a corresponding password 804. If the viewer identification and password are not found acceptable 805, the appropriate error message is transmitted to the television 806, and RAViT is returned to a state prior to the viewer play request 802.

If viewer identification and password are found acceptable 805, the processor checks for other restrictions to a user access 807. These additional restrictions include: time of day restrictions for the user, and/or accumulated usage during specified time frames. If restrictions are enabled that prevent usage 807, an appropriate error message 809 is transmitted to the television, and RAViT is returned to a state prior to the viewer play request 802. The user-permission capability enables a parent to have complete control over the use of RAViT, and provides for multiple individualized preferences.

If viewer control is not enabled 803, or if enabled, verification of the user 805 and verification of restrictions permit usage 807, program setup routines are initiated. Referring now to FIG. 8B, program setup routines 811 include reading, from the program source, program identification information. Based on the program identification information, which in addition to including a unique identification code also contains qualitative and classification program information, setup routines search to see if a corresponding viewer preferences/table for the identified program is available 812. Otherwise, the program category descriptive structures 813 are obtained from the program source to determine if a viewer preference is established for each of the program categories.

Once viewer preferences are established, the processor verifies set up status for editing privileges 814, to determine if the viewer has editing privileges for the class of programs to which the present program belongs and the categories included therein. The processor at this point transmits to the television a request for the viewer to indicate if the existing preferences are to be edited 815. If at step 814 edit privileges are not available for the viewer, the processor initiates normal play routines. If the viewer indicates that no editing privileges are to be exercised 815, normal play routines are initiated as well; otherwise, editing of the viewer preferences occurs at step 818.

The edited viewer preferences are interactively verified 819 until an adequate category preference match, as required by the program and the user is established, or the viewer selects to exit. Exiting at 819 returns RAViT to a state prior to the viewer play request 802.

If a viewer preferences for the login viewer for the selected program is not available 812, or at least one of the categories of the program is not contained in the viewer preferences 813, then the processor verifies if edit privileges are available for the viewer for the class of programs and the categories 816. If no edit privileges are available, an exit message 817 is transmitted to the television, and RAViT is returned to a state prior to the viewer play request 802. If edit privileges are available 816, then editing of the viewer preferences 818 is initiated.

Editing the viewer preferences 818 is supervised to insure that viewer modifications are consistent with the permissions established for that viewer. Individual viewer permissions are established broadly for any one or more classes of programs or categories, or specifically for any category. Once editing of the preferences is found complete 819, as required by the program category listing, play routines are initiated.

Referring now to FIG. 8C, following the enabling of the play routines 821, the program segment map is read 822 from the program segment map storage media or memory. As previously detailed, the program segment map defining the sequential and non-sequential segments of the selected program. At this point, RAViT's processing capabilities retrieve and apply the viewer's preferences, stored in a memory or a storage device, to the program segment map 823. The application of the viewer's preferences to the program segment map results in the automated logical selection of sequential and non-sequential segments of the selected video program 824 consistent with the viewer's video content preferences and the program segment map. Once the segments to be played and their sequence are determined 824, the random access retrieval and transmission capabilities of RAViT automatically retrieve the selected sequential and non-sequential video segments stored in the video program storage device, and transmit the video segments as a seamless, continuous video program 825.

In a interactive video game, the start and setup routines detailed with respect to FIGS. 8A, and 8B are integrated with each games setup routines.

As suggested previously, the capabilities of RAViT are particularly well suited to providing an editor (i.e. parent) complete control as to the video material to which a viewer/player (i.e. child) is exposed. As indicated above, AViT provides: user, time of day, amount of viewing controls; and individual preferences for each viewer/player or class of viewers/players. Additionally, supplementing or alternative routines are provided which are preferable in those instances where: i) segments cannot be rated according to standardized descriptive structures; ii) the utilization of a descriptive structure system is not desired; or iii) a simpler routine provides the desired functionality.

Specifically, the present invention permits an editor to automatically select segments of a video program previously identified in a program segment map as providing material which may not be suitable for a viewer; viewing the selected segments and determining their suitability for viewing by the viewer; automatically generating a listing of segments responsive to the segment suitability determination applied to the program segment map; automatically retrieving the listed segments; and automatically transmitting the retrieved segments as a continuous video program for said viewer. Segments not suitable for a viewer may be defined as segments providing content and form of expression which, in a conventional sense, is deserving of a rating other than a MPAA "G" rating.

Alternatively to, or in addition to the editing system based on the application of descriptive structures, a simplified editing system is based on the "flagging" of segments irrespective of the specific nature of the material which may not be suitable for a viewer. That is all segments containing material not suitable receives the same flag or code. The flagging of segments provides an efficient method of coding and retrieving the segments and indicating their inclusion/exclusion in a program/game to be viewed/played.

An example of the editing routines that provide for the efficient previewing of flagged segments are summarized with respect to FIG. 9. One of a number of RAViT setup routines present a listing of viewers over which the editor has editorial control. With respect to each viewer and the selected program, the listing indicates if a segment table is already available 901, and if viewer preferences are available 902 or not 903. Additionally the option to designate a new viewer 904 is made available to the editor.

If a corresponding table for the desired viewer is available 901 and the editor does not wish to make any changes, than selecting this option exits the routine, the operation of RAViT is then permitted as detailed previously. If a corresponding table for the selected viewer is not available, and the editor does not wish to create or update the viewer's preferences 902, than the routine proceeds by reading the program segment map 921. If the editor wishes to modify or create viewer preferences 903, than the routine proceeds with the appropriate routines 912. If the editor indicates the entry of a new viewer 904, the appropriate viewer entry routines are enabled 909, and the opportunity to create viewer preferences for the new viewer is provided 911.

The routines to update/create new preferences 912 permit both a .program specific or permanent updating of the selected viewer's preferences. Once viewer preferences are indicated, if any, the selected program's segment map is read 921 and compared to the preferences 922 to the extent that they are available.

If all the flagged segments are effectively excluded by the viewer preferences 922, than the resulting program segment table is saved 941 and the routine is exited. Otherwise, in addition to an initial segment table, a list is prepared 923 consisting of any flagged segments that have a descriptive level lower than the corresponding level in the preferences, and flagged segments for which there is no corresponding preferences. In the absence of viewer preferences every flagged segment is included in the segment list.

In a manner similar to the retrieval of non-sequential segments outlined previously, only the segments in the segment list are shown one after the other 931 as a continuous stream to the editor, pausing only if an include/exclude decision is not indicated 932. The process continuing automatically 934 until a decision on each of the flagged segments in the list is made 932. As each decision is made the segment table is updated 933. Alternatively, the segment table is updated and saved following the transmission of the last segment 941.

Each segment need not be viewed in its entirety 931, as soon as an include decision is made 932, the showing of the next segment begins instantaneously. Additionally, it should be understood that a showing of a flagged segment is not limited to, or indicate, the actual transmission of the flagged segment's video/sound. Appreciating that certain adults may not be interested in viewing the flagged segments, a character description of the contents of the segment may be provided instead or in advance of the option to view the corresponding segment.

The above is presented to emphasize the control features and capabilities of the present invention, the particular routines shown can be enhanced in a number of ways. Configuration routines are contemplated that further facilitate and automate viewer/player controls.

For example, a configuration can be selected that automatically creates for selected or new viewers/players a segment table excluding all flagged segments. In this case at system setup a viewer is simply associated with the exclusion of all flagged segments.

Similarly, additionally, or alternatively, a viewer/player is associated with a descriptor code paralleling the MPAA rating system as previously detailed with respect to FIG. 2D. At system setup a viewer/player is associated with an appropriate rating code, thereafter, the viewing/playing of a program is consistent with the rating code associated with the respective viewer. The simplicity of the architecture in combination with the teachings of the variable content program permits, for example, by means of a single code associated with each viewer, a parent to view an "R" version of a film, and permits a child to view a "G" version of the same film. It is noted that this architecture provides more tailored control than the simpler exclude all flagged segments architecture, but significantly less tailored control than a category specific video content preferences. In a preferred embodiment, the various structures detailed above are correlated to permit the application of a variety of content control options without requiring duplicating descriptor definition. For example a assigning a segment a descriptor other than "G" rating is equivalent to flagging the segment.

Clearly, a number of other interactive capabilities are made possible by the architecture of RAViT. For example during the viewing of a program, skip keys cause the automatic skipping of the present segment and the instantaneous viewing of the next logical segment. Other functions permit interactive modification of the segment map, such as flagging a segment, as the program is being viewed. It is intended that a number of other interactive capabilities be implemented which incorporate the teachings of prior art interactive and multimedia system. Specifically in this respect, the teachings of the patent to Bohrman, previously cited, are by reference incorporated herein.

Since the prior art is well established, and many of the features, components, and methods, found therein may be incorporated in the preferred embodiment; and since other modifications and changes varied to fit particular operating requirements and environments will be apparent to those skilled in the art, the invention is not limited to the presently preferred form of the present invention set forth here and above, it is to be understood that the invention is not limited thereby. It is also to be understood that the specific details shown are merely illustrative and that the invention may be carried out in other ways without departing from the spirit and scope of the following claims.

What is claimed is:

1. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

memory means for storing a video segment map and a video, said video segment map defining a plurality of video segments of said video responsive to said at least one content category;

processing means for automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

random accessing means for retrieving the selected video segments; and

transmitting means for transmitting the retrieved video segments as a continuous video.

2. The video system of claim 1, wherein said plurality of video segments comprises at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment.

3. The video system of claim 1, wherein said random accessing means further comprises seamless accessing means for seamlessly retrieving the selected video segments.

4. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

first memory means for storing a video segment map defining, a plurality of video segments of a video responsive to said at least one content category;

second memory means for storing said video;

processing means for automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

random accessing means for retrieving the selected video segments; and

transmitting means for transmitting the retrieved video segments as a continuous video.

5. A video system comprising:

preferencing means for establishing video content preferences responsive to a preestablished segment descriptive structure including a violence content category;

memory means for storing a video, said video comprising a plurality of video segments and a video segment map, said video segment map defining said plurality of video segments responsive to said preestablished segment descriptive structure;

processing means for automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

random accessing means for seamlessly retrieving the selected video segments; and

transmitting means for transmitting the retrieved video segments as a seamless video.

6. The video system of claim 5, wherein said plurality of video segments comprises at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment.

7. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

memory means for storing a video, said video comprising a plurality of video segments and a video segment map, said video segment map defining said plurality of video segments responsive to said at least one content category, said plurality of video segments comprising at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment;

processing means for automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

random accessing means for seamlessly retrieving the selected video segments; and

transmitting means for transmitting the retrieved video segments as a seamless video.

8. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map of said video, said video segment map defining said plurality of video segments;

random accessing means for retrieving said video segment map and for seamlessly retrieving the selected video segments from a memory means storing said video segment map and said video; and

transmitting means for transmitting the retrieved video segments as a seamless video.

9. The video system of claim 8, wherein said memory means for storing said video segment map and said video comprises a first memory means for storing said video segment map, and a second memory means for storing said video.

10. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map of said video, said plurality of video segments comprising at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment, said video segment map defining said plurality of video segments;

random accessing means for retrieving said video segment map and for seamlessly retrieving the selected video segments from a memory means storing said video segment map and said video; and

transmitting means for transmitting the retrieved video segments as a seamless video.

11. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map provided by said video, said video segment map defining said plurality of video segments;

random accessing means for retrieving said video segment map and for seamlessly retrieving the selected video segments from a laser readable means storing and transporting said video segment map and said video; and

transmitting means for transmitting the retrieved video segments as a seamless video.

12. The video system of claim 11, wherein said plurality of video segments comprises at least one non-sequential video segment selected from the group consisting of

a parallel video segment, a transitional video segment, and an overlapping video segment.

13. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map of said video, said video segment map defining said plurality of video segments responsive to said at least one content category;

random accessing means for retrieving said video segment map and for retrieving the selected video segments from a memory means storing said video segment map and said video; and

transmitting means for transmitting the retrieved video segments as a continuous video.

14. The video system of claim 13, wherein said random accessing means further comprises seamless accessing means for seamlessly retrieving the selected video segments.

15. A video system comprising:

preferencing means for establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map of said video, said video segment map defining said plurality of video segments responsive to said at least one content category, said plurality of video segments comprising at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment;

random accessing means for retrieving said video segment map and for seamlessly retrieving the selected video segments from a memory means storing said video segment map and said video; and

transmitting means for transmitting the retrieved video segments as a seamless video.

16. A video system comprising:

preferencing means for establishing video content preferences responsive to a preestablished segment descriptive structure including a violence category;

processing means for automatically selecting video segments from a plurality of video segments of a video responsive to an application of said video content preferences to a video segment map of said video, said video segment map defining said plurality of video segments responsive to said preestablished segment descriptive structure;

random accessing means for retrieving said video segment map from a first memory means storing said video segment map, and for seamlessly retrieving the selected video segments from a second memory means storing said video; and

transmitting means for transmitting the retrieved video segments as a seamless video.

17. The video system of claim 16, wherein said plurality of video segments comprises at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment.

18. A method of editing a video comprising the steps of:

establishing video content preferences responsive to at least one content category of possibly unsuitable content, said at least one content category including a violence category;

retrieving a video segment map defining a plurality of video segments of said video, said video segment map responsive to said at least one content category;

automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

retrieving the selected video segments; and

transmitting the retrieved video segments as a continuous video.

19. A method of editing a video comprising the steps of:

establishing video content preferences, said video content preferences responsive to a preestablished segment descriptive structure including a violence category;

retrieving a video segment map defining a plurality of video segments of said video, said video segment map responsive to said preestablished segment descriptive structure, said plurality of video segments comprising at least one non-sequential video segment selected from the group consisting of a parallel video segment, a transitional video segment, and an overlapping video segment;

automatically selecting video segments from said plurality of video segments responsive to an application of said video content preferences to said video segment map;

seamlessly retrieving the selected video segments; and

transmitting the retrieved video segments as a seamless video.

* * * * *

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United States Patent [19]

Lowe et al.

[11] Patent Number: 5,462,275

[45] Date of Patent: Oct. 31, 1995

[54] PLAYER INTERACTIVE LIVE ACTION FOOTBALL GAME

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[73] Assignees: Gordon Wilson; Danny D. Lowe, both of Calgary, Canada

[21] Appl. No.: 811,226

[22] Filed: Dec. 20, 1991

[51] Int. Cl.[6] A63F 9/00

[52] U.S. Cl. .... 273/94; 273/85 G; 273/85 R; 273/55 R; 273/434; 364/410

[58] Field of Search .... 273/55 R, 85 R, 273/94, 85 G, 433–436; 364/410; 273/433–436; 340/323 R

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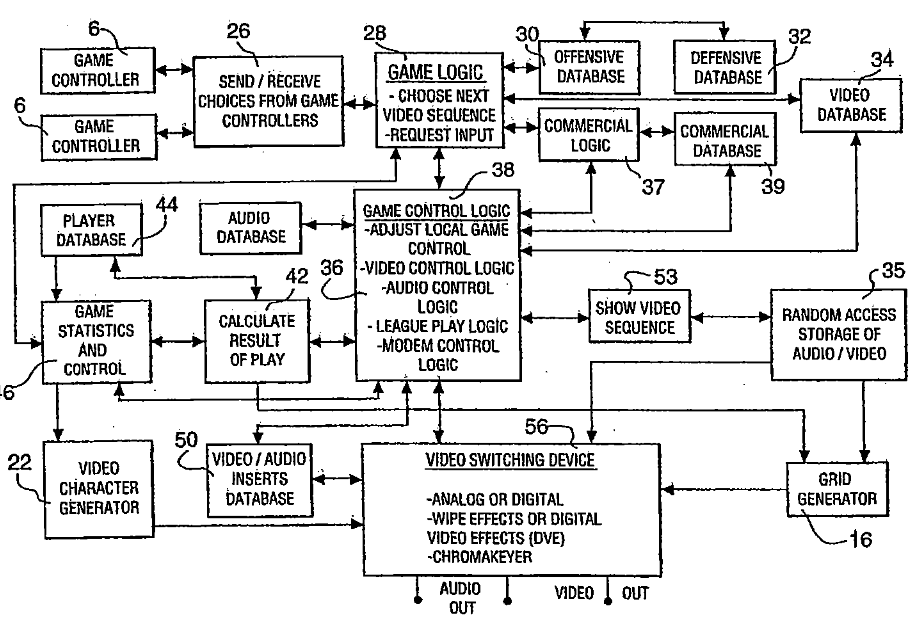
Primary Examiner—Jessica J. Harrison
Assistant Examiner—Kerry Owens
Attorney, Agent, or Firm—Burke-Robertson

[57] ABSTRACT

A player interactive live action football game which may be played for example on a television screen. A player interactive live action football game is provided which comprises a random access storage and retrieval device and a plurality of individual, pre-recorded action football plays illustrating interaction of players of opposite teams. This information is stored in random access storage and retrieval device and accessible according to type of play. The invention further comprises a microprocessor and microprocessor control device electronically associated with the random access storage and retrieval device. The microprocessor is programmed to enable one or more users to select in sequence, through the control device, different football plays according to play type. A display device is electronically associated with the microprocessor to enable the selected plays to be viewed by the users. The microprocessor is further programmed to evaluate and cumulate play results and report them to the users in a meaningful way. It is an object of the present invention to provide an interactive, live action football game that can be played by one or more persons in a home, bar or the like. It is a further object of the present invention to provide such a television game which permits players to select full motion video images, as opposed to computer graphics, to play such game and determine the outcome.

19 Claims, 7 Drawing Sheets



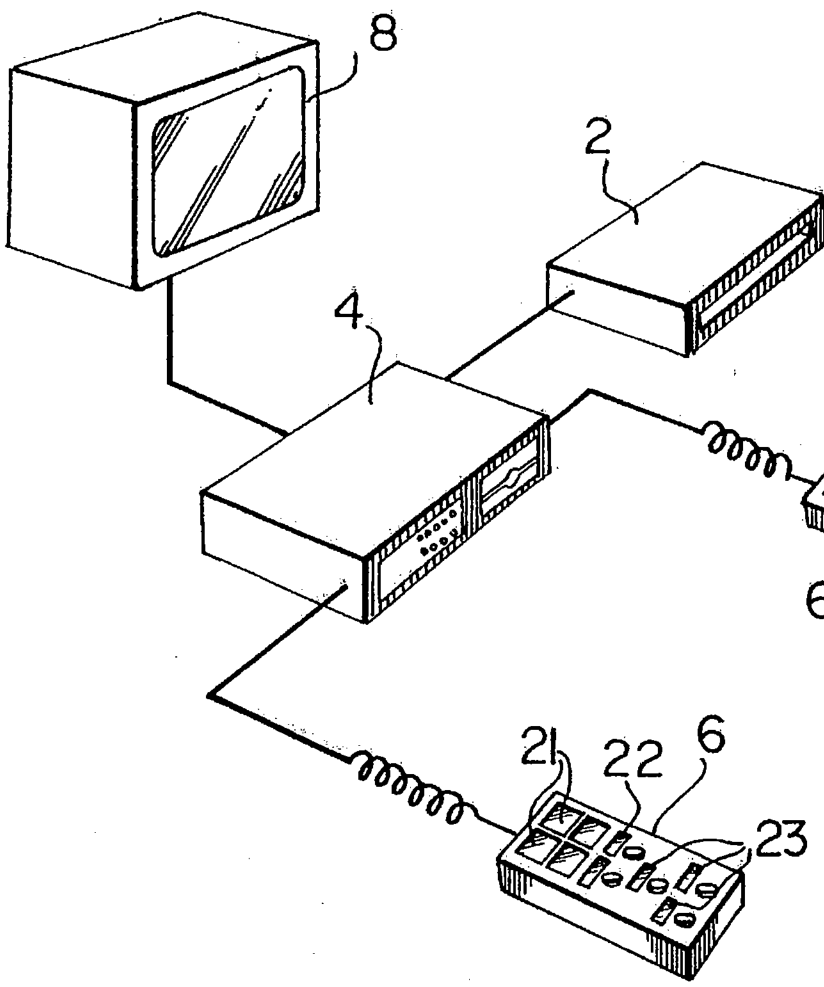


FIG.1

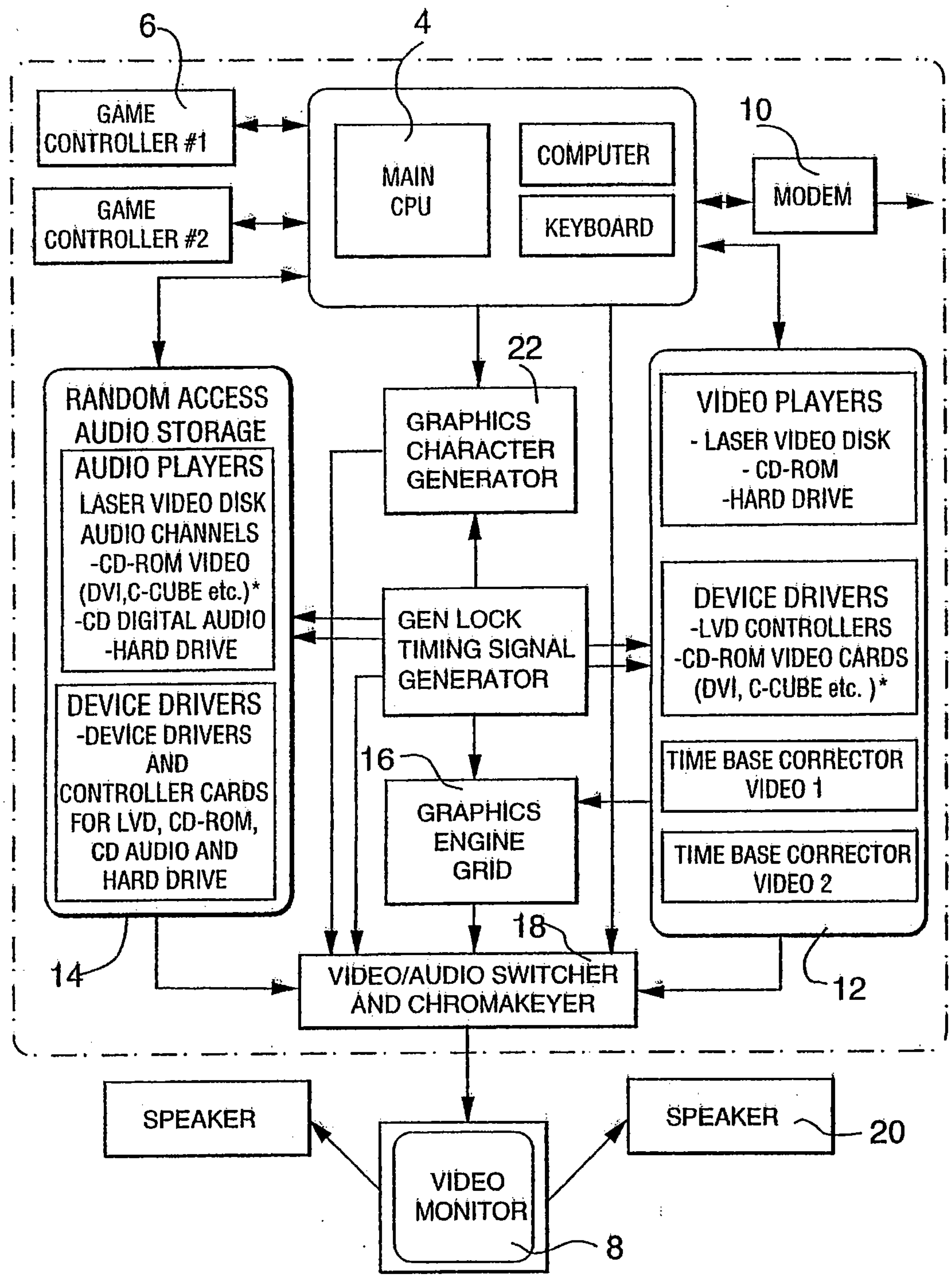

6
4
GAME CONTROLLER #1
GAME CONTROLLER #2
MAIN CPU
COMPUTER
KEYBOARD
10
MODEM
22
RANDOM ACCESS AUDIO STORAGE
AUDIO PLAYERS
LASER VIDEO DISK AUDIO CHANNELS
-CD-ROM VIDEO (DVI,C-CUBE etc.)*
-CD DIGITAL AUDIO
-HARD DRIVE
DEVICE DRIVERS
-DEVICE DRIVERS AND CONTROLLER CARDS FOR LVD, CD-ROM, CD AUDIO AND HARD DRIVE
GRAPHICS CHARACTER GENERATOR
GEN LOCK TIMING SIGNAL GENERATOR
16
GRAPHICS ENGINE GRID
VIDEO PLAYERS
- LASER VIDEO DISK
- CD-ROM
-HARD DRIVE
DEVICE DRIVERS
-LVD CONTROLLERS
-CD-ROM VIDEO CARDS (DVI, C-CUBE etc.)*
TIME BASE CORRECTOR VIDEO 1
TIME BASE CORRECTOR VIDEO 2
14
18
VIDEO/AUDIO SWITCHER AND CHROMAKEYER
12
SPEAKER
SPEAKER
20
VIDEO MONITOR
8

FIG.2

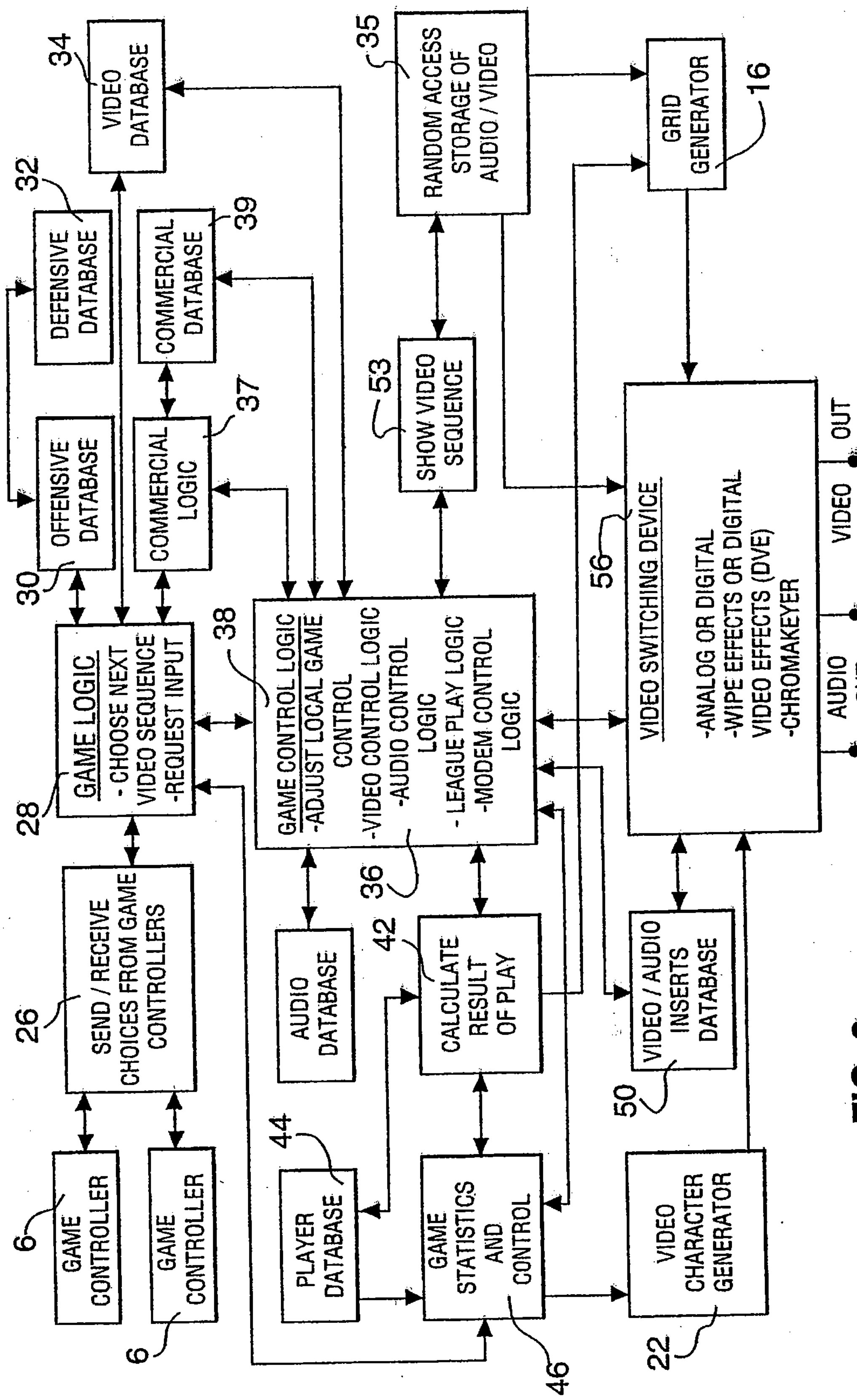

GAME CONTROLLER
GAME CONTROLLER
6
6
SEND / RECEIVE CHOICES FROM GAME CONTROLLERS
26
GAME LOGIC
- CHOOSE NEXT VIDEO SEQUENCE
-REQUEST INPUT
28
OFFENSIVE DATABASE
30
DEFENSIVE DATABASE
32
VIDEO DATABASE
34
COMMERCIAL LOGIC
37
COMMERCIAL DATABASE
39
GAME CONTROL LOGIC
-ADJUST LOCAL GAME CONTROL
-VIDEO CONTROL LOGIC
-AUDIO CONTROL LOGIC
- LEAGUE PLAY LOGIC
-MODEM CONTROL LOGIC
38
36
AUDIO DATABASE
PLAYER DATABASE
44
CALCULATE RESULT OF PLAY
42
GAME STATISTICS AND CONTROL
46
RANDOM ACCESS STORAGE OF AUDIO / VIDEO
35
SHOW VIDEO SEQUENCE
53
GRID GENERATOR
16
VIDEO SWITCHING DEVICE
-ANALOG OR DIGITAL
-WIPE EFFECTS OR DIGITAL VIDEO EFFECTS (DVE)
-CHROMAKEYER
56
AUDIO OUT
VIDEO OUT
VIDEO / AUDIO INSERTS DATABASE
50
VIDEO CHARACTER GENERATOR
22

FIG. 3

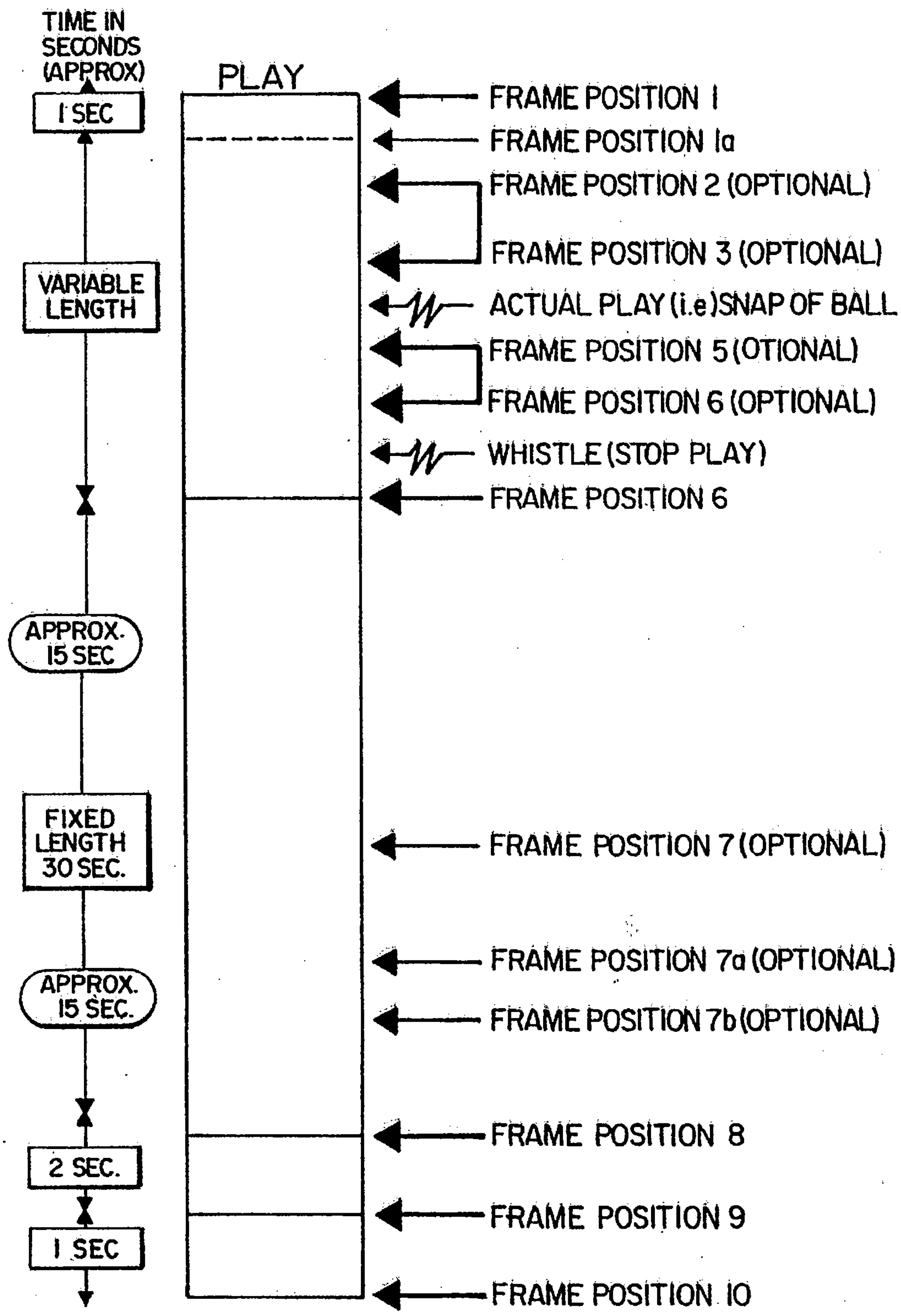

TIME IN SECONDS (APPROX)
PLAY
1 SEC
VARIABLE LENGTH
APPROX. 15 SEC
FIXED LENGTH 30 SEC.
APPROX. 15 SEC.
2 SEC.
1 SEC
FRAME POSITION 1
FRAME POSITION 1a
FRAME POSITION 2 (OPTIONAL)
FRAME POSITION 3 (OPTIONAL)
ACTUAL PLAY (i.e) SNAP OF BALL
FRAME POSITION 5 (OTIONAL)
FRAME POSITION 6 (OPTIONAL)
WHISTLE (STOP PLAY)
FRAME POSITION 6
FRAME POSITION 7 (OPTIONAL)
FRAME POSITION 7a (OPTIONAL)
FRAME POSITION 7b (OPTIONAL)
FRAME POSITION 8
FRAME POSITION 9
FRAME POSITION 10

FIG. 4

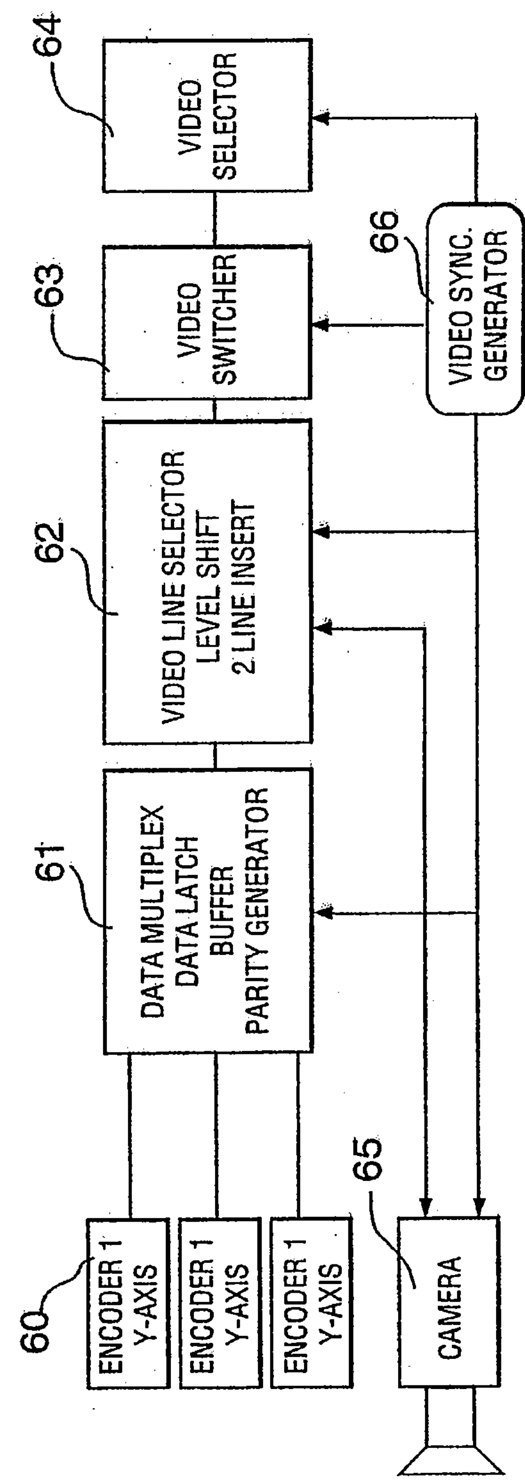

ENCODER 1 Y-AXIS
ENCODER 1 Y-AXIS
ENCODER 1 Y-AXIS
60
DATA MULTIPLEX DATA LATCH BUFFER PARITY GENERATOR
61
VIDEO LINE SELECTOR LEVEL SHIFT 2 LINE INSERT
62
VIDEO SWITCHER
63
VIDEO SELECTOR
64
CAMERA
65
VIDEO SYNC. GENERATOR
66

FIG.5

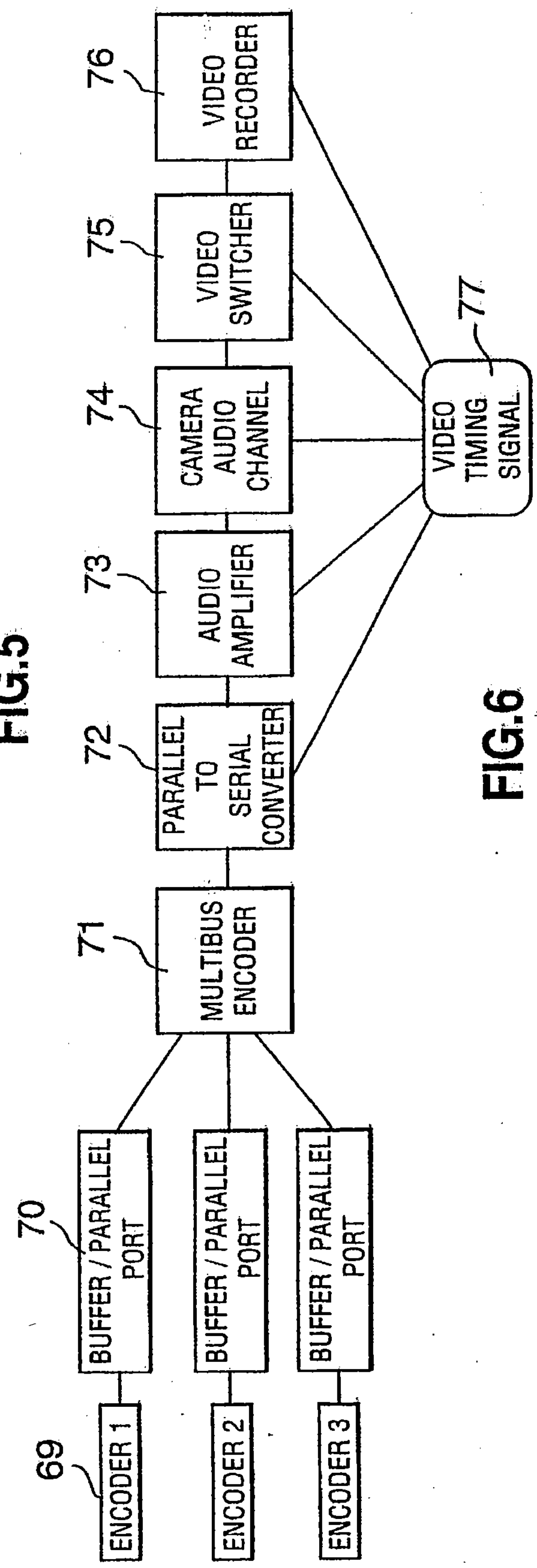

ENCODER 1
ENCODER 2
ENCODER 3
69
BUFFER / PARALLEL PORT
BUFFER / PARALLEL PORT
BUFFER / PARALLEL PORT
70
MULTIBUS ENCODER
71
PARALLEL TO SERIAL CONVERTER
72
AUDIO AMPLIFIER
73
CAMERA AUDIO CHANNEL
74
VIDEO SWITCHER
75
VIDEO RECORDER
76
VIDEO TIMING SIGNAL
77

FIG.6

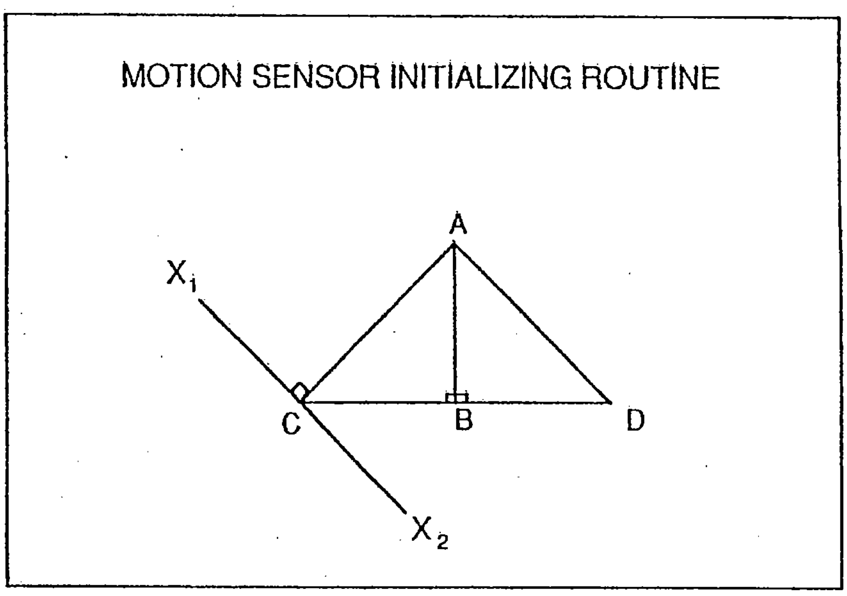

MOTION SENSOR INITIALIZING ROUTINE
A
X1
C
B
D
X2

FIG.7

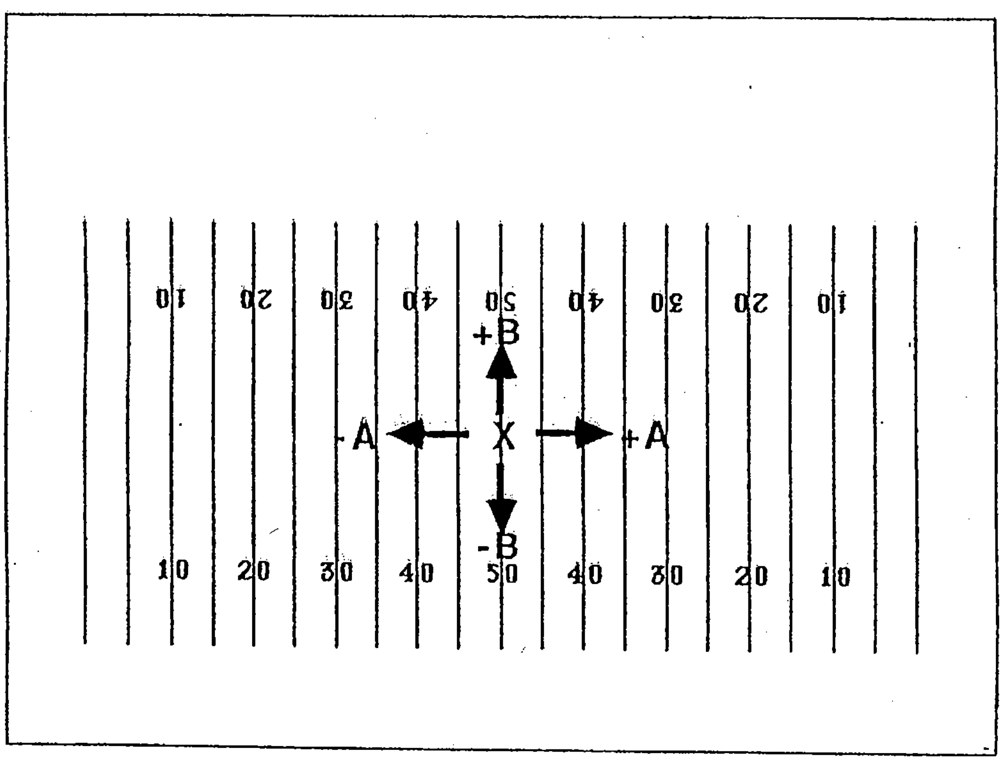

+B
-A
X
+A
-B
10
20
30
40
50
40
30
20
10

FIG.8

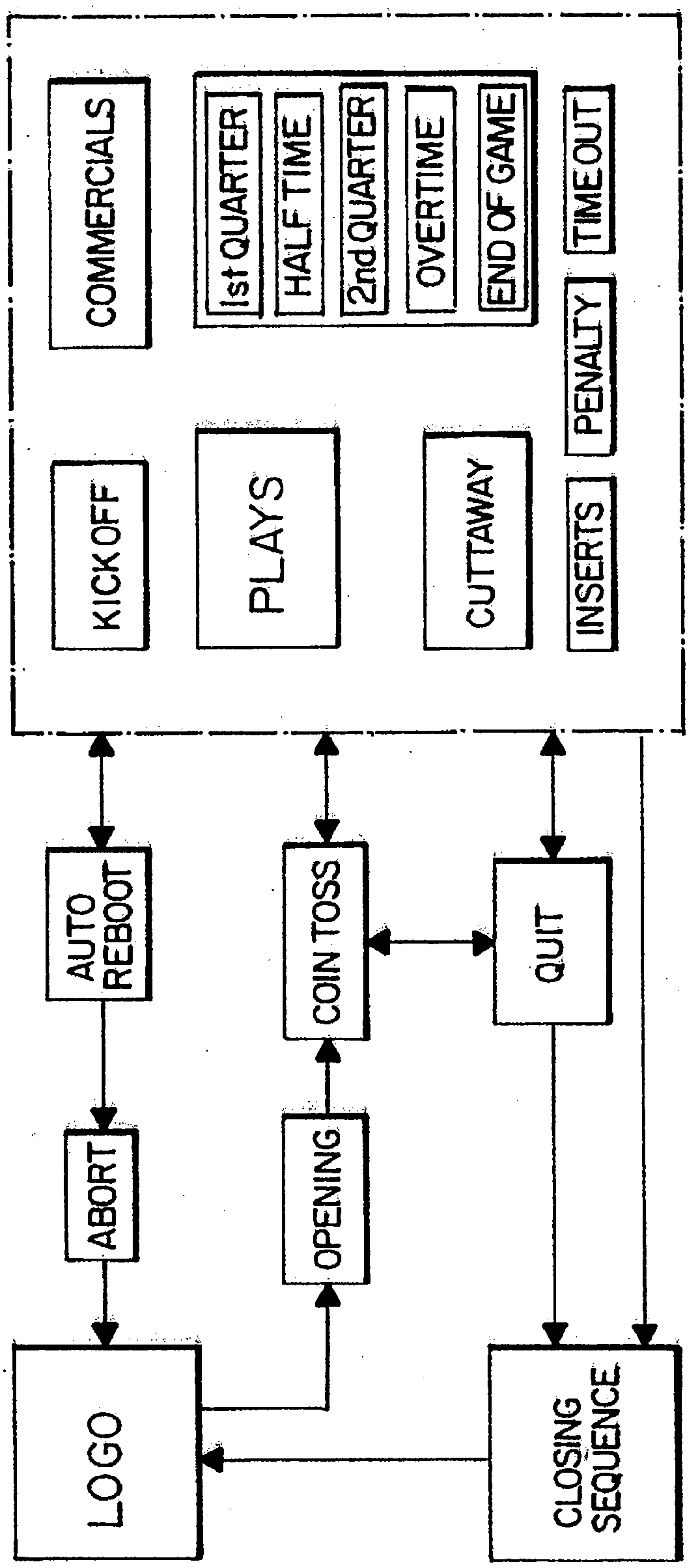

COMMERCIALS
1st QUARTER
HALF TIME
2nd QUARTER
OVERTIME
END OF GAME
TIME OUT
KICK OFF
PLAYS
CUTTAWAY
PENALTY
INSERTS
AUTO REBOOT
COIN TOSS
QUIT
ABORT
OPENING
LOGO
CLOSING SEQUENCE

FIG.9

PLAYER INTERACTIVE LIVE ACTION FOOTBALL GAME

BACKGROUND OF THE INVENTION

The present invention relates to a player interactive live action football game which may be played for example on a television screen.

Video games featuring sports including football are well known. Such video games generally incorporate computer generated graphics stored in a memory and accessed by a computer. Examples of such computer graphics video games are described and illustrated in Canadian Patent No. 1,221,761 issued May 12, 1987 of Hueda et al, Canadian Patent No. 1,236,217 issued May 3, 1988 of Bromley et al and Canadian Patent No. 1,232,093 issued Jan. 26, 1988 of Tatsumi et al.

U.S. Pat. No. 4,766,541 issued Aug. 23, 1988 of Bleich et al describes and illustrates a video game or the like which includes a real time interactive video disc game-play background generation system. The discs contain video data which is under the control of the game processor, whereby the sequence of frames to be played can be varied on a frame by frame basis.

SUMMARY OF THE INVENTION

In accordance with the present invention a pre-recorded live action and live or synthesized with electronically generated graphics overlay sound full motion video interactive football game is provided which comprises a random access storage and retrieval means and a plurality of individual, pre-recorded action football plays illustrating interaction of players of opposite teams. This information is stored in random access storage and retrieval means and accessible according to type of play. The invention further comprises a microprocessor and microprocessor control means electronically associated with the random access storage and retrieval means. The microprocessor is programmed to enable one or more users to select in sequence, through the control means, different football plays according to play type. A display means is electronically associated with the microprocessor to enable the selected plays to be viewed by the users. The microprocessor is further programmed to evaluate and cumulate play results and report them to the users in a meaningful way. The microprocessor then, by using statistical tables, to select the actual football play according to play type selected by the user.

Preferably the live action football plays are recorded on a field without grid lines and numbers. The game is further provided with means to electronically generate a display of a grid of yard lines and numbers on the field on the display means corresponding to the play action and location of the teams on the field.

The football game according to the present invention may store the video material using laser disc technology, and may also store audio material for real-time playback of voice, music and sound effects. The game as played appears to the viewers to be a real television broadcast of a live game, the content of which is dictated by selections of plays by the users. The game according to the present invention is unique in that it permits the viewer to interact with what appears to be an actual televised professional American style football game.

It is an object of the present invention to provide an interactive, live action football game that can be played by one or more persons in a home, bar or the like. It is a further object of the present invention to provide such a television game which permits the players to select full motion video images, as opposed to computer generated graphics, to play such game and determine the outcome.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the invention will become apparent upon reading the following detailed description and upon referring to the drawings in which:

FIG. 1 is a schematic view of the game components of the game in accordance with the present invention;

FIG. 2 is a schematic block diagram showing the component layout of the game according to the present invention;

FIG. 3 is a software block diagram of the game of the invention;

FIG. 4 is a schematic diagram of a video play sequence breakdown for the game in accordance with the present invention;

FIG. 5 is a block diagram illustrating an example method for sensing pan, tilt and zoom motion of the camera, encoding this motion into a digital signal or position code, and recording this position code onto an audio channel in the video display in synchronization with the video frame corresponding to that motion ensuring visually proper grid and number insertion into the video play sequence;

FIG. 6 is a block diagram of an alternative method of inserting the position code into a video line in the vertical interval of the video signal ensuring visually proper grid and number insertion into the video play sequence;

FIG. 7 is a geometric configuration for initializing the position coding of recorded play sequences; and

FIG. 8 is a schematic view of a football field grid generated in accordance with the invention modified for purposes of explanation.

FIG. 9 is a video sequence flow chart showing the various video pathways required in accordance with the invention to link the video sequences together to create a continuous, realtime game.

While the invention will be described in conjunction with an example embodiment, it will be understood that it is not intended to limit the invention to such embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

In the drawings, similar features have been given similar reference numerals.

FIG. 1 illustrates schematically the various hardware components of the football game system in accordance with the present invention. A random access storage and retrieval means 2, preferably a laser disc storage device 1 is electronically associated with a microprocessor 4, control modules 6 and T.V. monitor 8 as illustrated. Laser video disc storage device 2 preferably additionally provides for storage and retrieval of audio information on audio channels. Alternatively, audio information may be stored on a separate, audio storage means (not illustrated) with audio information being correlated to video information by means of microprocessor 4.

In more functional terms, the main components of the game system according to the present invention are illustrated in FIG. 2. These components may be defined as eight basic components:

1) input devices 6
2) central processing unit 4
3) modem 10
4) video storage/retrieval means 12
5) audio storage/retrieval means 14
6) graphic generation means 16
7) video/audio routing means 18
8) t.v. monitor 8, speakers 20

With the exception of the t.v. monitor and two game controlled modules 6, all of these components may be physically contained in a single enclosure or cabinet.

The input devices include the two game control modules 6 and a signal receiver (not illustrated) in main computer unit (CPU) 4. Control modules 6 communicate to the signal receiver using either infrared pulses, ultrasonic audio waves or low powered radio waves with a pulse code modulated security code. The game control modules 6 preferably have five input buttons that control all game functions. Each input command on the game control module will be accompanied with an appropriate prompt on the control module's LED or fluorescent LCD display. The display information is broken into four main sections:

1) prompt display
2) timer display
3) status display
4) input display

The prompt display is the main display 21, located near the top of the game controller, that will prompt the player for the next input or tell them to wait or display other such information. The display will flash either the word <SELECT> or the word <WAIT>. To the right of this flashing prompt, on the same prompt display line, there will be a 20 character display that will indicate the type of selection required (i.e. Type of Play) or explain the wait condition (i.e. Time Out Called). A full list of all character displays can be found in the section "Game Controller Character display Breakdown".

In the upper right corner of the game controller, there is preferably a two digit numeric display 22 with large sized characters. This numeric display is the Clock Timer display and will indicate the amount of time left to enter a decision once a prompt has been issued. The standard countdown during a play sequence will be from 30 seconds backward to zero. If an offensive call has not been made by that time there will be a Delay of Game Penalty issued to the offense.

In addition to the <SELECT> input prompt and the numeric Countdown Timer display, there is also a 14 character alphanumeric display 23 beside each of the 5 input buttons. These displays will identify the input command for each button. For example, if the prompt requests "<SELECT> Type of Play", then to the right of each of the 5 inputs buttons will be a display showing the type of play that button will select.

EXAMPLE

<SELECT> Type of Play
Run
Pass
Kick
Time Out
Quit

If "Run" is selected then the Prompt Display and the five Input Displays will change to read:

<SELECT> Type of Run
Wide Left
Dive Left
Up the Middle
Dive Right
Wide Right

The selected response is then received by CPU 4 and processed along with other game factors, as will be described in more detail hereinafter, to determine which video play sequence or other video sequence (such as Time Out, etc.) will be used next. It will then communicate with the other components in the system to set up the next video sequence.

CPU 4 also locates where all video and audio elements are stored in video storage and retrieval means 12 and audio storage and retrieval means 14. Once the locations of these elements have been identified, they must be ordered into the proper order for sequencing. Then commands are issued to the proper device controllers to cue up the first elements needed to start the sequence.

Video storage and retrieval means 2 can be any video storage system that has sufficient storage capacity for the required program, providing it is capable of random access, within the limited time frame of the parameters of the game, to all video sequences stored in this medium. Suitable storage mediums that meet these requirements include laser video disc, CD-ROM compact disc and RAM hard drive. (Video stored in a digital format will probably use compression techniques such as Intel's "DVI System" Trade-mark). As new storage mediums are developed any medium meeting the storage and random access requirements of the present invention can be used.

The video images stored in this medium will be full motion video (i.e. thirty video frames per second). These images can be stored in analog form as on a Laser Video Disk (CAV or CLV formats), or as compressed digital data (CD-ROM) using video compression techniques. The resolution of the image may vary depending on the type of system used but in all cases the final video output will match the video system used in the country or region of use. In North America for example, the video output will be NTSC Standard. In Europe it will be a PAL/Secam dual format. A Standards Conversion Unit can be installed down stream from the system so that all images are stored and controlled in NTSC format with the final video output going through the Standards Conversion Unit converting it to PAL/Secam. The other alternative is to store and display the video data entirely in the local broadcast format used and, since the video frame rate for PAL/SECAM is 25 video frames per second, this would require rewriting the control program and data base to work in base 25 rather than base 30.

The Audio Storage and retrieval means 14 can utilize several different formats. More than one of these formats may be utilized in the final design. The major storage format will be in accordance with the final video format used. If, for example, the final video format is Laser Video Disk, then most of the audio will be stored on the existing audio tracks used on Laser Video Disk. This format will permit the use of two audio tracks that share common frame numbers with the video portion. In other words, for each addressable video frame on the Laser Video Disk as there are two corresponding Audio frames with the same address. Additional audio tracks can be located on other Laser Video Disks run in sync with the main video sequence. Another possible source is a CD-Audio Company (Trade-mark) Disk running in sync with the video using a similar frame code addressing system. Digitized sound can also be stored on hard disk drive for extremely fast random access. Regardless of the Storage Format used, the audio storage requirements are the same as the video storage requirements in that they must have large capacity and random access capability.

The graphic character generation means 16 generates the yard lines and yard numbers for the field, in a manner which will be described more particularly hereinafter. The decoding of the digitized position code (referred to subsequently herein) is processed by the graphics engine independent of the CPU 4. Since the field markings must be generated in real time, the graphics engine (grid generator) must preferably be totally dedicated to the task and perform no other functions.

Other graphics such as game statistics and players names for the video inserts may be generated by a graphics character generator. This generator is required to generate characters and simple lines for underlining titles. It must generate several sizes of font in different colors. It does not operate in real time as does the graphics engine (grid generator) so that the speed requirements for this system are greatly reduced. There are several video character generators (analog and digital) currently available which fulfill these requirements.

All graphics are routed to the video/audio switcher and chromakeyer 18 for insertion into the video picture. The video/audio switcher 18 can be either analog or digital. In analog form the device would be a standard video/audio switcher controlled by the main CPU through a General Periphery Interface (GPI). The video switcher would generate the wipe effects that link the video sequences together and it would include an upstream chromakeyer. The chromakeyer enables the system to insert graphics over the entire picture (i.e. score inserts, statistics, players names etc.) or insert the grid markings of yard lines and numbers over the specific colour (i.e. chroma) that matches the grass on the playing field. Any other colour, such as the football players, will not be keyed out and therefore appear over top of the field markings.

The video switcher also manages audio routing of the final mixed audio.

There are a number of low cost analog switching devices available on the market. In the digital domain, video and audio switching as well as chromakeying can be handled with a number of "off the shelf" VGA to Video adaptor cards currently available for the IBM platform. Many of these cards allow the use of wipes and keys in their basic format as well as a number of other Digital Video Effects (DVE) that can be incorporated into the production design of the program.

The modem 10 will operate under control of the CPU 4. During play it may feed control Program information through to other game systems at other locations. When the system is not being used it will periodically report back to a central Service Center and Data Base (not illustrated) supplying current information on Usage for marketing analysis as well as reporting back to the Service Center for any trouble or equipment failure.

The software operating CPU 4 will be described now in more detail, having reference to the software block diagram of FIG. 3. The two game controller modules 6 are used to display information and options to the players and send the choices back to the computer via send/receive choices from game controllers 26.

The game logic 28 uses data from the send/receive choices from game controllers 26 to choose the next video sequence and to send information back to or request input from the game controller modules 6.

The offensive database 30 contains the information to rank the basic effectiveness of an offensive call.

The defensive database 32 contains the information to rank the effectiveness of each defense called versus the offense called.

The video database 34 contains information on every video sequence stored in random access storage of video/audio 35. The timing information for each video sequence is also located here and accessed by the video control logic 36.

The commercial logic or advertisement logic 37 works with the game control logic 38 to determine when and where commercials should be played.

The commercial or advertisement database 39 contains information on every commercial in random access storage and keeps a record of how many times each one is played.

The adjust local game control function of game control logic 38 will pass on information about the current video sequence to calculate the result of play at 42. The adjust local game control 38 also manages the logic for the timing and control of all video and audio sequences as well as the control program for the modem link.

The player database 44 contains the profile information on every player in the game. It is updated every time a result of play calculation is made.

The results of play calculations are also passed on to game statistics and control 46 which provides information on score, momentum, player performance and game control variables.

The video graphics character generator 22 creates the graphics for score, yardage and timing updates, player, game and league inserts and any titling or other character generation that may be required.

The video/audio inserts database 50 stores information on all inserts that are available to the video control logic.

The show video sequence 53 controls the driving of video and audio devices such as laser video disks, CD-Rom etc.

The random access storage of video/audio 35 contains all video and audio material. The number and types of devices may be intermixed and include such devices as laser video disk, CD compact audio disc, CD-Rom, computer hard drive and any other random access storage devices.

The grid generator 16 reads the position code information stored in the video signal and generates the appropriate grid of yardage lines and yard numbers.

The analog or digital video/audio switching device 56 is controlled by the video game control logic 38 and switches between all video and audio signals. This device also contains a chromakeyer for keying in the field markings from the grid generator 16 or graphics from the graphics character generator 22.

An important aspect of the game according to the present invention is the play sequence as illustrated in FIG. 4. In particular, the illustrated frame positions represent the following:

Frame Position 1—Start of Video and Audio Sequence

Frame Position 1a—End of 1 sec Video Transition

Frame Position 2 (Optional)—Optional Audio Window for "yardage and down" inserts

Frame Position 3 (Optional)—Actual play (i.e. Snap of Ball) starts approximately here

Frame Position 5 (Optional)—Optional Audio Window For "yardage and down" inserts

Frame Position 6 (Optional)—Whistle (Stop Play) approx. here

Frame Position 6—End of Play/Start of Replay Issue Prompts for Player Inputs (Approx. 3–5 seconds after whistle) Start color/SloMo Replay Sequence NOTE: Frame Position 6 (or Start of Replay) will usually occur during real time video before the Slow Motion replay starts, however, this position is backtimed from Frame Position 8 so it's actual position could be in either real time or slow motion video.

Frame Position 7 (Optional)—Optional end of Play sequence. If all prompts have been answered by this time then the Replay sequence can be cut short so the pace of the game can be speeded up in direct response to the players input.

Frame Position 7*a* (Optional)—Optional end of Play or Edit out Point (Same function as FP8)

Frame Position 7*b* (Optional)—Optional End of Video (Same function as FP9)

Frame Position 8—Ends prompts and deadline for player inputs. If offense has not entered next choice of play by this time they will be penalized. FP8 will occur 2 seconds before FP9 to allow time for cueing of the next video sequence.

Frame Position 9—End of Play sequence. This is the normal Edit Out point for this video sequence where a picture cut takes place or video transition such as a wipe effect begins. This is also the frame position for audio edits between video sequences.

Frame Position 10—End of video footage. Video transitions must be completed by this frame—1 second after FP9.

The play sequence consists of two main parts:

1) The Play

2) The Replay

The play sequence starts at frame position 1 which is also the first and main edit point in a play sequence. This is also the start of the play portion of the play sequence.

Frame position 1 a marks the end of the video transition that began at the first edit point at frame position 1. The end of the video transition at frame position 1*a* is not significant in the timing of the play sequence but is included here for clarity and to include all notable frame positions in the play sequence (It is important to keep clear and understand that although the main edit point has already passed and the audio has been edited, the video is still completing the 1 second wipe effect up until frame position 1*a*).

Prior to the start of play (i.e. snap of the ball), the play by play commentary will be tagged at frame position 2 and frame position 3 to locate an audio window where the existing sync dialogue of the play by play announcer can be deleted and replaced with a voice insert by the same announcer giving yardage and field position updates.

The frame position of the start of the actual football play (i.e. snap of the ball), could be anywhere between frame positions 3 and 4 in the play portion of the play sequence. It is not recorded with a frame position number since it is not important in the timing of the play sequence.

Frame Position 4 and Frame Position 5 mark the location of the in and out points of another audio window. This window occurs after the ball has been taken out of play and a new field position and down has been established. This gives the play by play narrator the opportunity to say where the ball has ended up and what the downage situation is so that the players can be informed for their next play decision.

(There are also readouts of yardage and downs on each player's game controller display. These readouts will be dedicated to this specific function and visible to the players at all times during normal play of the game.)

Both audio windows at Frame Positions 2 and 3 and Frame Positions 4 and 5, are optional windows that will not be automatically used every time they occur. The audio windows will be used at random intervals to vary the structure of the play sequence format. The amount of randomizing will be determined in Alpha/Beta testing of the prototype game and will probably favor the second audio window since it occurs after the current play has been completed, therefore the updated information in the second audio window (Frame Positions 4 to 5) is more useful to the players since they must now make their next play decision.

Although we will not normally use both windows in the same video play sequence, there will be occasions when both windows could be used in the same play. This would give the current yards and downs before the play and the new yards and downs immediately after the play is completed. This type of audio insertion has the added benefit of making the play by play announcing appear to be in real time.

Frame Position 6 marks a timing location backtimed from the end of the play sequence that will trigger the game controllers to prompt for the next player input. It is independent of the start of the slow motion video portion of the replay, but will always occur after the ball has been called out of play. The exact location of Frame Position 6 will be the number of seconds before the end of the play sequence (Frame Position 10) that is needed for the bar players' next play decision inputs, plus the video search buffer time plus the video transition time. In this example, given a player input time limit of 30 seconds, plus 2 second maximum search time, plus a 1 second video transition, frame position 6 will be located 33 seconds before the end of the play sequence (Frame Position 10).

Frame Position 7 will locate the position of an optional edit out point. The exact location of this frame position will vary since each play is different and the optional edit out point must be at a place where both video and audio can be edited together without a break in video or audio continuity.

There are several uses for the optional edit out point at Frame Position 7.

The primary function is to give the players the ability to speed up the pacing of the game for either enjoyment or strategy, by entering their play decisions quickly, within the first half of the time period allowed for entering an input response. This optional edit out point will shorten a play sequence by at least 10 to 15 seconds.

Another use for the optional edit out point is to reduce the amount of replay in the video play sequence and substitute it with a commercial insert, player or game statistics inserts (in the case of league play this could also include a league statistics update.), highlight replay or cutaway. This type of usage will not increase the pace of the game or be as a result of player input. The computer software will determine when and where the optional edit out point is used for these types of inserts.

Although these inserts are not necessary for the playing of the game, they are necessary if we are to break the continuous and ultimately, predictable sequence of play portion followed by replay portion that is standard for each video play sequence. This is one of the techniques we will be using to help create the illusion that the game being played is real and being switched by a live television crew with live announcers.

There are three frame positions given for each optional edit out point. Frame Position 7*a* will be at a location 8 seconds before the actual edit out point. This will allow a minimum of 5 seconds for the defensive players to react to the display change. Then Frame Position 7*b* will mark the last frame position available for video search and 1 second for the video transition before the actual edit point at Frame Position 7c.

If the offensive players have entered their 2 play decisions in time to use the optional edit out point, the countdown timer on the defensive player's game controller will change from a steady display of decreasing numbers indicating the normal time left to make a defensive call, to a flashing display showing the new time left to make a call if they are to keep up with the offense's change of pace. With the above timings, the minimum time that the flashing countdown will count is 5 seconds however, for this to actually occur the offensive player must enter their last decision within 30 video frames immediately proceeding Frame Position 7a. Any entry prior to this will give the defense a longer countdown warning on their game controller time display.

Frame Position 8 marks the end of the normal input time period for the players to call the next play. If no play has been called by the offense, there will be a delay of game penalty given to them. If no input was received by the defense, they will be given default values for the game factors which will decrease their chances for a successful defense. In the example given in diagram 1, Frame Position 8 will occur 3 seconds before the end of the play sequence. In a worst case scenario, where the players have entered their final input for the next play just 1 frame before Frame Position 8, the system will have 2 seconds to choose a play and locate it on the appropriate video disk before reaching Frame Position 9.

Frame Position 9 marks the end of the video play sequence and the beginning of the video transition (i.e. wipe effect) to the next video sequence. Position number 9 is also the position where the audio is edited to the beginning of the next video sequence.

The 1 second of video that makes up the video transition is used to overlap the video from the next sequence during the 1 second wipe effect or video transition.

Position number 10 marks the end of the video footage for the video play sequence.

Where a sequence of plays are to be undertaken, the first step in this sequence will be to cue the main video element, such as a video play sequence (selected from laser video storage retrieval means 12) at a location prior to the desired video material that will provide sufficient time for lockup or synchronization of the video picture. If for example the video lockup time is one second, the cue position for the video sequence will be one second or thirty video frames before the edit in point of the cued video sequence. Then when the current play sequence, already in progress, reaches a position one second (thirty video frames) before its "Edit Out Point" the next video sequence will start to roll and sync up with the current video sequence.

When the current Video Sequence reaches its Edit Out Point, the CPU 4 will issue a command to the Video Switching device to start the Video Transition (Wipe Effect Edit) between the two Video Sequences. Since both video sequences will now be synchronized together, when the current Play Sequence reaches its Edit Out Point, the new Play Sequence will reach its Edit In Point at the same time. Once the Edit Point is reached, the edit will take place and the Video Transition will begin.

The Video Transition will always have the current Play Sequence move off screen (i.e. wipe) over top of the next Video Sequence when the next Video Sequence starts in real time. This is almost always the case but one example of an exception would be when we insert a Graphic for game statistics. If this insert occurs during live video from the current play the Insert should wipe in over the current sequence. The video transition cannot exceed he length of the Video portions of the Video Sequence.

Once the final Frame Position on the current Video Sequence has been reached, that video source will go off-line and the new Video Sequence will continue as the Current Video Sequence. In the meantime, the CPU 4 will be issuing similar instructions for the audio inserts that are to be inserted into the selected Optional Audio Windows. It will determine whether the Audio Storage device is located and issue a command to the Audio Storage device to cue that insert an appropriate time ahead of the Insert that will allow sufficient time for the audio to 'lockup' with the Video Play Sequence. When this position is reached, just prior to Frame Position 2 in the Video Play Sequence, the Audio disk will roll and get up to speed in synchronization with the Video Play Sequence so that the starting location for the Audio Insert will correspond with Frame Position 2 (the beginning of the target Audio Window).

When the "in-point" at Frame Position 2 for the Audio Window is reached, the CPU 4 will instruct the Video/Audio Switching device to mute the track containing the Play by Play commentary and replace it with the Audio Insert. When Frame Position 3 is reached, the mute command will be revoked and the original Play by Play commentary will continue.

When the Video Play Sequence reaches Frame Position 6 (FIG. 4), the CPU 4 will send a command back to the Game Controllers requesting the next input from the players for the next video sequence. This sequence will then repeat itself over again.

A key concept that makes the game according to the present invention unique flows from the fact that all plays are videotaped on a playing field that will have all the yardage lines and yardage numbers removed. All other field markings such as hash marks, end zone and boundary lines will remain on the field for reference by the football players and television crew during videotaping of the football plays.

The yardage lines that have been removed will be electronically regenerated and inserted into the video picture in real time and in their proper size and perspective during the playing of the SAT game.

There are several reasons for electronically inserting these lines.

1) First, any play that is recorded and does not show the end zones of the field can be used as a generic play. Since we have not recorded the yard lines, when they are electronically inserted we can position them to suit the current game's field position. This will enable us to place a generic play at virtually any yard line on the field providing, that in the ensuing play action, as mentioned above, the cameras do not show the location of the end zones. This will reduce the number of plays that must be stored in video storage down to a manageable number.

2) By reducing the number of plays that must be stored, we are able to increase the number of video play sequences that can be chosen for any given call by the game players.

For example, if there are 8 possible sequences for any given play at any given field position, there are . . .

2 teams playing on . . .

2 sets of hash marks in . . .

2 directions . . .

we will have total of (8×2×2×2=) 64 play options possible for each generic play.

These yardage lines are generated by dedicated graphics engine 16 that operates independently from the main CPU. The generated grid will be a monochromatic image of 19 straight lines with numbers. This grid will be electronically inserted into the video play sequence through the use of the chromakeyer that will place it over (i.e. the colour green) and under the football players, referees and ball (i.e. any other colour).

In order to position the grid in relation to the camera angle and focal length of the lens, each camera used during videotaping will be equipped with 3 motion sensors. Since these cameras are being operated and moved by human input, there is no simple mathematical equation to describe this movement. Therefore, this motion must be accurately measured and recorded in real time as the play is being videotaped.

The motion sensors must record any movement of the camera in 3 axes. These axes will be the Pan axis (Azimuth) Tilt axis (Altitude) and Zoom axis (Focal Length of camera lens). The Zoom angle is measured by the amount of rotation of the camera lens' focus ring about its axis.

Since the movement of any axis may be very small, each motion sensor must record motion with sub-arcminute resolution.

As can be seen in FIG. 5, the output from the motion sensors is first converted to binary code at encoder **60**. The binary output from the motion sensors is sent to the data multiplex **61** where it is sequenced into correct order and format which records duplicate information and a parity check.

After the position code has been formatted in the data multiplex **61**, it is sent to the video line selector **62** when the next vertical sync pulse is received from the video sync generator **66**. The video line selector **62** then conforms the specially formatted serial position data to be electronically compatible with the video signal.

The video line selector **62** then selects the proper horizontal lines in the video signal that will store the specially formatted binary position code. The position code is then inserted into the target lines of horizontal video from the video camera **65**. This combined signal is then passed on to the video switcher **63** to be "taken" when required and recorded on video tape in the video recorder **64**.

Another method of storing this serial position code, as illustrated in FIG. **6** is to convert it into an analog audio signal and record it on one of the videotape's audio tracks in synchronization with each video frame. As seen in FIG. **6**, the output from the motion sensors is first converted into binary code at encoder **69**. The binary code is held in a buffer **70** for sequencing into proper order through a multibus encoder **71** to a parallel to serial converter **72**. The serial position code is stored in another buffer (not shown) until triggered by the next vertical sync pulse of the video timing signal 77. The serial code is then passed on through a signal or audio amplifier **73** to bring it up to the proper line voltage for insertion into an audio channel in the camera **74**. The combined video and audio signal is then passed through the video switcher **75** and recorded by the video recorder **76**.

The advantages of this method are that this procedure is easier to do electronically and that the recorded information is separated from the video information so it can be offset during post production if a timing buffer is required for grid generation by the graphics engine. A disadvantage to this method is that the frequency range of the longitudinal audio track limits the bandwidth or in other words, the amount of information that can be stored in this way. Also, since the recorded signal is now in analog form, any change in frequency response or the signal to noise level can cause loss of information.

While two methods of storing the serial position code have been described, others are available. In fact this code

may be stored on any other usable area of the recording medium.

The position code must accurately record four basic elements of information:

[Camera ID]+[X axis(Pan)]+[Y axis(Tilt)]+[Z axis(Zoom)]

The camera ID number identifies for the graphics generator, from which camera position we are now viewing the grid in relation to a standard reference position on the playing field. Since there will be 7 cameras shooting the plays, this number will vary from 1–7.

The X axis number identifies the amount of pan, left or right, in seconds of arc, the camera has moved in relation to the standard reference position.

The Y axis number identifies the amount of tilt, up or down, the camera has moved from the standard reference position. The Z axis number identifies the amount of magnification or zoom (i.e. change in focal length of the camera lens) of the video picture in relation to the standard reference position.

In addition to these standard elements the position code will contain an error checking code.

The position code will be read on playback of the video play sequence and sent to the graphics engine (grid generator). The graphics engine will decode the position information found in the video signal or on the audio track, and convert it into display co-ordinates and a magnification factor for the generated grid.

During setup of the video cameras in preparation for the video shoot, they will be initialized with reference to a common reference point and angle of view. The pan, title and zoom angle for each camera, when referenced to this standard reference point, will differ for each camera in relation to its position on or around the field. The values of these three angles will become known variables for each camera (i.e. Camera 1=Var 1x, Var 1y, Var 1z, or Camera 2=V2a etc.) (NOTE: Each camera will have three variable numbers designated as "VNa" where "V" is the value of the position or zoom angle, "N" is the camera identification number and "a" identifies the axis x, y or z, that is being referred to). The value of the variable V will be determined during the camera initialization routine using the standard reference point. The standard reference point is located approximately in the center of the playing field and is used by all camera's during the camera initialization routine.

The geometric configuration for the position code is shown in FIG. 7.

Point A represents the standard reference point

Point B represents a point of right angle intersection between the standard reference point (a) and the camera (c) with line AB being parallel to the yardage lines on the field.

Point C represents the position of the camera to the left of point B.

Point D represents another camera to the right of Point B.

Then angle CAB, or angle A, is the amount of counter clockwise rotation required of the grid, which is rotated 0 degrees when viewed from position B, to view it as it would be seen from position C. Clockwise rotation is represented by a positive number, counter clockwise rotation is represented by a negative number.

Any movement of the camera from this reference position can now be calculated by inserting this variable into the position code.

Therefore if the camera at position C is Camera Number 1 then it's position code would now be represented as:

[X axis+(V1x)] [Y axis+(V1y)] [Z axis+(V1z)]

This information will tell us the rotation of the angle of view and magnification of the field markings but is only valid for one position on the field, i.e. with the fifty yard line on the standard reference point. If we are to move the field markings on the field, then we must define two more numbers.

If the exact center of the football grid in FIG. 8 represents the standard reference point, then any shift or movement of the grid on the plane of the playing surface of the field, can be represented by plus or minus values of A and B. The positive values of A represents a positive movement of the grid to the right of the standard reference point and a negative value for A represents a negative movement to the left of the standard reference point.

A positive value for B represents a positive movement of the grid up towards the top of the diagram, or away from the camera position, and a negative value for B represents a negative movement down the diagram or toward the camera position.

The grid's position on the field will be determined by the game logic program in the central CPU. This will be the only communication between the graphics engine 16 and the CPU 4 (FIG. 2).

Using these co-ordinates we can now determine the correct grid position with reference to the ball (yardage line and hash mark) and combine that with the camera's position code to view the correct field position from any initialized camera position.

Therefore:

Grid Position=A,B

Position Code=[X+(Vnx)], [Y+(Vny)], [Z+(Vnz)]

As an alternative to using motion sensing as a means of inserting the grid into the video image, it is envisaged that the grid image could be digitized so that it could be processed in a digital domain. In this process, the video footage could be shot with yardage markings on the playing field, with every single yard line being marked in a repeating sequence of five unique colors. Once these colors have been digitized (i.e. through a digital chromakey) they will each have an assigned value according to the color system or computer program being used (i.e. a 256 color system will assign values for different colors ranging from 1 to 256).

Once these values are known, the computer program can select the four unwanted colors (i.e. four unwanted values) and change these values to represent the color green. This would make the lines disappear into the grass. The remaining wanted line can then be reassigned a value to make its color white. With this system, the need for sensing the motion of the cameras would be avoided since the video image would contain all the necessary positioning and sizing information.

As yet a further alternative approach to the question of grid lines, it would also be feasible for the pre-recorded action footage plays to display normal field markings of linage lines and numbers, with a limited number of lines of scrimmage available to the player, so that the results of each play used would be compatible with this limited number of lines of scrimmage.

The video play sequence is a basic element of the football game according to the present invention. It is the actual football play itself. The video play sequence will include all runs, passes and kicks (including punts, field goals, converts and kickoffs, i.e. all football plays stored in video).

The video play sequence will consist of two main parts, the play and the replay.

The play portion will always be in real time and start prior to bringing the ball into play and end after the ball is brought out of play with the referee's whistle. If the real time action continues with events such as penalties, injuries, fights etc. the play portion of the video play sequence will continue until no new action pertinent to the game occurs. Shortly after that, the game controllers will prompt their players to call their next decisions for the play.

The replay portion of the video play sequence will always start after the ball has been taken out of play and no more new action pertinent to the game occurs. The replay portion of the play sequence will recap the current play while the players are entering their next game decisions. The replay will always continue to the end of the video play sequence. In this way, the final frame of every video play sequence will always be either in slow motion, a freeze frame or a graphics insert and thus provide a universal edit point back into the real time motion of the beginning of the next video play sequence and avoid visual or audible continuity problems with the edit. The end of the video play sequence will always edit to the next video play sequence with a wipe effect so that it psychologically brings the viewer back into real time without causing time disorientation.

When the coin toss sequence is completed and the programs returns to the game from the commercial break, the first video play sequence, the opening kickoff, will take place.

Since the game players have already entered their calls for the type of kickoff (i.e. normal or short) during the commercial break at the end of the previous sequence (coin toss), the kickoff play sequence will go ahead without any additional player input. At the end of the kickoff, there will be an instant slow motion replay of the highlights of the current play while the game players are prompted, through their game controllers, to make two decisions.

First, they will be asked to select the type of play they want to call, either a run, pass or kick. They will also be given two other options at this time, time out and quit.

If the player calls time out and they have not used their allowed number of time outs, the game controller will ask if the player is sure (Y,N) and then either pause for the regulation time out period by going to a commercial break or, if told No, the game controller will ignore the time out request and continue with normal play.

Similarly, if a player enters a quit response, the game controller will ask the player if they are sure and then either end the game or continue the play, depending on the response. If a player does quit, the game is awarded, by default, to the other team.

If the players did respond correctly to the "select type of play" input command, they will be asked to enter the type of run, type of pass or type of kick they want to call.

The options for type of run will be:

1) Wide left
2) Dive left
3) Down the middle
4) Dive right
5) Wide right

The options for type of pass will be:

1) Deep left
2) Short left
3) Down the middle
4) Short right
5) Deep right

The options for type of kick will be:

1) Long punt
2) Short punt
3) Field goal

These two decisions (type of play and type of run, pass or kick) must be entered by the offense within a limited time period of 30 seconds. This is the length of time currently decided on and could change on testing the final design if it is found to be too short or too long.

If the offense has not made its next play decisions within the allotted time period, they will be penalized with a delay of game penalty and thus have the line of scrimmage moved back five yards.

If the defense fails to respond to the same input commands, they will be given a default value in the game factors so that their chances for a successful blockage of the next play will be reduced. In other words, they were either too slow in making a defensive call or were caught off guard by the offense speeding up the offensive huddle (see below).

Both game controllers will display a timer that will indicate to the players the amount of time remaining before they are penalized for a late call.

The play sequence will also contain an optional edit out point at some position in the replay portion of the play sequence. There are several uses for this optional edit out point.

First, they can be used to help break up the repetitious sequencing of play/replay in play sequence. Since the cutaway sequences are well over 30 seconds in length they can be randomly inserted at these positions to cutaway to crowd, stadium and player's bench shots.

Second, they can be used for inserts of updates of game statistics or player statistics. During league play, it can also be used for inserting league statistics and live updates.

In both of these examples, the timing of the players input responses would not be changed and the offense would not give a quick response.

This "quick response" is the third example of usage of the optional edit out point. If the offense wants to speed up the pace of the game, they can do so by entering their two play decisions before Frame Position 5, thereby allowing the game control program to end the replay sequence before the maximum time allowed, but since it must always be at least 6 seconds before the actual edit out point, for it to make any difference to the 30 second prompt period, it will usually be found approximately halfway (or about 15 seconds) through the replay portion of the play sequence.

They will be given an indication of when their call has been quick enough to end the replay sequence early however, with the same visual cue on the timer display given to the defense (see below).

The defense on the other hand will be given a warning when the offense makes a quick call, the timer on the defensive player's game controller will start flashing and adjust to the remaining time left before the next optional edit out point at Frame Position 5.

This may seem unfair but remember that the offense knows when they have made their inputs and in a real game, they would approach the line of scrimmage and therefore visually warn the defense to hurry up their call so the defense must be given some kind of warning that the quick call has been made.

An example video sequence flow chart is illustrated in FIG. 9, showing the various video pathways that may be provided to link the video sequences together to create a continuous, real time game. (The first video image to appear on the screen after initial bootup, in the illustrated flow chart, is the manufacturer's logo). Commercials and inserts may be included, as illustrated, to help create the illusion that the game is being televised live. The video portion of such inserts might be either wide shots of the stadium and crowds or still pictures of individual players or team logos. These images may be combined with a graphics overlay of the information pertinent to the insert such as a player's statistics, current game statistics such as yards carried, passed, etc. League standing statistics or other information that can be compiled from database information may also be provided. The graphics overlays would be generated by the graphics character generator 22. The video insert could also be a game clock which could be used very effectively during the final moments of a game.

It will be understood that certain game factors may be affected through programming of CPU 4. Those factors include:

1) Team playing factors. Each team will have its own set of playing factors stored in memory. These factors will affect the outcome of the play, for example, a team with a high value of passing will have a better chance for completing a pass play than a team with a low passing play value.

2) Field position. There is an established system for determining the chances of success for a run or pass play according to the field position of that play. This system is used by quarterbacks and coaches to help them determine when it is best to run or pass. We will be using this system or a system similar to it to assign values to a called play according to its field position. This will be most evidenced in field goal attempts.

3) Game situation. As the game progresses, the teams will fatigue. We will already be including player response time in the game factors but we should also consider overall game fatigue so that the more physically demanding plays will be less successful near the end of the quarters and near the end of the game. However, there will be other game situation factors that will also be taken into account such as previous successes. In other words, when a team gets marching down the field, their morale will overcome factors such as fatigue to at least some extent and conversely would probably increase the defense fatigue.

4) Wind conditions. This will be the only weather condition taken into account and will affect all passing and kicking plays. The wind conditions will be randomly determined and announced at the beginning of the game and should be subject to possible changes during the game. For simplicity and for finding a place to announce wind changes, they should only occur between quarters. We can announce wind conditions at the start of each quarter. Note: If the game is shot in an indoor stadium then wind direction and conditions will not be a factor.

5) Random chance. Not every play will be subject to a random factor, in fact, a random factor will only be occasionally included in the game factors. The frequency of this random factor will probably be less than 1 in 10 plays and possibly as low as 1 in 100 plays. It is included to provide sudden surprises in the play of the game and is not intended to replace the "player vs. player" aspect of the game. When the random factor is occasionally included, its affect on the outcome of the play will vary according to its value. A value of 0 (if it is being added into the equation) or 1 (if it is being multiplied) will have the least effect whereas a value of 100 (or whatever the maximum value used) would have the most effect on the outcome of the play. When this maximum value or near maximum value is used it will overpower the other game factors and, depending on the value of these other factors, be the deciding factor in choosing the outcome of the next play. In this way even the worst possible call from the worst possible field position can result in a great play providing the random factor is used and it's value is sufficiently large enough to overpower the other factors used. (Note: Penalties, injuries, fumbles and interceptions will not be determined on a random chance basis.)

When overall game factors are taken into consideration, this should still be a game of skill. When everything else is equal, the player who calls the right plays at the right time should do better than the player who calls it wrong. However, for any single play there will always be that random possibility that even the most novice player can score a touchdown from the worst possible field position. On the other hand, since the random factor is only occasionally used, it is also possible for a novice defensive player to guess exactly what the quarterback is going to do next and block any gains in yardage. A series of good guesses could effectively beat even a skillful experienced player.

In addition, several variations of control modules 6 and other types of input devices are envisaged:

1) Two input devices: This is the system described above and is the simplest form for public use. (Private use machines designed for home rentals should have an optional single user capability. The current design requires two players who represent opposing teams.)

2) Four input devices: By introducing four input devices into a bar area one input device can be designated for each offensive and defensive line on each team. In this way, since input devices will probably be physically attached to the table to prevent theft, this will now involve four tables in the bar, actively involving more patrons, making it more attractive to use.

3) Multiple input devices: It could also be beneficial to provide a multiple input system so that every table in the bar can become involved with this system. The microprocessor would determine which play is called by using the most common input. This could work exceptionally well with the following option.

4) Modem TV network: Since the video images and audio tracks are stored on disk and not in computer memory, the computer is only concerned with control commands for reading control information from the laser disks and stopping and starting the various disk players on preselected tracks. CPU 4 will also be involved with decision making in which disk to select and what track to select and when to start playing. The majority of digital information (i.e. picture and sound) are stored discretely on laser disk. Therefore, if two machines are loaded with the same disk, a modem link of microprocessor control commands should be able to control both sets of laser disks to produce the same program at both locations. This would enable true networking between game systems in different locations.

Thus it is apparent that there has been provided in accordance with the invention a player interactive live action football game that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the invention.

What we claim as our invention:

1. A pre-recorded, live action and sound with electronically generated graphics overlay, full motion video, interactive athletic contest comprising players of opposite teams playing at various positions on a background field, the game comprising:

(a) a random access storage and retrieval means;

(b) said random access storage and retrieval means for storing a plurality of individual, pre-recorded video images representative of live action plays of the athletic contest illustrating interaction of players of the opposite teams;

(c) a microprocessor and microprocessor control means electronically associated with said random access storage and retrieval means for enabling one or more users to select in sequence through said control means different ones of said plays according to play type, the microprocessor then, by using statistical tables, to select the video image of the actual play according to play type selected by the user; and

(d) display means electronically associated with said microprocessor for enabling the selected plays to be viewed by the users;

(e) said microprocessor control means further programmed to evaluate and accumulate play results and to generate an image representative of a position on said background field, said position being determined in accordance With said play results, said microprocessor control means superimposing said position image on said live action image to form a composite image to be displayed upon said display means.

2. A game according to claim **1** wherein said pre-recorded images comprise live action plays which have been recorded on a field without grid lines and numbers, and wherein said microprocessor control means electronically generates said background field image as a grid of yard lines and numbers on the field on the display means corresponding to the play action and location of the teams on the field.

3. A game according to claim **2** further provided with a separate dedicated graphics engine means to generate the grid lines and numbers.

4. A game according to claim **2** further provided with audio storage and audio generation means including synthesis means, the audio generation means correlated with the individual pre-recorded live action plays and arranged so as to provide audio commentary corresponding to the plays displayed on the display means through speaker means electronically associated with the microprocessor and display means, said audio further selected to correspond to the yardage related to the play at any given time.

5. A game according to claim **2**, wherein said random access storage means is selected from the group comprising laser disc, CD-ROM, computer hard drive, optical storage means, and magnetic storage means, said game being further provided with audio storage and retrieval means, said audio retrieval means correlated with the individual pre-recorded live action plays and arranged so as to provide audio commentary corresponding to the plays displayed on the display means through Speaker means electronically associated with said microprocessor and display means; said display means being selected from the group comprising TV monitors and display screens.

6. A game according to claim **2**, wherein said random access storage and retrieval means store signals representative of the relative axial position and focal length of each camera used to record the video images of the live action plays.

7. A game according to claim **6** wherein said code from the motion sensors is stored electronically in a vertical interval of the audio portion of the video signal in sync with its corresponding video frame of the recording medium.

8. A game according to claim **6** wherein said code from the motion sensors is stored electronically in a vertical interval of a video signal of the video signal in sync with any usable area of the recording medium.

9. A game according to claim **6** wherein the microprocessor is programmed to decode the binary position code and electronically generate a grid of yard lines and numbers that corresponds to the position angle and focal length of the camera that recorded the play.

10. A game according to claim 9 wherein the electronically generated grid of lines and numbers is chromakeyed into the recorded video image so that it is placed correctly on the field in accordance with the accumulated play results of the game at any particular time of the game, the microprocessor being programmed to adjust the yardage numbers and lines to match the yardage and field position for the play being played.

11. A game according to claim 1, wherein said random access storage is selected from the group comprising laser disc, CD-ROM, computer hard drive, optical storage means or magnetic storage means.

12. A game according to claim 1 further provided with audio storage and retrieval means, the audio retrieval means correlated with the individual pre-recorded live action plays and arranged so as to provide audio commentary corresponding to the plays displayed on the display means through speaker means electronically associated with the microprocessor and display means.

13. A game according to claim 12 wherein a plurality of individual commercial messages are stored in said random access storage means and accessed according to the time which has elapsed during play, said commercial messages to be displayed on said display means at predetermined times, and audio signals to accompany said commercial messages when displayed on said display means.

14. A game according to claim 1, wherein said display means are selected from the group comprising T.V. monitors and display screens.

15. A game according to claim 1 wherein said microprocessor is programmed to provide outcome play results based on stored team statistics incorporating a teams strength, momentum and fatigue.

16. A game according to claim 1 provided with a means of generating grid lines using a color encoding means to identify and then remove unwanted grid lines and numbers by changing their colors to match the color the playing surface and highlight wanted grid lines and numbers by changing their colors to white.

17. A game according to claim 1 wherein the pre-recorded plays are displayed on a normal field that includes markings of yardage lines and numbers, said game then to be played with a limited number of field positions from which the ball can be scrimmaged, the results of each play used therein being compatible with these limited number of field positions.

18. In a video game for generating and displaying on a display device a contest of opposing teams to be played by at least one user, each team comprising at least one character, the contest to be carried out at variable positions on a playing field, apparatus for displaying a selected one of a plurality of first images representing predetermined contest plays, said apparatus comprising:

a) means for storing said plurality of first images of contest plays;

b) means manually actuated by the user for providing a signal indicative of a selected one of said plurality of first images of the contest plays to be displayed;

c) means responsive to said signal for accessing from said storing means the selected one first image of a contest play to be displayed;

d) means for determining the variable playing field position as a result of the contest of the selected one first image of a contest play; and

e) means for generating a second image representative of the determined playing field position; and

f) means for superimposing said selected one first image of a contest play and said second image.

19. A pre-recorded, live action and sound with electronically generated graphics overlay, full motion video, interactive game to be played on at least one viewing screen by at least one user, said game comprising:

(a) random access storage and retrieval means for storing a plurality of individual, pre-recorded action plays illustrating interaction of players of opposite teams, a plurality of individual commercial messages being stored in said random access storage means and accessed according to the time which has elapsed during play;

(b) a microprocessor and microprocessor control means electronically associated with said random access storage and retrieval means for enabling at least one user to select in sequence through said control means different ones of said plays according to play type, said microprocessor then, by using statistical tables, to select the video image of the actual play according to play type selected by the user, said microprocessor further programmed to evaluate and accumulate play results and report them to the users in a meaningful way; and

(c) display means electronically associated with said microprocessor for enabling the selected plays to be viewed by the users; said audio storage and retrieval means comprising audio retrieval means correlated with the individual pre-recorded live action plays and arranged so as to provide audio commentary corresponding to the plays displayed on said display means through speaker means electronically associated with said microprocessor and said display means, said commercial messages to be displayed on said display means at predetermined times, and audio signals to accompany said commercial messages when displayed on said display means.

* * * * *

55-215 GP. 2317

#12

MAIL ROOM APR 29 1997

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application of:

Inventor:	Kulas, Charles J.
Filed:	May 31, 1994
Serial No.:	08/252,460
Art Unit:	2317
Examiner:	Huang, Po
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

270 TE 05/13/97 08252460 1 215 55.00 CK

Assistant Commissioner for Patents
Washington, DC 20231

REQUEST FOR EXTENSION OF TIME

Applicant hereby petitions for an automatic extension of time in the first month to respond to the office action dated 1-21-97.

Check number 1453 in the amount of $55.00 is included, made payable to the Commissioner of Patents and Trademarks.

Respectfully Submitted,

Charles J. Kulas

Charles J. Kulas
Registration No. 35,809

Dated April 22, 1997

NOTE NEW ADDRESS:
Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on: 4-23-97
by CHARLES J. KULAS Signature Charles J. Kulas

MAIL ROOM
APR 29 1997

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GROUP 2600

PATENT

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Assistant Commissioner for Patents
Washington, DC 20231

Transmittal Form

Enclosed is an amendment for filing in connection with the above-referenced matter. The signature and Certificate of Mailing below serve for all papers enclosed in the absence of any signatures or Certificates thereon.

Please find enclosed:

- A Certificate of Mailing
- A receipt post card
- Amendment
- Request for Extension of Time
- Check number 1453 in the amount of $55.00

Please date and stamp the enclosed receipt post card.

Respectfully Submitted,

Charles J. Kulas
Registration No. 35,809

Dated April 22, 1997

NOTE NEW ADDRESS:
Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on:
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by CHARLES J. KULAS Signature

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PATENT

#13
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5-16-97

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application of:

Inventor:	Kulas, Charles J.
Filed:	May 31, 1994
Serial No.:	08/252,460
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Examiner:	Huang, Po
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

okay to enter P. H. 5/23/97

Assistant Commissioner for Patents
Washington, DC 20231

AMENDMENT

Responsive to the Office Action dated January 21, 1997, please amend the subject application as follows:

IN THE CLAIMS:

Please amend claims 1, 5 and 11 as follows:

Claim 1, at line 8, insert --portions of-- before "the frames" (both instances).

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ins. D3

7 ~~5~~. (Thrice Amended) An apparatus for playing back an interactive production stored on a ~~CD-ROM,~~ medium, wherein the ~~CD-ROM~~ medium includes frames corresponding to a first animation sequence showing a first action interleaved with frames corresponding to a second animation sequence showing a second action to produce a series of frames wherein adjacent frames in the series correspond to different animation sequences, the apparatus comprising:

a computer system including a processor, user input device and display screen;

ins. D4 C1

a ~~CD-ROM drive~~ coupled to the computer system for retrieving frames from the series of frames on the ~~CD-ROM~~ medium;

means responsive to signals from the user input device to output a select signal indicating the selection of the second sequence; [and]

<u>selection means for selectively storing the interleaved frames while the interleaved frames are contiguously read from the ~~CD-ROM~~ medium; and</u>

displaying means coupled to the selection means for displaying on the display screen frames corresponding to the first animation sequence, and, upon generation of the select signal, for displaying on the display screen frames corresponding to the second animation sequence in place of displaying one or more frames corresponding to the first animation sequence.

Ins: D5

9 ~~11.~~ (Twice Amended) An apparatus for playing back an interactive production stored on a ~~CD-ROM~~, wherein the medium ~~CD-ROM~~ includes frames corresponding to a first animation sequence shwoing a first action interleaved with frames corresponding to a second animation sequence to produce a series of frames, wherein adjacent frames in the series correspond to different animation sequences, the medium ~~CD-ROM~~ further including tags associated with one or more frames on the medium ~~CD-ROM~~, wherein the tags indicate which sequence the one or more frames associated with a given tag belongs to, the apparatus comprising:

12

Ins: D4

a computer system including a processor, user input device and a display screen;

~~a CD-ROM drive~~ coupled to the computer system for retrieving frames from the series of frames on the medium ~~CD-ROM~~;

means for reading the tags from the medium ~~CD-ROM~~;

means responsive to signals from the user input device to select an animation sequence; and

means for using the tags to buffer and display frames from the selected animation sequence while skipping frames from the other non-selected animation sequence so that the skipped frames are not buffered.

REMARKS

This Amendment is responsive to the Office Action mailed 1/21/97 in which claims 1-3, 5, 6, 8 and 9 were rejected under 35 U.S.C. Section 103 over the Rodesch reference. Claims 4, 10 and 11 stand rejected under the same Title and Section in view of Rodesch and Cooper.

Formal Matters:

Applicant has corrected a Section 112 problem in claim 5 where "selection means" lacked antecedent basis.

The Cooper Reference:

The present Office Action is in contradiction to prior statements in the prosecution file wrapper. The present Office Action states "Cooper teaches storing the first sequence and second sequence in two different buffer [sic]. Since they are stored in different buffer and since frames from one buffer is display [sic], it is obvious that the other frames not being display [sic] is skipped." The limitation of "skipping" was explicitly discussed at the in-person interview with the Examiner on 8/13/96. The Interview Summary Record, as penned by the Examiner, shows that, at that interview, it "[w]as agree [sic] that Cooper does not teach dropping unnecessary frames in the buffer."

Applicant's subsequent Amendment mailed 11-7-96 states that claims 4 and 11 were amended to "include the limitation of 'skipping' frames of an animation sequence on CDROM so that the frames 'are not stored in the buffer.'" Applicant has noted that this limitation was not included in claim 11 and has added it to claim 11 in the present Office Action.

The argument that Cooper teaches dropping or skipping frames should be estopped by the file wrapper.

Regardless of the argument, Cooper does not teach dropping or skipping of frames, anyway. Cooper reads all of the video frames into buffers during playback. Thus no frames are "skipped." See Cooper at col. 8. Even in interleaved mode, each frame is read into either the A or B buffer. Claims 4, 10 and 11 each recite that frames are not "buffered" or "not stored in the buffer."

Thus, Claims 4, 10 and 11 should have received a Notice of Allowability and should receive an expedited Notice of Allowability at this time.

The Rodesch Reference:

Applicant has amended claims 1 and 5 to more clearly distinguish over Rodesch. Applicant's invention is significantly different from Rodesch although the prior language used in claims 1 and 5 may have failed to make this clear.

Claims 1 and 5 now use the term "contiguously" instead of the previously used term, "continuously." This is to distinguish spatial continuity invention from a temporal continuity disclosure. The present invention allows the read head to remain over a single track while data is being read so that all of the data on the track is read in sequence. This is spatial continuity, or contiguous reading of the data, which is achieved by dropping unnecessary data. In contrast, Rodesch's read head is constantly moved from one portion of a track to another every one-half turn of the video disc, or every $1/60^{th}$ sec. Rodesch's approach allows a continuous stream of data to be output and displayed. This is temporal continuity as it provides a continuous data stream although the read head must be constantly moved to different spaces on the video disc.

The approaches of the present invention and Rodesch could not be more different. Rodesch moves the read head (once every field, or twice each frame!) to achieve an interactive production. The present invention sacrifices data bandwidth so that the read head is never moved from it's track in normal playback. In Rodesch's field of video disc players, it is not possible to skip data since the spin of the video disk is matched to the display rate of the standard NTSC television signal. If data is skipped in Rodesch then the signal will lose synchronization or some other glaring video defect will appear.

Rodesch's thinking is the same thinking that was prevalent in the industry at the time the present invention was conceived. That is, maximize the rate of data coming from the video data source by reading, transferring and buffering every bit of data that passes under the read head. Because of this thinking, it was not obvious to sacrifice the data rate to improve interactivity by skipping data and yet maintaining spatially continuous tracking. In short, Rodesch teaches away from the present invention since it is so fundamentally different. Rodesch, neither alone nor in conjunction with other art, does not render the present invention as recited in claims 1 and 5 obvious.

The limitation of "contiguously" reading the interleaved frames clearly distinguishes claims 1 and 5 from Rodesch. Although this term is not used in the specification, "contiguous" is defined in Webster's Collegiate Dictionary, Random House, Inc., 1991, as "touching; in contact." Thus, the limitation is that the interleaved frame data is read from present data to the next "touching," or adjacent, data.

In view of this communication, all claims are now believed to be in condition for allowance and such is respectfully requested at an early date. The Examiner is invited to contact the undersigned attorney at 408-955-5485.

Respectfully Submitted,

Charles J. Kulas
Registration No. 35,809

Dated April 22, 1997

NOTE NEW ADDRESS:
Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commisioner for Patents, Washington, D.C. 20231 on: 4-23-97
by CHARLES J. KULAS Signature

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT		ATTORNEY DOCKETT NO.
08/252,460	05/31/94	KULAS	C	CJK1

B3M1/0529

CHARLES J. KULAS
244 TEXAS STREET
SAN FRANCISCO CA 94107

EXAMINER	
HUANG, P	
ART UNIT	**PAPER NUMBER**
2317	14

DATE MAILED: 05/29/97

EXAMINER INTERVIEW SUMMARY RECORD

All participants (applicant, applicant's representative, PTO personnel):

(1) Po Huang (3) ____________

(2) Charles Kulas (4) ____________

Date of Interview 5/22/97

Type: ☒ Telephonic ☐ Personal (copy is given to ☐ applicant ☐ applicant's representative).

Exhibit shown or demonstration conducted: ☐ Yes ☒ No. If yes, brief description: ____________

Agreement ☒ was reached with respect to some or all of the claims in question. ☐ was not reached.

Claims discussed: 1 & 2

Identification of prior art discussed: Prior art of record

Description of the general nature of what was agreed to if an agreement was reached, or any other comments: Examiner asked applicant to combine claims 1 & 2 to make it allowable over prior art of record. Applicant has agree to combine claims 1 & 2 by examiner's amendment

(A fuller description, if necessary, and a copy of the amendments, if available, which the examiner agreed would render the claims allowable must be attached. Also, where no copy of the amendments which would render the claims allowable is available, a summary thereof must be attached.)

☒ 1. It is not necessary for applicant to provide a separate record of the substance of the interview.

Unless the paragraph below has been checked to indicate to the contrary, A FORMAL WRITTEN RESPONSE TO THE LAST OFFICE ACTION IS NOT WAIVED AND MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW (e.g., items 1-7 on the reverse side of this form). If a response to the last Office action has already been filed, then applicant is given one month from this interview date to provide a statement of the substance of the interview.

☐ 2. Since the examiner's interview summary above (including any attachments) reflects a complete response to each of the objections, rejections and requirements that may be present in the last Office action, and since the claims are now allowable, this completed form is considered to fulfill the

Applicant Copy

1. An Examiner's Amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 C.F.R. § 1.312. To ensure consideration of such an amendment, it **MUST** be submitted no later than the payment of the Issue Fee.

Authorization for this Examiner's Amendment was given in a telephone interview with Mr. Charles Kulas on May 22, 1997.

2. Cancel claim 2.

3. Delete claim 1 and substitute therefor:

-- (Thrice Amended) Claim 1: A method for creating an interactive production on a medium having a spiral data track, comprising the following steps:

creating a first animation sequence of digital frames showing a first action;

creating a second animation sequence of digital frames for selectively display in place of the first animation sequence, wherein the second animation sequence is a selectable path in the interactive production and shows a second action;

writing the first and second animation sequences of frames to the medium by interleaving the frames of the first animation sequence with the frames of the second animation sequence to create the interactive production; and

wherein a computer system is used to play back the interactive production, wherein the computer system comprises a processor, user input device, display screen, and a drive for reading the medium, the method further comprising the following steps performed under the control of the processor:

continuously reading the interleaved frames from the medium;

displaying only the frames of the first animation sequence on the display screen to play back the first animation;

accepting signals from the user input device selecting the second animation sequence; and

in response to the signals from the user input device, displaying only the frames of the second animation sequence on the display screen to play back the second animation. --

4. Claim 3,

i. Line 1, change "claim 2" to -- claim 1 --.

ii. Line 7, change "CD-ROM" to -- medium --.

5. Claim 4,

i. Line 2, change first occurrence of "CD-ROM" to -- medium having a spiral data track --.

ii. Line 2, change second occurrence of "CD-ROM" to -- medium --.

iii. Line 3, change "CD-ROM" to -- medium --.

iv. Line 6, change "CD-ROM drive" to -- drive for reading the medium --.

v. Line 10, change "CD-ROM" to -- medium --.

vi. Line 20, change "CD-ROM" to -- medium --.

6. Claim 5,

i. Line 2, change first occurrence of "CD-ROM" to -- medium having a spiral data track --.

ii. Line 2, change second occurrence of "CD-ROM" to -- medium --.

iii. Line 8, change "CD-ROM drive" to -- drive for reading the medium --.

iv. Line 9, change "CD-ROM" to -- medium --.

v. Line 13, change "CD-ROM" to -- medium --.

7. Claim 8, line 1, change "claim 2" to -- claim 1 --.

8. Claim 11,

i. Line 2, change first occurrence of "CD-ROM" to -- medium having a spiral data track --.

ii. Line 2, change second occurrence of "CD-ROM" to -- medium --.

iii. Line 5, change "CD-ROM" to -- medium --.

iv. Line 6, change "CD-ROM" to -- medium --.

v. Line 10, change "CD-ROM drive" to -- drive for reading the medium --.

vi. Line 11, change "CD-ROM" to -- medium --.

vii. Line 12, change "CD-ROM" to -- medium --.

9. Pursuant to MPEP 606.01, the title has been changed to read:

-- **SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION** --

10. Any comments considered necessary by applicant must be submitted no later than the payment of the Issue Fee and, to

avoid processing delays, should preferably **accompany** the Issue Fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Po Huang, whose telephone number is (703) 308-5230. The examiner can normally be reached Monday through Friday from 7:30 AM to 5:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas C. Lee, can be reached at (703) 305-9717. The fax phone number for this Group is (703) 308-5359.

Any inquiry of a general nature of relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-9600.

Thomas Lee

Po Huang

May 22, 1997

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/252,460	05/31/94	KULAS C	CJK1

B3M1/0529

CHARLES J. KULAS
244 TEXAS STREET
SAN FRANCISCO CA 94107

EXAMINER	
HUANG, P	
ART UNIT	PAPER NUMBER
2317	10

~~05/29/97~~ 5/15

DATE MAILED:

NOTICE OF ALLOWABILITY

PART I.

1. ☒ This communication is responsive to Amdt C filed 4/29/97.
2. ☒ All the claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice Of Allowance And Issue Fee Due or other appropriate communication will be sent in due course.
3. ☒ The allowed claims are 1, 3-6, 8-11.
4. ☐ The drawings filed on ______ are acceptable.
5. ☐ Acknowledgment is made of the claim for priority under 35 U.S.C. 119. The certified copy has [_] been received. [_] not been received. [_] been filed in parent application Serial No. ______, filed on ______.
6. ☒ Note the attached Examiner's Amendment.
7. ☒ Note the attached Examiner Interview Summary Record, PTOL-413.
8. ☐ Note the attached Examiner's Statement of Reasons for Allowance.
9. ☐ Note the attached NOTICE OF REFERENCES CITED, PTO-892.
10. ☐ Note the attached INFORMATION DISCLOSURE CITATION, PTO-1449.

PART II.

A SHORTENED STATUTORY PERIOD FOR RESPONSE to comply with the requirements noted below is set to EXPIRE THREE MONTHS FROM THE "DATE MAILED" indicated on this form. Failure to timely comply will result in the ABANDONMENT of this application. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

1. ☐ Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL APPLICATION, PTO-152, which discloses that the oath or declaration is deficient. A SUBSTITUTE OATH OR DECLARATION IS REQUIRED.
2. ☒ APPLICANT MUST MAKE THE DRAWING CHANGES INDICATED BELOW IN THE MANNER SET FORTH ON THE REVERSE SIDE OF THIS PAPER.
   a. ☒ Drawing informalities are indicated on the NOTICE RE PATENT DRAWINGS, PTO-948, attached hereto or to Paper No. 2. CORRECTION IS REQUIRED.
   b. ☐ The proposed drawing correction filed on ______ has been approved by the examiner. CORRECTION IS REQUIRED.
   c. ☐ Approved drawing corrections are described by the examiner in the attached EXAMINER'S AMENDMENT. CORRECTION IS REQUIRED.
   d. ☒ Formal drawings are now REQUIRED.

Any response to this letter should include in the upper right hand corner, the following information from the NOTICE OF ALLOWANCE AND ISSUE FEE DUE: ISSUE BATCH NUMBER, DATE OF THE NOTICE OF ALLOWANCE, AND SERIAL NUMBER.

Attachments:

- X Examiner's Amendment
- X Examiner Interview Summary Record, PTOL-413
- _ Reasons for Allowance
- _ Notice of References Cited, PTO-892
- _ Information Disclosure Citation, PTO-1449
- _ Notice of Informal Application, PTO-152
- _ Notice re Patent Drawings, PTO-948
- _ Listing of Bonded Draftsmen
- _ Other

...EXAMINER
230

Thomas Lee

File Copy

1. An Examiner's Amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 C.F.R. § 1.312. To ensure consideration of such an amendment, it **MUST** be submitted no later than the payment of the Issue Fee.

Authorization for this Examiner's Amendment was given in a telephone interview with Mr. Charles Kulas on May 22, 1997.

2. Cancel claim 2.

3. Delete claim 1 and substitute therefor:

-- (Thrice Amended) Claim 1: A method for creating an interactive production on a medium having a spiral data track, comprising the following steps:

creating a first animation sequence of digital frames showing a first action;

creating a second animation sequence of digital frames for selectively display in place of the first animation sequence, wherein the second animation sequence is a selectable path in the interactive production and shows a second action;

writing the first and second animation sequences of frames to the medium by interleaving the frames of the first animation

D

sequence with the frames of the second animation sequence to create the interactive production; and

wherein a computer system is used to play back the interactive production, wherein the computer system comprises a processor, user input device, display screen, and a drive for reading the medium, the method further comprising the following steps performed under the control of the processor:

D

continuously reading the interleaved frames from the medium;

displaying only the frames of the first animation sequence on the display screen to play back the first animation;

accepting signals from the user input device selecting the second animation sequence; and

in response to the signals from the user input device, displaying only the frames of the second animation sequence on the display screen to play back the second animation. --

4. Claim 3,

i. Line 1, change "claim 2" to -- claim 1 --.

ii. Line 7, change "CD-ROM" to -- medium --.

UT

5. Claim 4,

i. Line 2, change first occurrence of "CD-ROM" to --

D2 medium having a spiral data track AM

ii. Line 2, change second occurrence of "CD-ROM" to -- medium --.

iii. Line 3, change "CD-ROM" to -- medium --.

iv. Line 6, change "CD-ROM drive" to -- drive for reading the medium --.

v. Line 10, change "CD-ROM" to -- medium --.

vi. Line 20, change "CD-ROM" to -- medium --.

6. Claim 5,

i. Line 2, change first occurrence of "CD-ROM" to --

D3 medium having a spiral data track AM

ii. Line 2, change second occurrence of "CD-ROM" to -- medium --.

iii. Line 8, change "CD-ROM drive" to -- drive for

D4 reading the medium AM

iv. Line 9, change "CD-ROM" to -- medium --.

v. Line 13, change "CD-ROM" to -- medium --.

7. Claim 8, line 1, change "claim 2" to -- claim 1 --.

8. Claim 11,

i. Line 2, change first occurrence of "CD-ROM" to --

D5 medium having a spiral data track --.

ii. Line 2, change second occurrence of "CD-ROM" to --

medium --.

iii. Line 5, change "CD-ROM" to -- medium --.

iv. Line 6, change "CD-ROM" to -- medium --.

v. Line 10, change "CD-ROM drive" to -- drive for

D6 reading the medium

vi. Line 11, change "CD-ROM" to -- medium --.

vii. Line 12, change "CD-ROM" to -- medium --.

9. Pursuant to MPEP 606.01, the title has been changed to read:

-- **SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION** --

10. Any comments considered necessary by applicant must be submitted no later than the payment of the Issue Fee and, to

avoid processing delays, should preferably **accompany** the Issue Fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Po Huang, whose telephone number is (703) 308-5230. The examiner can normally be reached Monday through Friday from 7:30 AM to 5:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas C. Lee, can be reached at (703) 305-9717. The fax phone number for this Group is (703) 308-5359.

Any inquiry of a general nature of relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-9600.

Thomas Lee

Po Huang

May 22, 1997

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address: Box ISSUE FEE
ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

NOTICE OF ALLOWANCE AND ISSUE FEE DUE

B3M1/0529

CHARLES J. KULAS
244 TEXAS STREET
SAN FRANCISCO CA 94107

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/252,460	05/31/94	009	HUANG, P	2317	05/29/97

First Named Applicant: KULAS, CHARLES J.

TITLE OF INVENTION: SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION (AS AMENDED)

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
2 CJK1	395-484.000	N55	UTILITY	YES	$645.00	08/29/97

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED.

THE ISSUE FEE MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED.

HOW TO RESPOND TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.
If the SMALL ENTITY is shown as yes, verify your current SMALL ENTITY status:

A. If the status is changed, pay twice the amount of the FEE DUE shown and notify the Patent and Trademark Office of the change in status, or
B. If the status is the same, pay the FEE DUE shown above.

If the SMALL ENTITY is shown as NO:

A. Pay FEE DUE shown above, or

B. File verified statementof Small Entity Status before, or with, payment of 1/2 the FEE DUE shown above.

II. Part B of this notice should be completed and returned to the Patent and Trademark Office (PTO) with your ISSUE FEE. Even if the ISSUE FEE has already been paid by charge to deposit account, Part B should be completed and returned. If you are charging the ISSUE FEE to your deposit account, section "6b" of Part B should be completed.

III. All communications regarding this application must give application number and batch number. Please direct all communication prior to issuance to Box ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

3. PATENT AND TRADEMARK OFFICE COPY

216-140

#16

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application of:

RECEIVED Publishing Division JUN 18 1997 04

Inventor:	Kulas, Charles J.
Filed:	May 31, 1994
Serial No.:	08/252,460
Art Unit:	2317
Examiner:	Huang, Po
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

Assistant Commissioner for Patents
Washington, DC 20231

REQUEST FOR EXTENSION OF TIME

Applicant hereby petitions for an automatic extension of time in the second month to properly file the Examiner's Amendment submitted with the Examiner Interview Summary Record mailed 5/29/97. A copy of both the Amendment and the Interview Summary are provided with this correspondence.

Note that Applicant has previously paid for an extension of time in the first month relating to correspondence after the final rejection dated 1/21/97. Thus, payment of the difference between the second and first month extensions (\$195-\$55 = \$140) is sufficient to extend the time to respond to 6/21/97.

Accordingly, check number 1484 in the amount of \$140 is included, made payable to the Commissioner of Patents and Trademarks.

Respectfully Submitted,

Charles J. Kulas
Registration No. 35,809

08/06/1997 RJOHNSON 00000029 08252460
01 FC:216 140.00 OP

Dated June 18, 1997

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commisioner for Patents, Box Issue Fee Washington, D.C. 20231 on: 6-18-97
by CHARLES J. KULAS Signature

RECEIVED ALLOWED FILES/CORRES PUBLISHING DIVISION

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application of:

Inventor:	Kulas, Charles J.
Filed:	May 31, 1994
Allowance:	May 29, 1997
Batch No.	N55
Serial No.:	08/252,460
Art Unit:	2317
Examiner:	Huang, Po
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

RECEIVED
Publishing Division
JUN 23 1997
05

Assistant Commissioner for Patents
Washington, DC 20231

Transmittal Form

Enclosed are papers for filing in connection with the above-referenced matter. The signature and Certificate of Mailing below serve for all papers enclosed in the absence of any signatures or Certificates thereon.

Please find enclosed:

- Issue Fee Transmittal
- Examiner's Interview Summary Record and Examiner's Amendment
- Comments on Statement of Reasons for Allowance
- A return receipt post card
- Request for Extension of Time (2d month)
- Check number 1484 in the amount of $140
- Check number 1485 in the amount of $645

Please date and stamp the enclosed return receipt post card.

Respectfully Submitted,

Charles J. Kulas
Charles J. Kulas
Registration No. 35,809

Dated June 18, 1997

Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Box Issue Fee, Washington, D.C. 20231 on:
6-18-97
by CHARLES J. KULAS Signature Charles J. Kulas

PATENT #17

RECEIVED

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

JUN 23 1997

05

In Re Patent Application of:

Inventor:	Kulas, Charles J.
Filed:	May 31, 1994
Allowance:	May 29, 1997
Batch No.:	N55
Serial No.:	08/252,460
Art Unit:	2317
Examiner:	Huang, Po
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

Assistant Commissioner for Patents
Washington, DC 20231

Comments on Statement of Reasons for Allowance

Responsive to the Examiner Intervew Summary Record mailed 5/29/97, Applicant adds the following comments:

The newly substituted phrase "medium having a spiral data track" includes, for example, CDROMs, Digital Video Disks (DVDs), laser disks and other media that include a spiral data track.

Respectfully Submitted,

Charles J. Kulas
Registration No. 35,809

Dated June 18, 1997

Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commisioner for Patents, Box Issue Fee Washington, D.C. 20231 on: 6-18-97
by CHARLES J. KULAS Signature

242-6215

PART B—ISSUE FEE TRANSMITTAL

MAILING INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE. Blocks 2 through 6 sholud be completed where appropriate. All futher correspondenc including the issue Fee Receipt, the Patent, advance orders and notification of maintenance fees will be mailed to addresses entered in Block 1 unless you direct otherwis by: (a) specifyinga new correspondence address in Block 3 below; or (b) providing the PTO with a separate "FEE ADDRESS" for maintenance fee notifications with the payme of issue Fee or thereafter. **See reverse for Certificate of Mailing, below.**

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending on the needs of the individual case. Any comments on the amount of time required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, D.C. 20231.
DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Issue Fee, Assistant Commissioner for Patents, Washington D.C. 20231

1. CORRESPONDENCE ADDRESS B3M1/0529

CHARLES J. KULAS
244 TEXAS STREET
SAN FRANCISCO CA 94107

2. INVENTOR(S) ADDRESS CHANGE (Complete only if there is a change)

INVENTOR'S NAME

Street Address

City, State and Zip Code

RECEIVED
Publishing Division

CO-INVENTOR'S NAME

JUN 23 1997

Street Address

City, State and Zip Code 05

☐ Check if additional changes are enclosed

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/252,460	05/31/94	009	HUANG, P	2317	05/29/97

First Named Applicant: KULAS, CHARLES J.

TITLE OF INVENTION: SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION (AS AMENDED)

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
2 CJK1	395-484.000	N55	UTILITY	YES	$645.00	08/29/97

3. Correspondence address change (Complete only if there is a change)

4. For printing on the patent front page, list the names of not more than 3 registered patent attorneys or agents OR, alternatively, the name of a firm having as a member a registered attorney or agent. If no name is listed, no name will be printed.

1 ____
2 ____
3 ____

5. ASSIGNMENT DATA TO BE PRINTED ON THE PATENT (print or type)

(1) NAME OF ASSIGNEE:

(2) ADDRESS: (CITY & STATE OR COUNTRY)

☒ This application is NOT assigned.
☐ Assignment previously submitted to the Patent and Trademark Office.
☐ Assignment is being submitted under separate cover. Assignment should be directed to Box ASSIGNMENTS.

PLEASE NOTE: Unless an assignee is identified in Block 5, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been perviously submitted to the PTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

6a. The following fees are enclosed:
☒ Issue Fee ☐ Advance Order - # of Copies ____

6b. The following fees should be charged to:
DEPOSIT ACCOUNT NUMBER ____
(ENCLOSE A COPY OF THIS FORM)
☐ Issue Fee ☐ Advance Order - # of Copies ____
☐ Any Deficiencies in Enclosed Fees

The COMMISSIONER OF PATENTS AND TRADEMARKS is requested to apply the Issue Fee to the application identified above.

(Authorized Signature) Charles J. Kulas (Date) 6-18-97

NOTE: The Issue Fee will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the Patent and Trademark Office.

08/06/1997 RJOHNSON 00000027 08252460
01 FC:242 645.00

Certificate of Mailing

Note: If this certificate of mailing is used, it can be used to transmit the Issue Fee. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing.

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficent postage as first class mail in an envelope addressed to: **Box ISSUE FEE**
Assistant Commissioner for Patents
Washington, D.C. 20231

on: 6-18-97 **(Date)**

CHARLES J. KULAS **(Name of person making deposit)**

(Signature)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/252,460	05/31/94	KULAS	CJK1

24M1/1103

CHARLES J. KULAS
244 TEXAS STREET
SAN FRANCISCO CA 94107

EXAMINER	
HUANG,P	

ART UNIT	PAPER NUMBER
2317	18

DATE MAILED: 11/03/97

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

The Letter Attachment filed on 6/23/97 for Comments on Statement of Reasons for Allowance has been received and is deemed appropriate.

THOMAS C. LEE
UPERVISORY PATENT EXAMINER
230

B#

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

19

In Re Patent Application of:
Inventor(s): Charles J. Kulas
Filed: May 31, 1994
Art Unit: 2317
Examiner: Huang Po
Docket Number: CJK-1
Title: SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS

Allowed: May 29, 1997
Batch No. N55
Serial No.: 08/252,460

Assistant Commissioner for Patents
Washington, DC 20231

Attn: Official Draftsman

TRANSMITTAL OF FORMAL DRAWINGS

Sir:

Enclosed herewith please find 17 sheets of formal drawings to be substituted for the informal drawings originally submitted in this application. Approval of these drawings is respectfully requested. No fee is believed required for this communication. A duplicate of this transmittal sheet is enclosed. Note that Fig. 13C has been placed on a separate sheet from Figs. 13A and 13C.

Respectfully submitted,

Charles J. Kulas
Registration No. 35, 809
Dated: September 29, 1997

CERTIFICATE OF MAILING
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on: 9-29-97 → ATTN: OFFICIAL DRAFTSMAN
CK

CHARLES J. KULAS
Reg. No. 35,809
(Applicant, Assignee or Reg. Representative)

(Signature)

DRAWINGS.FOR 1/5/94

OIPE
OCT 0 3 1997
JC3
PATENT & TRADEMARK OFFICE

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application of:

Inventor:	Kulas, Charles J.	
Filed:	May 31, 1994	Allowed: May 29, 1997
Serial No.:	08/252,460	Batch No.: N55
Art Unit:	2317	
Examiner:	Huang, Po	
Title:	SYSTEM FOR ELIMINATING ACCESS TIME IN CD-ROM BASED INTERACTIVE PRODUCTIONS	

Assistant Commissioner for Patents
Washington, DC 20231

REQUEST FOR EXTENSION OF TIME

Applicant hereby petitions for an automatic extension of time in the first month to respond to the office action dated 5-29-97.
Check number 1524 in the amount of 55.00 is included, made payable to the Commissioner of Patents and Trademarks.

Respectfully Submitted,

Charles J. Kulas
Registration No. 35,809

Dated September 29, 1997

Please send correspondence to:
Charles Kulas
244 Texas St.
San Francisco, CA 94107

Certificate of Mailing
I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commisioner for Patents, ATTN: OFFICIAL DRAFTSMAN Washington, D.C. 20231 on: 9-29-97
by CHARLES J. KULAS Signature
CK

/1997 BALEXAND 00000034 08252460
:215 55.00

APPROVED BY DRAFTSMAN | O.G. FIG. 5 | CLASS 395 | SUBCLASS 484

5734862

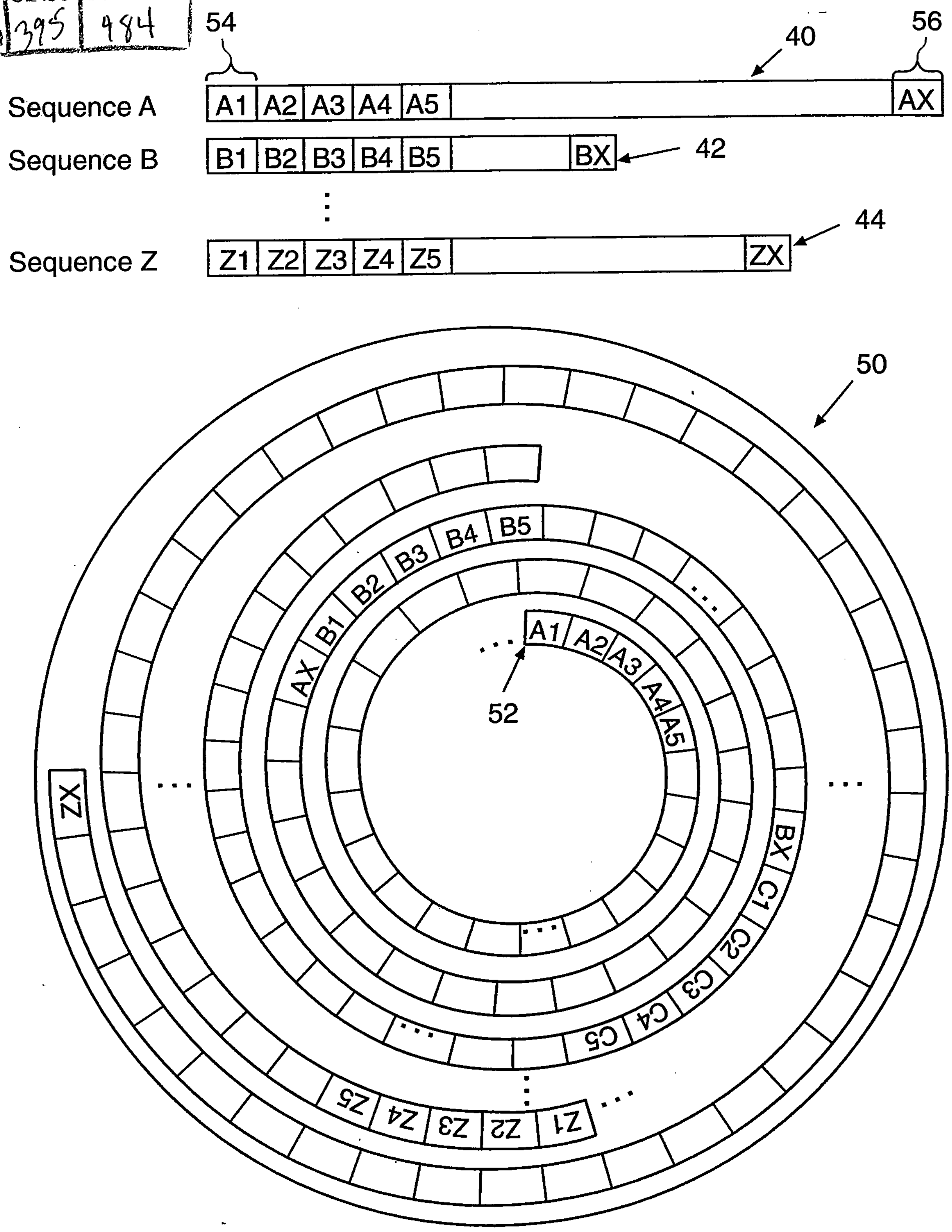


FIG. 1
(PRIOR ART)

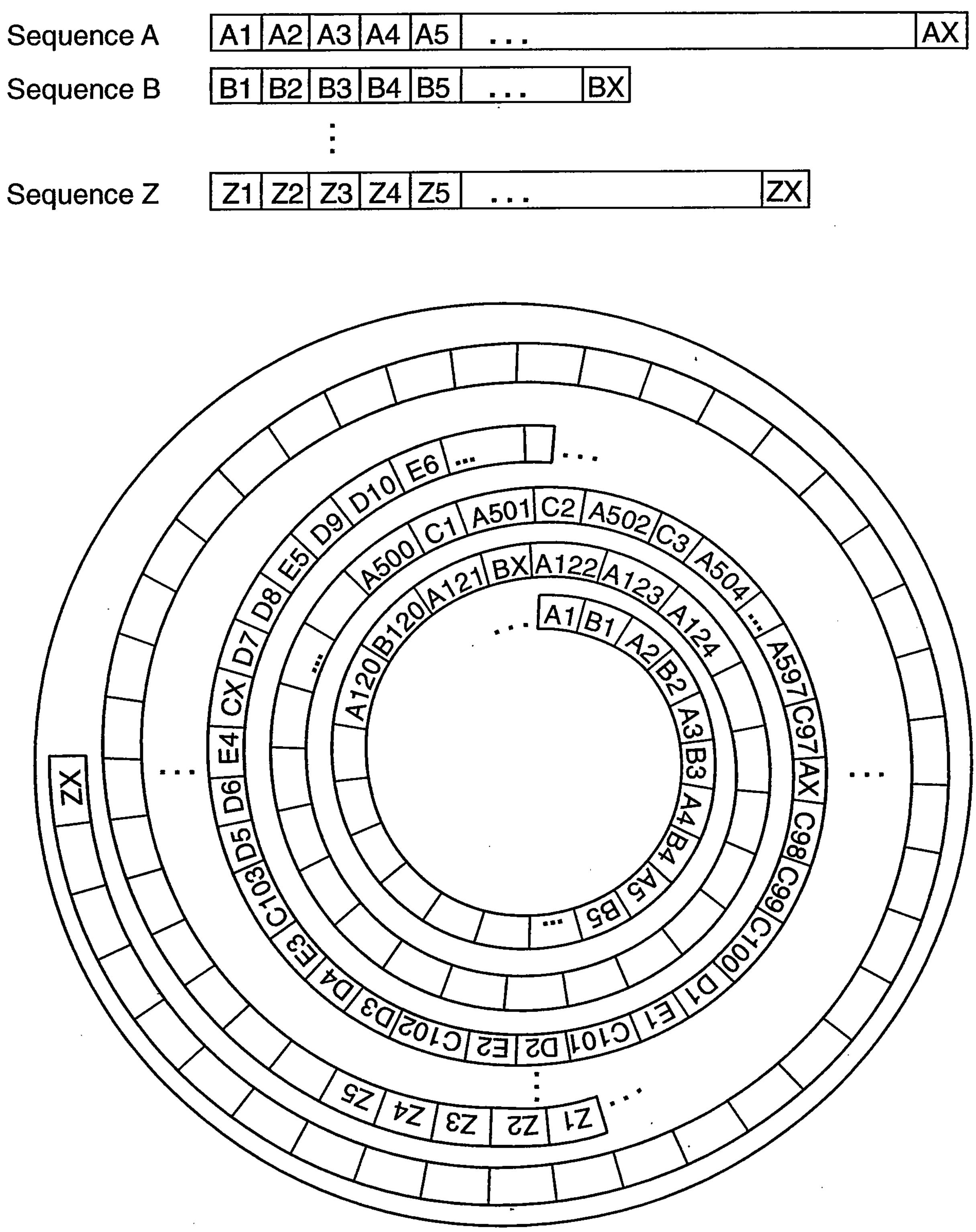

Sequence A
A1 A2 A3 A4 A5 ... AX
Sequence B
B1 B2 B3 B4 B5 ... BX
Sequence Z
Z1 Z2 Z3 Z4 Z5 ... ZX
A1 B1 A2 B2 A3 B3 A4 B4 A5 B5
A120 B120 A121 BX A122 A123 A124
A500 C1 A501 C2 A502 C3 A504 A597 C97 AX C98 C99 C100 D1 E1 C101 D2 E2 C102 D3 D4 E3 C103 D5 D6 E4 CX D7 D8 E5 D9 D10 E6
ZX
Z1 Z2 Z3 Z4 Z5

FIG. 2

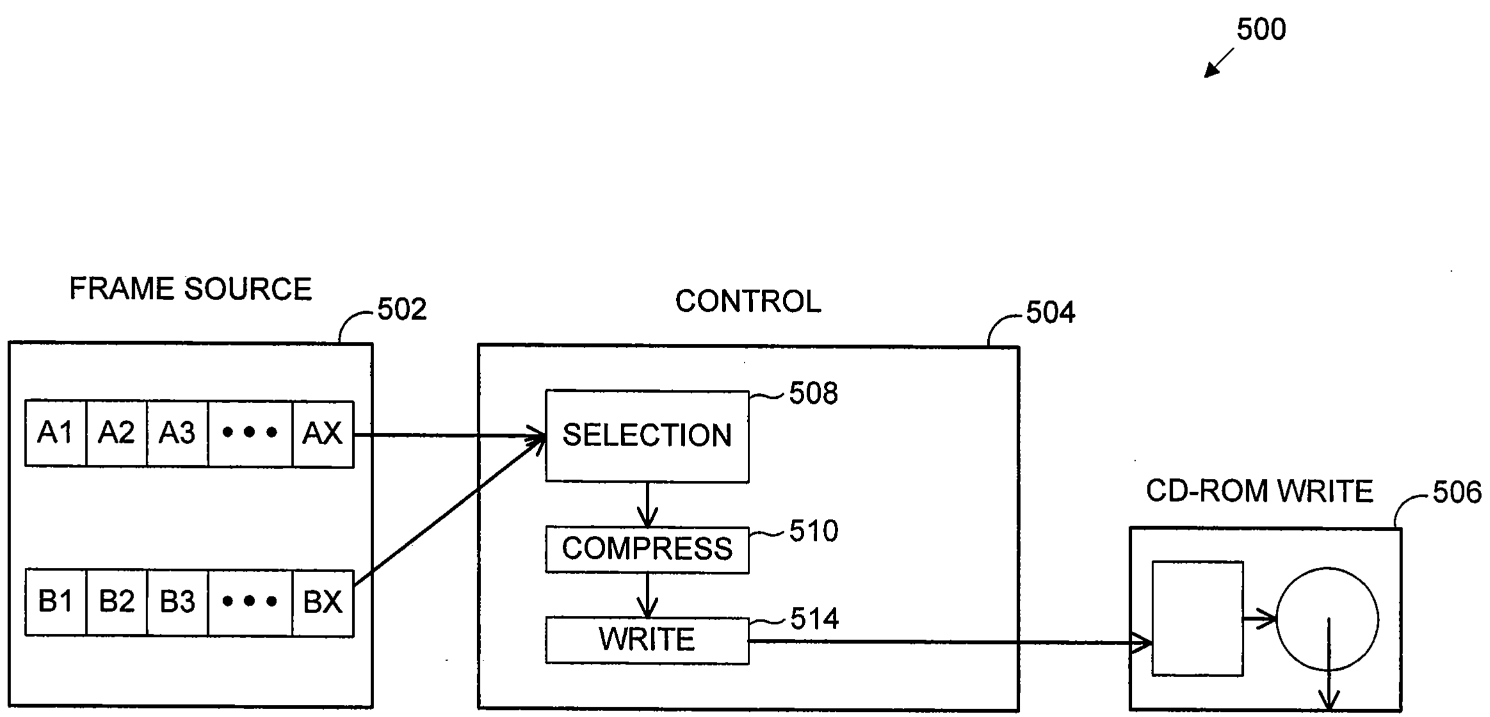

500
FRAME SOURCE
502
A1
A2
A3
AX
B1
B2
B3
BX
CONTROL
504
SELECTION
508
COMPRESS
510
WRITE
514
CD-ROM WRITE
506

Fig. 2A

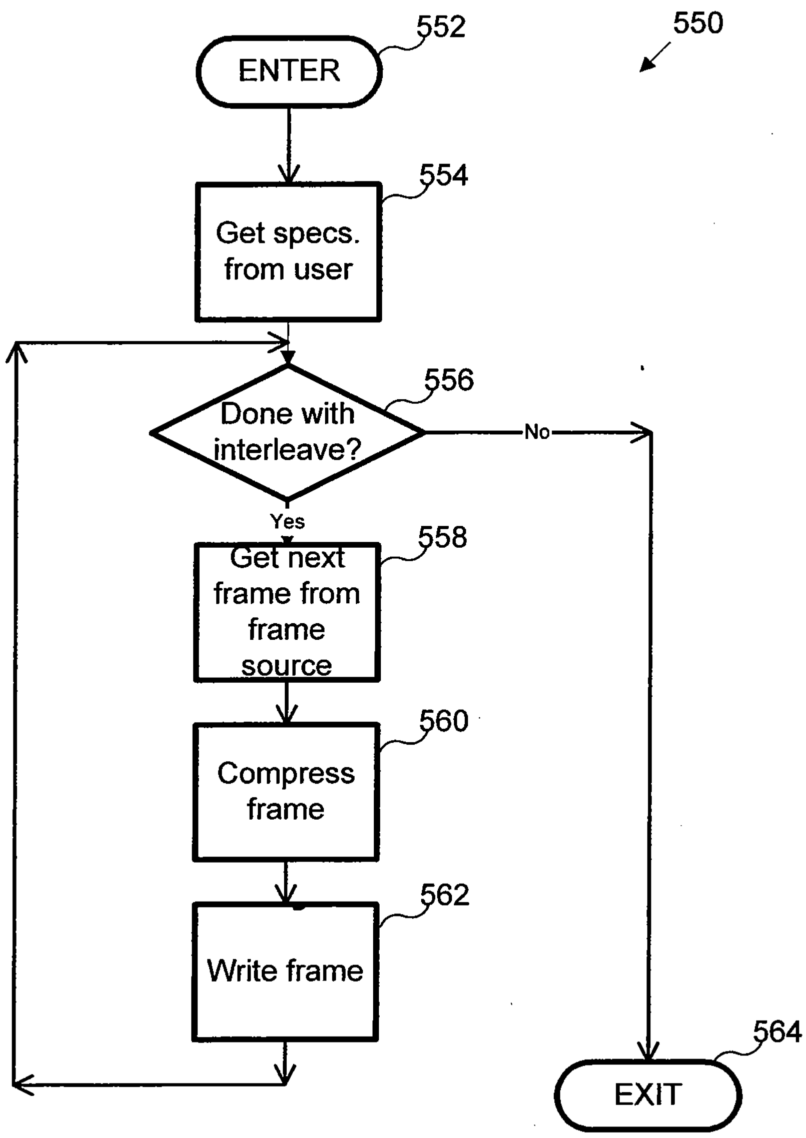

550
552
ENTER
554
Get specs. from user
556
Done with interleave?
No
Yes
558
Get next frame from frame source
560
Compress frame
562
Write frame
564
EXIT

Fig. 2B

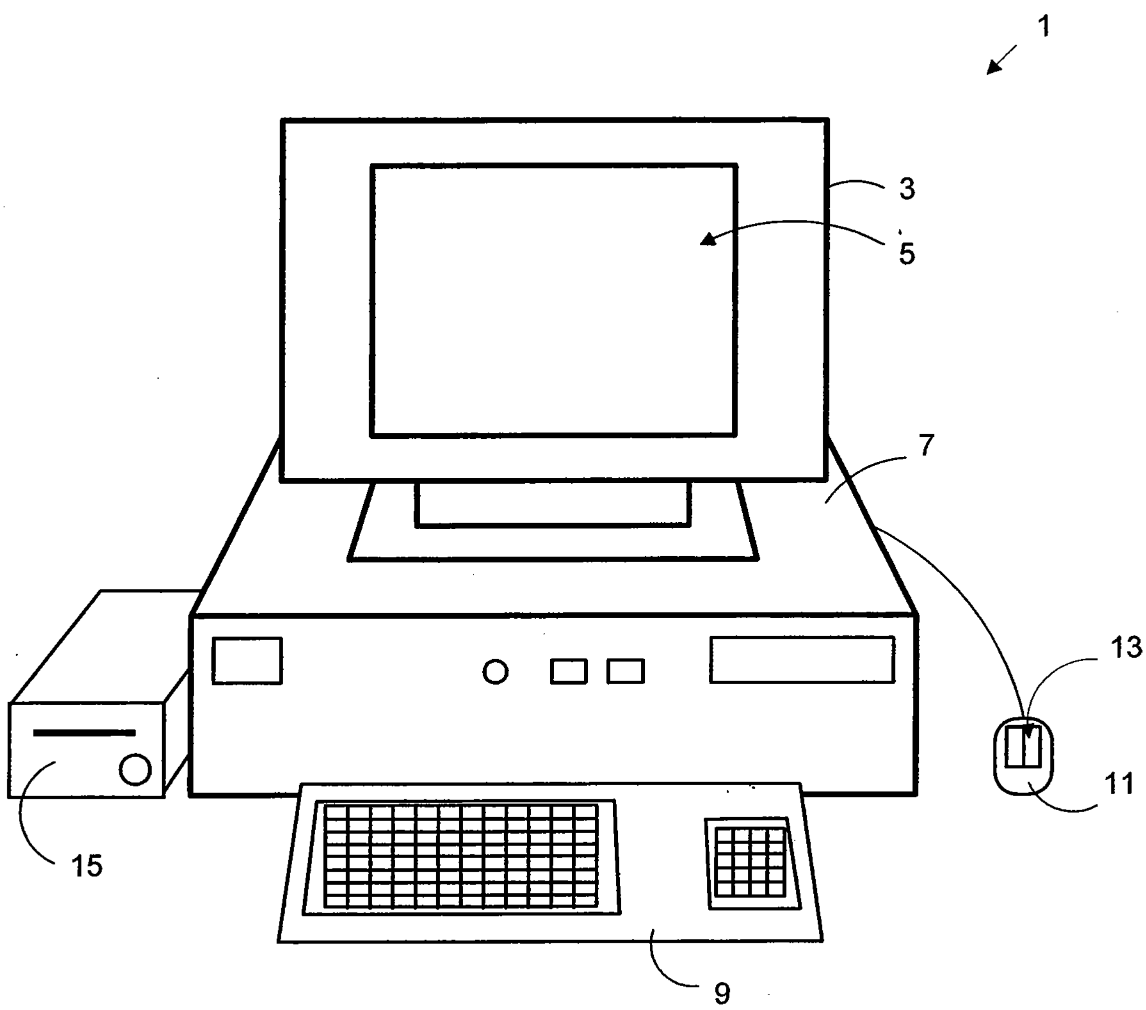


Fig. 3

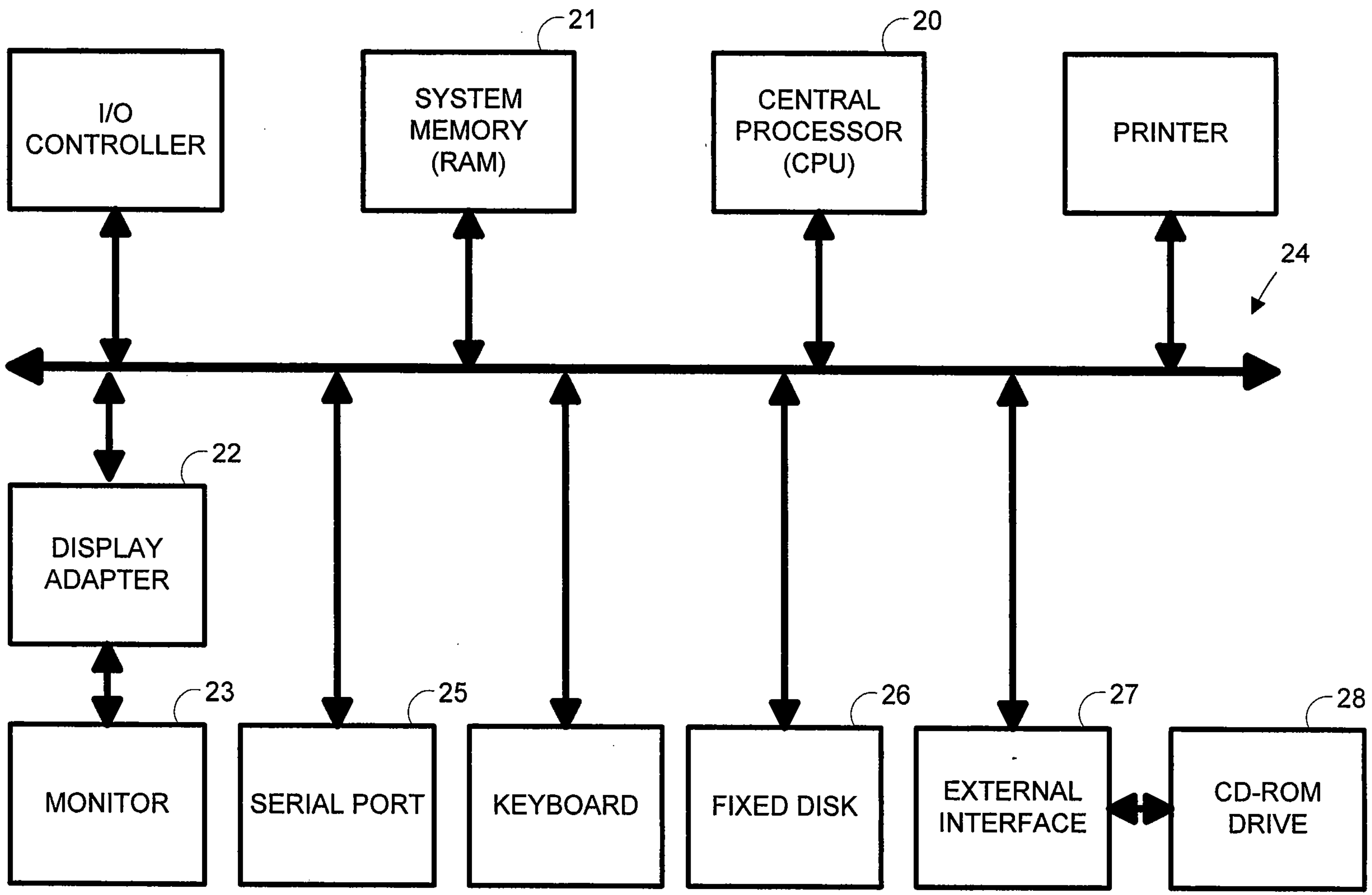

I/O CONTROLLER
SYSTEM MEMORY (RAM)
21
CENTRAL PROCESSOR (CPU)
20
PRINTER
24
DISPLAY ADAPTER
22
MONITOR
23
SERIAL PORT
25
KEYBOARD
FIXED DISK
26
EXTERNAL INTERFACE
27
CD-ROM DRIVE
28

Fig. 4

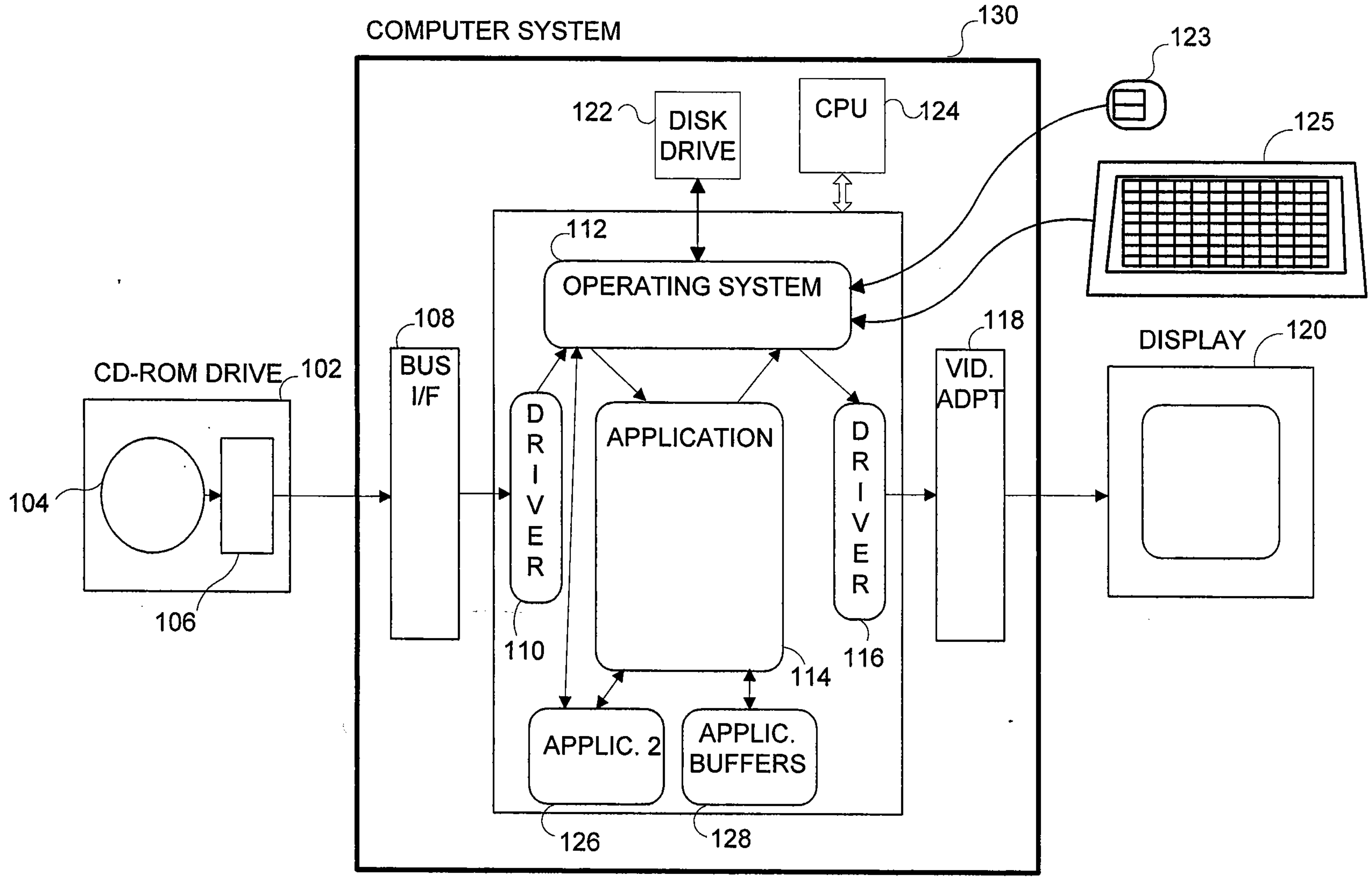

COMPUTER SYSTEM
130
122
DISK DRIVE
CPU
124
123
125
112
OPERATING SYSTEM
108
BUS I/F
CD-ROM DRIVE
102
104
106
DRIVER
110
APPLICATION
114
DRIVER
116
118
VID. ADPT
DISPLAY
120
APPLIC. 2
126
APPLIC. BUFFERS
128

Fig. 5

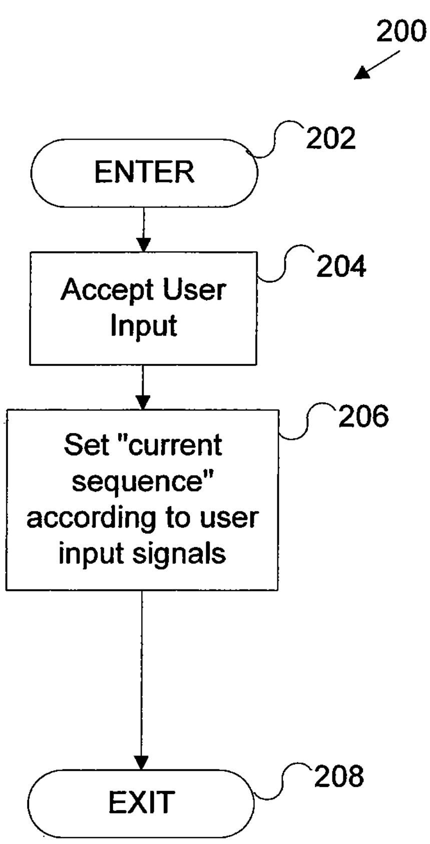

200
ENTER
202
Accept User Input
204
Set "current sequence" according to user input signals
206
EXIT
208

Fig. 6A

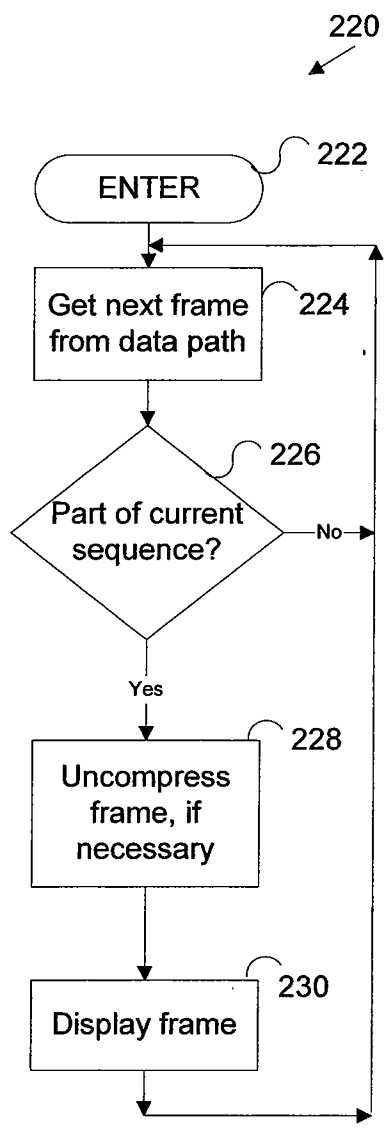

220
ENTER
222
Get next frame from data path
224
Part of current sequence?
226
No
Yes
Uncompress frame, if necessary
228
Display frame
230

Fig. 6B

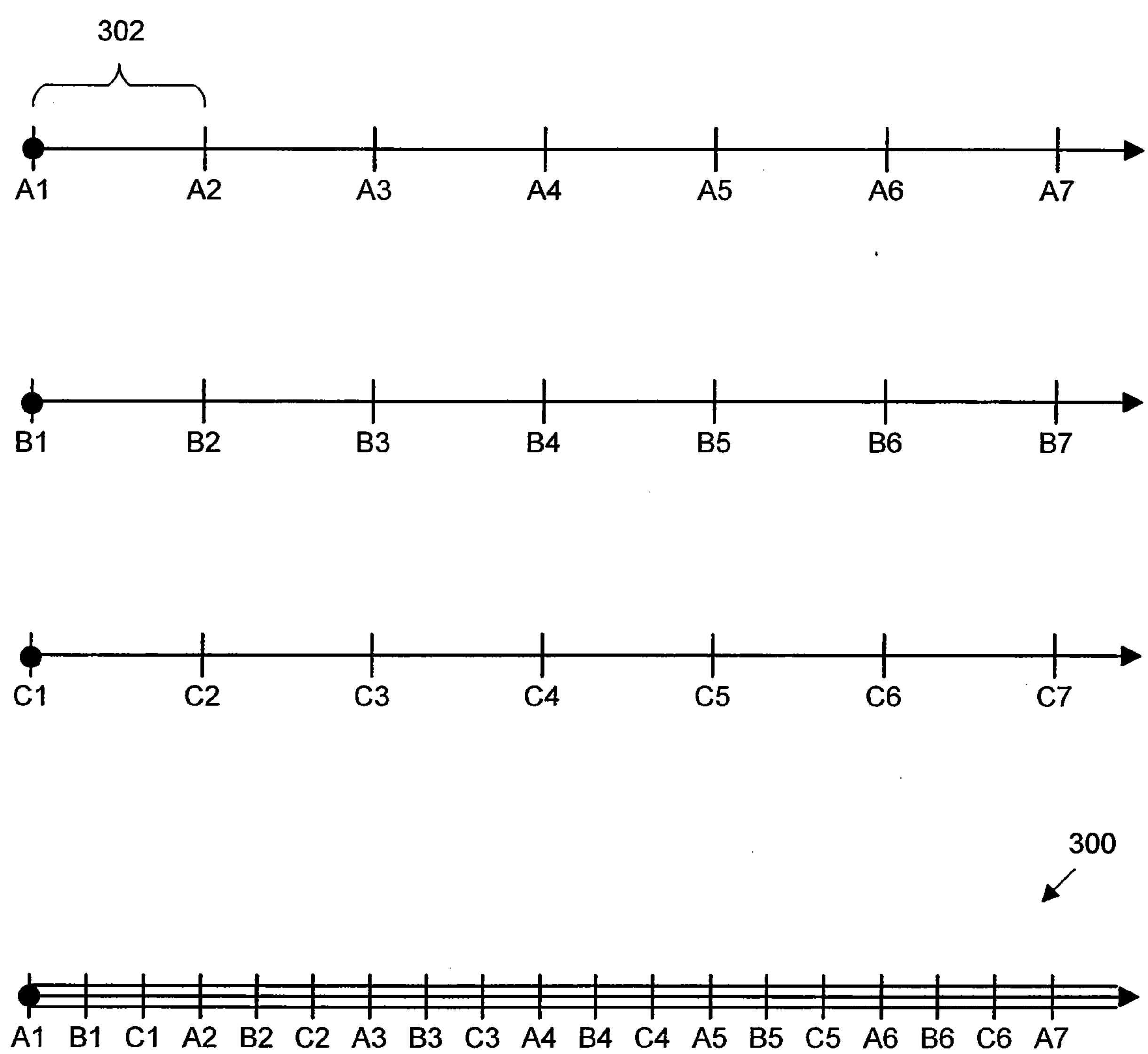

302
A1
A2
A3
A4
A5
A6
A7
B1
B2
B3
B4
B5
B6
B7
C1
C2
C3
C4
C5
C6
C7
300
A1 B1 C1 A2 B2 C2 A3 B3 C3 A4 B4 C4 A5 B5 C5 A6 B6 C6 A7

Fig. 7

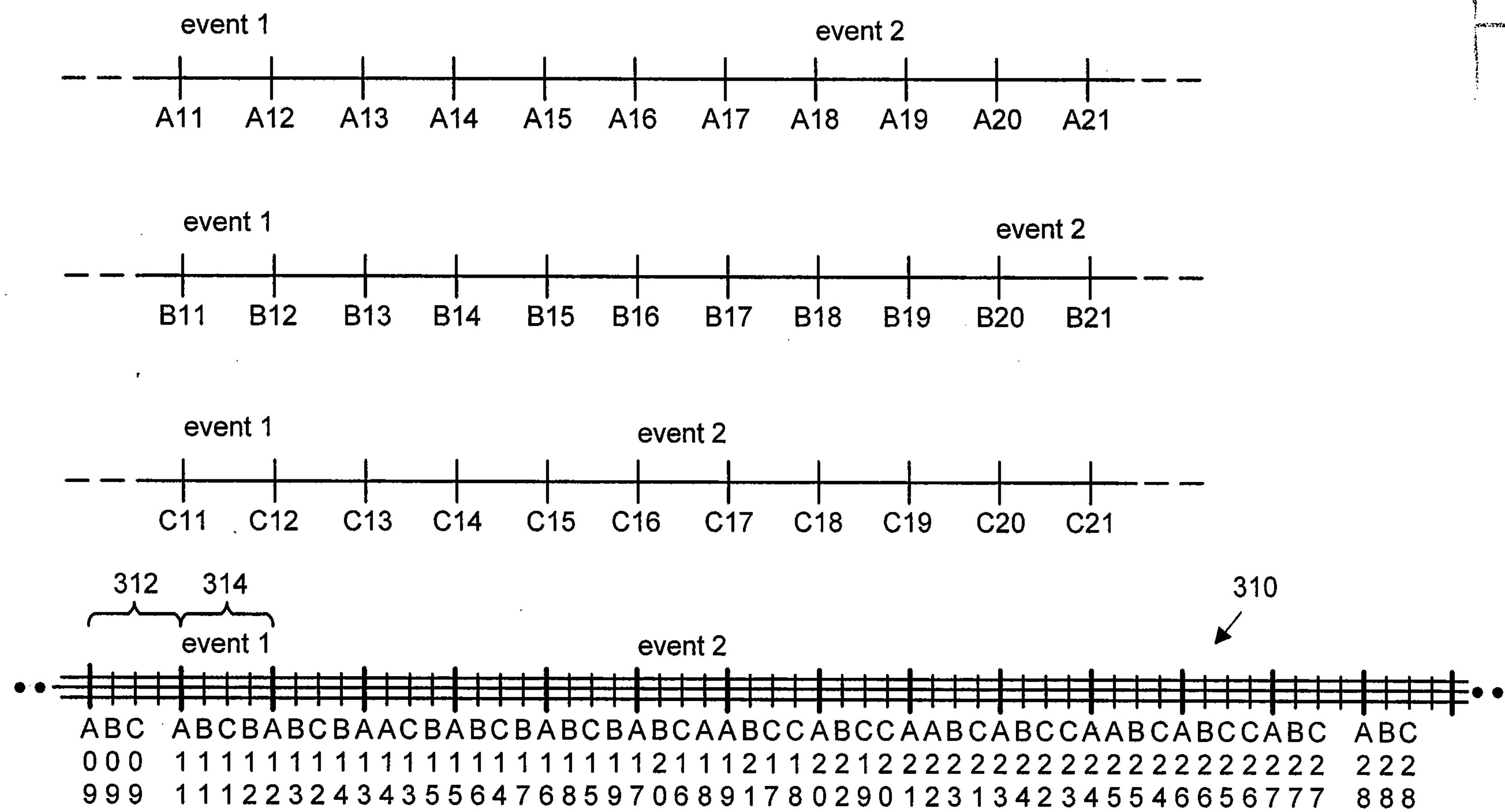

event 1
event 2
A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21
event 1
event 2
B11 B12 B13 B14 B15 B16 B17 B18 B19 B20 B21
event 1
event 2
C11 C12 C13 C14 C15 C16 C17 C18 C19 C20 C21
312
314
310
event 1
event 2
ABC ABCBABCBAACBABCBABCBABCAABCCABCCAABCABCCAABCABCCABC ABC
000 11111111111111111111121112112212222222222222222222 222
999 11122324343556476859706891780290123134234554665677 7 888

Fig. 8

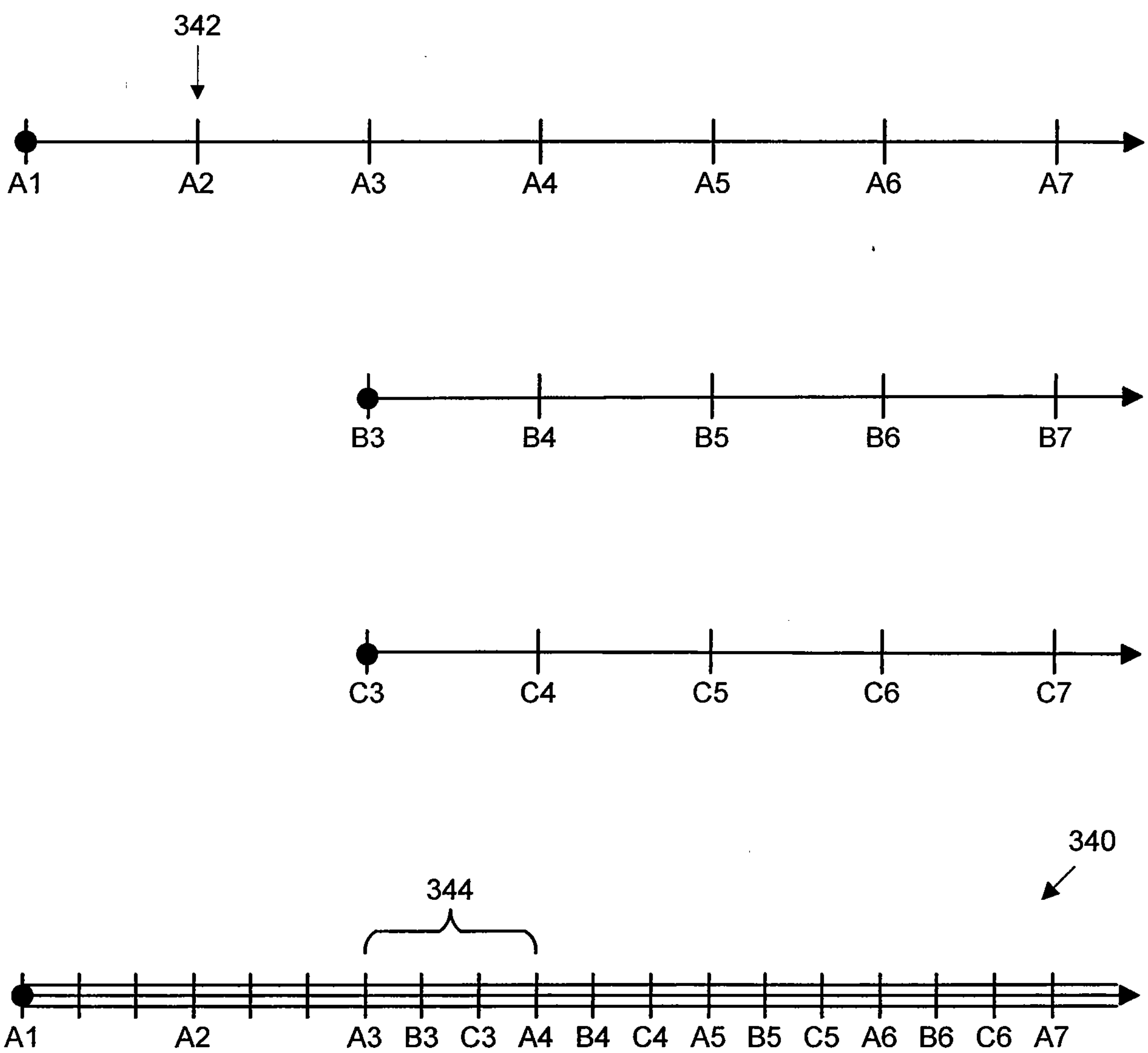

342
A1
A2
A3
A4
A5
A6
A7
B3
B4
B5
B6
B7
C3
C4
C5
C6
C7
340
344
A1
A2
A3
B3
C3
A4
B4
C4
A5
B5
C5
A6
B6
C6
A7

Fig. 9

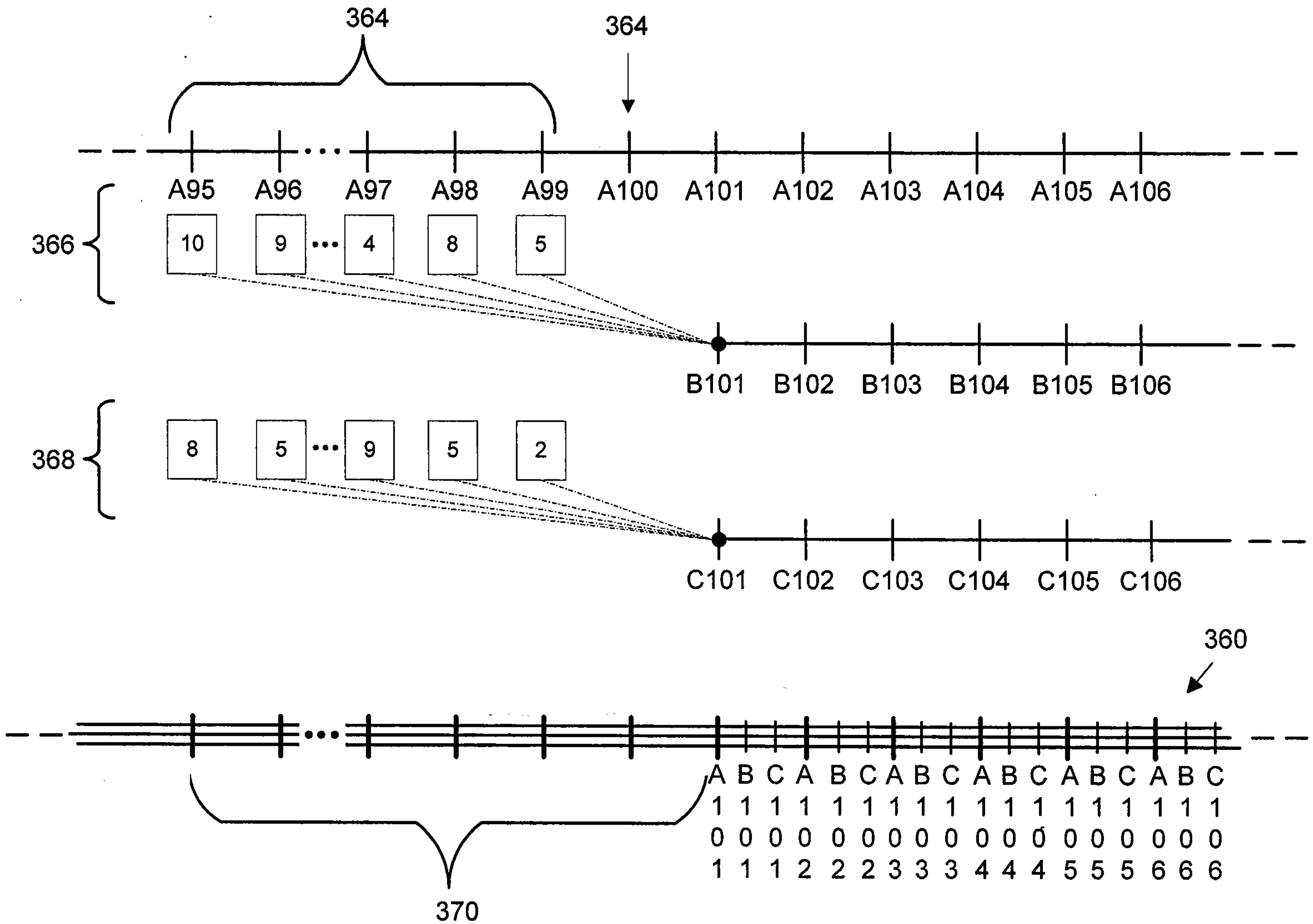

364
364
A95
A96
A97
A98
A99
A100
A101
A102
A103
A104
A105
A106
366
10
9
4
8
5
B101
B102
B103
B104
B105
B106
368
8
5
9
5
2
C101
C102
C103
C104
C105
C106
360
A B C A B C A B C A B C A B C A B C
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 2 2 2 3 3 3 4 4 4 5 5 5 6 6 6
370

Fig. 10

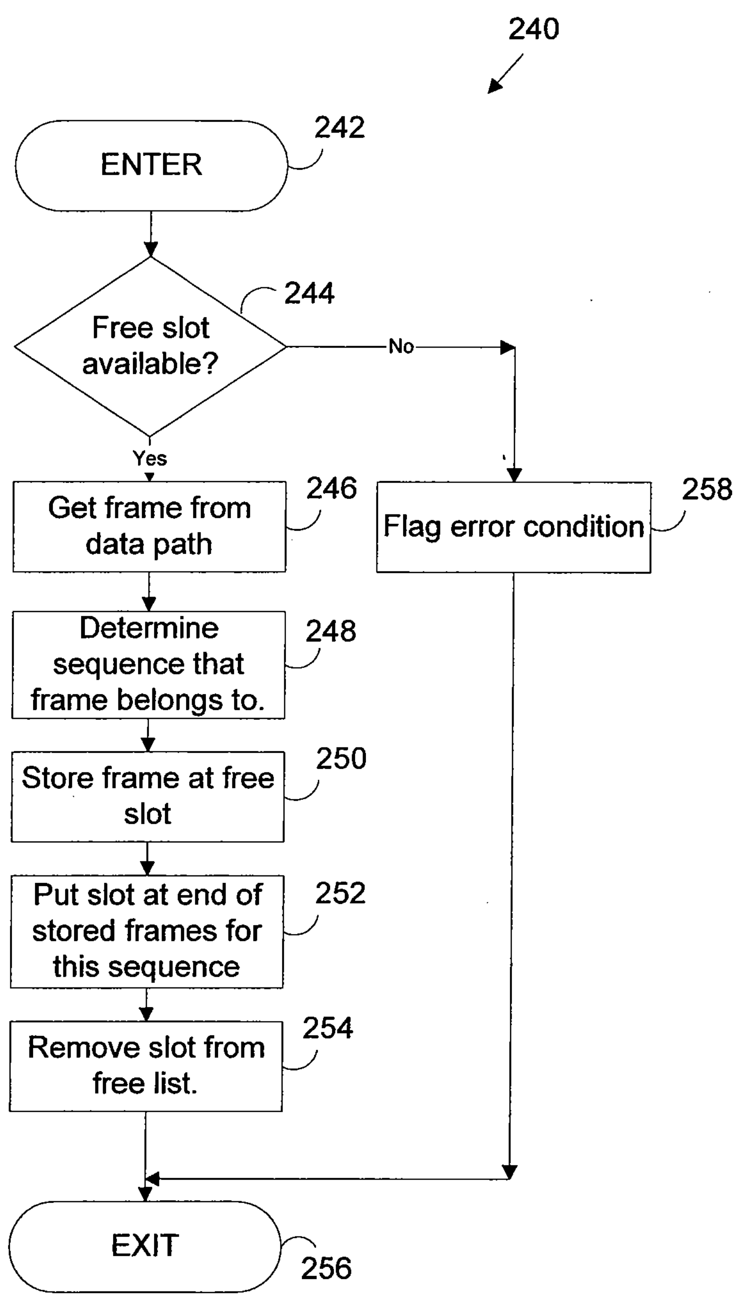

240
ENTER
242
Free slot available?
244
No
Yes
Get frame from data path
246
Flag error condition
258
Determine sequence that frame belongs to.
248
Store frame at free slot
250
Put slot at end of stored frames for this sequence
252
Remove slot from free list.
254
EXIT
256

Fig. 11

APPROVED BY DRAFTSMAN | O.G. FIG | CLASS | SUBCLASS

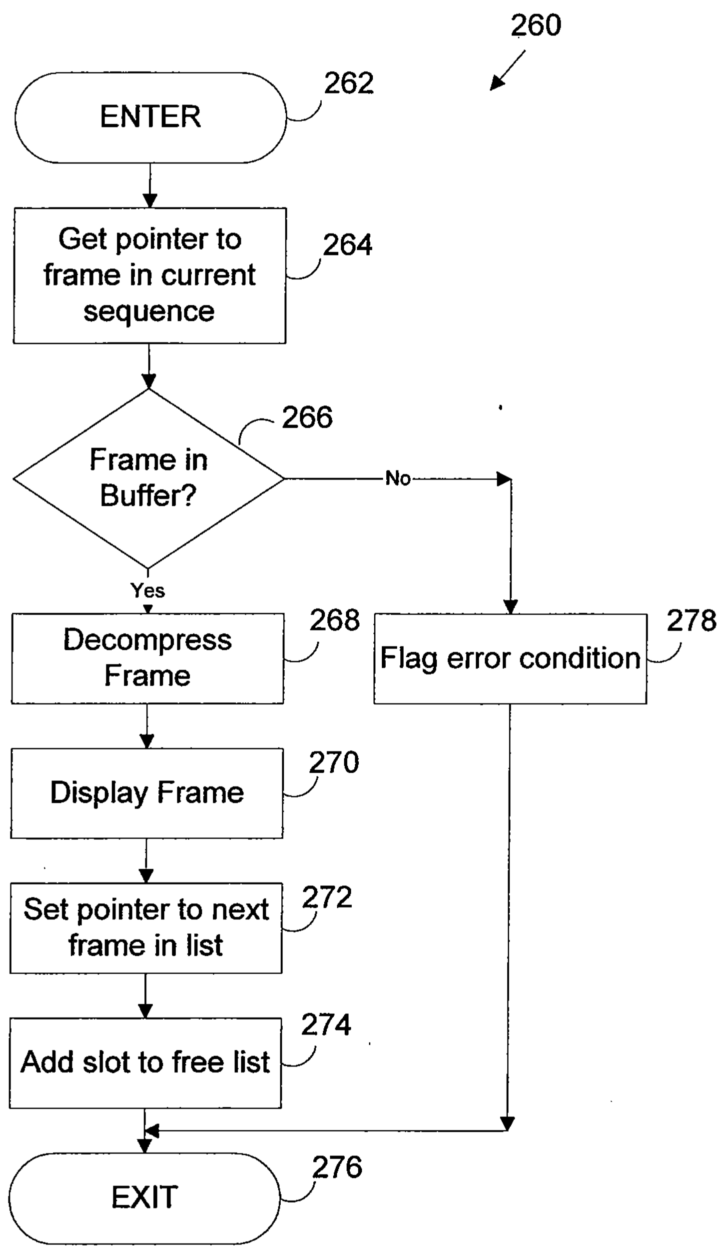


Fig. 12

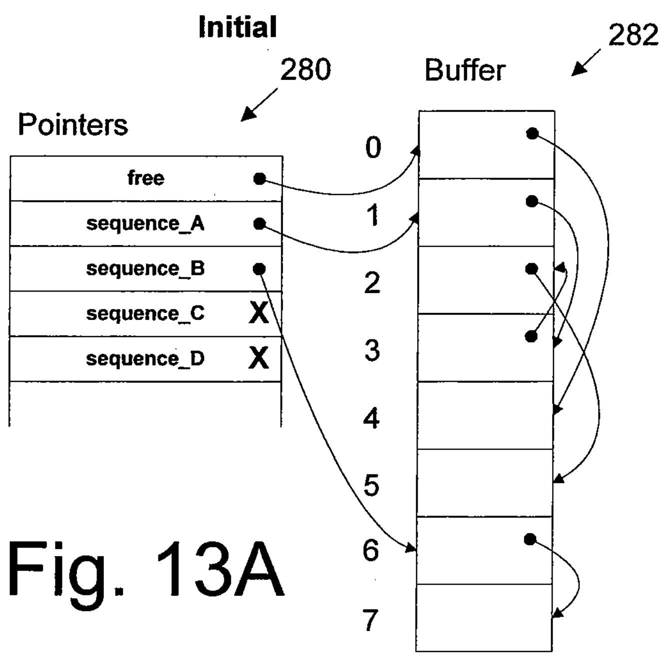


Fig. 13A

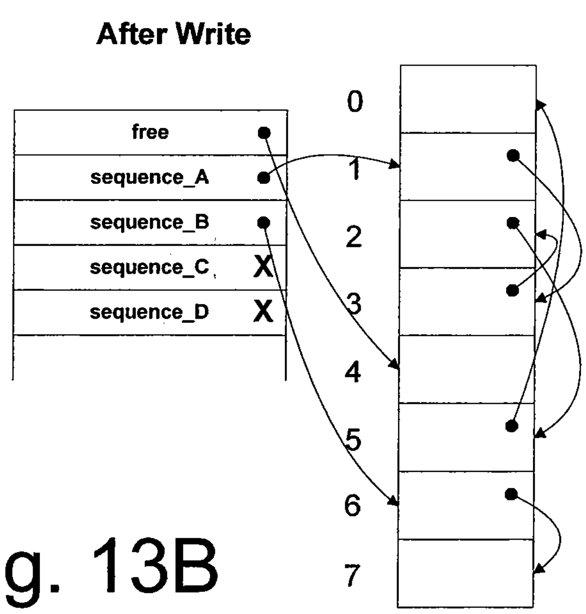


Fig. 13B

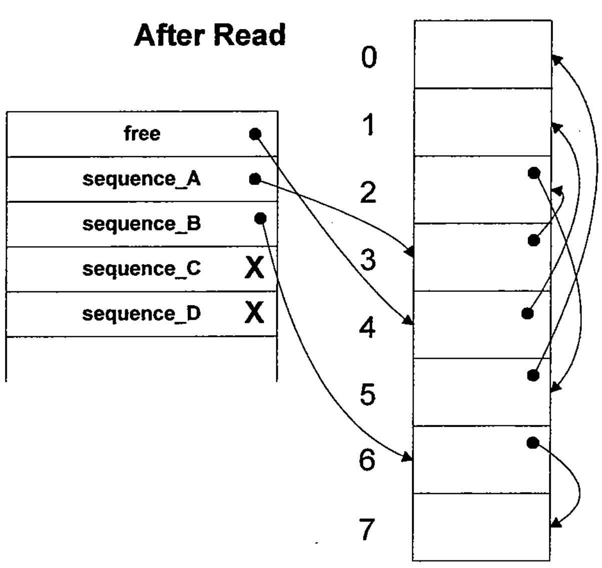

After Read
free
sequence_A
sequence_B
sequence_C
X
sequence_D
X
0
1
2
3
4
5
6
7

Fig. 13C

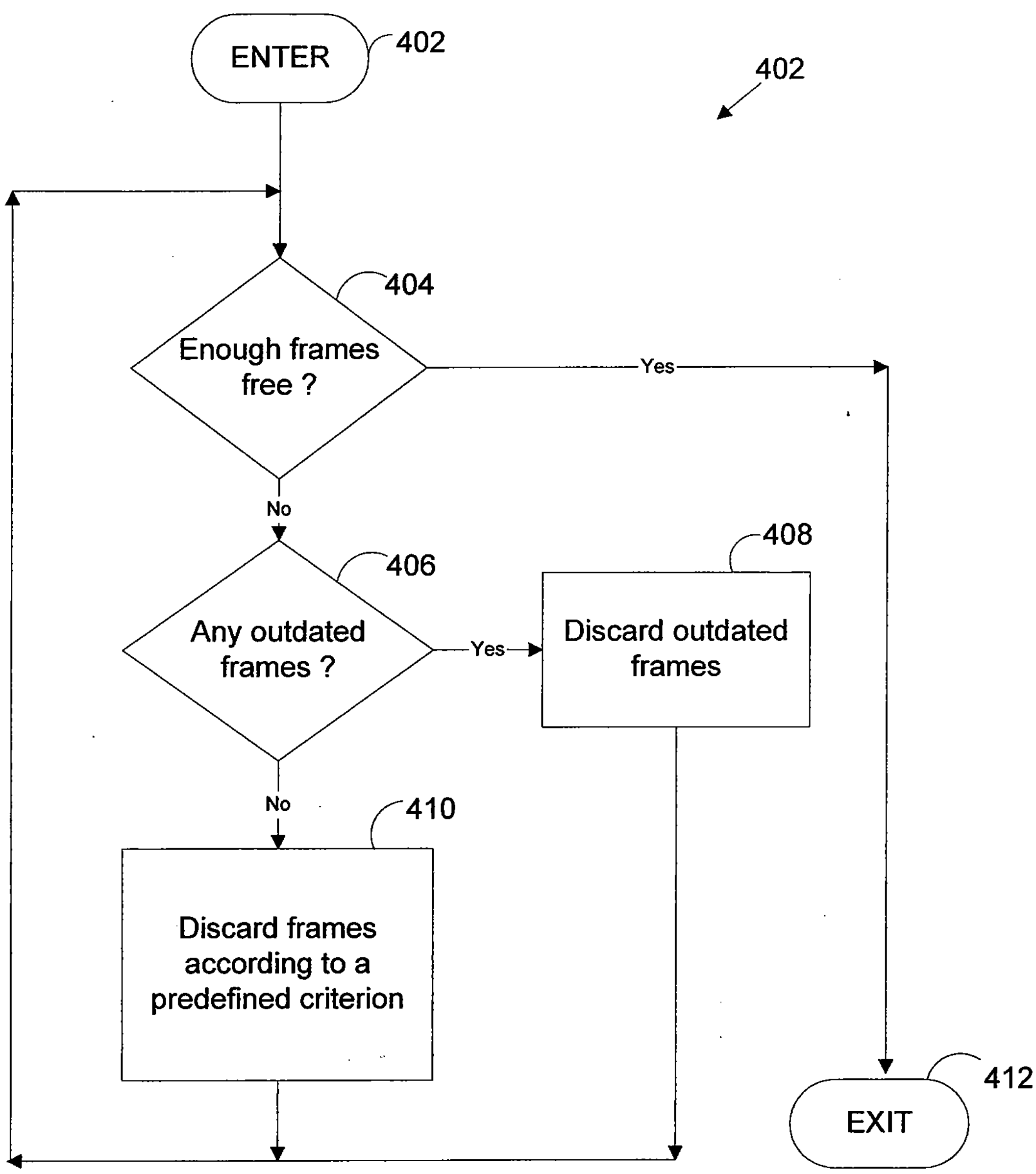

ENTER
402
402
404
Enough frames free ?
Yes
No
406
Any outdated frames ?
Yes
408
Discard outdated frames
No
410
Discard frames according to a predefined criterion
412
EXIT

Fig. 14

[redacted]

PTO UTILITY GRANT

Paper Number 20

The United States of America

The Commissioner of Patents and Trademarks

Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

United States Patent

Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America for the term set forth below, subject to the payment of maintenance fees as provided by law.

If this application was filed prior to June 8, 1995, the term of this patent is the longer of seventeen years from the date of grant of this patent or twenty years from the earliest effective U.S. filing date of the application, subject to any statutory extension.

If this application was filed on or after June 8, 1995, the term of this patent is twenty years from the U.S. filing date, subject to an statutory extension. If the application contains a specific reference to an earlier filed application or applications under 35 U.S.C. 120, 121 or 365(c), the term of the patent is twenty years from the date on which the earliest application was filed, subject to any statutory extension.

Bruce Lehman

Commissioner of Patents and Trademarks

Melvinia Gary

Attest

PATENT AND TRADEMARK OFFICE ★ UNITED STATES OF AMERICA ★

Form PTO-1584 (Rev. 2/97)

United States Patent [19]
Mell et al.
[11] 3,802,099
[45] Apr. 9, 1974

[54] METHOD AND APPARATUS FOR TRAINING POLICEMEN

[75] Inventors: **Leonard E. Mell**, Orange; **Loran A. Norton**, Santa Ana; **David Keith Crosser**, Placentia, all of Calif.

[73] Assignee: **Carter Industries, Inc.**, Santa Ana, Calif.

[22] Filed: **Sept. 25, 1972**

[21] Appl. No.: **292,105**

[52] **U.S. Cl.** **35/25**, 273/101.1
[51] **Int. Cl.** **F41j 1/00**
[58] **Field of Search** 35/25; 273/101.1, 102.1, 273/102.2, 105.1

[56] **References Cited**

UNITED STATES PATENTS

2,957,695	10/1960	DeValle Arizpe	273/105.1
1,035,811	8/1912	Paterson	273/102.2
2,404,653	7/1946	Plebanek	273/101.1

Primary Examiner—Harland S. Skogquist
Assistant Examiner—J. H. Wolff
Attorney, Agent, or Firm—Gausewitz, Carr & Rothenberg

[57] **ABSTRACT**

The present apparatus provides an accurate simulation of the environment in which a police trainee may later find himself during continuance of an emergency condition, such as a confrontation with a killer. The apparatus fills the void between traditional training and actual field conditions, and permits the trainee to interact with the simulated environment in a highly realistic manner. The apparatus includes a plurality of film projectors and tape decks, a screen on which the films are projected, sensing devices to determine whether or not the trainee has fired his gun or has hit a predetermined portion of the screen, logic and control devices interrelated to the film and adapted to cause different operations of the projectors and tape decks in accordance with the actions of the trainee, and simulating devices intended to make the trainee feel that he himself has been hit by a bullet in the event that his prior performance was unsatisfactory.

The method relates to a predetermined manner of interrelating the various apparatus in order to achieve the maximum degree of training effectiveness.

10 Claims, 5 Drawing Figures

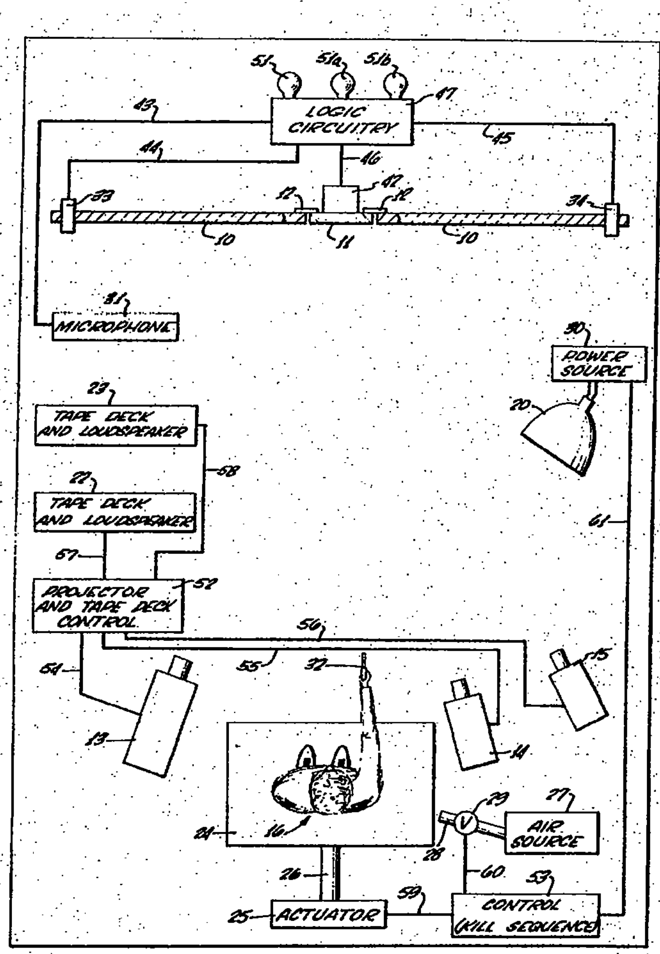
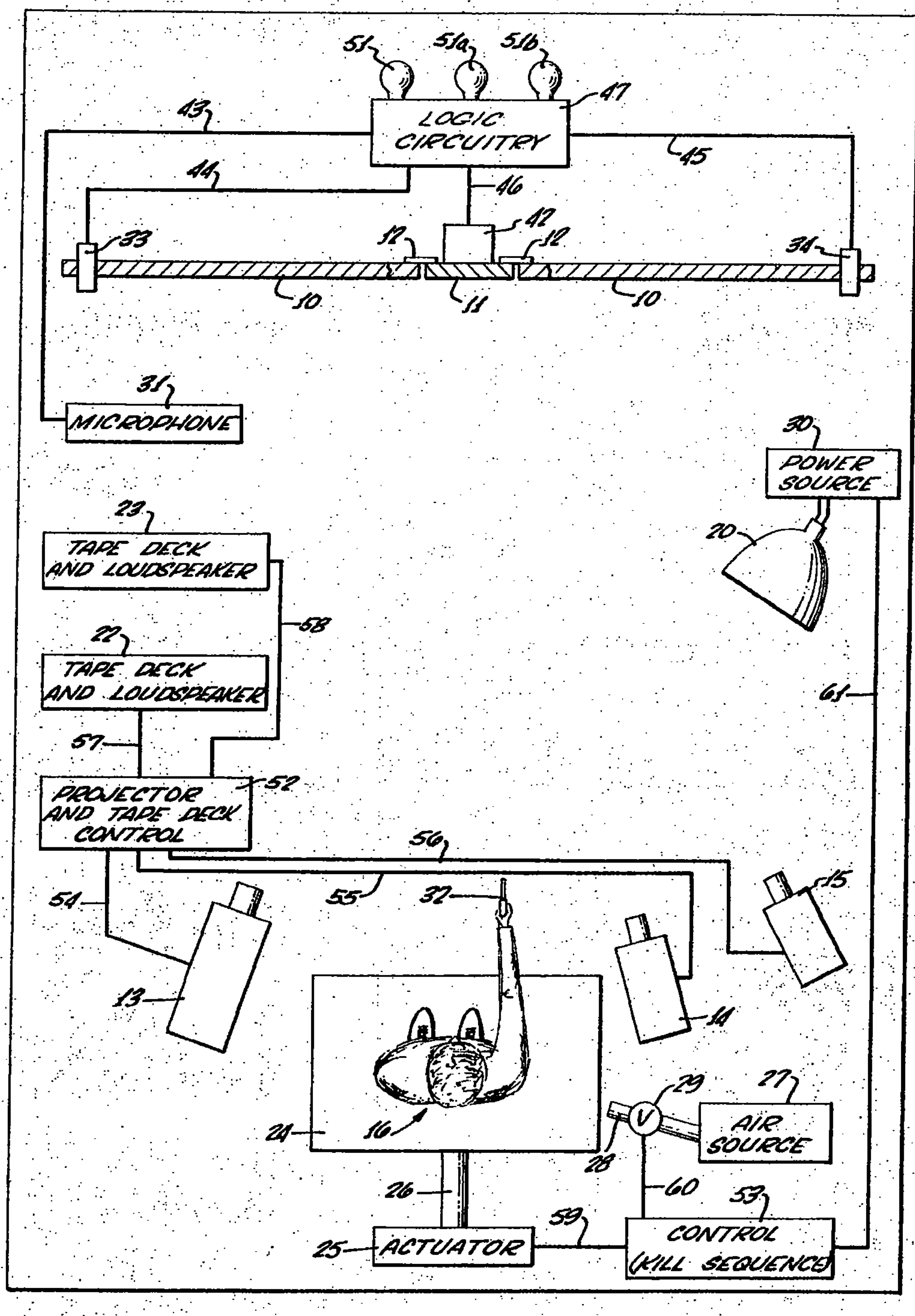


FIG. 1


LOGIC CIRCUITRY
MICROPHONE
POWER SOURCE
TAPE DECK AND LOUDSPEAKER
TAPE DECK AND LOUDSPEAKER
PROJECTOR AND TAPE DECK CONTROL
AIR SOURCE
ACTUATOR
CONTROL (KILL SEQUENCE)

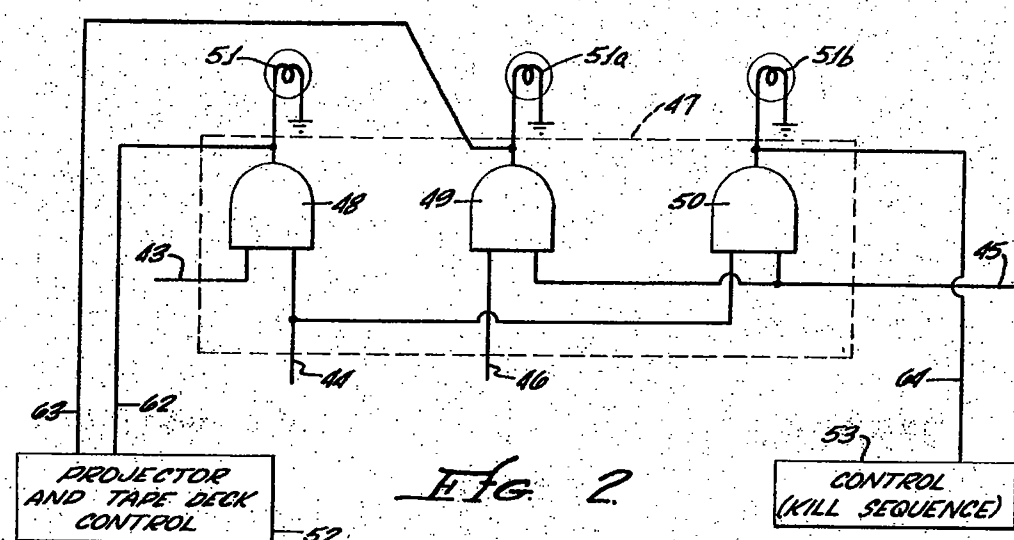
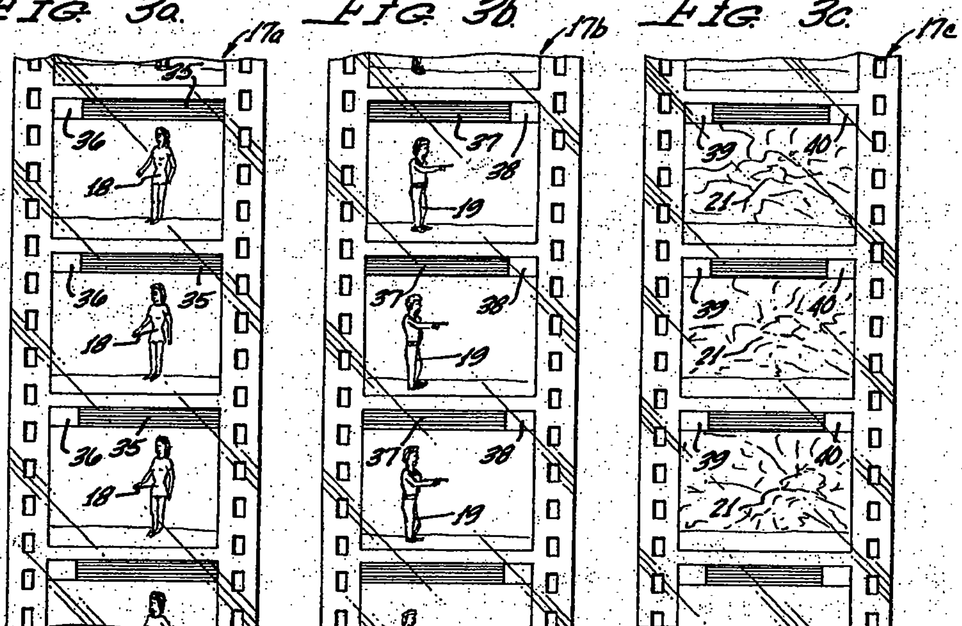


FIG. 2

FIG. 3a. FIG. 3b. FIG. 3c.



METHOD AND APPARATUS FOR TRAINING POLICEMEN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of methods and apparatus for training policemen and others who are required to employ guns during periods of critical emergency.

2. Description of Prior Art

There exist prior-art patents which relate to the teaching of military trainees to shoot various types of weapons at the projected images of moving targets, relate to the shooting at targets in amusement parts, and relate to sports-training equipment (for example, teaching golfers to hit golf balls correctly). However, insofar as is known to applicants, there does not now exist a training method or apparatus which permits law enforcement trainees, etc., to become totally involved with what is occurring on a screen and to interact realistically with various environment-simulating devices. More specifically, prior art known to applicants does not cause the projected images to change in certain ways, and to shoot at the trainee, in accordance with whether or not the trainee fires accurately at the correct target during the correct time interval. Furthermore, the prior art does not subject the trainee, if he does not perform properly, to a psychological simulation of some of the adverse consequences which he might suffer if he were shot and wounded by a suspect.

SUMMARY OF THE INVENTION

The apparatus comprises a projection screen having at least one portion which is a predetermined target area, such portion being associated with a sensing means adapted to determine when the target area is struck by a projectile. A plurality of film projectors are provided in order to effect sequential showing of photographic and other images on the screen. Sensing and logic means correlate the target area of the screen with certain portions of a motion picture film being projected by one of the projectors, and correlate a microphone with other portions of such motion picture film. The sensing and logic means are associated with control means for the projectors, and also with tape deck and loudspeaker means. Furthermore, the sensing and logic means are associated (when still different portions of the film are being projected) with control means for apparatus adapted to make the police trainee exerience psychologically some of the feelings which may be incident to being wounded by a bullet.

In accordance with the method, a motion picture film is projected on the screen by one of the projectors, and incorporates a sequence of images showing a decoy or false target which should not be shot at by the trainee. If, however, the trainee shoots at the decoy, the film is stopped and turned off; and a second film is projected on the screen in order to show the decoy in a dead or dying condition. Furthermore, a tape deck is actuated to inform the trainee that he made a mistake. If the trainee does not shoot the decoy, the motion picture film is continued to show the true suspect or target, who should be shot by the trainee. Shooting of the correct target area of the suspect, during a predetermined correct time period, causes the film to stop, causes an image of the dead or dying suspect to be projected, and activates a tape deck to inform the trainee that he has performed well. If the correct target area is not hit during the proper time interval, the motion picture film continues and shows the suspect shooting the trainee. The trainee is then subjected to various effects which psychologically simulate being wounded.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic top plan view, but showing the projection screen in horizontal section, and which illustrates the trainee in the position assumed during the training operation;

FIG. 2 is a diagram showing the logic circuitry which is illustrated at the upper portion of FIG. 1, in combination with control circuits for the projectors and tape decks and for the kill-simulating apparatus; and

FIGS. 3*a*, 3*b* and 3*c* illustrate sections of motion picture film and which are coded in such manner as to inform the logic circuitry which portions of the film are being projected on the screen.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Throughout this specification and claims, the "trainee" is the policeman or other individual who is employing the apparatus in order to learn how to react properly under emergency conditions. The "decoy" is an individual who may give the appearance of a criminal but who, actually, is innocent and should not be shot. The "suspect is the actual criminal who is armed and dangerous and who will, unless shot by the trainee, effect his killing or wounding.

Referring first to FIG. 1, the entire illustrated apparatus is enclosed in a room or booth which is maintained in a relatively dark condition, and is free of extraneous light sources. At one end of the room or booth is a projection screen 10 which is solid at all portions thereof except at one (or more) predetermined target area 11. Such target area 11 is not rigidly connected to the remainder of screen 10, being instead connected thereto (or to another suitable support means) by resilient elements such as the strap springs which are indicated at 12.

The location of target area 11 is accurately correlated to the location of the heart of the suspect during a certain period while the suspect is shown on the screen as described below relative to FIG. 3*b*. Stated otherwise, the image of the "heart area" of the chest of the suspect is projected onto target area 11 during the stated time. Such coincidence between the location of target area 11, and the location of the heart of the projected suspect image when the film portion of FIG. 3*b* is on the screen, only occurs during a relatively short predetermined time period. It is during this time period that the trainee must, in order to perform the training exercise satisfactorily, shoot the heart of the projected image of the suspect and thus hit the target area 11.

The apparatus of FIG. 1 further comprises a plurality, illustrated as three, of film projectors 13, 14 and 15 all directed at the projection screen 10. Projector 13 is a motion picture projector, of a suitable type which not only projects onto screen 10 the images on a motion picture film, but also generates sound which is synchronized with and audibly reproduces words being spoken by the projected images of the decoy and suspect. The sound also comprises background description by a narrator. Such sound is heard by the trainee, who is shown at 16, either by means of a loudspeaker or by use of headphones, not shown.

The motion picture film 17 which is projected by projector 13 is indicated, in part, in FIGS. 3a, 3b and 3c. Another portion of the film not shown, is projected by the projector 13 prior to projection of any of the film portions of FIGS. 3a, 3b or 3c. Such prior film portion illustrates the environmental situation at which the confrontation will take place. For example, the environment may comprise a barroom at which an armed robbery is in progress. The film sound track associated with such prior portion of the film 17 also explains the general situation to the trainee, in a "you are there" manner.

There is next projected by motion picture projector 13 the portion 17a of the film (FIG. 3a), which portion shows the decoy 18. Thereafter, if the trainee doesn't shoot at the image of the decoy, there is projected by projector 13 the portion 17b of the film (FIG. 3b), and which shows the suspect 19. There is next projected by projector 13 the portion 17c of the film (FIG. 3c), which comprises strange moving color patterns 21 psychologically simulative of unconsciousness. Such portion 17c of the film should not be projected if the trainee has fired at the image of the suspect 19, during the correct time period, and has hit the target area 11 of screen 10.

It is emphasized that the sound track, not shown, of the film 17 contains (in addition to words) all suitable sound effects such as gunshots, fight noises, crowd noise, and everything else realistically associated with the images being projected on the screen.

The second projector 14 is preferably a motion picture projector, but may be an automatic slide projector adapted to effect rapid-sequence projection of sequentially related slides on the projection screen 10. The images projected onto the screen by projector 14 (whether it is a motion picture projector or a slide projector) show the decoy 18 falling and dying.

Similarly to the case relative to projector 14, the third projector 15 is preferably a motion picture projector but may be an automatic slide projector. The images projected onto the screen 10 by projector 15, whether it is a motion picture projector or slide projector, show the suspect 19 falling and dying. It is within the scope of the invention to provide films whereby the projectors 14 and 15 show the decoy and/or the suspect being wounded, or following some other representative course of action, instead of falling and dying.

Although projectors 14 and 15 may be sound-type projectors, it will be assumed that they are not. Thus, tape decks are provided as stated below.

Preferably, each of projectors 14 and 15 is a motion picture projector containing a short closed-loop length of motion picture film, not shown. The closed-loop length of film shows the entire sequence and then automatically stops the associated projector as soon as the beginning point is reached. Similarly, projector 13 is preferably a motion picture projector containing a longer length of closed-loop film, which also stops itself as soon as the beginning point is reached in the closed-loop film.

Relative to each of projectors 13–15, the film effects stopping of the projectors (when the beginning point is reached) in ways well known in the art, for example by mounting a suitable indicating means (such as a short length of metal strip) on the film, and causing a switching means (for example, two probes adapted to be electrically connected to each other by the metal strip) in the projector to sense when the indicating means reaches a predetermined point corresponding to the beginning and ending point of the film. Each of the projectors 13–15 is started by receiving a suitable electrical pulse, which operates a relay and holding circuit (not shown) to maintain the respective projectors in operation until automatically stopped as stated. It is pointed out that the projectors 13, 14 and 15 do not operate at the same time, but in sequence in accordance with the present method as described hereinafter.

It is within the scope of the invention to provide a plurality of motion picture projectors operating in synchronism with each other, and containing films related to each other in a certain manner. Masking or other means are then employed to switch back and forth between the projectors, quickly, only one film being seen at any one time. The switching is responsive to the actions of the trainee.

There is provided a combination tape deck and loudspeaker 22 which is activated simultaneously with activation of projector 14, and contains a tape which explains to the trainee 16 that he has made a mistake. More specifically, the tape explains to the trainee that he should not have shot the decoy 18. Correspondingly, there is provided a tape deck and loudspeaker 23 which is activated simultaneously with activation of projector 15, and which informs the trainee 16 that he has performed correctly and has shot and killed the suspect 19. Each of the tapes incorporated in units 22 and 23 is preferably of the closed-loop type adapted automatically to shut the unit off, as described relative to projectors 13–15. The duration of the recorded message on the tape in each of units 22 and 23 corresponds to the duration of the film projection periods, respectively, of projectors 14 and 15.

There will next be described the means for causing the trainee 16 to receive sensory impressions simulative of those which might occur in the event that he himself were wounded or dying. These sensory impressions do not actually harm the trainee in any way but do give him a psychological jolt. One such means is a horizontally movable rectangular platform 24, on which the trainee stands throughout the entire operation. The platform is suddenly moved horizontally, through a short distance such as one or two inches, in response to operation of an actuator 25 which connects to the platform by means of a connecting rod 26. When the platform 25 suddenly and unexpectedly moves, the stability of the trainee 16 is interrupted, and he is given some of the sensations which would occur if he were falling.

Another such means is an air source 27 which contains air under pressure (or contains a blower) and connects through a conduit 28 to a point adjacent the trainee 16. A solenoid valve 29 incorporated in conduit 28 is automatically opened, as described below, causing the source 27 to blow air through conduit 28 at the head of the trainee 16.

A further psychological effect is created by a strobe light 20 which is associated with a power source 30, and which flashes a bright light toward the trainee 16 at short intervals.

Other psychological impressions result from the fact that the trainee sees projected on screen 10 by motion picture projector 13 the images or patterns present on the film strip 17c shown in FIG. 3c. In addition, the sound track associated with film strip 17c may generate strange noises adapted to enhance the psychological or psychedelic effect being produced.

It is pointed out that platform 24 also performs the important function of locating the trainee relative to the screen. Therefore, the suspect image on the screen will appear to shoot directly at the trainee. Desirably, the platform location is correlated to the location of the camera which exposed the motion picture film 17.

DESCRIPTION OF THE SENSING, LOGIC AND CONTROL MEANS

The sensing means comprises a sensor 31 which is a microphone adapted to sense the sound created by firing of a gun 32 employed by the trainee 16. The microphone 31 is insensitive to other sounds. The gun 32 may be a standard service revolver adapted to fire a plastic projectile which will create a substantial impact on target area 11 but will not be damaging or dangerous. The plastic projectile may be fired by the primer powder alone; there need be no other powder contained within the cartridge in gun 32.

Two additional sensors 33 and 34 are provided in the form of photodetectors which are located, respectively, at the upper lefthand and upper right-hand corners of projection screen 10. The locations of photodetectors 33 and 34 are correlated, respectively, to the locations of coded information on the film strips 17a, 17b and 17c (FIGS. 3a–3a–).

Referring first to FIG. 3a, the entire upper portion of each frame of the motion picture film scene is caused to be black, as indicated at 35, except at a light-transmissive film portion 36 which is provided at the upper left-hand corner of each frame. Portion 36 is adapted to permit transmission of light from the projection lamp to photodetector 33, thus activating the latter. During this period, photodetector 34 is not activated since light transmission thereto is prevented by the black portion 35. It will be remembered that the film strip 17a is the one which contains the images of the decoy.

Referring next to FIG. 3b, which is the scene containing the images of the suspect, the entire upper portion of each frame is black, as shown at 37, except at the upper right-hand corner which has a light-transmissive opening 38. Opening 38 permits transmission of light from the projection lamp to photodetector 34, whereas black portion 37 blocks transmission of light to the detector 33.

In the film strip of FIG. 3c, there are light-transmissive openings at both the upper left-hand corner and the upper right-hand corner of each frame, as shown respectively at 39 and 40. Thus, when the scene of film strip 17c is being projected on the screen 10, both photodetectors 33 and 34 are simultaneously activated. It is to be remembered that this film strip 17c is the one which is projected immediately after the suspect film strip 17b has been projected.

The remaining sensor, indicated at 42, is a piezoelectric transducer adapted to sense when the target area 11 of projection screen 10 has been hit by a projectile (namely, by the plastic bullet). When the target area is thus hit, a voltage pulse is produced due to the fact that target area 11 moves slightly as permitted by the springs 12. The piezoelectric transducer may be, for example, a cartridge of the kind used in a phonograph turntable.

Sensors 31, 33, 34 and 42 are connected, respectively, by wires 43–46 to logic circuitry indicated generally at 47. Referring to FIG. 2, the logic circuitry 47 comprises three AND gates 48, 49 and 50 the outputs of which are adapted, respectively, to energize lamps 51, 51a and 51b. AND gate 48 has two inputs which are respectively connected to wires or leads 43 and 44, the result being that lamp 51 is illuminated in response to the receipt of a signal from the microphone 31 during a period when photodetector 33 is energized.

The two inputs of AND gate 49 are connected, respectively, to leads 45 and 46, so that lamp 51a is illuminated in response to receipt of a signal from piezoelectric transducer 42 during a period when photodetector 34 is energized. The inputs of AND gate 50 are connected, respectively, to the two photodetectors 33 and 34, the result being that lamp 51b is illuminated when both photodetectors are energized (namely, when film strip 17c of FIG. 3c is being projected on the screen).

The control circuitry comprises a projector and tape deck control 52, and a control (kill sequence) 53. The projector and tape deck control 52 incorporates a plurality of switches adapted to effect starting of the three projectors 13–15 and the two tape decks 22 and 23. This is effected by means of current transmitted through leads 54, 55, 56, 57 and 58.

The kill-sequence control 53 (thus named because it operates when the trainee is being wounded or killed) incorporates switching means associated with the actuator 25, with the valve 29 for air source 27, and with the power source 30 for strobe light 20. The lead from control 53 to actuator 25 is numbered 59; that to valve 29 is numbered 60; and that to power source 30 is numbered 61.

Projector 13 is started by switch means on control 52, and continues until manually or automatically stopped. Projector 14 and tape deck 22 are started simultaneously by control 52, either manually or automatically, and continue for the same length of time after which they either shut themselves off (as described above) or are shut off by switch means on the control 52. The projector 15 and the tape deck 23 are started simultaneously by the control 52, either manually or automatically, and continue for the same length of time after which they either shut themselves off (as described above) or are shut off by switch means on the control 52.

The various kill-sequence elements 25, 29 and 30 are activated simultaneously by the kill-sequence control 53 and continue until manually or automatically shut off.

The two control elements 52 and 53 may be disposed adjacent each other and operated by an operator, in manual manner, the operator pressing and releasing various switches. Preferably, however, no such operator is necessary. Instead, the control elements 52 and 53 function automatically in response to the logic 47, and incorporate suitable relay and other means to effect the described operation of the projectors, tape decks, kill-sequence elements, etc. For such automatic operation, the outputs of the respective AND gates 48 and 49 are connected through leads 62 and 63 to control 52, whereas the output of gate 50 is connected through lead 64 to control 53.

DESCRIPTION OF THE METHOD

In the following description of the method, it will be assumed that the controls 52 and 53 are operated manually by an operator, who is pressing and releasing switches, although it will be understood that the apparatus may also (preferably) be operated automatically and independently of any operator.

The law enforcement trainee 16 mounts the movable platform 24, and picks up the gun 32. The operator then actuates a switch on control 52 to effect starting of the motion picture sound projector 13. The trainee then sees on screen 10 a projected motion picture image of a scene, for example a barroom, where (for example) a robbery is in progress. He also hears a "you are there" narrator's description of the circumstances of the hypothetical situation.

The film strip portion 17*a* (FIG. 3*a*) then passes through the projector, so that the image of the decoy 18 is projected on screen 10. The decoy moves and talks in such manner as to induce an inexperienced police officer to fire at her, despite the fact that an experienced officer would not. As soon as the decoy appears on the screen, light projected through opening 36 in film strip portion 17*a* (FIG. 3*a*) activates the photodetector 33 to thereby set up an AND gate 48 for energization of lamp 51 in response to firing of a shot by gun 32 while the image of decoy 18 remains on the screen. If the trainee 16 then fires the gun 32, the sound is sensed by microphone 31, and causes the AND gate to energize light 51. The operator then actuates switches on control 52 to turn off the projector 13, and substantially simultaneously activate the projector 14 as well as the tape deck and loudspeaker 22. Projector 14 projects on screen 10 images of the decoy falling and dying, whereas the tape deck and loudspeaker explains to the trainee 16 that he has made a mistake. At the end of this sequence, both elements 22 and 14 are shut off by the operator, operating the control 52, or else they shut themselves off as described above.

The operator then has the election of either starting the entire method over, or else continuing from the point at which the projector 13 was stopped. Assuming the latter to be the case, the operator operates a switch on control 52 to again start projector 13. This causes film strip portion 17*b* (FIG. 3*b*) to be projected on the screen, so that the image of the suspect 19 appears. The image of the suspect acts and talks in such manner that an experienced police officer would shoot him. Light passing through opening 38 in film strip 17*b* then (during a precise, predetermined time period) activates the photodetector 34, to set up the AND gate 49 for illumination of lamp 51*a* in response to striking of target 11 by the projectile from gun 32.

Thus, if the trainee 16 fires gun 32 and hits area 11 during, and only during, the predetermined time period when the suspect 19 is on the screen and is in the predetermined position correlated to the target area 11, the lamp 51*a* will be illuminated. If this occurs, the operator will see the lamp 51*a* light and will immediately actuate switches on control panel 52 to turn off the projector 13 and simultaneously activate the projector 15 and the tape deck and loudspeaker means 23. The projector 15 then shows the suspect falling and dying, and the tape deck and loudspeaker 23 explains to the trainee that he has acted in a proper and correct manner.

It is pointed out that the length of time during which the trainee may fire effectively is determined by the number of film frames containing openings 38.

In the event that the target area 11 is not struck by the projectile during the predetermined time period while the image 19 of the suspect is on the screen, the film strip 17*c* (FIG. 3*c*) comes on the screen and causes simultaneous activation of both photodetectors 33 and 34. Lamp 51*b* is then illuminated, which is a signal to the operator that he should operate the control 53 to effect simultaneous operation of all of the kill-sequence devices 25, 29 and 30. Actuator 25 then effects horizontal jerking of platform 24 to startle the trainee 16, valve 29 is opened to cause air from source 27 to pass through tube 28 and blow in the face of the trainee, and power source 30 is activated to cause strobe lamp 20 to flash a bright light in the face of the trainee. Furthermore, as shown in FIG. 3*c*, the projector 13 then projects weird psychedelic images on the screen. The total result is a psychological simulation of wounding or dying of the trainee 16.

It is emphasized that the present simulator may be made more complex and elaborate than that which is described above. For example, a riot may be simulated, complete with throwing of bricks at the trainee. In addition, it is pointed out that other environment simulating means may be provided, for example to generate odors simulative of those present at the scene.

The code means on film 17 (namely, openings 36, 38, 39 and 40) and the photodetectors 33 and 34 may in some cases be replaced by other types of correlating means. For example, means may be provided to count the frames of the film. As another example, signal means may be provided on the sound track of the film.

It is within the scope of the appended claims to employ reverse logic. Thus, for example, the motion picture film 17 may have a first portion showing the suspect in the act of performing antisocial behavior, and a second portion showing the suspect in a killed or wounded condition. The logic and control circuitry would then, in response to failure of the trainee to hit target area 11 during the predetermined time period, stop the film 17 and substitute a film showing the suspect shooting at the trainee.

The projectors may be replaced by other image reproducers, for example of the video tape type, without avoiding the accompanying claims.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

We claim:

1. A training method for simulating the environment incident to a law enforcement confrontation, which comprises:

a. projecting on a screen a motion picture film scene showing a hypothetical suspect who is about to commit, or is in the act of committing, antisocial behavior of such nature that a law enforcement officer should shoot said suspect,

b. determining whether or not a law enforcement trainee has shot accurately at a predetermined area of said screen during a predetermined time period when a part of the body of said suspect was being projected on said predetermined area, and

c. following one of a plurality of alternative procedures depending upon whether or not said shot was accurately directed at said predetermined area during said predetermined time period,

one of said procedures being followed if said shot was accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen a second film scene which shows said suspect in a wounded or killed condition,

another of said procedures being followed if said shot was not accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen another film scene showing said suspect shooting at said trainee,

d. causing said trainee to employ a pistol which shoots a projectile at said screen, and effecting said determination of whether or not said shot was accurately aimed by means of an impact-sensing means associated with said predetermined area of said screen,

e. providing code means on said film to determine said predetermined time period, and effecting said determination of whether or not said shot was accurately directed by ANDing a signal from said impact-sensing means with a signal generated in response to said code means.

2. A training method for simulating the environment incident to a law enforcement confrontation, which comprises:

a. projecting on a screen a motion picture film scene showing a hypothetical suspect who is about to commit, or is in the act of committing, anitsocial behavior of such nature that a law enforcement officer should shoot said suspect,

b. determining whether or not a law enforcement trainee has shot accurately at a predetermined area of said screen during a predetermined time period when a part of the body of said suspect was being projected on said predetermined area, and

c. following one of a plurality of alternative procedures depending upon whether or not said shot was accurately directed at said predetermined area during said predetermined time period,

one of said procedures being following if said shot was accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen a second film scene which shows said suspect in a wounded or killed condition,

another of said procedures being followed if said shot was not accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen another film scene showing said suspect shooting at said trainee,

d. determining said predetermined time period by determining which frames of said motion picture film are being projected by the projector for said motion picture film.

3. A training method for simulating the environment incident to a law enforcement confrontation, which comprises:

a. projecting on a screen a motion picture film scene showing a hypothetical suspect who is about to commit, or is in the act of committing, antisocial behavior of such nature that a law enforcement officer should shoot such suspect,

b. determing whether or not a law enforcement trainee has shot accurately at a predetermined area of said screen during a predetermined time period when a part of the body of said suspect was being projected on said predetermined area, and

c. following one of a plurality of alternative procedures depending upon whether or not said shot was accurately directed at said predetermined area during said predetermined time period,

one of said procedures being followed if said shot was accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen a second film scene which shows said suspect in a wounded or killed condition,

another of said procedures being followed if said shot was not accurately directed at said predetermined area during said predetermined timer period, and comprising projecting on said screen another film scene showing said suspect shooting at said trainee,

d. creating, after said following of said other of said procedures, psychological responses in said trainee and which simulate the wounding of said trainee, creating one of said psychological responses by causing said trainee to be standing on a platform, and then suddenly moving said platform at about the same time that the projected image of said suspect shoots at said trainee.

4. A training method for simulating the environment incident to a law enforcement confrontation, which comprises:

a. projecting on a screen a motion picture film scene showing a hypothetical suspect who is about to commit, or is in the act of committing, antisocial behavior of such nature that a law enforcement officer should shoot said suspect,

b. determining whether or not a law enforcement trainee has shot accurately at a predetermined area of said screen during a predetermined time period when a part of the body of said suspect was being projected on said predetermined area, and

c. following one of a plurality of alternative procedures depending upon whether or not said shot was accurately directed at said predetermined area during said predetermined time period,

one of said procedures being followed if said shot was accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen a second film scene which shows said suspect in a wounded or killed condition,

another of said procedures being followed if said shot was not accurately directed at said predetermined area during said predetermined time period, and comprising projecting on said screen another film scene showing said suspect shooting at said trainee,

d. creating, after said following of said other of said procedures, psychological responses in said trainee and which simulate teh wounding of said trainee, and creating one of said psychological responses by projecting images of psychologically impressive patterns on said screen.

5. A method of training a law enforcement trainee by simulating realistically a law enforcement emergency condition involving a confrontation between the trainee and a suspect, which method comprises:

a. providing a projection screen incorporating a target area which is associated with means to determine whether or not a projectile strikes said target area,

b. causing the trainee to be located in a predetermined position relative to said screen,

c. projecting on said screen a motion picture film which shows the environment of a location where a confrontation is taking place or is about to take place,

d. projecting on said screen a motion picture film showing a decoy,

e. determining whether or not the trainee fires a weapon while the image of said decoy is being projected on said screen,

f. stopping the training procedure if said trainee does fire his weapon, and communicating to the trainee the information that he had made a mistake,

g. projecting on said screen a motion picture film showing a suspect,

h. determining whether or not the trainee fires a weapon and hits said target area of said screen during a predetermined time period when a portion of the image of the body of said suspect is coincident with said target area,

i. following one of at least two alternative procedures depending upon whether or not said projectile hits said target area during said predetermined time period,

the first of said alternative procedures being to project on said screen a first alternative film scene showing said suspect in a dead or dying condition, and being followed if said projectile does strike said target area during said predetermined time period,

the second of said alternative procedures being to project on said screen a second alternative film scene showing said suspect firing at said trainee, and being followed if said projectile does not strike said target area during said predetermined time period, and

j. creating physical and psychological responses in said trainee if said second of said alternative procedures was followed, said responses being related to the wounding of said trainee by said suspect.

6. Training apparatus comprising

a plurality of film projectors for projecting image sequences from first and second films, at least said first film including a first scene comprising a first group of frames and a second scene comprising a second group of frames,

means for producing a first scene identifying signal as frames of said first group are projected and for producing a second scene identifying signal as frames of said second group are projected,

a screen,

means for causing said first film to be projected thereon,

means for firing a projectile at the screen,

control means for controlling said projectors,

a first sensor for generating a first action signal in response to the firing of said projectile,

first logic means responsive to said first action signal and to said first scene identifying signal for operating said control means to stop projection of said first film upon the screen and start projection of the second film upon the screen,

said control means including means for controlling termination of projection of said second scene,

a second sensor associated with the screen for generating a second action signal indicative of the accuracy of the firing of said projectile at the screen, and

second means responsive to said second scene identifying signal and to said second action signal for operating said control means to stop projection of said first film upon the screen.

7. The apparatus of claim 6 wherein said control means includes means for stopping projection of said first film if a predetermined accuracy of the projectile firing exists and starting projection of a third film upon the screen.

8. The training apparatus of claim 7 wherein said first logic means comprises a coincidence gate responsive to simultaneous occurrence of said first action signal and said first scene identifying signal and wherein said second logic means comprises a second coincidence gate responsive to simultaneous occurrence of said second scene identifying signal and said second action signal.

9. The apparatus of claim 6 wherein said first scene presents the image of a decoy simulating a suspect, wherein said first sensor comprises a microphone responsive to the sound of said projectile firing an independent of the accuracy of the projectile firing, wherein said second scene comprises the image of a suspected assailant and wherein said second sensor comprises means on the screen for detecting impact of a projectile thereon.

10. The training apparatus of claim 6 wherein said means for producing a first scene identifying signal comprises a pattern of opaque and transparent areas on each of the frames of said first group of frames, whereby said first logic means will receive said first scene identifying signal substantially throughout the projection of said first scene, said first sensor comprising a photosensitive detector mounted to said screen for illumination by said pattern of opaque and transparent areas.

* * * * *

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United States Patent [19]

Fidel

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[45] Date of Patent: Nov. 11, 1986

[54] PARALLEL PROCESSING OF SIMULTANEOUS ULTRASOUND VECTORS

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[73] Assignee: Irex Corporation, Ramsey, N.Y.

[21] Appl. No.: 476,672

[22] Filed: Mar. 18, 1983

[51] Int. Cl.[4] G01S 7/52; G01S 7/62; G06F 13/00; G06F 15/42

[52] U.S. Cl. 364/414; 73/626; 128/660; 364/200

[58] Field of Search .... 364/414, 200 MS File, 364/900 MS File; 358/112, 140; 343/5 SC; 367/11, 113; 128/660; 73/626

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Primary Examiner—Jerry Smith

Assistant Examiner—Clark Jablon

Attorney, Agent, or Firm—W. Brinton Yorks, Jr.

[57] ABSTRACT

Apparatus and a method are provided for processing simultaneously produced vector information signals in an ultrasonic diagnostic imaging system. Two vector signals in the form of simultaneous sequences of digital words are alternately sampled and a sequence of interleaved words of the two simultaneous sequences is stored in consecutive locations of a memory. The words are then read out of the memory by first addressing even memory locations, then odd locations, to produce the two vector information signals in a serial sequence.

8 Claims, 4 Drawing Figures

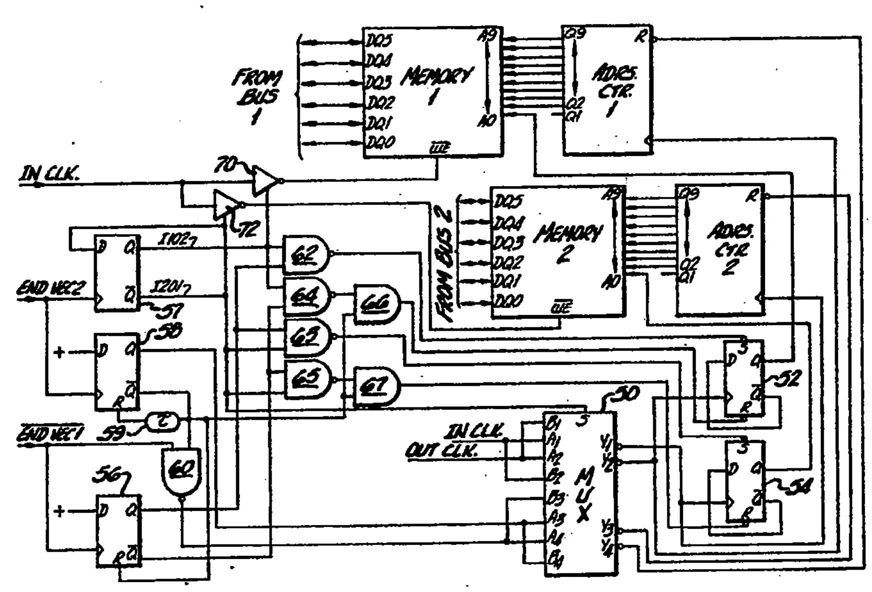
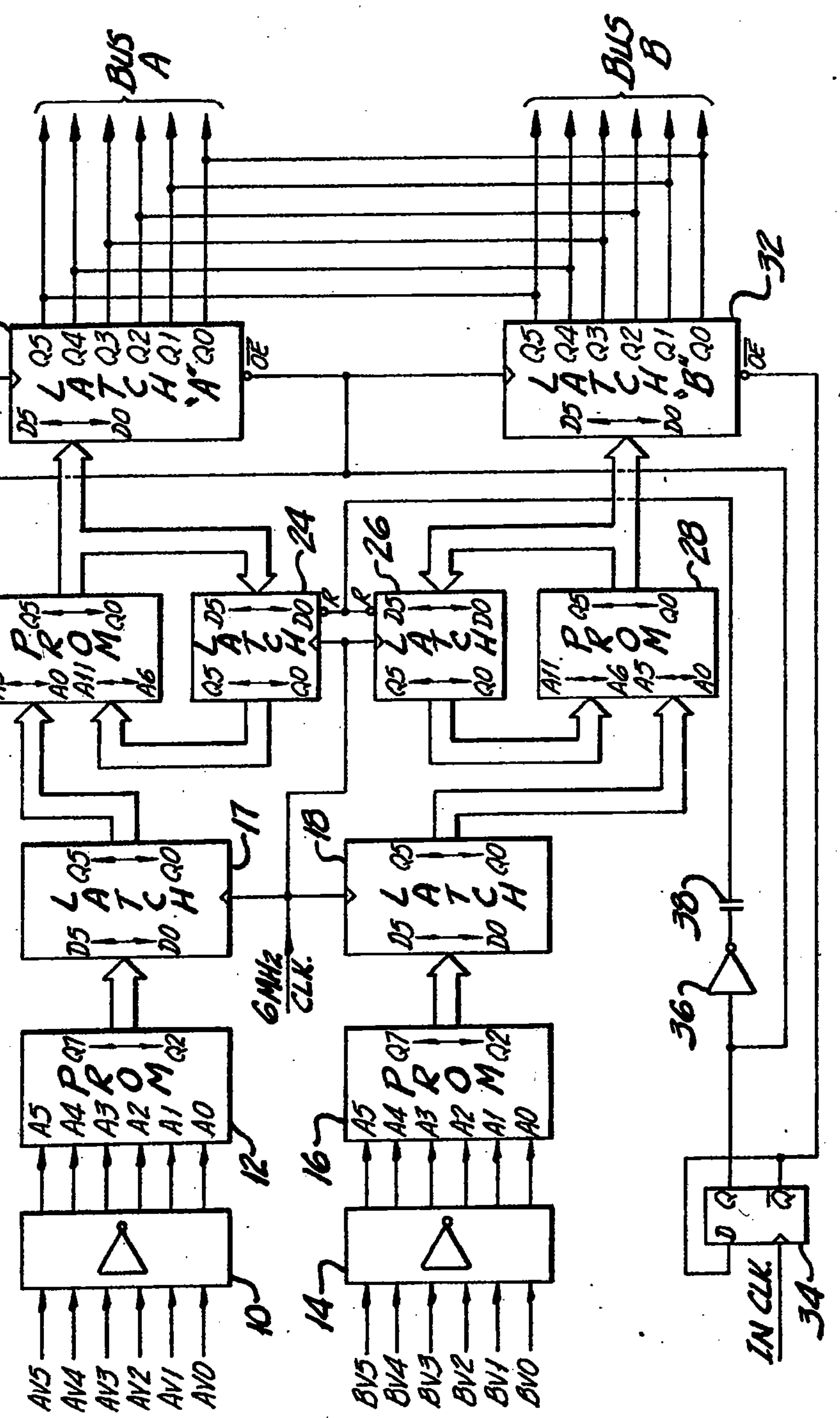


FIG-1


BUS A
BUS B
PROM
LATCH
LATCH "A"
LATCH "B"
6MHz CLK.
IN CLK.
AV5
AV4
AV3
AV2
AV1
AV0
BV5
BV4
BV3
BV2
BV1
BV0
10
12
14
16
17
18
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28
30
32
34
36
38

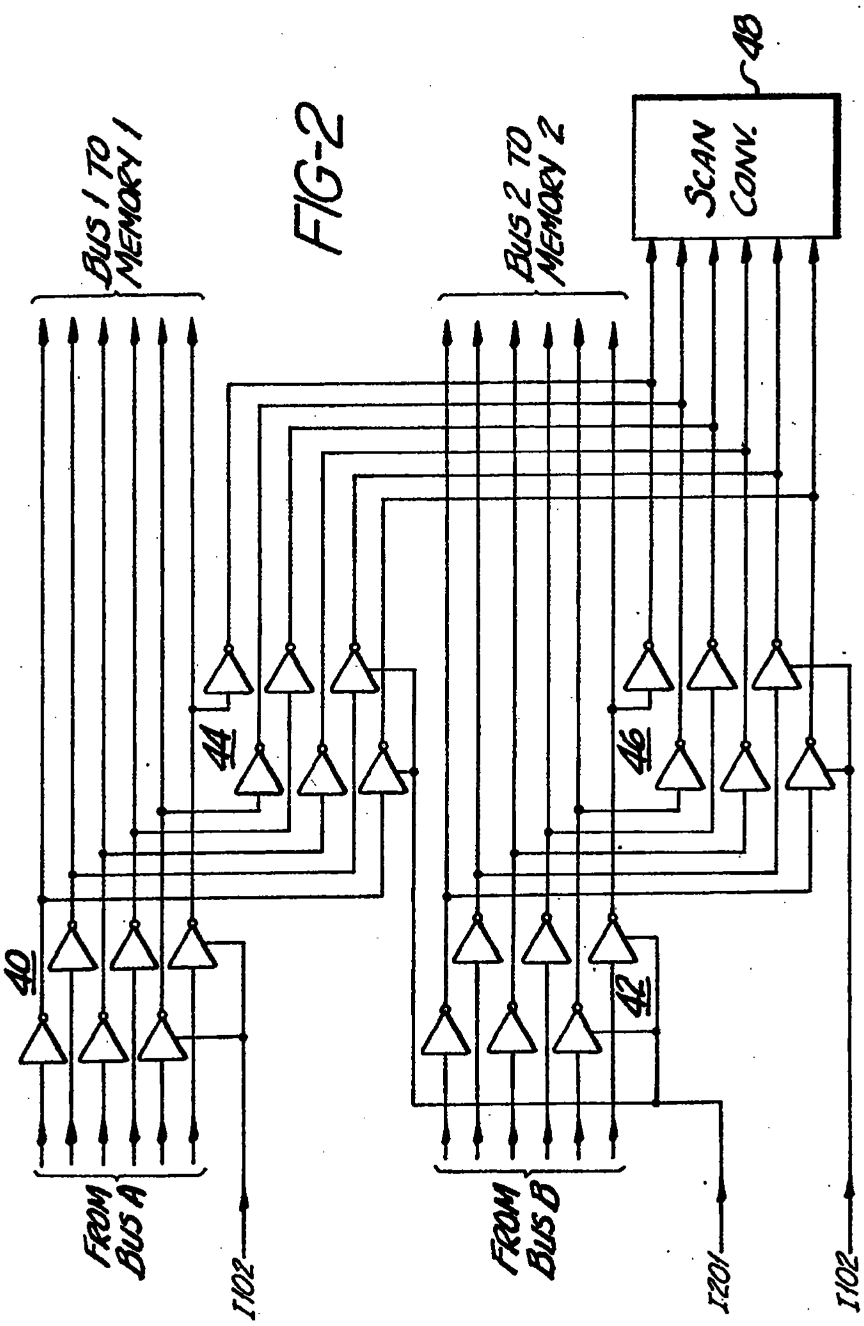
BUS 1 TO MEMORY 1
BUS 2 TO MEMORY 2
SCAN CONV.
48
40
44
46
42
FROM BUS A
FROM BUS B
I102
I201
I102

FIG-2

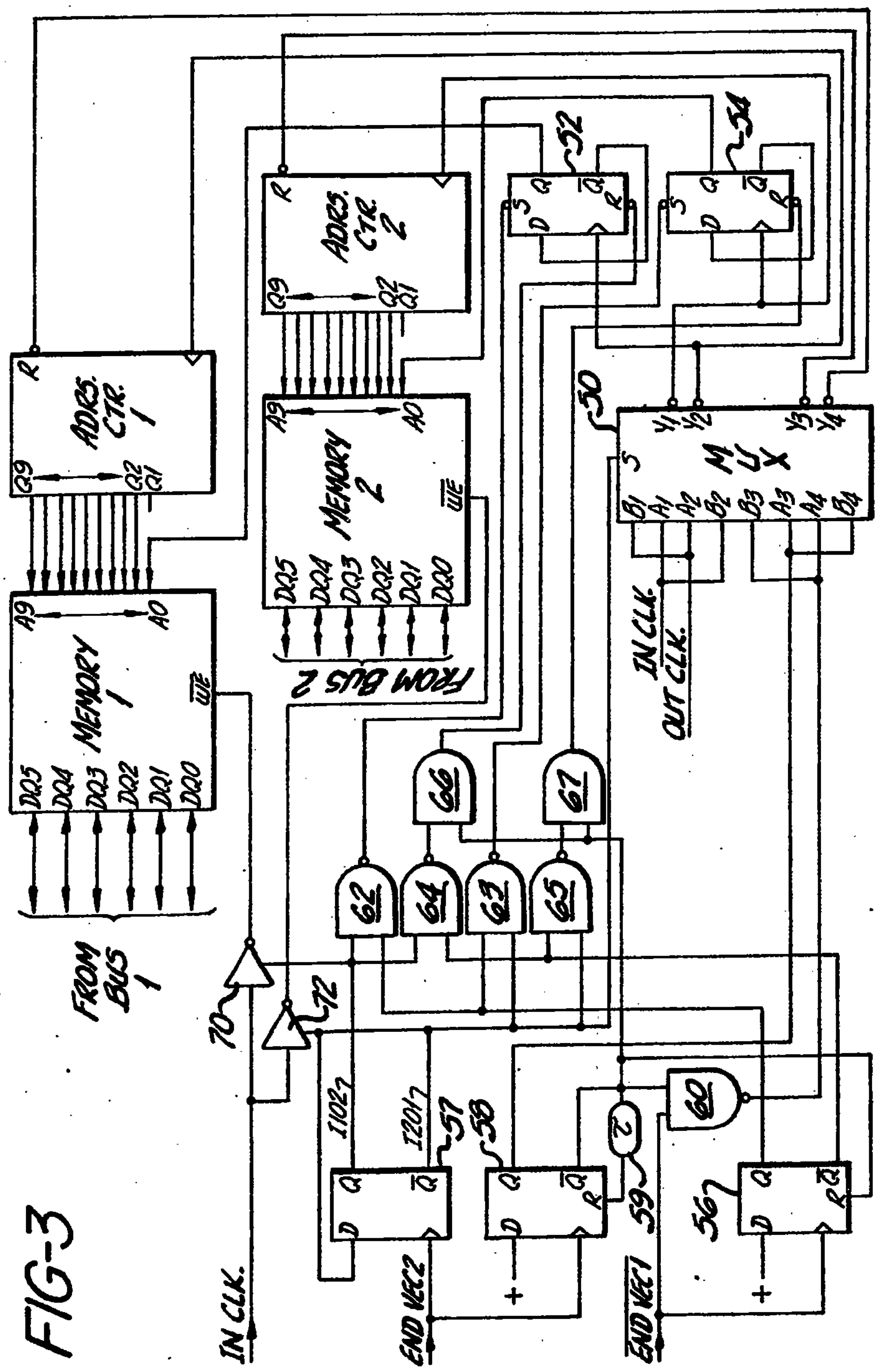
MEMORY 1
ADRS. CTR. 1
MEMORY 2
ADRS. CTR. 2
FROM BUS 1
FROM BUS 2
MUX
IN CLK.
OUT CLK.
END VEC2
END VEC1

FIG-3

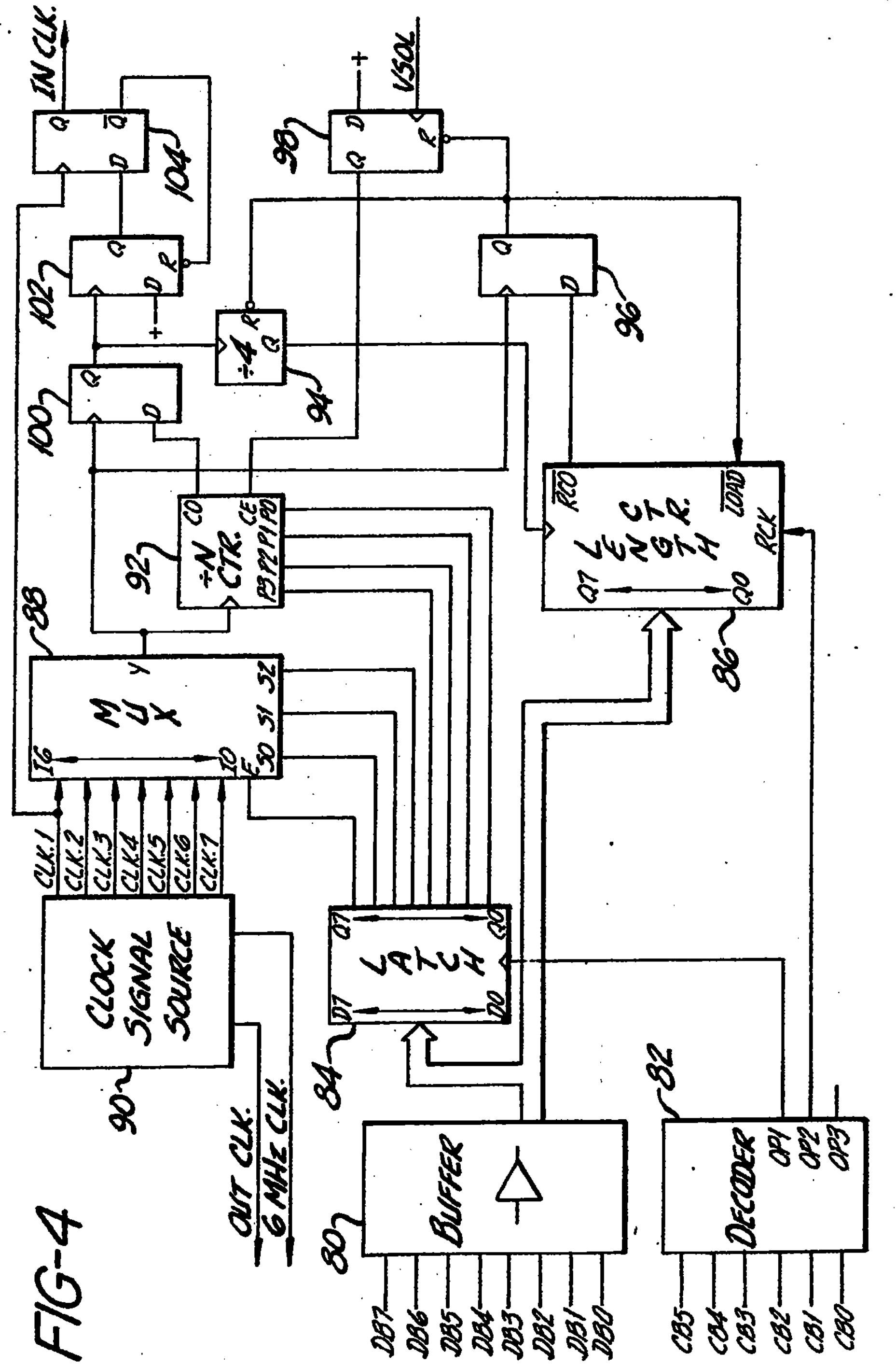
IN CLK.
VSOL
CLOCK SIGNAL SOURCE
MUX
÷N CTR.
÷4
LATCH
LENGTH CTR.
BUFFER
DECODER
OUT CLK.
6 MHz CLK.
CLK.1
CLK.2
CLK.3
CLK.4
CLK.5
CLK.6
CLK.7
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0
CB5
CB4
CB3
CB2
CB1
CB0
OP1
OP2
OP3
80
82
84
86
88
90
92
94
96
98
100
102
104

FIG-4

PARALLEL PROCESSING OF SIMULTANEOUS ULTRASOUND VECTORS

This invention relates to the parallel processing of simultaneous ultrasound vectors in an ultrasonic diagnostic imaging system and, in particular, to the parallel processing of simultaneous vectors for image display.

In an ultrasonic diagnostic imaging system, echo information from a patient's body is received by one or more ultrasonic transducers. A continuous stream of echo information from a given direction relative to the transducer plane comprises a line or vector of information. A number of these lines from different directions in a common plane may be combined to form an image of that tissue plane of the patient's body.

When a linear array of transducer elements is used to receive the echo information, the signals received by the elements are passed through signal delay paths of different lengths and combined to form an ultrasound vector. Vectors at different angles relative to the transducer array plane are obtained by passing the echo information from numerous ultrasound transmissions through differing combinations of delay paths.

Essentially the same result obtained from several transmissions can be produced by passing the echo information received from a single transmission through several combinations of delay paths at the same time. The delayed signals from the different combinations of delay paths are then combined by respective signal combining networks to produce several different ultrasound vectors simultaneously, a technique known as parallel processing. Techniques for delaying and combining echo information signals in parallel are described in British Patent Application No. 8,307,654, entitled "PARALLEL ULTRASONIC INFORMATION PROCESSING," filed on Mar. 18, 1983.

Once the ultrasound vectors have been received, they must be put into a form suitable for display. This is generally done by a digital scan converter in conventional ultrasound systems. The digital scan converter receives the vectors, which correspond to polar coordinate information, and converts the vector information into X-Y coordinate information suitable for display on a television screen. Present scan converters are only capable of processing one vector at a time, however. Thus, it is necessary to provide means for processing simultaneous vectors so that they can be sequentially applied to the scan converter with a minimal amount of circuitry which does not result in any loss of vector information.

In accordance with the principles of the present invention, a system is provided for processing simultaneous ultrasound vectors so that they may be sequentially entered into a scan converter. Two vectors, each comprising a sequence of digital words, are sampled in parallel, and stored in a first memory in a format in which the words of the two vectors are interleaved. At the same time, vector words are read from a second memory which has been loaded in the same manner by first reading out even address location words comprising one vector, and then reading out odd address location words comprising the other vector. The sequentially read vector information is entered into the scan converter. After the process is completed the system switches to simultaneously load the second memory with new vector words and read the previously stored vector words from the first memory. In a preferred embodiment of the present invention the data rates and lengths of the parallel vectors are variable in accordance with the depth and size of the image of the patient's body and the output data rate is constant in accordance with the performance characteristics of the scan converter.

In the Drawings:

FIG. 1 illustrates in block diagram form, an input circuit for receiving parallel ultrasound vector information;

FIG. 2 illustrates a steering circuit for the parallel ultrasound vector information received by the arrangement of FIG. 1;

FIG. 3 illustrates in logic diagram form an arrangement for processing the parallel ultrasound vector information of FIGS. 1 AND 2 in accordance with the principles of the present invention; and

FIG. 4 illustrates circuitry for producing the clock signals for the arrangements of FIGS. 1-3.

Referring to FIG. 1, circuitry for processing two ultrasound vectors in parallel is shown in block diagram form. Words of an "A" vector consist of six bits, AVO-AV5, which are received by a buffer 10. A simultaneous "B" vector, also six bits in word length, is received by a buffer 14. The vector words are coupled from the buffers to the address inputs of programmable read-only-memories (PROM'S) 12 and 14. The PROM'S may be used to compress or expand the vector word data over certain parts of their dynamic range, or may be used to convert the six-bit words to words of other bit lengths in the event that the scan converter used does not accept six-bit words. In this example it will be assumed that no conversion is done by the PROM's, and that the six-bit A and B vector words produced by PROM's 12 and 14 are latched into respective latches 17 and 18 by a 6 MHz clock.

The vector words are then applied to a peak or average detector 20. Each vector word is applied to some of the address bits of PROM's 22 and 28, respectively, along with data from respective latches 24 and 26. Each PROM 22 and 28 then produces an output word which is the peak or the average value of the two words at the address inputs, depending upon the program data. The PROM output words are latched into the latches 24 and 26 by the 6 MHz clock, and the latched words are applied to the PROM address inputs. The latches will thus always hold the peak or average value of the applied data until such time as they reset, which values will likewise be produced by the PROM's 22 and 28 and applied to the inputs of latches 30 and 32.

An input clock signal, identified as INCLK, is applied to the clock input of a flip-flop 34. The Q output of flip-flop 34 is connected to its D input so that the flip-flop 34 will divide the INCLK signal frequency by two. The Q output of flip-flop 34 is coupled to the clock inputs of latches 32 and 30 so that the leading edge of the Q output signal will load the peak- or average-detected A and B words into the latches simultaneously. The Q output of flip-flop 34 is also coupled to the output enable input of latch 30 so that the high Q output signal will put the latched A word on the Bus A and Bus B by enabling the tristate outputs of the latch 30. The $\overline{Q}$ output of latch 34 is coupled to the output enable input of latch 32 to put the B words on the Bus A and Bus B when the $\overline{Q}$ signal is high. The Q output signal of flip-flop 34 is also applied to the input of an inverter 36, the output of which is coupled by a capacitor 38 to the reset inputs of the latches 24 and 26. When the Q output signal goes high, a low-going spike is applied to the latches 24 and 26 to reset them at the occurrence of every other INCLK signal. The peak or average value detectors 20 will detect the peak or average of the vector words passing between the times that the PROM data is loaded into the latches 30 and 32 by the Q output signal of flip-flop 34.

Buses A and B are coupled to tri-state gates, which conduct the vector words into and out of memories, as shown in FIG. 2. The gates shown at 40 are coupled to conduct vector word data from Bus A and Bus B to Bus 1 when the gates are enabled by the low state of control signal I102. The low condition of the I102 signal also enables the output gates shown at 46, which conduct vector words from memory Bus 2 to the inputs of a scan converter pre-processor 48. The gates shown at 42 couple vector words from Bus A and Bus to memory by way of Bus 2 when enabled by the low state of a control signal identified as I201. The low I201 signal also enables the output gates shown at 44, which couple data from BUS 1 and memory 1 to the inputs of the scan converter pre-processor 48.

Referring to FIG. 3, an arrangement for converting the parallel ultrasound vector words to a serial format for the scan converter is shown. Bus 1 of FIG. 2 is coupled to the input/output lines DQ0–DQ5 of a memory 1 and Bus 2 is coupled to the input/output lines of a memory 2. The least significant address bit AO of memory 1 is coupled to the Q output of a flip-flop 52 and the remaining address lines of memory 1 are coupled to the Q2–Q9 outputs of an address counter 1. The least significant address bit of memory 2 is coupled to the Q output of a flip-flop 54, and the remaining memory 2 address lines are coupled to the Q2–Q9 outputs of an address counter 2. An output clock signal, identified as OUTCLK, is coupled to the B1 and A2 inputs of a quad two-input inverting multiplexer 50, and the INCLK signal is coupled to the A1 and B2 inputs of the multiplexer 50. The Y1 output of the multiplexer 50 is coupled to the clock input of flip-flop 54 and to the clock input of address counter 2. The Y2 output of the multiplexer 50 is coupled to the clock inputs of flip-flop 52 and address counter 1. The Q outputs of each of flip-flops 52 and 54 are coupled to the respective D inputs of the flip-flops. The Y3 output of multiplexer 50 is coupled to the reset input of address counter 2, and the Y4 output of multiplexer 50 is coupled to the reset input of address counter 1.

A signal $\overline{\text{ENDVEC1}}$ is applied to the clock input of a flip-flop 56 and to an input of a NAND gate 60. A signal ENDVEC2 is applied to the clock inputs of flip-flops 57 and 58. The I102 signal is produced at the Q output of flip-flop 57 and is applied to the control input of a tristate inverter 70 and inputs of NAND gates 62 and 64, as well as the control inputs of the gates shown at 40 and 46 in FIG. 2. The I201 signal is produced at the $\overline{\text{Q}}$ output of flip-flop 57, which is coupled to the D input of the flip-flop, the control input of a tri-state inverter 72, inputs of NAND gates 63 and 65, and the select input S of the multiplexer 50, as well as the gates shown at 42 and 44 in FIG. 2.

The Q output of flip-flop 58 is coupled to the A3 and B4 inputs of multiplexer 50. The $\overline{\text{Q}}$ output of flip-flop 58 is coupled to the reset input of the flip-flop by a delay element 59, to inputs of NAND gate 60 and AND gates 66 and 67, and to the reset input of flip-flop 56. The output of NAND gate 60 is coupled to the B3 and A4 inputs of multiplexer 50.

The Q output of flip-flop 56 is coupled to inputs of NAND gates 62 and 63, and the $\overline{\text{Q}}$ output of flip-flop 56 is coupled to inputs of NAND gates 64 and 65. The output of NAND gate 64 is coupled to an input of AND gate 66, and the output of NAND gate 65 is coupled to an input of AND gate 67. The output of NAND gate 62 is coupled to the set input of flip-flop 52 and the output of AND gate 66 is coupled to the reset input of flip-flop 52. The output of NAND gate 63 is coupled to the set input of flip-flop 54 and the output of AND gate 67 is coupled to the reset input of flip-flop 54. The output of inverter 70 is coupled to the write enable input of memory 1 and the output of inverter 72 is coupled to the write enable input of memory 2. The INCLK signal is applied to the inputs of inverters 70 and 72.

In operation, the arrangement of FIG. 3 writes alternate words of the A and B vectors into consecutive memory locations of one of the memories. This will result in the storage of the A vector words in consecutive even address memory locations, for instance, and the storage of B vector words at consecutive odd address memory locations. At the same time, vector information is read out of the other memory, which has previously been loaded in the same manner. Vector words are read first from sequential even address locations and sent to the scan converter pre-processor 48. This transmits the A vector words in sequence to the scan converter in this example. After all the A vector words have been transmitted, vector words are read from the odd address locations of the memory, which transmits the B vector information to the scan converter. After all the incoming A and B vector words have been stored in the first memory and the stored vectors read from the second memory, the system switches so that new information is written into the second memory and the previously stored vectors are read from the first memory and transmitted to the scan converter. The memories are ping-ponged in this manner until all vectors are stored in the scan converter for the construction and display of an ultrasound image.

To follow this example in greater detail, assume that flip-flop 57 is reset so that the I102 signal is low and that the I201 signal is high. The low I102 signal will assume control of the system to write data into memory 1 and read data out of memory 2. The I102 signal will enable gates 40 in FIG. 2 so that A and B vector words from alternately enabled latches 30 and 32 of FIG. 1 will be conducted into memory 1 by way of Bus 1. The I102 signal also enables gates 46 to conduct data words out of memory 2 by way of Bus 2 and into the scan converter preprocessor 48. The low I102 signal enables gate 70 so that the INCLK signal is applied to the write enable input of memory 1 to load data words into that memory.

Tri-state gates controlled by the high I201 signal are disabled at this time.

The high I201 signal at the select input of multiplexer 50 connects the B inputs of the multiplexer to their respective Y outputs. The INCLK signal appears in inverted form at the Y2 output, which toggles flip-flop 52. The Q output signal of flip-flop 52 changes state with every INCLK pulse so that the least significant address line AO of memory 1 changes state in synchronism with the INCLK signal and the arrival of each new data word on BUS 1. The inverted INCLK signal at the Y2 output of the multiplexer 50 also clocks address counter 1, which addresses sequential locations of memory 1. The A and B vector words are thus written into sequential locations of memory 1 in an A, B, A, B, etc. format beginning with address location zero.

As the writing of words into memory 1 commences, the low I102 signal at the inputs of NAND gates 62 and 64 cause the outputs of these gates to be high. Flip-flop 58 is reset at this time, and the high Q output signal of flip-flop 58 produces high signals at respective inputs of AND gates 66 and 67. The high output signal of NAND gate 62 is applied to the set input of flip-flop 52, and the high output signal of NAND gate 64 is applied by way of AND gate 66 to the reset input of flip-flop 52, enabling flip-flop 52 to toggle with the inverted INCLK signal at its clock input.

Flip-flop 56 is reset at this time, and its outputs apply a low input signal to one input of NAND gate 63 and a high input signal to one input of NAND gate 65. NAND gate 63 thus applies a high signal to the set input of flip-flop 54. Because the I201 signal is high, the two high input signals of NAND gate 65 produce a low output signal for that gate, which low signal is applied to the reset input of flip-flop 54. Flip-flop 54 is thereby held in a reset state and applies a low signal to the least significant address bit AO of memory 2. The inverted OUTCLK signal at the Y1 output of the multiplexer 50 clocks the address counter 2, which reads vector words out of even address locations of memory 2. In this example, the A vector words at the even address locations would be read sequentially from memory 2 and transmitted to the scan converter pre-processor 48 by way of Bus 2 and gates 46.

When all the A vector words have been read from memory 2, the $\overline{\text{ENDVEC1}}$ signal goes low momentarily, which sets flip-flop 56 and produces a momentary high signal at the output of NAND gate 60. The signal from NAND gate 60 is applied to the B3 input of the multiplexer 50 and appears as a short low pulse at the Y3 output. This pulse resets address counter 2 back to zero. The low $\overline{Q}$ output signal of flip-flop 56 produces a high signal at the output of NAND gate 65, which is applied to the reset input of flip-flop 54. The high Q output signal of flip-flop 56 in combination with the high I201 signal produces a low signal at the output of NAND gate 63, which low signal is applied to the set input of flip-flop 54. Flip-flop 54 is now forced to apply a steady high signal to the least significant address bit AO of memory 2. The inverted OUTCLK signal at the Y1 output of the multiplexer 50 causes the address counter 2 to resume counting, and this time odd address locations are read in sequence. This reads out the B vector words, which are transmitted to the scan converter pre-processor.

When all the B vector words have been read from memory, an $\overline{\text{ENDVEC2}}$ pulse sets flip-flops 57 and 58. Flip-flop 58 is set only momentarily, because its Q output is connected to its reset input so that the flip-flop will reset itself after a delay of T. During the short time that flip-flop 58 is set, its low $\overline{Q}$ output signal is applied to the reset inputs of flip-flops 52 and 54 by way of AND gates 66 and 67, thereby resetting these two flip-flops to their initial condition. The high Q output signal of flip-flop 58 is applied to the B4 input of the multiplexer 50, which produces a low signal at the Y4 output to reset address counter 1 to zero. The low $\overline{Q}$ output signal of flip-flop 58 is conducted by way of NAND gate 60 and the B3 input of the multiplexer 50 to the Y3 output which resets the address counter 2 to zero.

When flip-flop 57 changes state, the states of the I102 and I201 signals change. This switches operation of the system so that the next arriving vector words will be written into memory 2, and the vector words previously written into memory 1 will be read out, even addresses first, and transmitted to the scan converter. The change of state of the I201 signal selects the A inputs of the multiplexer 50 so that the INCLK signal will be applied to address counter 2 and flip-flop 54, and the OUTCLK signal applied to address counter 1. Memory operation is switched back and forth in this manner by the toggling of flip-flop 57 until all of the parallel vectors have been transmitted sequentially to the scan converter.

Clock signals for a preferred embodiment of the present invention are provided by the arrangement of FIG. 4. Data bits DBO–DB7 from a controller (not shown) are applied by way of a buffer 80 to inputs of a latch 84 and a length counter 86. Control bits CBO–CB5 from the controller are applied to a decoder 82, which decodes the applied signals to produce operational control signals at outputs OP1 and OP2. The OP1 output is coupled to the clock input of latch 84 and the OP2 output is coupled to the RCK input of the length counter 86. Outputs QO–Q3 of the latch 84 are coupled to preset inputs PO–P3 of a divide-by-N counter 92, outputs Q4–Q6 of latch 84 are coupled to select inputs S0–S2 of a multiplexer 88, and latch output Q7 is coupled to the enable input of the multiplexer 88.

A clock signal source 90, including a crystal oscillator and a count-down chain of flip-flops, produces the OUTCLK signal and the 6 MHz clock signal for the arrangement of FIG. 1. The clock signal source 90 also produces a plurality of different frequency clock signals which are applied to inputs of the multiplexer 88. The CLK1 signal of the source 90 is also applied to the clock input of a flip-flop 104.

The Y output of the multiplexer 50 is coupled to the clock inputs of the divide-by-N counter 92 and flip-flops 100 and 96. The carry-out output of the counter 92 is coupled to the D input of flip-flop 100. The Q output of flip-flop 100 is coupled to the clock inputs of a flip-flop 102 and a divide-by-four counter 94. The Q output of flip-flop 102 is coupled to the D input of flip-flop 104 and the $\overline{Q}$ output of flip-flop 104 is coupled to the reset input of flip-flop 102. The INCLK signal is produced at the Q output of flip-flop 104.

The output of the divide-by-four counter 94 is coupled to the clock input of the length counter 86. The carry-out output $\overline{\text{RCO}}$ of the length counter 86 is coupled to the D input of flip-flop 96. The output of flip-flop 96 is coupled to the reset inputs of the divide-by-four counter 94 and a flip-flop 98, and to the load input of the length counter 86. A vector start signal VSOL is applied to the clock input of flip-flop 98. The output of flip-flop 98 is coupled to the counter enable input of the divide-by-N counter 92.

Pulses of the INCLK signal must necessarily be aligned in time with the arrival of the parallel A and B vector words. The frequency of the INCLK signal in the preferred embodiment is a function of the size of the image display and the depth of the vector in the patient's tissue. Three size clocks are available: a 24.6 MHz clock for a full size display, a 16.38 MHz clock for a two-thirds size display and an 8.19 MHz clock for a one-third size display. The appropriate size clock is chosen by the select signal lines of the multiplexer 88. The image depth in centimeters can range from four to twenty-four centimeters in increments of two centimeters. The image depth is accounted for by the value of N chosen by the preset input signals to the divide-by-N counter 92. The INCLK signal in the preferred embodiment follows the formula:

$$INCLK = \frac{\text{Size Clock}}{\text{Depth in cm.}/2}$$

Finally, the length counter counts the INCLK pulses so that an INCLK pulse is produced for each vector word. Each vector can have a maximum length of 320 words, or a total of 640 words for two parallel vectors of maximum length. The length counter stops the INCLK signal when the appropriate number of pulses has been produced.

The sequence of operation of the arrangement of FIG. 4 is as follows. First, data bits DBO–DB7 arrive containing information as to the desired frequency of the size clock and the value of N. The control bits CBO–CB5 are decoded at this time to produce a pulse at the OP1 output of the decoder 82, which latches the size clock and N values into the latch 84. The multiplexer 88 then selects the proper size clock, which is produced at the Y output, and the proper N value is preset into the divide-by-N counter 92.

Next, data bits representing the vector length are applied to the buffer 80 and an OP2 control signal is decoded to load the vector length value into the length counter 86. System initialization is now complete, and the system awaits the arrival of a VSOL signal.

When the vector words are about to enter the system, the VSOL signal sets flip-flop 98. The Q output signal of flip-flop 98 enables the divide-by-N counter 92, which counts pulses of the size clock and produces pulses at regular intervals at its CO output. These pulses cause flip-flop 100 to be set, which aligns the pulses in time with the size clock pulses. The pulses produced by flip-flop 100 are then aligned in time with pulses of the high frequency signal CLK1 by flip-flops 102 and 104, the latter producing INCLK signal pulses of the desired pulse length, phase and frequency.

The pulses produced by flip-flop 100 clock the divide-by-four counter 94, which prescales the input clock signal frequency for the length counter 86. The length counter 86 counts the prescaled clock pulses until an appropriate number of pulses have been counted in accordance with the previously loaded length value. At that time a low-going carry-out signal is produced at the $\overline{RCO}$ output of the length counter. This signal causes flip-flop 96 to be reset by a size clock pulse, and the Q output of the flip-flop 96 goes low. This low signal resets the divide-by-four counter 94 and resets flip-flop 98. When flip-flop 98 is reset its Q output signal goes low, which disables the divide-by-N counter 92. The production of INCLK pulses then stops. The low Q output signal of flip-flop 96 is also applied to the load input of the length counter 86 so that the counter 86 is initialized and ready to begin counting the length of the next pair of vectors. Initialization of the length counter 86 also causes the $\overline{RCO}$ output of the counter to go high, which in turn causes flip-flop 96 to be clocked to a high output state by the next size clock pulse at its clock input. The system is now initialized and awaits the arrival of the next VSOL pulse.

If desired, the OUTCLK signal can be gated on and off under control of a second length counter for the production of an OUTCLK signal of a known number of pulses, in the same manner that the length counter 86 gates the INCLK signal.

What is claimed is:

1. In an ultrasonic diagnostic imaging system, apparatus for processing simultaneous first and second ultrasonic vector information signals, each of which comprises a sequence of digital words, comprising:
   - a first digital memory having an input and an output;
   - means, responsive to said simultaneous vector information signals, for alternately steering words of said first and second vector information signals to the input of said first memory;
   - first address means, coupled to said first memory, for addressing sequential locations of said first memory in synchronism with the arrival of words of vector information at said input of said first memory so as to load words of said respective vector information signals alternately into sequential memory locations;
   - control means, coupled to said first address means, for controlling said first address means to read vector information signal words from sequential even memory locations of said first memory and from sequential odd memory locations of said first memory; and
   - a scan converter, coupled to said output of said first memory for receiving vector information signal words read from said first memory under control of said control means.

2. The arrangement of claim 1, further comprising:
   - a second digital memory having an input coupled to said steering means and an output coupled to said scan converter, wherein said steering means alternately steers words of said first and second vector information signals to the inputs of said first and second memories;
   - second address means, coupled to said second memory and to said control means, for addressing sequential locations of said first memory in synchronism with the arrival of words of vector information at said input of said second memory so as to load words of said respective vector information signals alternately into sequential memory locations,
   - wherein said control means further controls said second address means to read vector information signal words from sequential even memory locations of said second memory and from sequential odd memory locations of said second memory, said control means alternating the operation of each memory between loading and reading cycles,
   - whereby one memory is performing a loading operation while the other memory is performing a reading operation.

3. The arrangement of claim 2, wherein said first and second address means each includes a flip-flop having clock, set, and reset inputs and an output coupled to the least significant address bit of said respective memory,
   - wherein each flip-flop is toggled by a clock signal at its clock input in synchronism with the arrival of words of vector information at said input of said respective memory during said loading operation, and is controlled to be alternately set and reset during substantially respective halves of said reading operation by said control means.

4. The arrangement of claim 3, wherein said control means includes
   - a read control flip-flop having outputs coupled to said set and reset inputs of said address means flip-flops, and responsive to first and second control signals

for alternating the state of each of said address means flip-flops during the reading cycle of its respective memory between set and reset conditions; and

a read/write control flip-flop, responsive to said second control signal and having an output coupled to said address means flip-flops, for selecting the address means flip-flop which is controlled by said read control flip-flop.

5. The arrangement of claim 4, wherein said read/write control flip-flop output is further coupled to said steering means, for controlling the steering of said alternate words of said first and second vector information signals to one of said memories.

6. A method of formatting two simultaneous sequences of digital ultrasound vector information words for a digital scan converter comprising the steps of:

(a) selecting words alternately from each sequence to form a single sequence of interleaved words of said two sequences;

(b) storing said single sequence in consecutive locations of a memory;

(c) reading out even address locations of said memory to form a first sequence of output vector words for transmittal to said scan converter; and

(d) reading out odd address locations of said memory to form a second sequence of output vector words for transmittal to said scan converter.

7. The method of claim 6, further comprising the steps of:

(e) during steps (a) and (b), reading out even address locations of a second memory to form a third sequence of output vector words for transmittal to said scan converter, then reading out odd address locations of said second memory to form a fourth sequence of output vector words for transmittal to said scan converter; and

(f) during steps (c) and (d), selecting words alternately from each simultaneous sequence to form a single sequence of interleaved words of said two sequences and storing said single sequence in consecutive locations of said second memory.

8. The method of claim 7, wherein said simultaneous sequences are of the form $A_1, A_2, A_3 \ldots A_n$ and $B_1, B_2, B_3 \ldots B_n$, respectively; said single sequences are of the form $A_1, B_1, A_2, B_2, A_3, B_3 \ldots A_n, B_n$; said first and third sequences are of the form $A_1, A_2, A_3 \ldots A_n$; and said second and fourth sequences are of the form $B_1, B_2, B_3 \ldots B_n$.

* * * * *

US005272713A

United States Patent [19]

Sobey et al.

[11] **Patent Number: 5,272,713**

[45] **Date of Patent: Dec. 21, 1993**

[54] **HIGH REPETITION RATE PULSED LASER**

[75] Inventors: **Mark S. Sobey**, San Carlos; **Bertram C. Johnson**, Sunnyvale; **Glen R. Blevins**, San Jose, all of Calif.

[73] Assignee: **Spectra-Physics Lasers, Inc.**, Mountain View, Calif.

[21] Appl. No.: **937,358**

[22] Filed: **Aug. 27, 1992**

[51] **Int. Cl.**[5] **H01S 3/09**

[52] **U.S. Cl.** **372/69**; 372/97; 372/105; 372/68; 372/25

[58] **Field of Search** 372/97, 69, 68, 10,29, 372/25, 105

[56] **References Cited**

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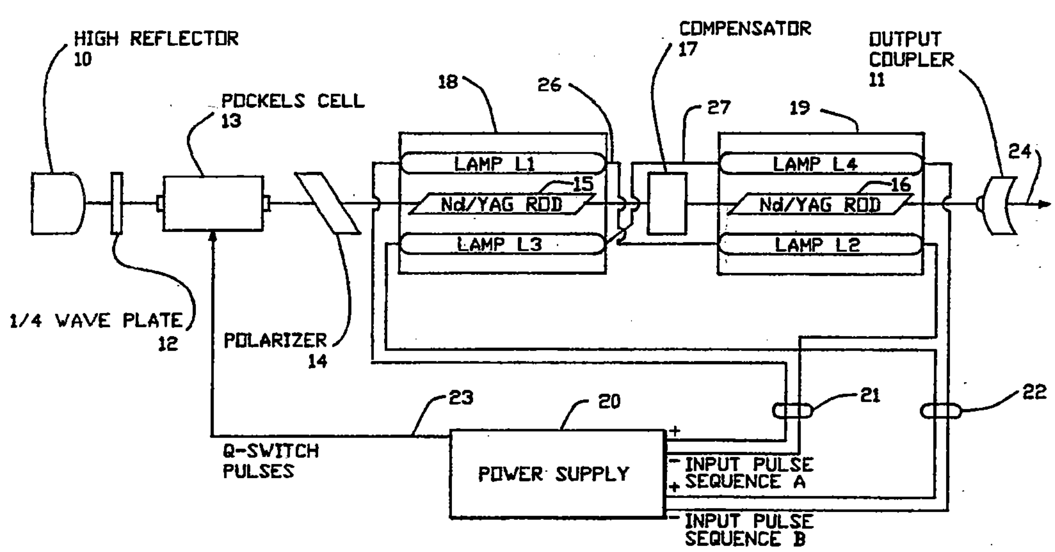
Primary Examiner—Leon Scott, Jr.

Attorney, Agent, or Firm—Fliesler, Dubb, Meyer and Lovejoy

[57] **ABSTRACT**

A pulsed laser system capable of operating at higher repetition rates, while maintaining the efficiency and beam quality of the output pulses comprises first and second gain media with one or more pump energy transducers, such as flashlamps, coupled with each of the gain media. A power supply generates a first sequence of pulses of input power and a second sequence of pulses of input power which drive respective subsets of the pump energy transducers in an independent timing relationship. Thus, two non-aligned 50 Hz sequences of input pulses which are interleaved generate an output pulse stream at 100 Hz from the laser system with the efficiency, beam quality, and average power comparable to that of a 50 Hz laser. By pumping subsets of the pump energy transducers coupled to a laser system in an interleaved fashion, higher repetition rates may be achieved with better output beam quality and higher average power than has been obtainable with prior art systems. The non-aligned timing also allows for variable pulse timing offsets.

52 Claims, 6 Drawing Sheets



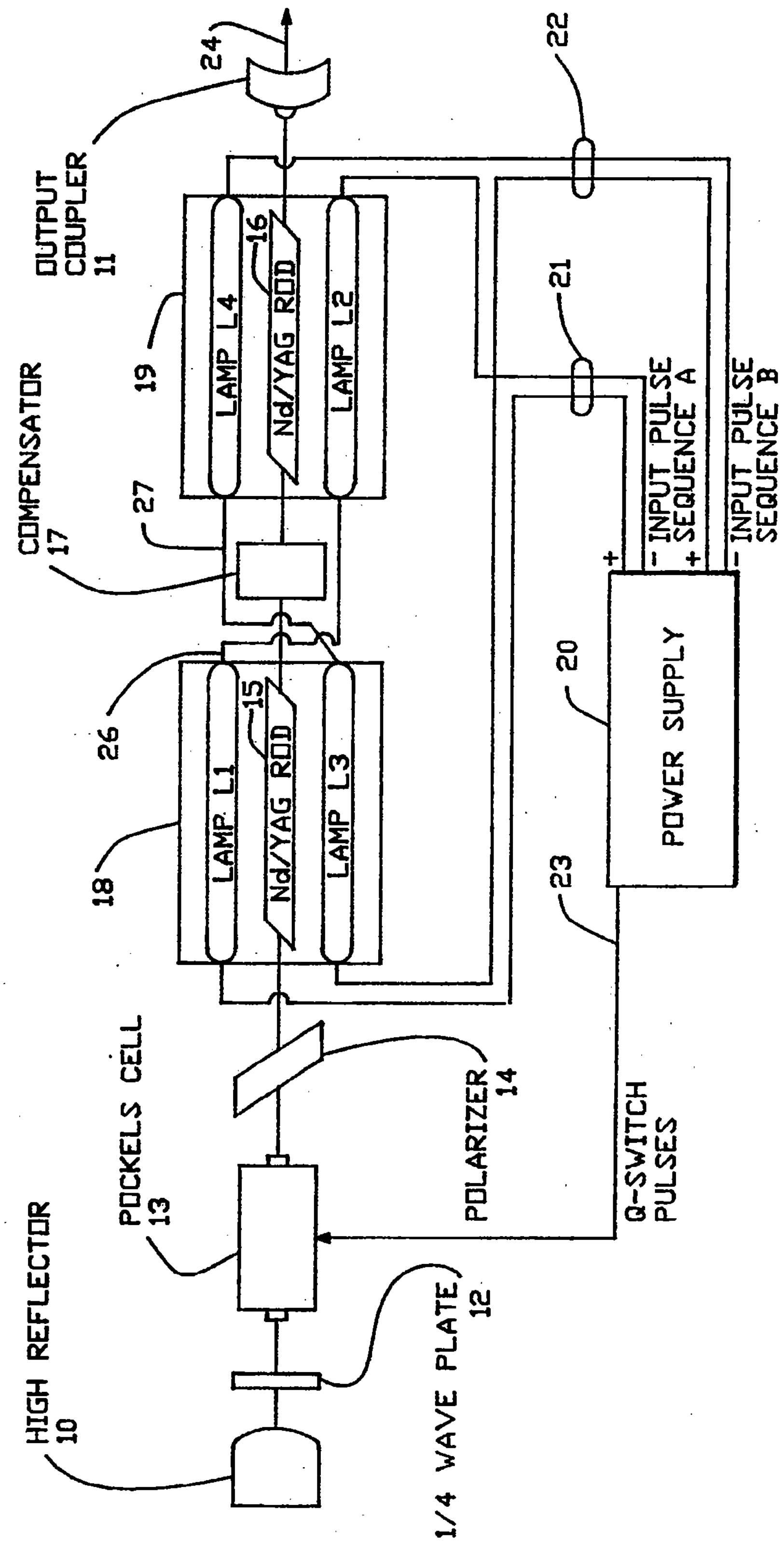
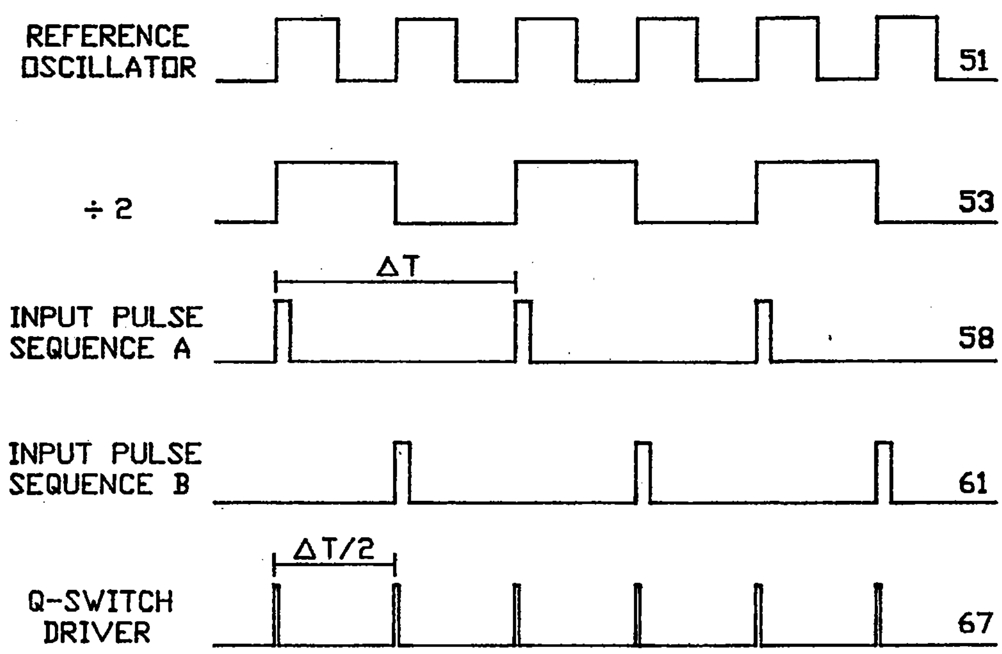

HIGH REFLECTOR
10
1/4 WAVE PLATE
12
POCKELS CELL
13
POLARIZER
14
Q-SWITCH
PULSES
18
LAMP L1
15
Nd/YAG ROD
LAMP L3
26
23
POWER SUPPLY
20
COMPENSATOR
17
27
19
LAMP L4
16
Nd/YAG ROD
LAMP L2
OUTPUT
COUPLER
11
24
21
22
INPUT PULSE
SEQUENCE A
INPUT PULSE
SEQUENCE B

FIG. —1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51
÷ 2
53
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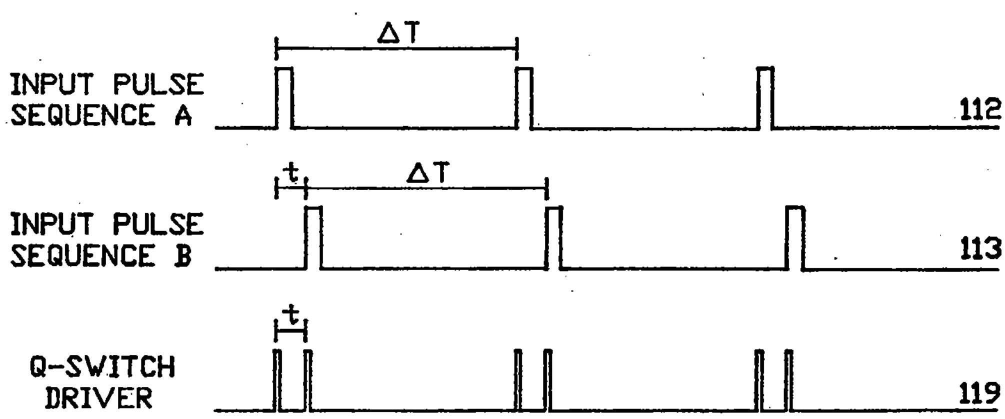
58
INPUT PULSE SEQUENCE B
61
ΔT/2
Q-SWITCH DRIVER
67

FIG.—2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112
t
ΔT
INPUT PULSE SEQUENCE B
113
t
Q-SWITCH DRIVER
119

FIG.—4

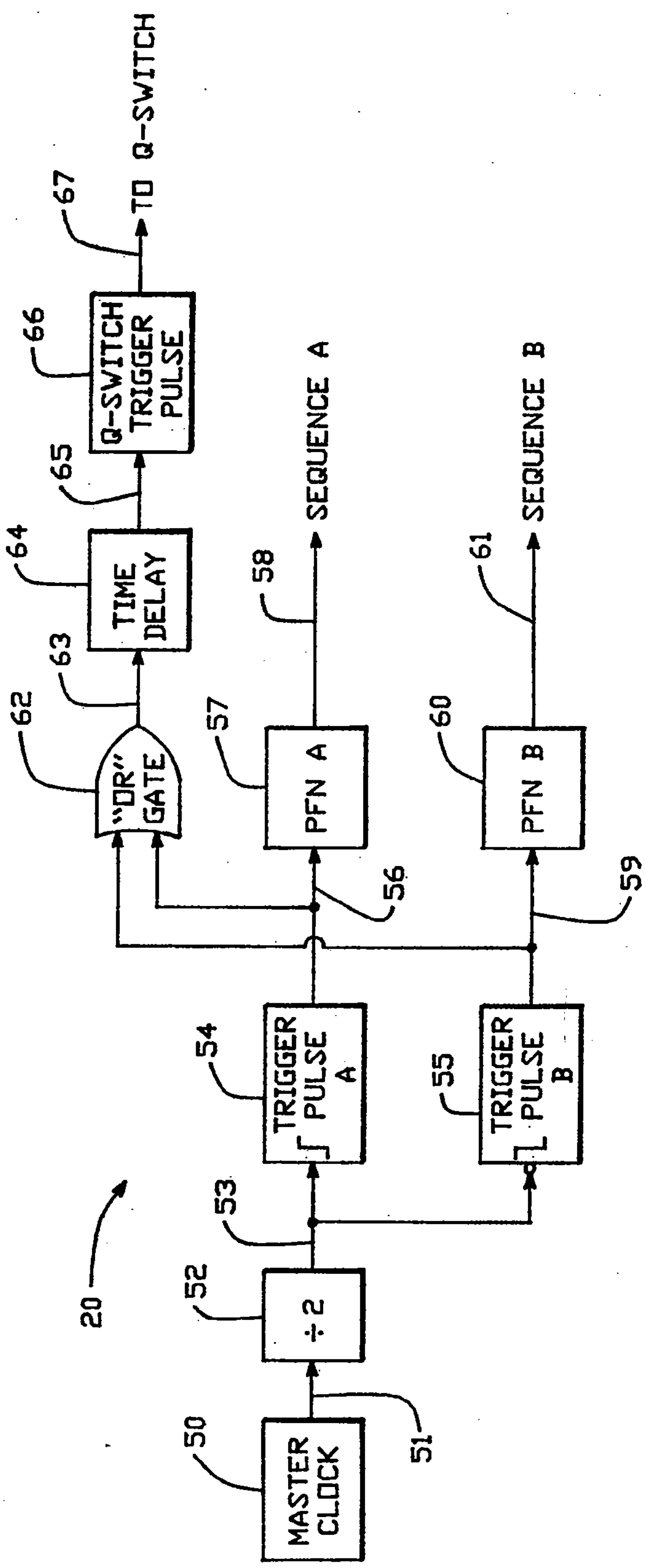

20
MASTER CLOCK
50
51
÷ 2
52
53
TRIGGER PULSE A
54
TRIGGER PULSE B
55
56
59
PFN A
57
PFN B
60
"OR" GATE
62
63
TIME DELAY
64
65
Q-SWITCH TRIGGER PULSE
66
67
TO Q-SWITCH
58
SEQUENCE A
61
SEQUENCE B

FIG.—3A

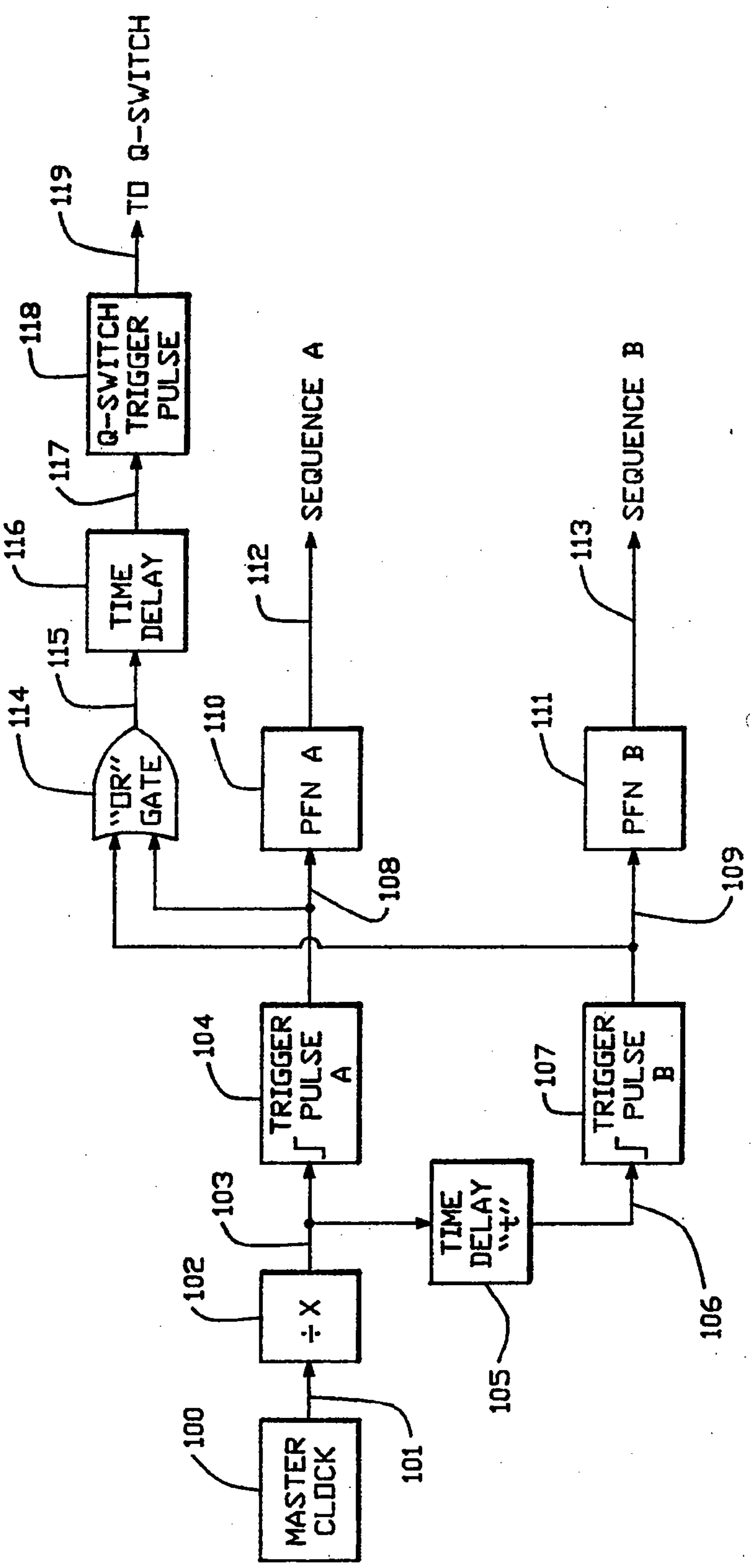
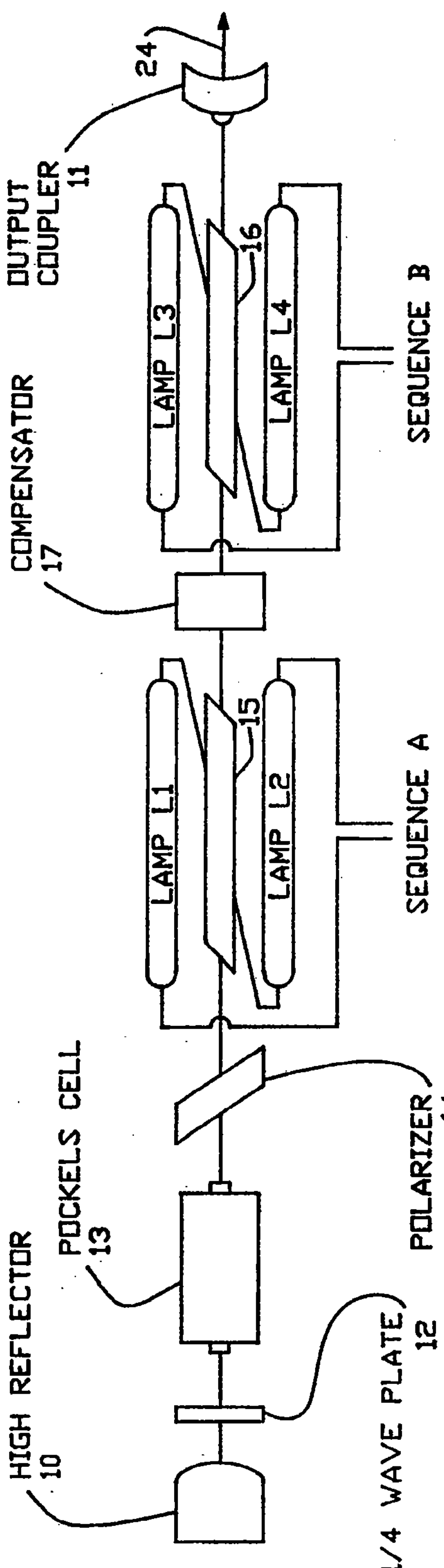
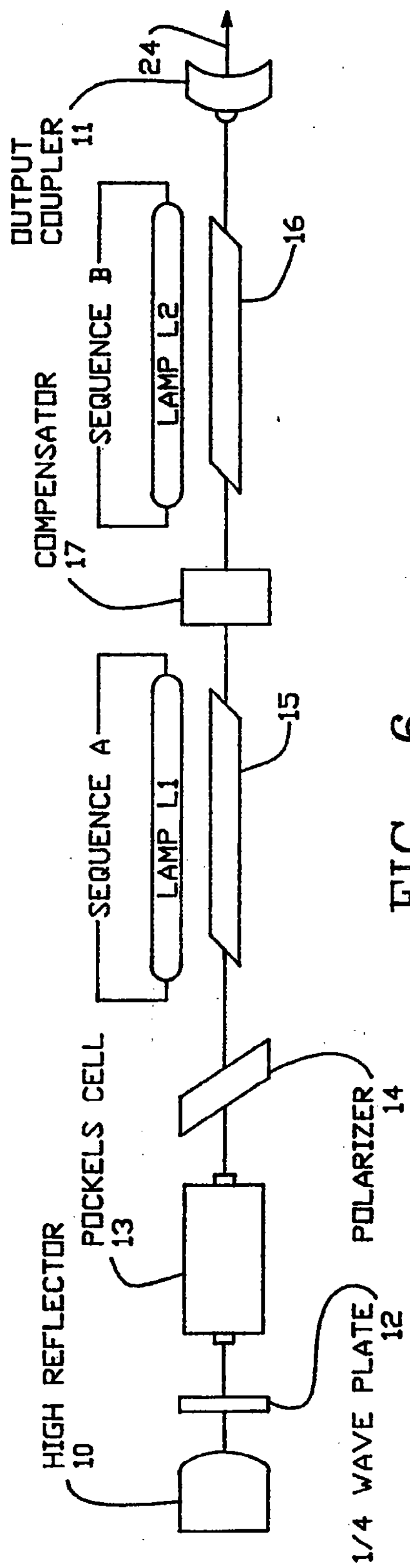

MASTER CLOCK
100
101
÷ X
102
103
TRIGGER PULSE A
104
TIME DELAY "t"
105
106
TRIGGER PULSE B
107
108
109
PFN A
110
PFN B
111
112
SEQUENCE A
113
SEQUENCE B
"OR" GATE
114
115
TIME DELAY
116
117
Q-SWITCH TRIGGER PULSE
118
119
TO Q-SWITCH

FIG.—3B



HIGH REFLECTOR 10
1/4 WAVE PLATE 12
POCKELS CELL 13
POLARIZER 14
LAMP L1
LAMP L2
15
SEQUENCE A
COMPENSATOR 17
LAMP L3
LAMP L4
16
SEQUENCE B
OUTPUT COUPLER 11
24

FIG.—5



HIGH REFLECTOR 10
1/4 WAVE PLATE 12
POCKELS CELL 13
POLARIZER 14
SEQUENCE A
LAMP L1
15
COMPENSATOR 17
SEQUENCE B
LAMP L2
16
OUTPUT COUPLER 11
24

FIG.—6

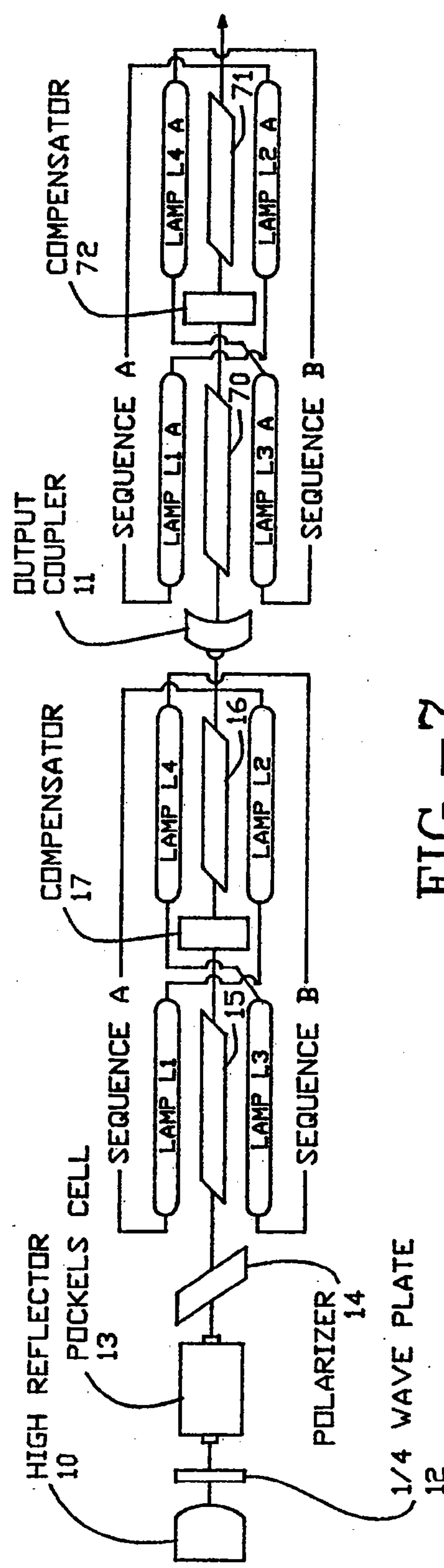

HIGH REFLECTOR
10
1/4 WAVE PLATE
12
POCKELS CELL
13
POLARIZER
14
SEQUENCE A
SEQUENCE B
LAMP L1
LAMP L3
15
COMPENSATOR
17
LAMP L4
LAMP L2
16
OUTPUT
COUPLER
11
LAMP L1 A
LAMP L3 A
70
COMPENSATOR
72
LAMP L4 A
LAMP L2 A
71

FIG.—7

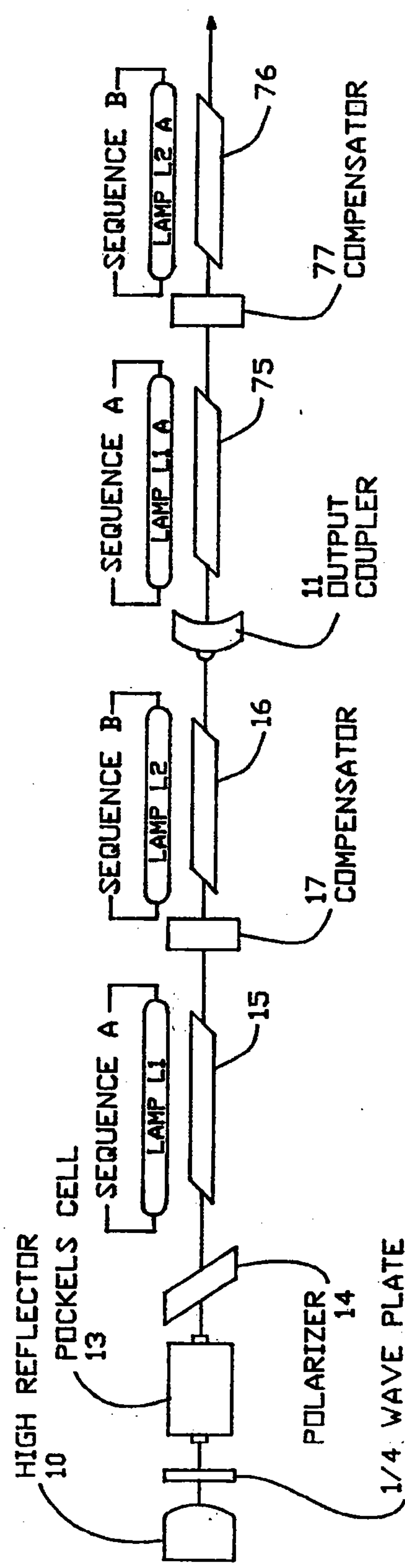

HIGH REFLECTOR
10
1/4 WAVE PLATE
12
POCKELS CELL
13
POLARIZER
14
SEQUENCE A
LAMP L1
15
17
COMPENSATOR
SEQUENCE B
LAMP L2
16
11
OUTPUT
COUPLER
SEQUENCE A
LAMP L1 A
75
77
COMPENSATOR
SEQUENCE B
LAMP L2 A
76

FIG.—8

HIGH REPETITION RATE PULSED LASER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to pulsed laser systems, and more particularly to solid state laser systems for generating high power laser pulses at relatively high repetition rates with good beam quality.

2. Description of Related Art

High powered pulsed lasers that generate high quality output beams are being used in a variety of applications. A typical prior art system is offered by Spectra-Physics Lasers, Inc., under model number GCR-4-50. The GCR-4-50 is typical of the higher repetition rate systems. It includes two neodymium doped YAG rods in series within a resonant cavity. The two YAG rods are mounted in respective dual-ellipse pump cavities having two flashlamps each. The system is operated at about 50 Hz by simultaneously pumping all four flashlamps. The input pulse energy in each of the two pump chambers at 50 Hz is typically around 50 lamp joules, or 5 kW input (2×50 Hz×50 joules). Specified output energy is 700 millijoules per pulse for 35 W average output power with 50 pulses per second, at 1064 nm in a high quality 70% Gaussian fit beam profile. Total laser output power to lamp input power efficiency is greater than 0.65% near 0.70%.

Many applications require a repetition rate of higher than 50 Hz. However, as the repetition rate for pumping the flashlamps increases, the average power and beam quality decrease dramatically. For instance, in an experiment using a GCR-4-50 at 100 Hz, the input pulse energy in each of the two pump chambers at 100 Hz was halved to 25 lamp joules thus maintaining 5 kW input power (2×100 Hz×25 joules). Average output power in this 100 Hz configuration fell off about 70% from the 50 Hz system. In a GCR-4-50 system configured for 700 millijoules per pulse at 50 Hz, the 100 Hz pumping at 5 kW input power would therefore yield about 105 millijoules per pulse for 10.5 W average output power, and output power to lamp input power efficiency of about 0.21%.

Thus, prior art systems have been unable to achieve high powers with consistent beam quality with higher repetition rates. Accordingly, it is desirable to provide a laser system design capable of operating at higher pulse rates, while maintaining high efficiency and high quality output beams.

SUMMARY OF THE INVENTION

The present invention provides a pulsed laser system capable of operating at higher repetition rates, while maintaining efficiency and beam quality of the output pulses.

The system of the present invention can be characterized as comprising at least one pair of gain media, such as rods of Nd:YAG, with at least one pump energy transducer, such as a flashlamp, laser diode, or laser diode array, coupled with each of the gain media in the pair. Each gain media pair may be configured in an oscillator or amplifier system. The pump energy transducers are organized in subsets having at least one member each, which may be driven independently of one another. Each subset of pump energy transducers is fired in a non-aligned timing relationship and the time between firing of the subsets can be varied.

In one aspect of the invention, a power supply generates pulses of input power according to a first sequence and according to a second sequence which drive respective subsets of the pump energy transducers coupled to the pair of gain media in a staggered timing relationship. Thus, two interleaved sequences of input pulses having a controlled offset generate an output pulse stream from the laser system at twice the pulse rate of each of the sequences of input pulses.

In another aspect, the present invention utilizes substantially similar gain media such as rods of Nd:YAG which exhibit thermal lensing and/or thermally induced birefringence in response to heating by the pump energy sources. In such system, a rotator is placed between the gain media, so that effects of thermally induced birefringence on the beam in the first gain medium are compensated for by the effects in the second gain medium. The timing of the input pulse sequences and the lamp energy per pulse settings are selected in a manner which maintains the average input power to each of the gain media substantially similar. In this way, the thermally induced effects in both gain media are substantially the same. Therefore, using this technique, it is possible to operate each of the two pump chambers at 50 Hz independently and obtain 100 Hz laser output, with the associated thermal birefringence and lensing of a 50 Hz laser. This is critical to maintain high efficiency, high average power, and good spatial mode.

The present invention is extendable to a variety of configurations of gain media and of pump energy transducers. Thus, it may be generalized for the laser system including a pair of gain media with more than one pump energy transducer per gain medium, such that the first sequence of input pulses drives a first subset of pump energy transducers and a second sequence of pulses of input power drives a second subset of pump energy transducers. In one pumping configuration termed a diagonal interleaf, the first subset of pump energy transducers driven by the first sequence of pump energy pulses includes a pump energy transducer coupled to the first gain medium in the pair and a pump energy transducer coupled to the second gain medium in the pair, while the second subset of pump energy transducers driven by the second sequence of pulses includes a pump energy transducer coupled to the first gain medium in the pair and a pump energy transducer coupled to the second gain medium in the pair.

In an alternative pumping configuration termed a parallel interleaf, the first subset driven by the first sequence of pulses includes pump energy transducers coupled only to the first gain medium in the pair, and the second subset driven by the second sequence of pulses includes pump energy transducers coupled only to the second gain medium in the pair.

In a system which includes N pump energy transducers per gain medium, the power supply may generate N sequences of input pulses equally spaced in time. The input pulses in each sequence S_i may be spaced in time by a period ΔT at an input pulse repetition rate of $1/\Delta T$. The pulses in sequence S_i for $i=1$ through $N-1$, occur at about $i\Delta T/N$ after pulses in the first sequence S_0. Thus, in a system including two sequences and two subsets of pump energy transducers, the laser output pulses can be generated at twice the input pulse repetition rate with half the period. In a system including three sequences, and three subsets of pump energy transducers, the laser output pulses can be generated at three-times the input pulse repetition rate, etc.

In alternative systems, the output pulses may not be equally spaced in time. For instance, a system may be configured so that a sequence of pairs of output pulses is generated in response to a first sequence of input pulses supplied at times $j\Delta T$, and a second sequence of input pulses supplied at times $j\Delta T+t$, where t is less than ΔT.

The present invention is extendable to systems involving a plurality of pairs of gain media. For instance, one pair of gain media may be configured within a resonant cavity to operate as a laser oscillator, and a second pair may be configured outside a resonant cavity to operate as a laser amplifier.

It is found that by pumping subsets of the pump energy transducers coupled to a laser system in a staggered or interleaved fashion, higher repetition rates may be achieved with better output beam quality and higher efficiency, while limiting thermal effects, like thermal birefringence, to levels associated with lower repetition rates.

Other aspects and advantages of the present invention can be seen upon review of the figures, the detailed description, and the claims which follow.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a schematic diagram of a laser system according to a preferred embodiment of the present invention.

FIG. 2 is a timing diagram illustrating the input pulse sequences and the Q-switched driver sequence for the system of FIG. 1.

FIG. 3A is a schematic diagram of a power supply for use with the system of FIGS. 1 and 2.

FIG. 3B is a schematic diagram of an alternative power supply for use with laser systems of the present invention.

FIG. 4 is a timing diagram for an alternative pulse sequence according to the present invention such as may be produced using the power supply of FIG. 3B.

FIG. 5 is a schematic diagram of an alternative laser design according to the present invention using two gain media and four flashlamps configured so that one gain medium at a time receives a pulse of pump energy.

FIG. 6 is a schematic diagram of an alternative laser system according to the present invention with one flashlamp per gain medium.

FIG. 7 is a schematic diagram of yet an alternative system according to the present invention including a first pair of gain media with two lamps each in a laser oscillator configuration, and a second pair of gain media with two lamps each in a laser amplifier configuration.

FIG. 8 is a schematic diagram of yet another alternative embodiment of the present invention having two gain media with one flashlamp each in a laser oscillator configuration, and two gain media with one flashlamp each in a laser amplifier configuration.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A detailed description of preferred embodiments of the present invention is provided with respect to FIGS. 1-8.

FIG. 1 illustrates a preferred embodiment of the present invention. The system includes a resonant cavity defined by high reflector **10** and output coupler **11**, which are configured in an unstable resonator design. A Q-switch comprised of a quarter wave plate **12**, a pockels cell **13**, and a polarizer **14** is included in the resonant cavity. A first gain medium **15** and a second gain medium **16** each of which consists of a substantially similar rod of Nd:YAG are placed in series in the resonant cavity. A compensator **17** is placed between the gain media **15**, **16**. See, for example, U.S. Pat. No. 3,484,714. The compensator **17** consists of a 90° rotator so that effects on polarization caused by the first rod **15** are compensated for by effects on polarization caused by the second rod **16**. Each of the gain media **15**, **16** is mounted in a dual ellipse pump cavity **18**, **19**, each of which include two lamps. Pump cavity **18** encloses rod **15** and includes lamps L1 and L3. Pump cavity **19** encloses rod **16** and includes lamps L4 and L2.

The components of one tested system in the configuration of FIG. 1 were the same as those used in the Spectra-Physics model GCR-4-50, which is commercially available from Spectra-Physics Lasers, Inc., Mountain View, Calif., using 8.5 mm diameter by 2 inches long Nd:YAG rods.

According to the present invention, a power supply **20** is included which generates a plurality of input pulse sequences. For the system shown, an input pulse sequence A is generated on lines **21** for driving lamp L1 in cavity **18** and lamp L2 in cavity **19** which are connected in series across line **26**. Input pulse sequence B is generated on lines **22** for driving the lamp L3 in cavity **18** and lamp L4 in cavity **19**, which are connected in series across line **27**.

The Q-switch pulses are supplied on line **23** to the pockels cell **13** such that one pulse occurs for each input pulse in sequence A and each input pulse in sequence B.

FIG. 1 illustrates a "diagonal" interleaf, in which the first and third flashlamps L1 and L3 are mounted on opposing sides of rod **15**; and the fourth and second flashlamps L4 and L2 are mounted on opposing sides of rod **16**. Lamp L1 and L4 are on substantially a first side of the gain media **15**, **16**, and lamps L3 and L2 are on substantially a second side. In the "diagonal" interleaf configuration shown, lamp L1 and lamp L2, driven by input pulse sequence A, lie on opposite sides of the respective gain media and lamps L3 and L4 driven by input pulse sequence B lie on opposite sides of the respective gain media for the purpose of output beam uniformity. In an alternative "series" interleaf system (not shown), lamps L1 in pump cavity **18** and L2 in pump cavity **19** are mounted on the first side, and lamps L3 in pump cavity **18** and L4 in pump cavity **19** are mounted on the second side.

FIG. 2 is a timing diagram illustrating the operation of the power supply **20** in the system of FIG. 1. Input pulse sequence A and input pulse sequence B have a non-aligned, interleaved timing relationship. An output pulse is generated on path **24** on each firing of the Q-switch. Thus, on a first firing of the Q-switch, an input pulse from sequence A fires lamps L1 and L2 and results in generation of an output pulse on path **24**. On the next firing of the Q-switch, an input pulse from sequence B results in firing of lamps L3 and L4 and the generation of an output pulse on path **24**. It can be seen that the average power supplied to each gain medium **15**, **16** is the same. Thus, the effects of thermally induced birefringence in the rods are balanced out by compensator **17**.

FIG. 3A is a block diagram of the power supply **20** in the system of FIG. 1 as implemented for generating the sequences of FIG. 2B. Traces in FIG. 2 are labelled with the reference numbers of corresponding signal lines in FIG. 3A. Thus, the power supply **20** includes a master clock **50** operating at for instance 100 Hz, which supplies an output on line **51** to divide-by-2 circuit **52**, such as a flip-flop. The divide-by-2 circuit **52** supplies a signal on line **53** to trigger pulse generator A **54** which is responsive to the positive going transition of the signal on line **53**, and to trigger pulse generator B **55** which is responsive to the negative going transition of the signal on line **53**. The trigger pulse generator A supplies a trigger pulse on line **56** for driving a pulse forming network A **57**. The output of the pulse forming network A is sequence A on line **58** of input pulses.

Similarly, the trigger pulse generator B supplies trigger pulses on line **59** which drive a pulse forming network B **60** for generating sequence B on line **61**. The outputs on lines **56** and **59** of trigger pulse generators A and B are supplied to OR gate **62**. The output of OR gate on line **63** is supplied to timing delay circuit **64**, and from there on line **66** to a Q-switch trigger pulse generator **66**. The Q-switch trigger pulse generator **66** supplies a Q-switch trigger on line **67** to the Q-switch in a proper timing relationship with the pulses in sequences A and B.

The trigger pulse generator A **63** and trigger pulse generator B **64** may be implemented using monostable flip-flops which generate an output pulse with about a 20% duty cycle. The monostable flip-flop for trigger pulse generator A **63** is positive edge triggered and the monostable flip-flop for trigger pulses generator B **64** is negative edge triggered so that the sequence A and sequence B are 180° out of phase. The outputs of the monostable flip-flops are then supplied through respective isolation circuits such as an emitter follower driving an opto-coupler. The outputs of the opto-couplers are then supplied as the trigger pulse on lines **65** and **68**, respectively to pulse forming networks.

The waveforms generated by the power supply of FIG. **3A** are shown in FIG. **2**. As can be seen, the output on line **51** of the reference oscillator is essentially a square wave along trace **51**. The output of the divide by 2 circuit **61** is a square wave at half the frequency on trace **62**. Input pulse sequence A is triggered on the positive going edge of the signal on line **62** while input pulse sequence B is triggered on the negative going edge of the signal on line **62**. A Q-switch driver supplies a Q-switch pulse in time with the input pulses on both sequence A and sequence B.

Thus, there is a period ΔT between the input pulses in sequence A. The period between input pulses and sequence B is also ΔT. The time between pulses of the Q-switch driver is $\Delta T/2$. Thus, for 20 milliseconds between pulses within sequence A and within sequence B, with a 10 millisecond offset, the Q-switch driver generates a pulse every 10 milliseconds. This results in an output pulse in time with the Q-switch driver pulses with a 10 millisecond spacing, or at 100 Hz.

In tests using a modified GCR-4-50 in the configuration of FIGS. **1–3A**, driven with 5 kW at 50 lamp joules per input pulse in each of sequence A and sequence B, a 100 Hz output pulse sequence of approximately 350 millijoules per pulse is generated in the Q-switched embodiment for about 35 W of output power. This substantially matches the specified average output power for the GCR-4-50 operating at 50 Hz. For a long pulse test (without operating the Q-switch) and driving at 50 lamp joules per pulse in both sequences, a 100 Hz sequence of output pulses of approximately 265 millijoules per pulse was generated. As can be seen, the higher frequency output pulses have been achieved using the system of FIG. **1** without any loss in average power or efficiency. Furthermore, the beam quality has been maintained using the interleaved pumping scheme. The beam quality demonstrated greater than 70% correlation between actual beam profile and the best least squares fit gaussian profile in the near field.

This is to be compared with driving all lamps simultaneously at 100 Hz with the same average input power discussed in the background above, where the Q-switched average power output for 5 kW input was reduced by 70%.

The generation of pulses could be generalized to include N sequences, where pulses in each of the N sequences are spaced in time by a period ΔT, and pulses in sequence S_i, for $i=1$ through $N-1$, occur at about $i\Delta T/N$ after pulses in a first sequence S_o. Alternatively, the timing between pulses could be irregular, and sequences generated having completely independent timing.

In addition, the energy per pulse can be independently controlled for each sequence, such that the output pulses may vary in intensity, so long as any thermal effects on pumping with variable input power are balanced out.

FIG. **3B** illustrates an alternative implementation of the power supply for generating non-aligned sequences of input pulses, having a controllable offset. Thus, the system of FIG. **3B** includes a master clock **100**, which generates an output on line **101**. The output on line **101** is supplied to a divide-by-X circuit **102** which generates an output on line **103** having a desired frequency characteristic. The signal on line **103** is supplied to a trigger pulse generator A **104** and to a timing delay circuit **105** which is controllable by the user to delay the signal by an amount "t". The output of the timing delay circuit **105** is supplied as input to trigger pulse generator B **107**. Trigger pulse generators A and B are both positive edge triggered in the embodiment of FIG. **3B**. The outputs of trigger pulse generators A and B are supplied on lines **108** and **109**, respectively, to respective pulse forming networks A **110** and B **111**. Sequence A is supplied on line **112** from pulse forming network A, and sequence B is supplied on line **113** from pulse forming network B.

The outputs on lines **108** and **109** of the trigger pulse generators A and B are supplied as inputs to OR gate **114**. The output of OR gate **114** on line **115** is supplied to a timing delay circuit **116**, and from there on line **117** as input to Q-switch trigger pulse generator **118**. The Q-switch trigger pulses are supplied on line **119** to the Q-switch.

FIG. **4** illustrates an alternative timing sequence for generating pulse pairs using a power supply such as that shown in FIG. **3B**. In the sequence of FIG. **4**, input pulse sequence A has a period of ΔT. Input pulse sequence B also has a period of ΔT, but the pulses are offset by an amount t, such as may be set by delay circuit **105**, after the pulses in sequence A. Thus, for pulses occurring at times $j\Delta T$ in sequence A, the pulses in sequence B occur in $j\Delta T+t$. The Q-switch driver is driven with pulse pairs synchronized with the input pulse sequences A and B with the time between pulses within each pair of t and a period between pulse pairs of ΔT.

The power supply can be modified using well known techniques to generate a wide variety of timing sequences, with or without user control. For instance, pulse timing could be microprocessor controlled. A user may require more than one pulse forming network per input sequence (see FIGS. **7** and **8** below). Also, a power supply with a single pulse forming network could be used, with an appropriate switching circuit between the pulse forming network and the transducers, to supply the independent input pulse sequences.

Furthermore, the system can be extended by including more than two lamps per gain medium. For instance, with a system having three lamps per gain medium, three input pulse sequences could be generated in a variety of timing relationships, the simplest being three times the base repetition rate.

For gain media which exhibit thermal effects due to pump energy, it is desirable that the input pulse sequences be configured in time and energy per pulse so that the average pump power delivered to each gain medium is the same, and so that the thermal effects occurring in each gain medium remain substantially constant for each of the input pulses.

In a system such as that described in FIG. 1, where the gain medium is Nd:YAG, the gain medium exhibits thermally induced birefringence and thermal lensing in response to pump energy. It is important to balance the thermal effects in each of the rods so that thermal lensing does not unduly affect the laser threshold and cause other harmful effects on the beam. Similarly, it is important that the thermal effects be balanced so that the compensator 17 will properly cause offsetting of the polarization effects of birefringence in each of the rods.

In alternative systems, other gain media may be used, such as Nd:YLF or Ti:Sapphire, which do not exhibit thermally induced birefringence. In such systems, the compensator 17 may be omitted. Also, only one gain medium may be needed within the resonant cavity.

FIGS. 5–8 illustrate representative alternative configurations of the system of the present invention. In the system of FIG. 5, the components are given the same reference numbers as those in FIG. 1. However, the power supply and pump cavities are not shown for simplicity. FIG. 5 illustrates a "parallel" interleaf configuration which differs from the "diagonal" interleaf in FIG. 1 in the configuration of the lamps L1 through L4. Series connected lamps L1 and L2, which are driven according to input pulse sequence A are both coupled with rod 15 in FIG. 5. Similarly, series connected lamps L3 and L4, which are driven by input pulse sequence B, are both coupled to rod 16. In this manner, rod 15 is pumped by input pulse sequence A, while rod 16 is pumped by input pulse sequence B. The thermal effects of pumping the two rods are balanced because of the repetition rate is sufficiently high that the thermal effects do not relax between input pulses. It is found that the configuration of FIG. 5 operates almost as well as the configuration of FIG. 1. Tests of a modified GCR-4-50 show that the output pulses generated on line 24 in the configuration of FIG. 5 with 50 lamp joules per pulse in each sequence resulted in Q-switched pulses at 100 Hz with approximately 25% decrease in average power over the conventional 50 Hz system. This remains substantially greater than the 100 Hz simultaneous pumping mode with the same average input power as described above which suffered a 70% decrease.

FIG. 6 illustrates yet an alternative embodiment of the present invention in which there is a single lamp per pump cavity. Thus, the system includes high reflector 10 and output coupler 11 defining a resonant cavity. A Q-switch, consisting of quarter wave plate 12, pockels cell 13, and polarizer 14, is included in the resonant cavity. A first rod 15 and a second rod 16 are mounted in series within the resonant cavity with a compensator 17 mounted therebetween. A single lamp L1 is coupled with rod 15 and a single lamp L2 is coupled with rod 16. The lamp L1 is pumped with input sequence A and the lamp L2 is pumped with input sequence B.

FIG. 7 illustrates yet another alternative of the present invention where it has been extended to a plurality of pairs of gain media in which at least one is mounted within the laser resonant cavity. Thus, the laser resonant cavity consists of high reflector 10 and output coupler 11 with a Q-switch consisting of quarter wave plate 12, pockels cell 13, and polarizer 14. A first rod pair 15, 16 is included within the resonant cavity with a compensator 17 mounted therebetween. A second rod pair 70, 71 is mounted outside the resonant cavity in an amplifier configuration with a compensator 72 mounted therebetween. Each of the rods 15, 16, 70, 71 is mounted within a two lamp pump cavity. The lamps are configured similarly to that shown in FIG. 1. Lamp L1 coupled with gain medium 15 in series with lamp L2 coupled with gain medium 16, and lamp L1A coupled with gain medium 71 in the amplifier in series with lamp L2A coupled with gain medium 71 in the amplifier are all pumped according to sequence A by two synchronized pulse forming networks. Series connected lamps L3 and L4 coupled with rods 15 and 16, respectively, and series connected lamps L3A and L4A, coupled with rods 70 and 71, respectively, are pumped in accordance with sequence B by two synchronized pulse forming networks.

FIG. 8 illustrates yet another alternative embodiment of the present invention. FIG. 8 is configured like FIG. 7, except that it includes a single lamp per gain medium. Thus, a resonator is defined by high reflector 10 and output coupler 11. A Q-switch consisting of quarter wave plate 12, pockels cell 13, and polarizer 14 is mounted in the resonant cavity. A first rod 15 and a second rod 16 are mounted on opposite sides of compensator 17. Lamp L1 and lamp L2 are coupled with rods 15 and 16, respectively. Rods 75 and 76 are mounted in an amplifier configuration outside the resonant cavity with compensator 77 mounted therebetween. Lamps L1A and L2A are coupled with rods 75 and 76, respectively. Lamps L1 and L1A are pumped according to sequence A, while lamps L2 and L2A are pumped according to sequence B.

As can be seen, the present invention is extendable to any number of pairs of rods in oscillator/amplifier configurations. There can be more than one pair of rods within the resonant cavity, and/or more than one pair of rods outside the resonant cavity in amplifier configurations.

The pulsed laser system, according to this aspect of the present invention, can be characterized as a plurality of pairs of first and second gain media. A laser resonant cavity includes an output coupler for extracting the output pulses from the resonant cavity and defines a resonant optical path through at least one pair of gain media. Each pair of gain media is coupled with a set of pump energy transducers, where each set includes at least one transducer coupled to each gain medium in the pair. The power supply generates a plurality of sequences of pulses of input power which may independently drive corresponding subsets of the sets of pump energy transducers in non-aligned timing relationships. The subsets of transducers for each gain medium pair are configured in a substantially similar manner so that the given sequence of input pulses drives a similar subset in each pair of gain media.

Using non-aligned timing relationships for pumping subsets of pump energy transducers, a sequence of output pulses at a higher repetition rate can be achieved with higher beam quality and greater efficiency than prior art systems. Furthermore, the timing relationship between output pulses can be configured into output pulse pairs or other patterns of output pulses as suits the needs of a particular application.

The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

1. A pulsed laser system, comprising:

a first gain medium;

a second gain medium;

a laser resonant cavity including an output coupler for extracting output pulses from the resonant cavity, and defining a resonant optical path through the first and second gain media;

a first pump energy transducer coupled to the first gain medium to supply pump energy to the first gain medium in response to input power;

a second pump energy transducer coupled to the second gain medium to supply pump energy to the second gain medium in response to input power; and

means, coupled with the first and second pump energy transducers, for supplying pulses of input power according to a first sequence to drive the first pump energy transducer and according to a second sequence to drive the second pump energy transducer, wherein the first and second sequences have a non-aligned timing relationship.

2. The pulsed laser system of claim 1, wherein the first and second sequences are interleaved.

3. The pulsed laser system of claim 1, wherein pulses in the first sequence are spaced in time by a period ΔT, and pulses in the second sequence occur at about $\Delta T/2$ after pulses in the first sequence.

4. The pulsed laser system of claim 1, wherein the pulses in the first sequence are supplied at times $j\Delta T$, and the pulses in the second sequence are supplied at times $j\Delta T+t$, wherein t is less than ΔT, so that a sequence of pairs of laser output pulses spaced in time by t, is generated, where j is an index from 2–N, and N is a number of pairs of laser output pulses in the sequence.

5. The pulsed laser system of claim 1, further including:

means, between the first and second gain media, for rotating polarization so that effects on polarization in the second gain medium compensate for polarization effects in the first gain medium.

6. The pulsed laser system of claim 1, wherein the first and second gain media are substantially similar solid state gain media.

7. The pulsed laser system of claim 1, wherein the first and second gain media are substantially similar, and comprise respective pieces of solid state gain material each producing thermal lensing in response to heating by pump energy.

8. The pulsed laser system of claim 1, wherein the first and second gain media are substantially similar and comprise respective pieces of solid state gain material each producing thermally induced birefringence in response to heating by pump energy, and further including:

means, between the first and second gain media, for rotating polarization so that thermally induced birefringence in the second gain medium compensates for thermally induced birefringence in the first gain medium.

9. The pulsed laser system of claim 1, wherein the first and second pump energy transducers comprise first and second flash lamps, respectively.

10. The pulsed laser system of claim 1, wherein the first and second pump energy transducers comprise laser diodes.

11. The pulsed laser system of claim 1, wherein the first and second gain media comprise substantially similar rods of neodymium doped YAG.

12. The pulsed laser system of claim 1, further including:

a third gain medium;

a fourth gain medium;

a third pump energy transducer coupled to the third gain medium to supply pump energy to the third gain medium in response to input power;

a fourth pump energy transducer coupled to the fourth gain medium to supply pump energy to the fourth gain medium in response to input power; and

means, coupled with the means for supplying and the third and fourth pump energy transducers, for supplying pulses of input power to the third pump energy transducer according to the first sequence and to the fourth pump energy transducer according to the second sequence.

13. The pulsed laser system of claim 12, wherein the third and fourth gain media are within the resonant optical path.

14. The pulsed laser system of claim 12, wherein the third and fourth gain media are outside the resonant optical path.

15. The pulsed laser system of claim 1, further including:

a Q-switch mounted in the resonant optical path; and

means, coupled with the Q-switch, for driving the Q-switch in coordination with the first and second sequences of input power.

16. A pulsed laser system, comprising:

a first gain medium;

a second gain medium;

a laser resonant cavity including an output coulper for extracting output pulses from the resonant cavity, and defining a resonant optical path through at least one of the first and second gain media;

a first set of pump energy transducers coupled to the first gain medium to supply pump energy to the first gain medium in response to input power;

a second set of pump energy transducers coupled to the second gain medium to supply pump energy to the second gain medium in response to input power; and means, coupled with the first and second pluralities of pump energy transducers, for supplying pulses of input power according to a plurality of sequences to drive a corresponding plurality of subsets of the first and second sets of pump energy transducers, wherein sequences in the plurality of sequences have a non-aligned timing relationship.

17. The pulsed laser system of claim 16, wherein the plurality of sequences of pulses of input power includes first and second interleaved sequences.

18. The pulsed laser system of claim 16, wherein the plurality of sequences of pulses of input power includes N sequences and the pulses in the N sequences are spaced in time by a period ΔT, and pulses in the sequence S_i, for i equal to 1 to N−1, occur at about iΔT/N after pulses in a first sequence S_o.

19. The pulsed laser system of claim 16, wherein the pulses of input power in a first sequence are supplied at times jΔT, and the pulses of input power in a second sequence are supplied at times jΔT+t, wherein t is less than ΔT, so that a sequence of pairs of output pulses spaced in time by t, is generated, where j is an index from 10-N and N is a number of pairs of laser output pulses in the sequence.

20. The pulsed laser system of claim 16, further including:

means, between the first and second gain media, for rotating polarization so that effects on polarization in the second gain medium compensate for polarization effects in the first gain medium.

21. The pulsed laser system of claim 16, wherein the first and second gain media are substantially similar solid state gain media.

22. The pulsed laser system of claim 16, wherein the first and second gain media are substantially similar and comprise respective pieces of solid state gain material each producing thermal lensing in response to heating by pump energy.

23. The pulsed laser system of claim 16, wherein the first and second gain media are substantially similar and comprise respective pieces of solid state gain material each producing thermally induced birefringence in response to heating by pump energy, and further including:

means, between the first and second gain media, for rotating polarization so that thermally induced birefringence in the second gain medium compensates for thermally induced birefringence in the first gain medium.

24. The pulsed laser system of claim 16, wherein the pump energy transducers comprise flash lamps.

25. The pulsed laser system of claim 16, wherein the pump energy transducers comprise laser diodes.

26. The pulsed laser system of claim 16, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of pump energy transducers and a second sequence to drive a second subset of pump energy transducers, and wherein the first subset includes first and second pump energy transducers in the first set coupled to the first gain medium, and the second subset includes third and fourth pump energy transducers in the second set coupled to the second gain medium.

27. The pulsed laser system of claim 16, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of pump energy transducers and a second sequence to drive a second subset of pump energy transducers, and wherein the first subset includes a first pump energy transducer in the first set coupled to the first gain medium and a second pump energy transducer in the second set coupled to the second gain medium, and the second subset includes a third pump energy transducer in the first set coupled to the first gain medium and a fourth pump energy transducer in the second set coupled to the second gain medium.

28. The pulsed laser system of claim 16, wherein the first and third pump energy transducers are mounted on opposing sides of the first gain medium, and the second and fourth pump energy transducers are mounted on opposing sides of the second gain medium such that the first and fourth pump energy transducers are substantially on a first side and the second and third pump energy transducers of substantially on a second side of the respective first and second gain media.

29. The pulsed laser system of claim 16, wherein the first and second gain media comprise substantially similar rods of neodymium doped YAG.

30. The pulsed laser system of claim 16, further including:

a Q-switch mounted in the resonant optical path; and

means, coupled with the Q-switch, for driving the Q-switch in coordination with the plurality of sequences of pulses of input power.

31. A pulsed laser system, comprising:

a plurality of pairs of first and second gain media;

a laser resonant cavity including an output coupler for extracting output pulses from the resonant cavity, and defining a resonant optical path through at least one gain medium in the plurality of pairs;

a plurality of sets of pump energy transducers, each set in the plurality coupled to a corresponding pair of the plurality of pairs of gain media and including at least one pump energy transducer coupled with each of the first and second gain media in the corresponding pair; and

means, coupled with the plurality of sets of pump energy transducers, for supplying pulses of input power according to a plurality of sequences to drive a corresponding plurality of subsets of the sets of pump energy transducers, wherein sequences in the plurality of sequences have a non-aligned timing relationship.

32. The pulsed laser system of claim 31, wherein the plurality of sequences of pulses of input power includes first and second interleaved sequences to drive two subsets of each of the sets of pump energy transducers.

33. The pulsed laser system of claim 31, wherein the plurality of sequences of pulses of input power includes N sequences to drive N subsets of each of the sets of pump energy transducers, and the pulses in the N sequences are spaced in time by a period ΔT, and pulses in the sequence S_i, for i equal to 1 to N−1, occur at about iΔT/N after pulses in a first sequence S_o.

34. The pulsed laser system of claim 31, wherein the pulses of input power in a first sequence are supplied at times jΔT, and the pulses of input power in a second sequence are supplied at times jΔT+t, wherein t is less than ΔT, so that a sequence of pairs of output pulses spaced in time by t, is generated, where j is an index from 1-N, and N is a number of pairs of laser output pulses in the sequence.

35. The pulsed laser system of claim 31, further including:

means, between the first and second gain media of at least one of the plurality of pairs, for rotating polarization so that effects on polarization in the second gain medium compensate for polarization effects in the first gain medium.

36. The pulsed laser system of claim 31, wherein the first and second gain media in each of the plurality of pairs are substantially similar solid state gain media.

37. The pulsed laser system of claim 31, wherein the first and second gain media in each pair in the plurality of pairs are substantially similar and comprise respective pieces of solid state gain material each producing thermal lensing in response to heating by pump energy.

38. The pulsed laser system of claim 31, wherein the first and second gain media in each pair in the plurality of pairs are substantially similar and comprise respective pieces of solid state gain material each producing thermally induced birefringence in response to heating by pump energy, and further including:

means, between the first and second gain media in each pair, for rotating polarization so that thermally induced birefringence in the second gain medium compensates for thermally induced birefringence in the first gain medium.

39. The pulsed laser system of claim 31, wherein the pump energy transducers in at least one set in the plurality of sets comprise flash lamps.

40. The pulsed laser system of claim 31, wherein the pump energy transducers in at least one set in a plurality of sets comprise laser diodes.

41. The pulsed laser system of claim 31, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of pump energy transducers and a second sequence to drive a second subset of pump energy transducers in at least one of the sets, and wherein the first subset includes first and second pump energy transducers coupled to the first gain medium of the pair, and the second subset includes third and fourth pump energy transducers coupled to the second gain medium in the pair.

42. The pulsed laser system of claim 31, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of pump energy transducers and a second sequence to drive a second subset of pump energy transducers in at least one of the sets, and wherein the first subset includes a first pump energy transducer coupled to the first gain medium in the pair and a second pump energy transducer coupled to the second gain medium in the pair, and the second subset includes a third pump energy transducer coupled to the first gain medium in the pair and a fourth pump energy transducer coupled to the second gain medium in the pair.

43. The pulsed laser system of claim 42, wherein the first and third pump energy transducers are mounted on opposing sides of the first gain medium in the pair, and the second and fourth pump energy transducers are mounted on opposing sides of the second gain medium in the pair such that the first and fourth pump energy transducers are substantially on a first side and the second and third pump energy transducers of substantially on a second side of the respective first and second gain media.

44. The pulsed laser system of claim 31, wherein the first and second gain media in at least on pair in the plurality of pairs comprise substantially similar rods of neodymium doped YAG.

45. The pulsed laser system of claim 31, further including:

a Q-switch mounted in the resonant optical path; and

means, coupled with the Q-switch, for driving the Q-switch in coordination with the plurality of sequences of pulses of input power.

46. A pulsed laser system, comprising:

a first solid state gain medium;

a second solid state gain medium;

a laser resonant cavity including an output coupler for extracting output pulses from the resonant cavity, and defining a resonant optical path through the first and second solid state gain media;

means, between the first and second solid state gain media, for rotating polarization so that thermally induced birefringence in the first solid state gain medium compensates for thermally induced birefringence in the second solid state gain medium;

a first pump cavity enclosing the first solid state gain medium, including a first set of flash lamps to supply pump energy to the first gain medium in response to input power;

a second pump cavity enclosing the second solid state gain medium, including a second set of flash lamps to supply pump energy to the second gain medium in response to input power;

means, coupled with the first and second sets of flash lamps, for supplying pulses of input power according to a plurality of sequences to drive a plurality of subsets of the first and second sets of flash lamps, wherein sequences in the plurality of sequences have a non-aligned timing relationship;

a Q-switch mounted in the resonant optical path; and

means, coupled with the Q-switch, for driving the Q-switch in coordination with the plurality of sequences of pulses of input power.

47. The pulsed laser system of claim 46, wherein the plurality of sequences of pulses of input power includes first and second interleaved sequences.

48. The pulsed laser system of claim 46, wherein the plurality of sequences of pulses of input power includes N sequences and the pulses in the N sequences are spaced in time by a period ΔT, and pulses in the sequence S_i, for i equal to 1 to $N-1$, occur at about $i\Delta T/N$ after pulses in a first sequence S_o.

49. The pulsed laser system of claim 46, wherein the pulses of input power in a first sequence are supplied at times $j\Delta T$, and the pulses of input power in a second sequence are supplied at times $j\Delta T+t$, wherein t is less than ΔT, so that a sequence of pairs of output pulses spaced in time by t, is generated, where j is an index from 1-N, and N is a number of pairs of laser output pulses in the sequence.

50. The pulsed laser system of claim 46, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of flash lamps and a second sequence to drive a second subset of flash lamps in first and second pluralities of flash lamps, and wherein the first subset includes first and second flash lamps in the first set coupled to the first gain medium, and the second subset includes third and fourth flash lamps in the second set coupled to the second gain medium.

51. The pulsed laser system of claim 46, wherein the plurality of sequences of pulses of input power include a first sequence to drive a first subset of flash lamps and a second sequence to drive a second subset of flash lamps in the first and second sets of flash lamps, and wherein the first subset includes a first flash lamp in the first set coupled to the first gain medium and a second flash lamp in the second set coupled to the second gain

medium, and the second subset includes a third flash lamp in the first set coupled to the first gain medium and a fourth flash lamp in the second set coupled to the second gain medium.

52. The pulsed laser system of claim 51, wherein the first and third flash lamps are mounted on opposing sides of the first gain medium in the first pump cavity, and the second and fourth flash lamps are mounted on opposing sides of the second gain medium in the second pump cavity such that the first and fourth pump energy transducers are substantially on a first side and the second and third pump energy transducers of substantially on a second side of the respective first and second gain media.

* * * * *

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United States Patent [19]

Kulas

[11] Patent Number: 5,734,862

[45] Date of Patent: Mar. 31, 1998

[54] **SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION**

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[21] Appl. No.: **252,460**

[22] Filed: **May 31, 1994**

[51] **Int. Cl.**[6] **G06F 13/00**

[52] **U.S. Cl.** **395/484**; 395/173; 395/427; 395/849; 395/872; 360/18; 360/48

[58] **Field of Search** 369/47, 48; 345/22; 348/155, 483; 360/48, 18; 386/52, 92; 395/173, 680, 427, 481, 484, 849, 872; 463/3, 4

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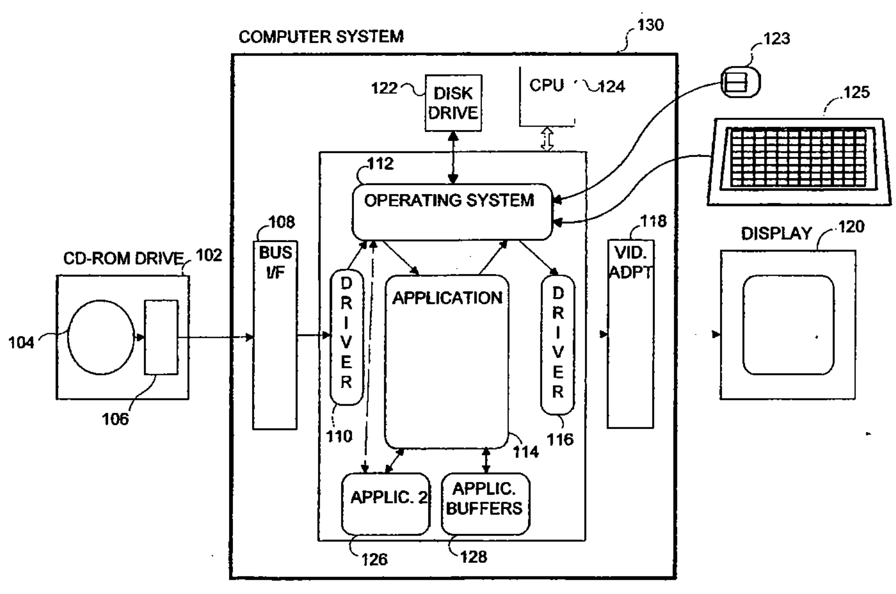
Primary Examiner—Thomas C. Lee
Assistant Examiner—Po C. Huang

[57] **ABSTRACT**

A system for eliminating access time in CD-ROM based interactive video applications. A CD-ROM disc is formatted with multiple interleaved animation sequences. During playback, a user is able to select a sequence as the current sequence. Only those frames corresponding to the current sequence are displayed while other frames are dropped. The interleaved pattern of frames allows multiple sequences to be available from the CD-ROM drive without requiring repositioning of the CD-ROM drive's read head thereby eliminating access time. Specific patterns of interleaving that advantageously improve interactivity of an interactive production are described. A frame buffering implementation is described.

9 Claims, 17 Drawing Sheets



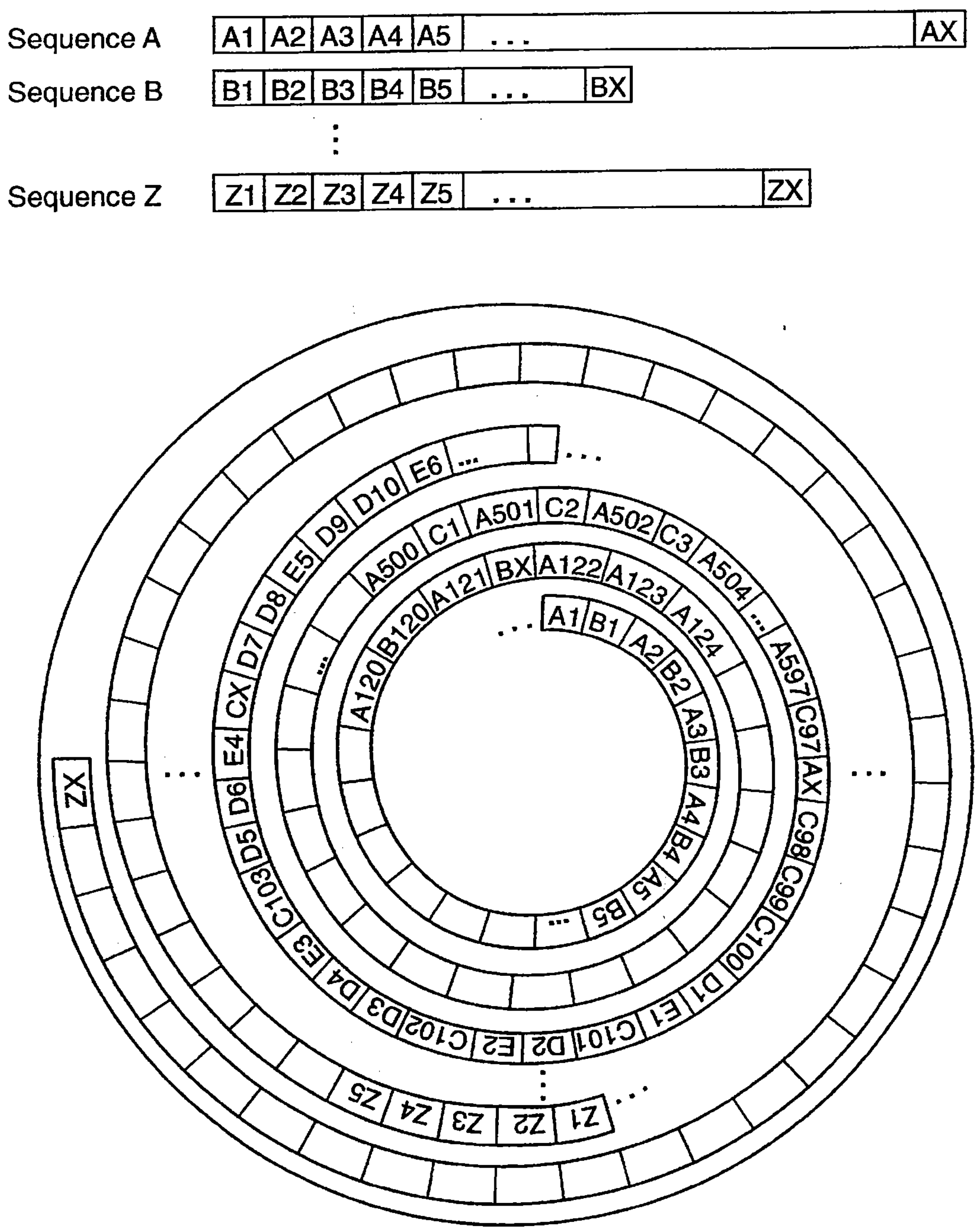

Sequence A
A1 A2 A3 A4 A5 ... AX
Sequence B
B1 B2 B3 B4 B5 ... BX
Sequence Z
Z1 Z2 Z3 Z4 Z5 ... ZX
A1 B1 A2 B2 A3 B3 A4 B4 A5 B5
A120 B120 A121 BX A122 A123 A124
A500 C1 A501 C2 A502 C3 A504 A597 C97 AX C98 C99 C100 D1 E1 C101 D2 E2 C102 D3 D4 E3 C103 D5 D6 E4 CX D7 D8 E5 D9 D10 E6
Z1 Z2 Z3 Z4 Z5
ZX

FIG. 2

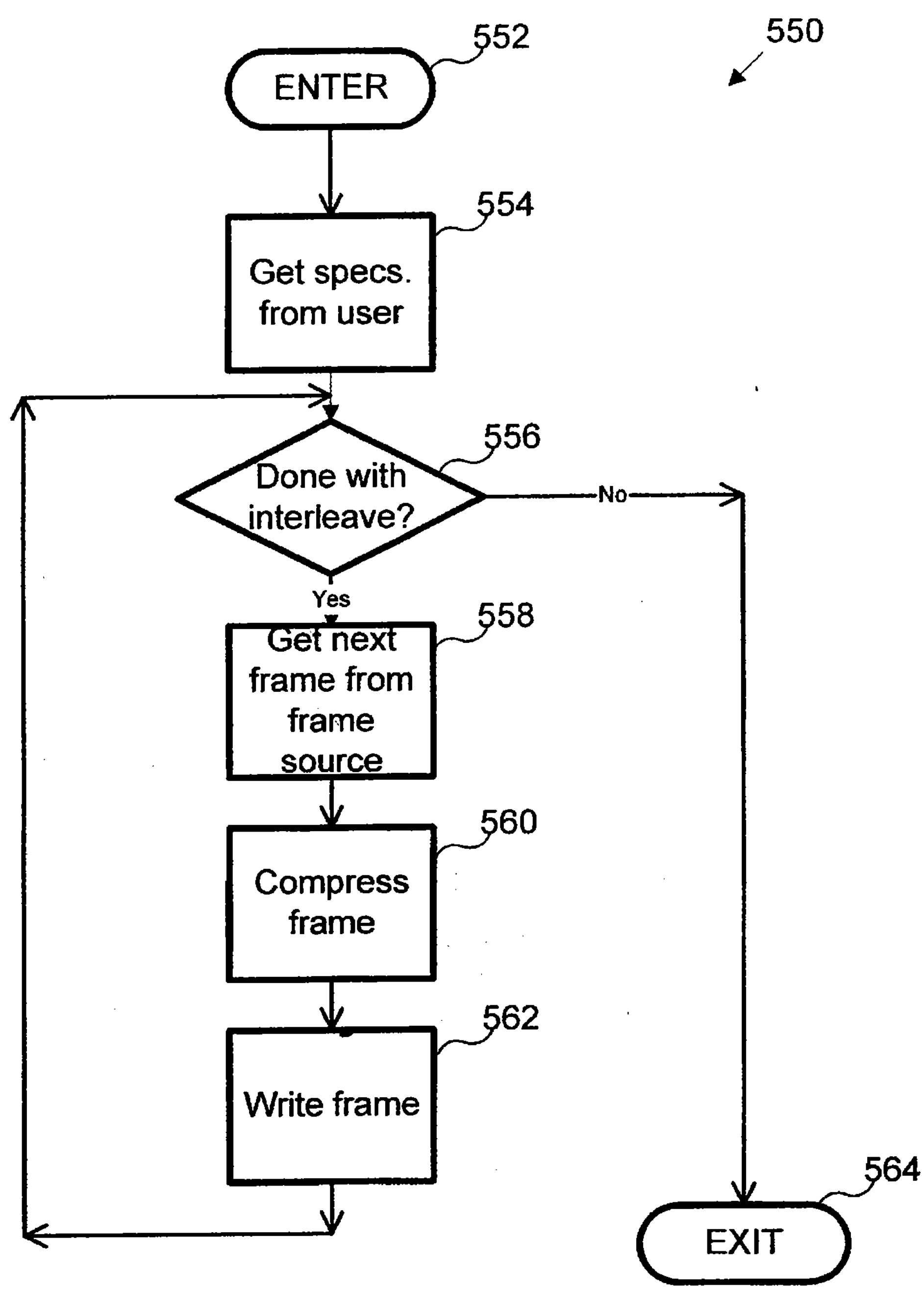

550
ENTER
552
Get specs. from user
554
Done with interleave?
556
No
Yes
Get next frame from frame source
558
Compress frame
560
Write frame
562
EXIT
564

Fig. 2B

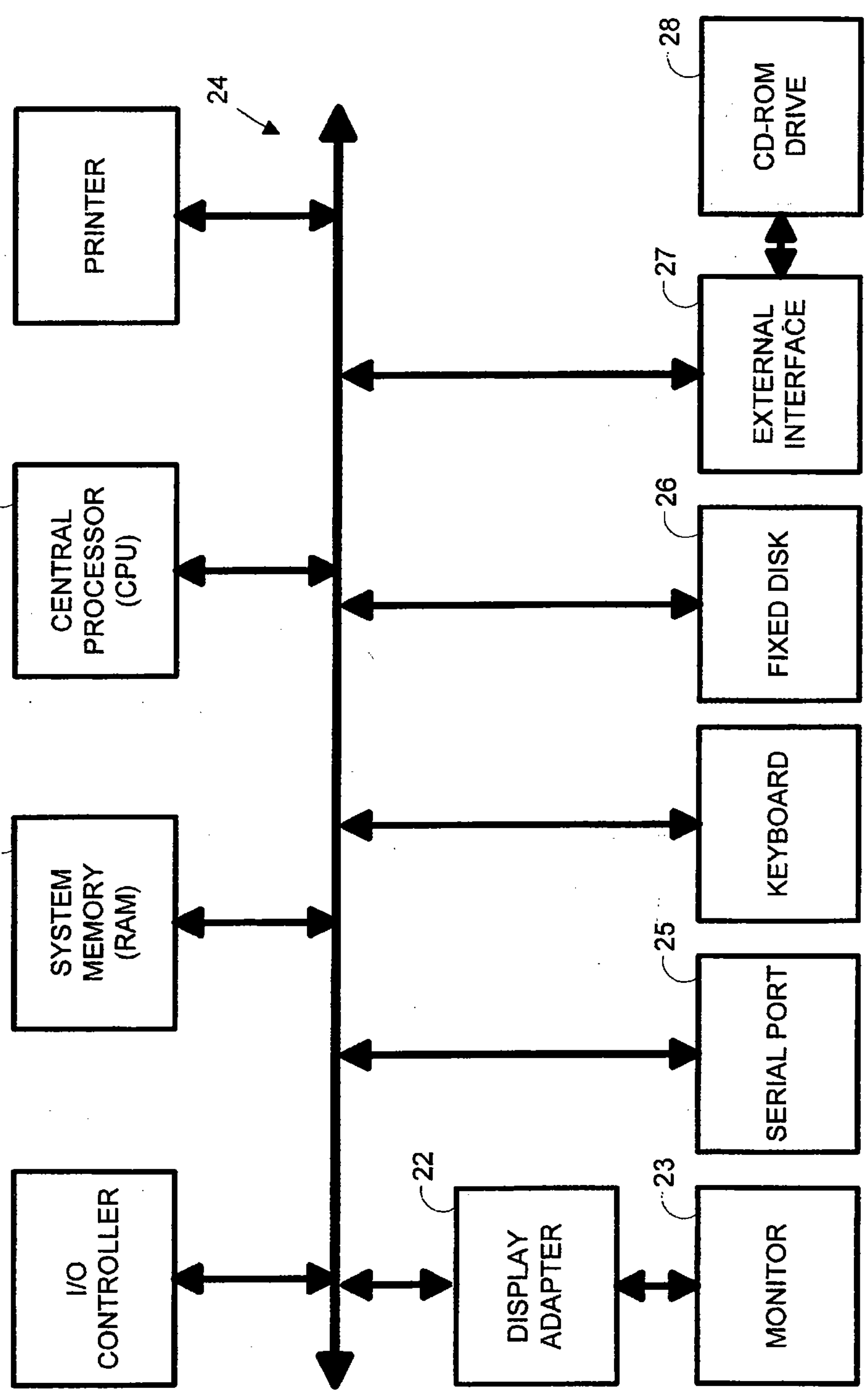

PRINTER
24
CENTRAL PROCESSOR (CPU)
20
SYSTEM MEMORY (RAM)
21
I/O CONTROLLER
CD-ROM DRIVE
28
EXTERNAL INTERFACE
27
FIXED DISK
26
KEYBOARD
SERIAL PORT
25
DISPLAY ADAPTER
22
MONITOR
23

Fig. 4

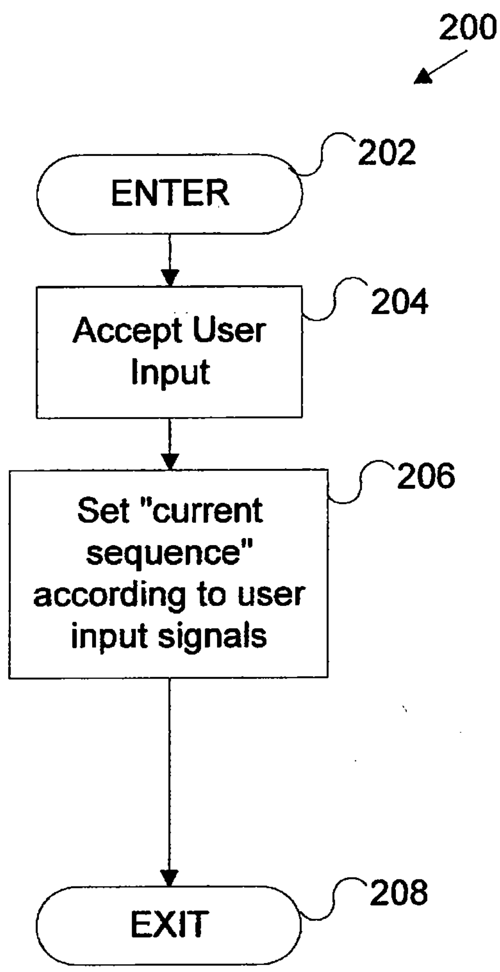

200
202
ENTER
204
Accept User Input
206
Set "current sequence" according to user input signals
208
EXIT

Fig. 6A

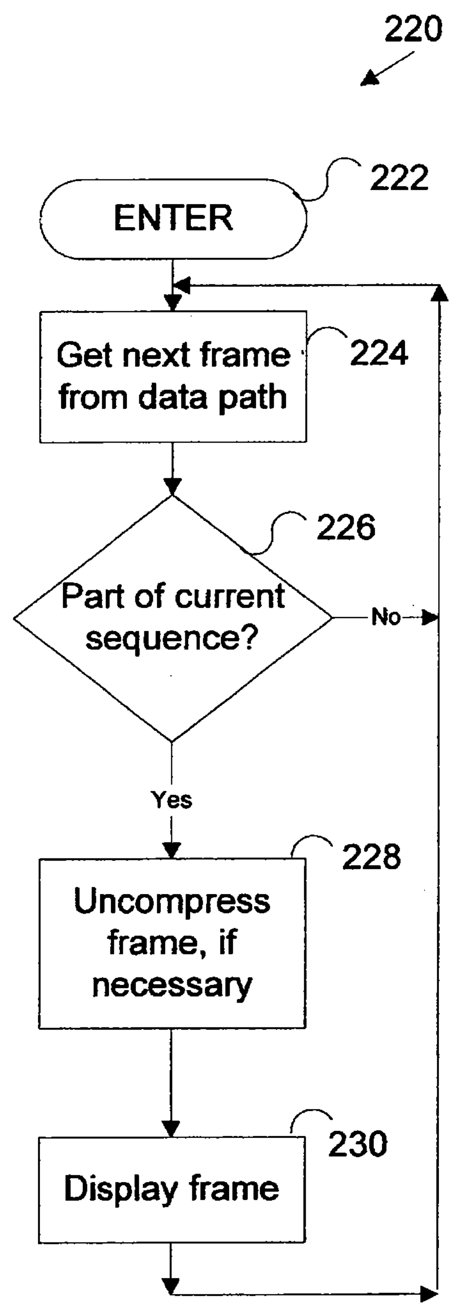

220
222
ENTER
224
Get next frame from data path
226
Part of current sequence?
No
Yes
228
Uncompress frame, if necessary
230
Display frame

Fig. 6B

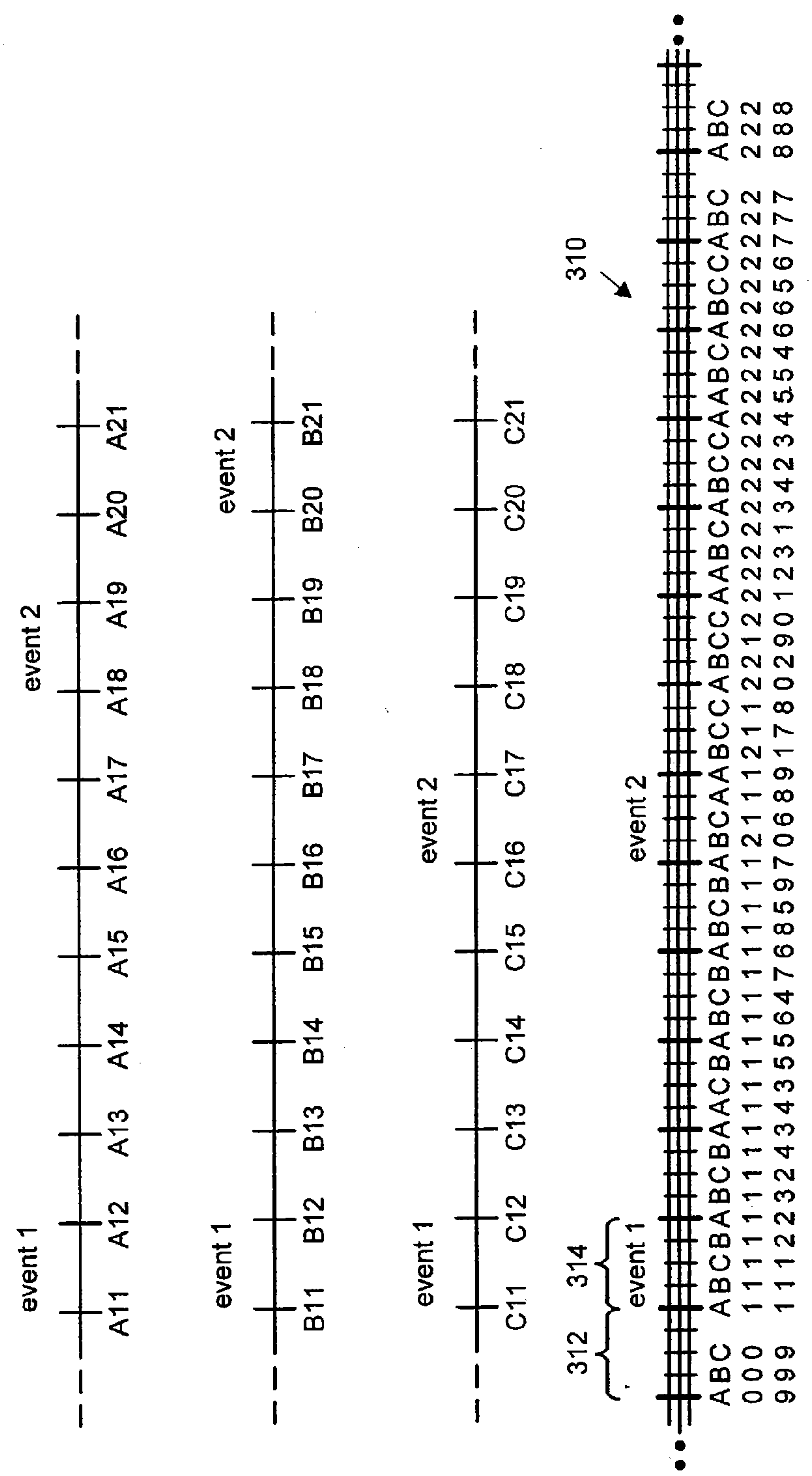

event 1
event 2
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
B11
B12
B13
B14
B15
B16
B17
B18
B19
B20
B21
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
C21
310
312
314

Fig. 8

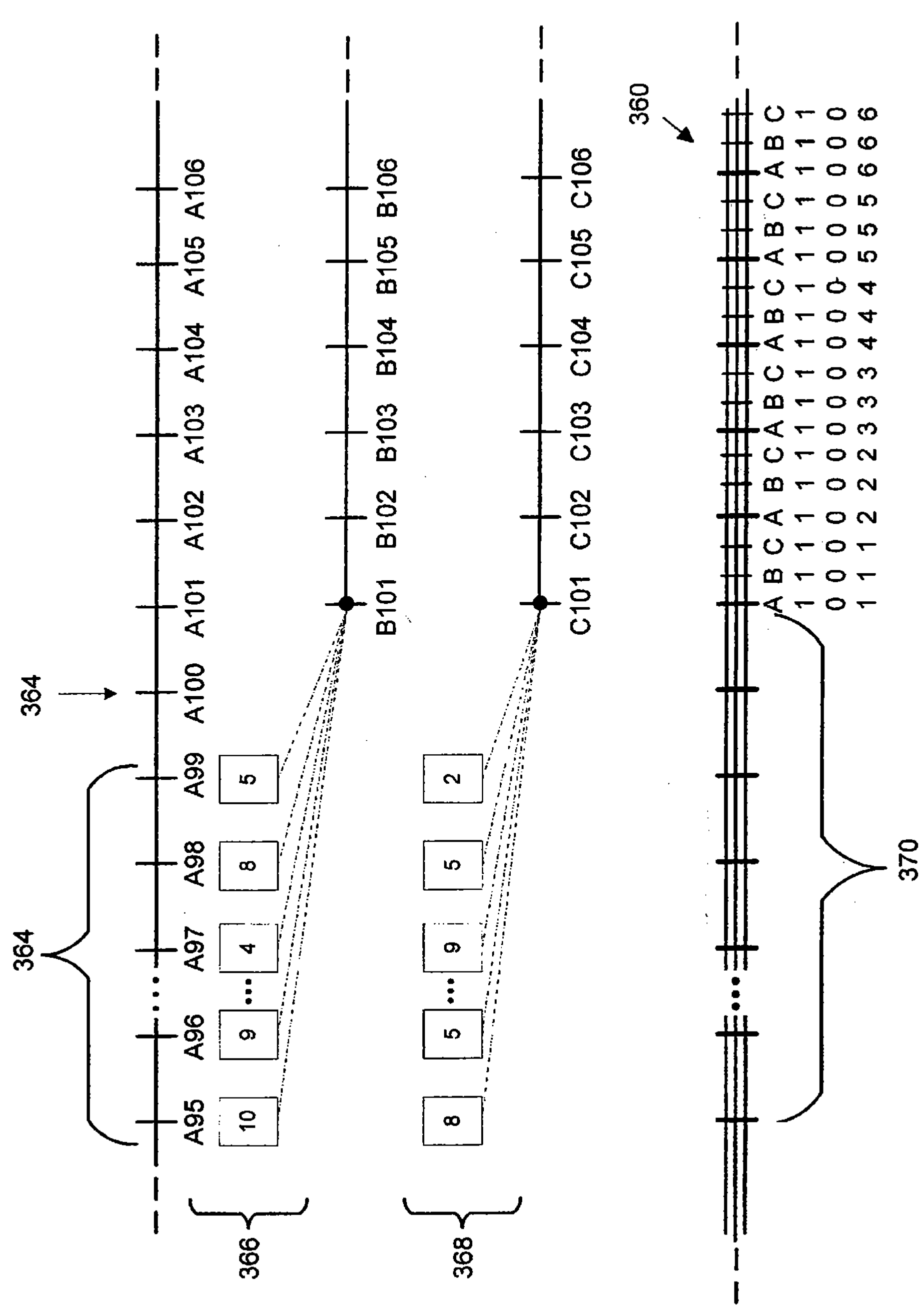

364
364
A95
A96
A97
A98
A99
A100
A101
A102
A103
A104
A105
A106
B101
B102
B103
B104
B105
B106
C101
C102
C103
C104
C105
C106
366
368
360
370

Fig. 10

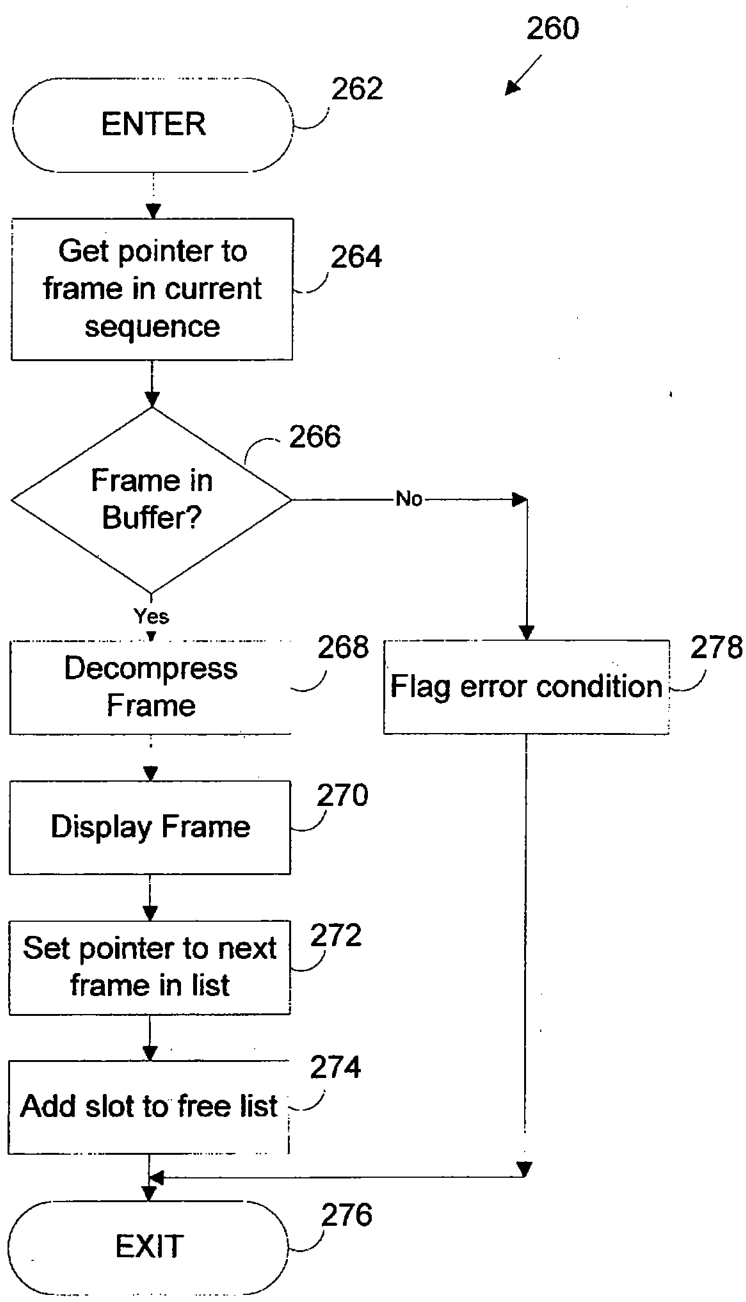

260
ENTER
262
Get pointer to frame in current sequence
264
Frame in Buffer?
266
No
Yes
Decompress Frame
268
Flag error condition
278
Display Frame
270
Set pointer to next frame in list
272
Add slot to free list
274
EXIT
276

Fig. 12

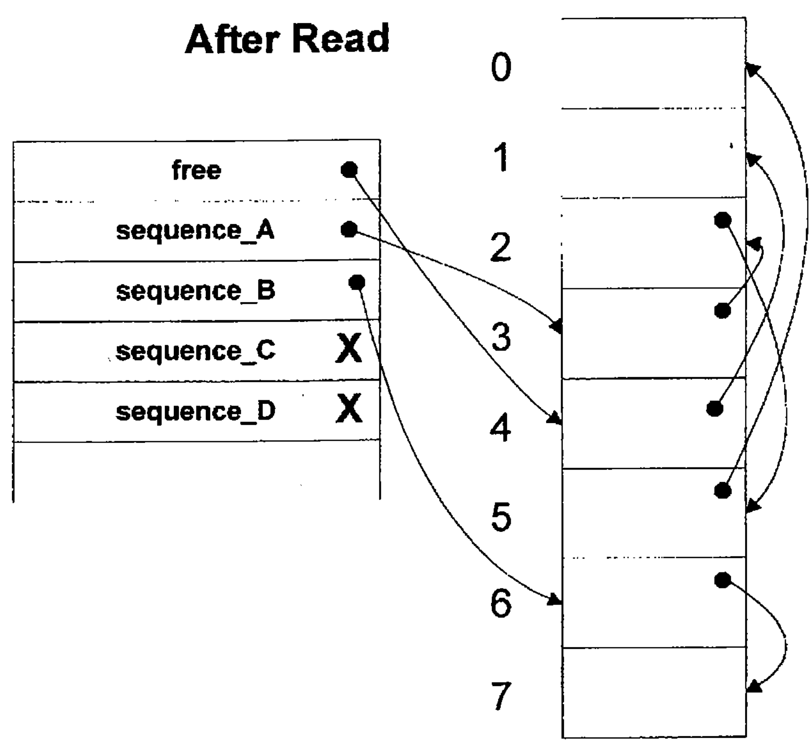

After Read
free
sequence_A
sequence_B
sequence_C
X
sequence_D
X
0
1
2
3
4
5
6
7

Fig. 13C

SYSTEM FOR SELECTIVELY BUFFERING AND DISPLAYING RELEVANT FRAMES FROM INTERLEAVING FRAMES ASSOCIATED WITH RESPECTIVE ANIMATION SEQUENCES STORED IN A MEDIUM IN RESPONSE TO USER SELECTION

BACKGROUND OF THE INVENTION

This invention relates generally to displaying animation sequences in a computer system and specifically to displaying video data from a compact disc read only memory (CD-ROM) device in a computer system running an interactive application.

Interactive productions allow a user of a computer system to interact with movies, video or other displayed images while the images are being updated at a rapid rate. The purpose of these productions is to present useful information, educate or entertain the user. The ultimate goal of interactive technology is to make the user feel as though they are interacting with images on the screen so that, for example, characters or objects in a drama react to the users actions. The user's actions can affect characters, objects or other images on the display screen and change the course of the storyline.

One method for providing a high degree of interaction is to make the production completely computer generated. This means that the computer models a three dimensional world and calculates and displays the orientation of figures and objects on the screen. However, this approach is limited by today's technology because the computing power to fully calculate and render lifelike images, especially human figures, at resolutions approaching television quality in real time at video or film refresh rates is beyond the current technology for mass-marketed systems.

A different approach is to prerecord video, film or computer generated image sequences and play the prerecorded images, or frames, back at high speed. This achieves the resolution of television, or better, and is sufficiently lifelike to create a level of believability comparable to television. However, in this approach the user has a very limited amount of interactivity with the production since the user's ability to affect the story is limited to the small number of different "paths" of prerecorded image sequences that are branched to at predetermined decision points in the video or animation sequence. The use of any prerecorded sequences of images that are played back so as to achieve animation while allowing a user to interact with the images is referred to broadly here as "interactive video."

Interactive video productions typically use a compact disc read-only memory (CD-ROM) disc to store the images and a CD-ROM drive to retrieve images during playback. The CD-ROM disc stores information in a concentric spiral on optical media and is "read" or played back with a CD-ROM drive that uses a "read head" with a laser beam. The big problem with CD-ROM based interactive production is the break in continuity due to delays of about a half-second or more required to locate a desired branch path that is different from the current path that the drive's read head is tracking. Another problem is that CD-ROM based interactive video productions are severely limited in the number and types of ways that a user may interact with the video.

The length of time to access a different video path ("access time" or "seek time") depends upon the location of the different video path with respect to the current placement of the CD-ROM drive's read head. In order to access a given video sequence, a computer controller looks up the location of the sequence in an index and instructs the CD-ROM drive to access the new sequence by moving the read head to the beginning of the new sequence on the disc. Since the read head is moved by a mechanical mechanism it takes a comparatively long time to reposition the read head to a new point on the track to access the different video path.

The prior art uses caches to try to improve the performance of accessing data in a CD-ROM. The cache can be in the CD-ROM drive, in an interface card between the processor and the drive, in the memory of the computer system controlled by software or even on a hard disk or other storage medium. However, these caches only provide marginal improvement in access times where video is concerned because of the relatively small sizes of the caches compared to the data rate of the information coming off of the CD-ROM. Also, when a different path is branched to the information in the caches is usually useless since they don't contain the new data. The caches must be "purged" and loaded with new information.

While current CD-ROM drives are not adequate to provide sufficient interactivity in interactive video productions, they represent a huge installed base since hundreds of thousands have already been sold to consumers. Therefore, a system which eliminates the access time in CD-ROM based interactive videos without requiring modification of existing CD-ROM drives is desired. Further, a system that allows an interactive video production to use many paths to improve interactivity without suffering degraded performance is desired.

SUMMARY OF THE INVENTION

The invention uses a special formatting of a CD-ROM disc where portions of a first animation sequence are interleaved with portions of a second animation sequence on the CD-ROM disc itself. The invention also takes special advantage of the interleaved information during playback of the CD-ROM to completely eliminate the necessity of moving the read head in the CD-ROM drive while playing back an interactive video production. The invention uses several patterns of interleaved animations to provide vastly improved interactivity.

The invention works to special advantage with image compression techniques and with caches. Other advantages of the present invention will be apparent.

In one embodiment, the system of the present invention executes on a computer and includes a method of creating an interactive production on a CD-ROM. In the method, first and second animation sequences of digital frames are created and the animation sequences of frames are written to the CD-ROM by interleaving the frames of the first animation sequence with the frames of the second animation sequence to create the interactive production.

Another embodiment of the invention provides for playing back an interactive production created as described above. A computer system is used that includes a processor, user input device and display screen. The computer system is coupled to a CD-ROM drive. The following steps are performed under the control of the processor: continuously reading the interleaved frames from the CD-ROM; displaying only the frames of a first animation sequence on the display screen to play back a first animation; accepting signals from the user input device selecting a second animation sequence; and, in response to the signals from the user input device, displaying only the frames of the second animation sequence on the display screen to play back the second animation.

audio data as well as for image data. A portion of an audio track is included in each frame corresponding to a time interval occupied by the display of the frame image data upon playback. For example, at the video rate of 30 frames per second (fps) an audio portion of 1/30 second of speech, sound effects, music, etc., can be included adjacent to its corresponding frame. Other methods of associating audio data with interleaved frames are possible.

Interleaving may occur with amounts of information less that a complete frame. Portions of frames may be interleaved so that, for example, where a frame is 640 columns by 480 rows, single rows or groups of rows from a frame of a first sequence may be interleaved with single rows or groups of rows from a frame of a second sequence. Also, information other than frame data can be included in each of the "frames" shown in FIG. 2 so that other useful information may be associated with, or read conveniently while reading, frame information.

One type of data that is useful to keep associated with frame information is a frame "tag" or identification (ID) number. A tag is useful to decide which frames to display and which frames to "drop" during frame selection as discussed below. Other types of information such as multi-frame branching information, buffering information, etc., can be put on the CD-ROM within or adjacent to the frames, or between series' of frames on the CD-ROM.

Interleaving is also used advantageously with compression techniques. As is known in the art, compression techniques reduce the amount of data needed to represent information such as a frame. Popular compression techniques such as Motion Picture Experts Group (MPEG) currently achieve about 25:1 compression ratios thus reducing the amount of data to about one twenty-fifth of the original requirement. Compressed frames may be interleaved as described above. Similarly, where portions of frames are interleaved the frame portions may be compressed. Any information needed by decompression routines to later decompress the information can be stored with the compressed information within the frame on the CD-ROM, between frames or in a different portion of the CD-ROM.

Some compression schemes are "inter-frame." This means that the compression/decompression ("codec") scheme of one frame depends on the data in a different frame. Where inter-frame compression is used it is usually more advantageous to do the compression between frames in the same sequence. That is, where two sequences are interleaved one frame at a time the inter-frame codec is best achieved by skipping frames so that, to the codec routines, it is as if the frames are non-interleaved. However, some advantages may be found by performing inter-frame codec on adjacent frames in an interleaved series. This is especially true where the interleaved frames differ only slightly from each other even though they are from different sequences. This is a common occurrence in interactive video productions using branch points where the action in the scene branches from a single frame into two gradually differing sequences.

The CD-ROM track need not be a spiral in order for the present invention to function. Any track arrangement that allows continuous reading of data from the CD-ROM in one mode is suitable for use with the present invention. For example, the CD-ROM track could have many concentric circles instead of a continuous spiral. This is similar to the format for magnetic media floppy and hard disk drives. Floppy and hard drives suffer from a similar, although less pronounced, problem in access time since they, too, use mechanical mechanisms to move read heads when it becomes necessary to look for data in different video paths. The advantage of interleaving is that it allows multiple sequences of animation to be available during playback of the CD-ROM (or other similar media) without requiring the slow mechanical repositioning of the read head. Thus the present invention is adaptable to a floppy or hard disk by formatting the floppy or hard disk in the interleaved manner as described herein.

Frame interleaving may also be used without a CD-ROM as where animated sequences are transmitted over a cable, fiber optic line, or other data link, or by electromagnetic transmission. For example, where an interactive video production is transmitted via cable to a user's home computer or television (computer/tv) frame interleaving could be used by alternating the transmission of frames in the transmitted signal. In other words, instead of writing the information to a CD-ROM disc the information could be transmitted in the ordering shown in FIG. 2 over a transmission medium. The user interaction with respect to decision points and the operation of the playback software at the user's computer/tv would be the same as where the information is read from a CD-ROM disc that is local to the user's computer as described above.

FIG. 2A is a simple block diagram of a system suitable for use in creating a CD-ROM with an interleaved frame format such as the frame format shown in FIG. 2.

In FIG. 2A system **500** includes a frame source **502**, control unit **504** and CD-ROM record device **506**. Frame source **502** may be a hard disk or other media where the frames of at least two separate animation sequences are stored in a digital format. Control unit **504** is preferably a digital computer executing software allowing a user to specify the any of the interleaving patterns discussed above. In a preferred embodiment, boxes within control unit **504** in FIG. 2A are implemented as software processes executed by a central processing unit (CPU) in a digital computer, such as the computer system described below in connection with FIGS. 3 and 4. The software processes use various computer system resources such as buses, I/O ports, etc. to accomplish their tasks as is known in the art.

Selection process **508** chooses between frames from sequence A and B according to the user's specifications. Selection process **508** sends each selected frame to compression process **510**. Compression is used in a preferred embodiment of the invention but is not necessary to practice the present invention. Compression process **510** compresses each frame according to any of a variety of known compression techniques, e.g., MPEG. Once compressed, write process **514** writes each frame to CD-ROM record device **506** according to the order determined by selection process **508**. Suitable CD-ROM recording devices are, e.g., Kodak PCD Writer 200 or Philips CDD-521.

Thus, system **500** is capable of creating a CD-ROM disc in any of the interleaved formats discussed above.

FIG. 2B shows flowchart **200** illustrating the basic steps in creating a CD-ROM with interleaved formatting. The method illustrated in the flowchart of FIG. 2B may be used with the system shown in FIG. 2A.

The routine of flowchart **550** is entered at step **552** where it is assumed that multiple animation sequences made up of frames are residing on a storage device that is used as the frame source. At step **554** the user specifies the sequences to interleave and the type of interleaving. Next, step **556** is executed where a check is made as to whether the interleaving is completed. Assuming that there are still more frames

CPU **124** is used to accomplish the transfer of information between driver **116** and adapter **118**.

As mentioned above, each hardware system in FIG. **5** may include software as part of its operation. Software and hardware boxes may be added to or omitted from the data path shown in FIG. **5**. Depending on compatibility versus speed considerations, an application program may not use the operating system to communicate with peripherals such as disk drive **122**, CD-ROM drive **102** and display **120**. Also, hardware systems may be employed in place of software processes if speed is more important than flexibility. For example, if DMA techniques are used by bus interface **108** then driver **110** is not needed and may be replaced by a buffer area in memory. In this case, a DMA controller is used to place data into the buffer area.

B. Selection of Frames

The present invention uses frame selection methods to discard frames during playback so that only frames of a desired sequence are displayed. These frame selection methods may be implemented in hardware or software at any point in the system of FIG. **5** from controller **106** to video adapter **118**. In a preferred embodiment, the frame selection is made under the direction of application program **114**. While this sacrifices speed and efficiency it allows the interactive video production to be compatible with standard operating systems such as Microsoft Windows 3.0 by Microsoft, Inc., or the Macintosh operating system by Apple Computer, Inc. A description of these operating systems may be found in Microsoft Windows User's Guide Version 3.0 by Microsoft Corporation, and Macintosh User's Guide, by Apple Computer, Inc. Performing frame selection at the application program level allows the features of the present invention to be transparent to existing computer systems, prevents conflicts among other software that may be executing in the computer system and is in keeping with standard computer hardware and software practices. Further, it allows the present invention to be practiced without modifying existing hardware or software that consumers may already own.

FIGS. **6A** and **6B** show flowcharts of methods of the present invention to select frames from a series of frames read from a CD-ROM.

In general, the flowcharts in this specification illustrate one or more software routines executing in a computer system such as computer system **130** of FIG. **5**. The routines may be implemented by any means as is known in the art. For example, any number of computer programming languages, such as "C", Pascal, FORTRAN, assembly language, etc., may be used. Further, various programming approaches such as procedural, object oriented or artificial intelligence techniques may be employed.

The steps of the flowcharts may be implemented by one or more software routines, processes, subroutines, modules, etc. It will be apparent that each flowchart is illustrative of merely the broad logical flow of the method of the present invention and that steps may be added to, or taken away from, the flowcharts without departing from the scope of the invention. Further, the order of execution of steps in the flowcharts may be changed without departing from the scope of the invention. Additional considerations in implementing the method described by the flowchart in software may dictate changes in the selection and order of steps. For example, event handling may be by interrupt driven, polled, or other schemes. A multiprocessing or multitasking environment could allow steps to be executed "concurrently." For ease of discussion the implementation of each flowchart is referred to as if it is implemented in a single "routine".

FIG. **6A** shows a flowchart for a routine **200** to select the "current sequence" according to user input. Routine **200** may be implemented by a variety of means as is known in the art, such as by using operating system routines to accept keyboard or mouse signals at predetermined times. The accepted signals are processed to set a variable to one of several states that indicate a current sequence such as sequence_A or sequence_B. In a preferred embodiment, routine **200** is invoked by an interrupt and entered at step **202** when a user input is detected. Routine **200** runs concurrently with the routine of FIG. **6B**.

Routine **200** is greatly simplified. At step **204** user input is accepted. At step **206** the user input signals are used to set a variable indicating the current sequence. For example, at a decision point the user has the opportunity to enter a response that selects between two paths, or sequences of images. If the user inputs "yes" at the keyboard the value for sequence A is assigned to the current sequence variable. If the user does not enter "yes" the value for sequence B is assigned to the current sequence variable. After the current sequence has been updated, routine **200** exits at step **212**.

FIG. **6B** shows a flowchart for a routine **220** to select and display frames according to the state of the current sequence variable as set by routine **200**. Routine **220** executes concurrently with routine **200** so that the current sequence is selectable while a sequence is being displayed. Routine **220** is also greatly simplified and may be implemented by a variety of means. A preferred implementation of key steps in routine **220** of FIG. **6B** is discussed below.

Routine **220** is entered at step **222** where it is assumed that frame data is being read from a CD-ROM formatted in an interleaved manner as described above. At step **224** the next frame is obtained from the data path. Assuming routine **220** is implemented in an application program such as application program **114** of FIG. **5**, the next frame will reside in a buffer such as buffers **128** after having been placed there by other routines in application **114** in concert with operating system **112**, driver **110**, bus interface **108**, etc., as is known in the art. However, certain advantages may be realized by implementing routine **220** at different points in the data path as discussed below.

At step **226** a check is made as to whether the next frame is part of the current sequence as specified by the value of the current sequence variable set by routine **200**. If so, execution proceeds to step **228** where the frame data is decompressed, if necessary. Next, the decompressed frame is displayed at step **230** so that the sequence is presented to the user as an animation. Execution returns to step **224** for subsequent frames.

If, at step **226**, it is determined that the next frame is not part of the current sequence then execution proceeds back to step **224** where the next frame is obtained for similar checking. In short, only those frames that are part of the current sequence are decompressed and displayed so that only the selected sequence is presented to the user. The association of frames with sequences can be by tags as described above, where frames in a given sequence include an identifying symbol such as the letter A for frames in sequence A. Other methods of association are possible, such as where two sequences are interleaved frame-by-frame so that it is known, once the series starts, that alternating frames belong to the same sequence.

The selection methods of FIGS. **6A** and **6B** allow an application program to have instant access to different sequences of frames on the CD-ROM disc. Thus, the time to switch between sequence A and sequence B is not limited by as the frame tag and codec information. Buffer **282** has 8 slots numbered **0–7**. The buffer size may be larger or smaller depending on the demands of the system and the interactivity requirements as discussed below. The number of pointers used may vary. Additional pointers are shown in FIG. **13A** such as sequence_C and sequence_D pointers which do not have any list of slots associated with them. Therefore, these sequences are not available for the user to select during playback of the interactive production. However, they may become available at a later time when frames designated for these sequences are obtained from the data path and placed into the buffer.

Pointers **280** each point to the beginning of a linked list of slots although the list pointed to by a pointer may be empty, or null. Each slot in a given list includes a pointer to the next slot in the list. Thus, the slots in a list may be in arbitrary order with respect to the slot numbering. This is a so-called "singly" linked list. Refinements on this approach, such as by using back pointers between slots in the list to create a "doubly" linked list, and "tail pointers" to show the end of a list may be used. Many modifications to the present buffering scheme are possible. Also, many different ways of implementing the system of the present invention are possible, the use of buffers as described here being but one possible way.

Routine **240** of FIG. **11** is entered at step **242**. Routine **240** is called often enough to obtain each frame from the data path without missing frames as they are read off of the CD-ROM disc at a more or less constant rate. At step **244** a check is made as to whether there is a free slot available in the buffer. Using the pointer scheme shown in FIG. **13A** this merely requires looking at the pointer called "free" to see whether it points to a slot or not. If no slot is available, an error condition is flagged at step **258** and routine **240** exits at **256**.

With the pointer values as shown in FIG. **13A**, slots **0** and **4** are on the free list. In other words there are two free slots so execution proceeds from step **244** to step **246** in routine **240** of FIG. **11**. At step **246** a frame is obtained from the data path. Obtaining a frame is dependent on the components used in the data path. One way to obtain a frame is to copy the frame from an auxiliary buffer used by operating system routines (or other hardware and software) after the routines have transferred the data from the CD-ROM. Alternatively, some systems allow a pointer to an area of memory, such as slot **0** of buffer **282**, to be passed to hardware or software components whereupon the area of memory is filled with the data from the data path, e.g., by DMA transfer or by other means. In the latter case, the steps of flowchart **11** need to be modified in order to reflect the automatic placement of data into the buffer.

Assuming that the frame data must be copied from an auxiliary buffer, routine **240** of FIG. **11** executes step **248** to determine the animation sequence that the frame belongs to. In a preferred embodiment this is done by examining a tag or other identification associated with the obtained frame. At step **250** the frame is stored into a free slot. In the present example the first slot in the free list, slot **0**, is used. Next, step **252** is executed in routine **240** so that slot **0** is added to the list for its associated sequence. Assuming the obtained frame belongs to sequence A, FIG. **13B** shows the obtained frame added to the sequence_A list so that the list of slots is now **1, 3, 2, 5, 0**. Step **254** in routine **240** removes slot **0** from the free list so that the free list now contains only slot **4**. Finally, routine **240** of FIG. **11** is exited at step **256**.

FIG. **12** shows a routine **260** for retrieving and displaying a frame from the buffer. In FIG. **12**, routine **260** is entered at **262**. Routine **260** is typically called after each frame refresh interval at a fixed frame rate where interactive video is used. However, routine **260** need only be called often enough to present smooth information to a user of the interactive production and the frame rate may be of varying rates in different productions and even within a given production.

At step **264** routine **260** checks the pointer for the list of slots of frames that corresponds to the current sequence. In the present example sequence A is the current sequence (as indicated by a current sequence variable, discussed above) so pointer sequence_A in FIG. **13B** is checked. Step **266** determines whether or not the list pointed to by sequence_A is empty. If the list is empty then step **278** is executed which flags an error condition and the routine is exited. At this point in time, pointer sequence_A points to a list of slots **1, 3, 2, 5, 0** so step **268** is executed to decompress the next frame in the list, namely, the frame in slot **1**.

After the frame in slot **1** is decompressed the frame information is displayed on the display screen at step **270**. At step **272** the pointer sequence_A is set to point to the next frame in the list. Step **274** adds slot **1** to the free list so that it may be reused. At this point, the pointer and buffer arrangement is as shown in FIG. **13C**.

Thus, the description above illustrates how frames from the data path are written to a buffer and read from the buffer and displayed.

A deficiency exists in the system described so far since, in a preferred embodiment, one frame per refresh interval is being displayed to the user while multiple frames are being read from the CD-ROM disc and stored to the buffer in any given frame refresh interval. This means that the buffer will quickly fill up.

FIG. **14** shows a routine **400** for clearing the buffer based on outdated frames or some other criterion. Routine **400** is entered at step **402** and is called frequently enough, e.g., once every refresh interval, to remove unneeded frames from the buffer. At step **404** a check is made as to whether there are enough free slots in the buffer. If so, the routine is exited at step **412**. It is desirable to keep as many frames in the buffer as possible since this is more efficient use of buffer space and since there may be some use for frames, even outdated frames, by an application program.

At step **406** a check is made as to whether any outdated frames are in the buffer. Outdated frames are detected by including a frame number with each frame within the frame's tag. Frames from any sequence that have passed their opportunity for display will be discarded from the buffer by removing the frame from the list and adding the frame's slot to the free list. The discarding step is performed at step **408** of FIG. **14**. Should none of the frames be outdated then a frame is discarded from the buffer according to some other criterion at step **410**. For example, one criterion is to discard a frame that it is known will not be used because, e.g., the sequence has become unselectable at some time after the sequence frames were stored into the buffer. Other criterion are possible to free up a slot. For example, a slot may simply be discarded even though the need for the slot's frame at some later time may produce a "dropout" on the display.

In general, the design of a buffering scheme for frames at the application level is affected by many factors. In an ideal system, the frames are provided by the data path in perfect synchronization with the refresh rate so that no buffering is necessary. However, because of errors in hardware such as misreadings from the CD-ROM drive, sharing of resources

For example, in an interactive production where the user is able to be present in different rooms in a house in order to observe different characters there could be a ringing doorbell that is heard throughout the rooms. A second event could be someone announcing over an intercom system that they will get the door. However, if these sequences are originally filmed or taped with live actors in real time (as opposed to computer generated characters) then it is unlikely that the spacing of the two events will occur in the same number of frames in each of the sequences. In other words, it is likely that there will be a difference in the two events of greater than 1/30 second. This could result in the user hearing a partial repeat of the announcement over the intercom should the user switch from a first sequence to a second sequence where the announcement came a fraction of a second later in the second sequence. While such a discrepancy could conceivably be corrected by shifting the audio track within the sequences, it may arise that characters or objects on the screen are affected in accordance with the sound events. For example, the announcement may be heard in the first sequence and then the user may switch to the room where the person making the announcement is seen speaking into the intercom. Other visual events could occur that need to be coordinated among the different sequences such as a flash of lightning that's visible in multiple rooms.

One approach to correct this is to use time stepped path switching patterns. This is a way to compensate for differences in the number of frames between two same events on different sequences. Time stepped path switching requires a faster data transfer rate than simple switching to allow for one or more sequences to "catch up" with other sequences.

FIG. 8 shows three timelines similar to those of FIG. 7. In FIG. 8, the timeline for sequence A has a first event, event **1**, occurring at frame **A11**. Event **2** occurs at frame **A18**. In sequence B, event **1** occurs at frame **B11** but event **2** occurs at frame **B20**. Thus, there is a two frame difference in the interval of the events in sequence B from sequence A. This small discrepancy is used here for ease of discussion. In practice much larger discrepancies can be handled by the system described here as will be apparent to one of ordinary skill in the art.

In sequence C, there are only **6** frames between the occurrences of events **1** and **2**.

CD-ROM track **310** is shown at the bottom of FIG. **8**. At interval **312** frames **A9**, **B9** and **C9** are stored, similarly to the format of FIG. 7. However, the bandwidth, or transfer rate, of track **310** is greater than that of FIG. **7** to allow at least one more frame per interval to be stored. Thus, the transfer rate of the playback of track **310** is at least 120 fps although the instant rate for interval **312** is only 90 fps since only three frames are stored in the interval.

At interval **314** event **1** has occurred. At interval **314** special use is made of the ability to store an extra frame by having frame **B12** stored in the interval along with frames **A11**, **B11** and **C11**. It can be seen that extra frames from sequence B are stored in four intervals of track **310** between events **1** and **2**. This accounts for the greater number of frames in sequence B between the two events. Thus, frame **B20** is available for playback at the position of event **2** on track **310**. Similarly, for sequence A there are additional frames inserted so that, at event **2**, frame **A18** is available.

The requirement for increased bandwidth is calculated as the number of extra frames from all sequences (besides the shortest one) between the two events divided by the number of frames in the shortest sequence between the two events. This yields the number of extra frames per interval that must be stored. In the present example the calculation is (2+4)/6=1. This is in accordance with the ability to store an extra frame per interval in track **310** when time stepped path switching is performed.

One problem with time stepped path switching is that a large number of frames may have to be buffered. Where frames for a given sequence are being transferred from the CD-ROM at faster than the display frame rate the additional frames must be held in a buffer until they can be used. Each time two frames from sequence B are obtained in an interval one of the frames must be stored. This, of course, assumes that sequence B is currently selected and is being displayed. Otherwise, the additional sequence B frames, indeed all sequence B frames, may simply be dropped according to the system described above. For short discrepancies between sequences this is not a problem. The current example, only requires that two frames from sequence B be buffered. However, where the discrepancy is two seconds, this method requires that 30 frames be buffered somehow. One possibility is to spool the buffered frames to a hard disk but this depends on disk storage availability. Another solution is to insure that such large discrepancies don't exist in the sequences when the sequences are filmed.

Once event **2** has been reached on track **310** it may be necessary to re-synchronize the three sequences. This can be done in a similar manner to the discussion above except that it is sequence C's along with sequence A's frames that are "doubled up" in an interval to catch up to sequence B's frame numbers. This is shown on track **310** subsequent to event **2**. Again, buffering is necessary where multiple frames from a displayed sequence are available within a given interval. The three sequences are synchronized again at interval **314** and only three frames per interval need be stored thereafter.

The method presented in FIG. **8** is a general way to time shift two sequences with respect to each other. This may be useful for a variety of purposes in interactive productions. The additional frame capacity can be used for other purposes when not used for time stepped path switching patterns.

C. Single Point Transitions

A single point transition is shown in FIG. **9**. A single point transition is similar to the simple path switching pattern of FIG. **7** except that multiple sequence data does not appear on track **340** until the decision point at **342**, or frame **A2**, is reached. As before, track **340** represents a track on the CD-ROM that is played back at a transfer rate that allows multiple frames to be available during an interval corresponding to the interval used to display a frame from the current sequence on the display screen. The transfer rate does not have to be a multiple of the frame display rate. In a preferred embodiment, the data transfer rate allows three frames to be obtained within each interval. For convenience, each frame from sequence A is the start of what is referred to as an "interval" on track **340**. Such as interval **344** at frame **A3**.

At decision point **342**, the user is able to affect the interactive video by causing either of sequences B or C to be played. An example of a single point transition is where a character can perform one of two or more actions such as continuing to type a patent at a word processor, smashing the keyboard of the word processor or getting up and going home. In the example, the action of continuing to type is sequence A. The action of smashing the keyboard is sequence B and the action of getting up and going home is sequence C.

Though these actions are all very different, they start from a single common frame at **A2**. That is, frame **A2** is the accepting signals from the user input device selecting the second animation sequence; and

in response to the signals from the user input device, displaying only the frames of the second animation sequence on the display screen to play back the second animation.

2. The method of claim 1, further comprising the following steps:

prior to the "writing the first and second animation sequences" step, compressing one or more of the digital frames;

wherein the "writing the first and second animation sequences" step further includes the substep of writing the compressed digital frames to the medium; and

decompressing a frame prior to displaying the frame on the display screen.

3. The method of claim 1, further comprising the steps of:

writing a tag, wherein the tag indicates that data representing one or more frames belongs to a specific sequence; and

using the tag during the play back of the interactive production to determine whether to display the associated data representing one or more frames.

4. The method of claim 3, wherein the computer system includes memory comprising a buffer, wherein frames are stored into the buffer prior to display on the display device, the method further comprising the step of:

using the tag to prevent loading of the associated data representing one or more frames into the buffer.

5. A method for playing back an interactive production recorded on a medium having a spiral data track, wherein the medium includes a first animation sequence of digital frames interleaved with frames from a second animation sequence of digital frames, wherein the medium further includes identification information associated with data describing the frames, wherein a computer system is used to play back the interactive production, wherein the computer system comprises a processor, user input device, display screen memory including a buffer, and drive for reading the medium, the method further comprising the following steps performed under the control of the processor:

continuously reading the interleaved frames and identification information from the medium;

using the identification information to store only frames of the first animation sequence into the buffer and to skip frames of the second animation sequence so that the skipped frames of the second animation sequence are not stored in the buffer;

displaying the frames in the buffer on the display screen to play back the first animation;

accepting signals from the user input device selecting the second animation sequence; and

in response to the signals from the user input device performing the following steps:

continuously reading the interleaved frames and identification information from the medium,

using the identification information to store frames of the second animation sequence into the buffer and to skip frames of the first animation sequence so that the skipped flames of the first animation sequence are not stored in the buffer; and

displaying the frames in the buffer on the display screen to play back the second animation.

6. The method of claim 5, wherein the identification information comprises:

a tag for indicating that one or more frames are from a particular sequence.

7. An apparatus for playing back an interactive production stored on a medium having a spiral data track, wherein the medium includes frames corresponding to a first animation sequence showing a first action interleaved with frames corresponding to a second animation sequence showing a second action to produce a series of frames wherein adjacent frames in the series correspond to different animation sequences, the apparatus comprising:

a computer system including a processor, user input device and display screen;

a drive for reading the medium coupled to the computer system for retrieving frames from the series of frames on the medium;

means responsive to signals from the user input device to output a select signal indicating the selection of the second sequence;

selection means for selectively storing the interleaved frames while the interleaved frames are contiguously read from the medium; and

displaying means coupled to the selection means for displaying on the display screen frames corresponding to the first animation sequence, and, upon generation of the select signal, for displaying on the display screen frames corresponding to the second animation sequence in place of displaying one or more frames corresponding to the first animation sequence.

8. The apparatus of claim 7, wherein the frames in the series are compressed, the apparatus further comprising:

selection means responsive to signals from the user input device to output a select signal indicating the selection of the second sequence; and

decompression means for selectively decompressing frames in response to the select signal, wherein only frames corresponding to the first animation sequence are decompressed unless the select signal is present, in which case only frames corresponding to the second animation sequence are decompressed.

9. An apparatus for playing back an interactive production stored on a medium having a spiral data track, wherein the medium includes frames corresponding to a first animation sequence shwoing a first action interleaved with frames corresponding to a second animation sequence to produce a series of frames wherein adjacent frames in the series correspond to different animation sequences, the medium further including tags associated with one or more frames on the medium, wherein the tags indicate which sequence the one or more frames associated with a given tag belongs to, the apparatus comprising:

a computer system including a processor, user input device and a display screen;

a drive for reading the medium coupled to the computer system for retrieving frames from the series of frames on the medium;

means for reading the tags from the medium;

means responsive to signals from the user input device to select an animation sequence; and

means for using the tags to buffer and display frames from the selected animation sequence while skipping frames from the other non-selected animation sequence so that the skipped frames are not buffered.

* * * * *

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PACE DATA ENTRY CODING SHEET

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APPLICATION NUMBER	TYPE APPL	FILING DATE (MONTH DAY YEAR)	SPECIAL HANDLING	GROUP ART UNIT	CLASS	SHEETS OF DRAWING
08/252460	1	05 31 94	0	2301	364	16

TOTAL CLAIMS	INDEPENDENT CLAIMS	SMALL ENTITY?	FILING FEE	FOREIGN LICENSE	ATTORNEY DOCKET NUMBER
17	4	1	392	1	CJK1

CONTINUITY DATA

CONT CODE	STATUS CODE	PARENT APPLICATION SERIAL NUMBER	PCT APPLICATION SERIAL NUMBER	PARENT PATENT NUMBER	PARENT FILING DATE (MONTH DAY YEAR)
			PCT/ /		
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PATENT APPLICATION FEE DETERMINATION RECORD

Effective October 1, 1992

Application or Docket Number

CLAIMS AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	SMALL ENTITY RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
BASIC FEE					$355.00	OR		$710.00
TOTAL CLAIMS	7	minus 20 =	*	x$11=		OR	x$22=	
INDEPENDENT CLAIMS	4	minus 3 =	* 1	x 37=	37	OR	x 74=	
MULTIPLE DEPENDENT CLAIM PRESENT				+115=		OR	+230=	
				TOTAL	392	OR	TOTAL	

* If the difference in column 1 is less then zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	* 13	Minus	** 20	=	x$11=		OR	x$22=	
Independent	* 6	Minus	*** 4	= 2	x ~~37~~ 39=	78-	OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+ 115=		OR	+230=	
					TOTAL ADDIT. FEE	78-	OR	TOTAL ADDIT. FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x 37=		OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+ 115=		OR	+ 230=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x 37=		OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+115=		OR	+230=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875
(Rev.10-92)

Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT NUMBER

APPLICATION SERIAL NUMBER

08/252,460

APPLICANT'S NAME (PLEASE PRINT)

CHARLES J. KULAS

REISSUE, ORIGINAL PATENT NUMBER

INTERNATIONAL CLASSIFICATION

G	0	6	F		13/00
					/
					/
					/

ORIGINAL CLASSIFICATION

CLASS	SUBCLASS
395	484

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
395	173	427	849	872
360	18	48		

GROUP ART UNIT: 2317

ASSISTANT EXAMINER (PLEASE STAMP OR PRINT FULL NAME): PO C. HUANG

PRIMARY EXAMINER (PLEASE STAMP OR PRINT FULL NAME): [illegible]

PTO 270
(REV. 5-91)

ISSUE CLASSIFICATION SLIP

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

Staple Issue Slip Here

POSITION		ID NO.	DATE
CLASSIFIER		18	6/[illegible]
EXAMINER		230	6-23-96
TYPIST		336	7/16
VERIFIER		258	7/6
CORPS CORR.			
SPEC. HAND			
FILE MAINT.			
DRAFTING			

INDEX OF CLAIMS

Claim Final	Claim Original	Date 9/27/96	Date 6/3/96	Date 11/15/97	Date 5/23/97				
1	1	✓	✓	✓	=				
	~~2~~	✓	✓	✓					
2	3	✓	✓	✓	=				
5	4	✓	✓	✓	=				
7	5	✓	✓	✓	=				
8	6	✓	✓	✓	=				
	~~7~~	✓	✓						
3	8		✓	✓	=				
4	9		✓	✓	=				
6	10		✓	✓	=				
9	11		✓	✓	=				
	~~12~~		✓						
	~~13~~		✓						
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SYMBOLS

- ✓ .... Rejected
- = ... Allowed
- - (Through numeral) Canceled
- + ... Restricted
- N .... Non-elected
- I .... Interference
- A .... Appeal
- O .... Objected

Claim Final	Claim Original	Date							
	51								
	52								
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[redacted]

SEARCHED

Class	Sub.	Date	Exmr.	
369	47	9/22/95	P.H.	
369	48	9/22/95	P.H.	
~~395~~	~~152~~	~~9/22/95~~	~~P.H.~~	P.H. 5/23/97
~~395~~	~~154~~	~~9/22/95~~	~~P.H.~~	P.H. 5/23/97
~~395~~	~~275~~	~~9/22/95~~	~~P.H.~~	P.H. 5/23/97
345	22	6/3/96	P.H.	
348	155	6/3/96	P.H.	
360	48	6/3/96	P.H.	
348	483	1/15/97	P.H.	
386	52	1/15/97	P.H.	
"	92	"	"	
395	173	1/15/97	P.H.	
"	680	"	"	
463	3	1/15/97	P.H	
"	4	"	"	
360	18	5/23/97	P.H.	
395	427	5/23/97	P.H.	
"	481	"	"	
"	484	"	"	
"	849	"	"	
"	872	"	"	

SEARCH NOTES

	Date	Exmr.
Search APS & JPOABS (see attach sheet)	9/22/95	P.H.
Search Computer Select	9/22/95	P.H.
Search APS (see attach sheet)	6/3/96	P.H.
Search APS (see attach sheet)	1/15/97	P.H.
Search APS (see attach sheet)	5/21/97	P.H.

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
345	22	5/23/97	P.H.
348	155	5/23/97	P.H.
"	483	"	"
360	18	5/23/97	P.H.
"	48	"	"
369	47	5/23/97	P.H.
"	48	"	"
386	52	5/23/97	P.H.
"	92	"	"
395	173	5/23/97	P.H.
"	427	"	"
"	481	"	"
"	484	"	"
"	680	"	"
"	849	"	"

08/ 252460

[redacted]

APPROVED FOR LICENSE ☐

INITIALS ~~JUN 2 1 9446~~

CONTENTS

Date Entered or Counted	No.	Contents	Date Received or Mailed
	1.	Application ✓ papers.	RECEIVED JUL 15 1994 GROUP 2300
9.28	2.	Rej 3 Mos	10-5-95
	3.	Ext. of time (1) (2)	3-11-96 CM 3-5-96
	4.	Amdt A w/ drawing	3-11-96
	5.	Ext of Time (1 mos.)	3-25-96 CM 3-22
6-5	6.	Rejection (3 mos)	6-7-96
	7.	Exr Interview Summary	8-13-96
	8.	Ext of Time (2 mos.)	11-13-96 CM 11-7
	9.	Notice of Change of address	11-13-96
	10.	Amdt B	11-13-96
1-16-97	11.	Final Rejection 3 months	1/21/97
	12.	Ext of time (1 mos.)	4-29-97 CM 4-23
	13.	Amdt C (~~1 ...~~)	4-29-97
	14.	Exr Interview Summary	5/29/97
5-27	15.	Exr Amdt/D	5/29/97
	16.	Ext of time (1 mos.)	6-18-97
	17.	Letter & attachments	6-23-97 CM 6-18
	18.	Letter	11-3-97
12-4	19.	Formal Drawings (17 shts) 1 Ext. 1 month CM 9-29-97	8-29-97
	20.	PTO Grant MAR 31 1998	
	21.		
	22.		
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