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O'Connor et al.

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(54) **TIME SHIFTING BY SIMULTANEOUSLY RECORDING AND PLAYING A DATA STREAM**

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(76) Inventors: **Dennis M. O'Connor**, Chandler, AZ (US); **Mark P. Chuang**, Cupertino, CA (US)

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Correspondence Address:
TROP PRUNER & HU, PC
8554 KATY FREEWAY
SUITE 100
HOUSTON, TX 77024 (US)

(57) **ABSTRACT**

A video stream may include portions that are stored while other portions are being displayed. In one embodiment, a portion of the video stream may be stored in digital storage media at one instance while in the next instance another portion of the stream is being read out of the storage media.

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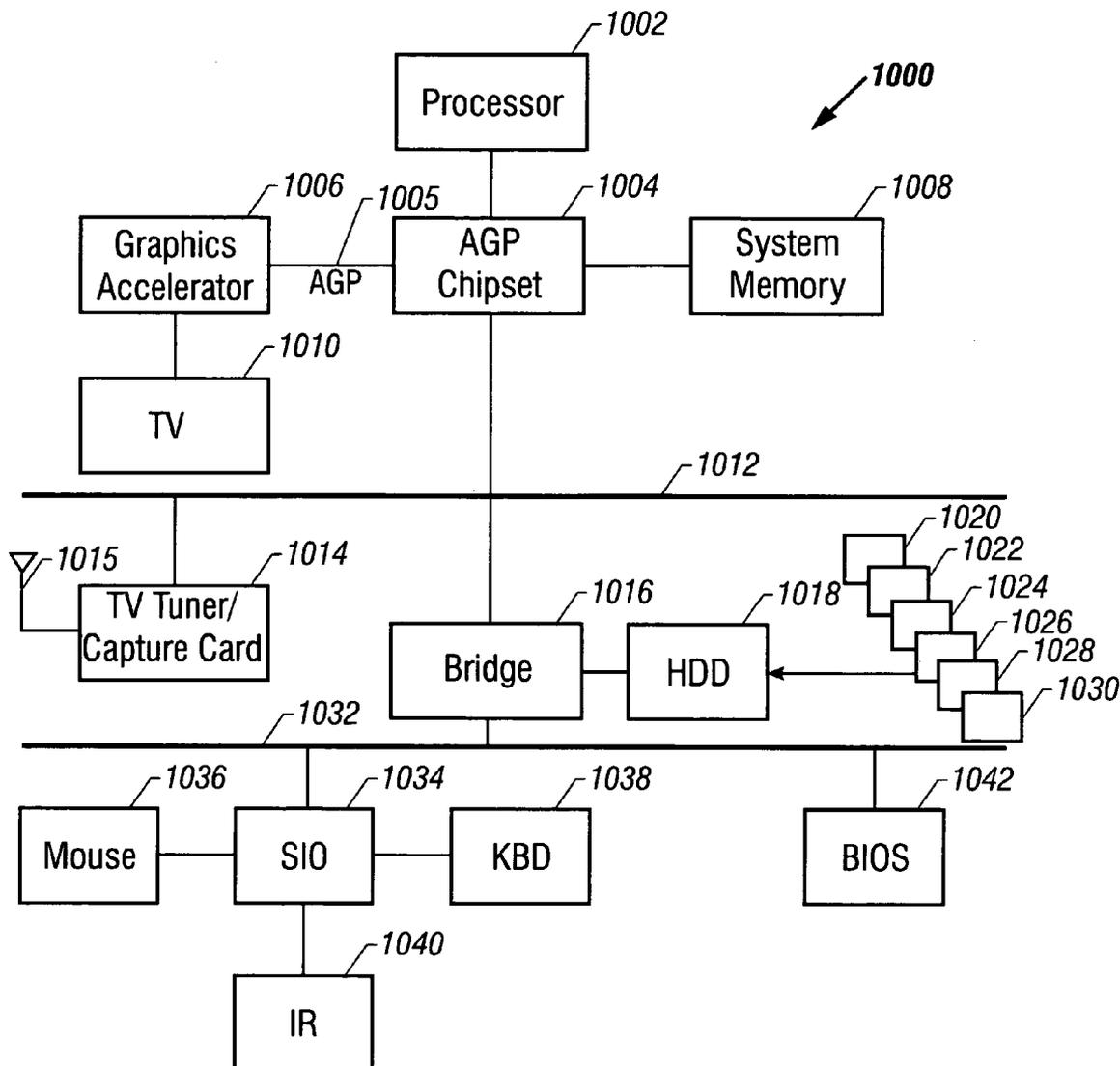


FIG. 1

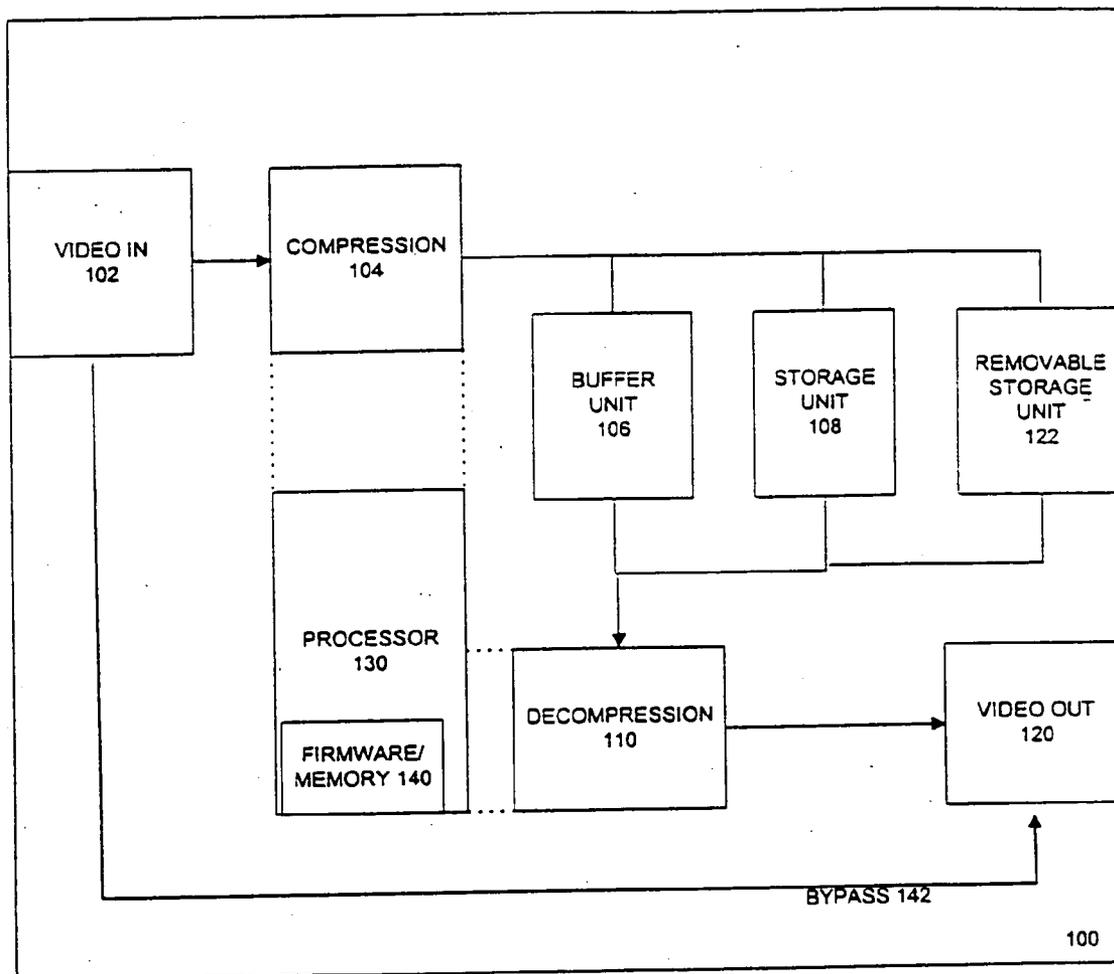


FIG. 2

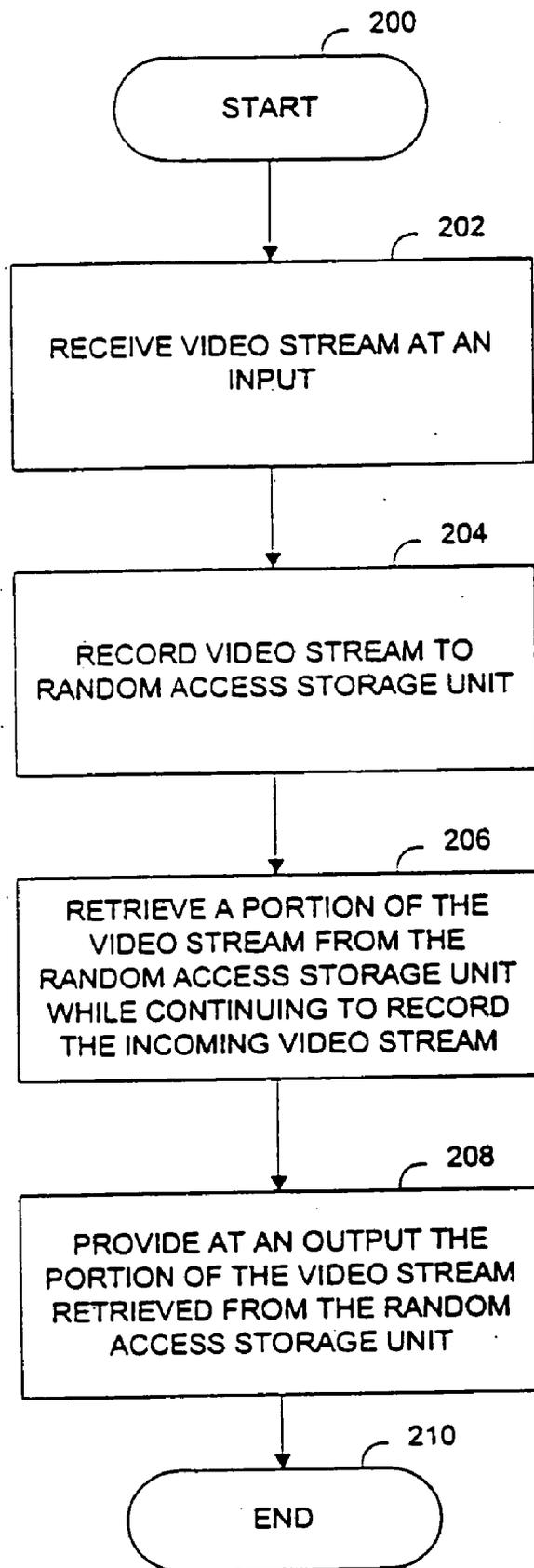


FIG. 3

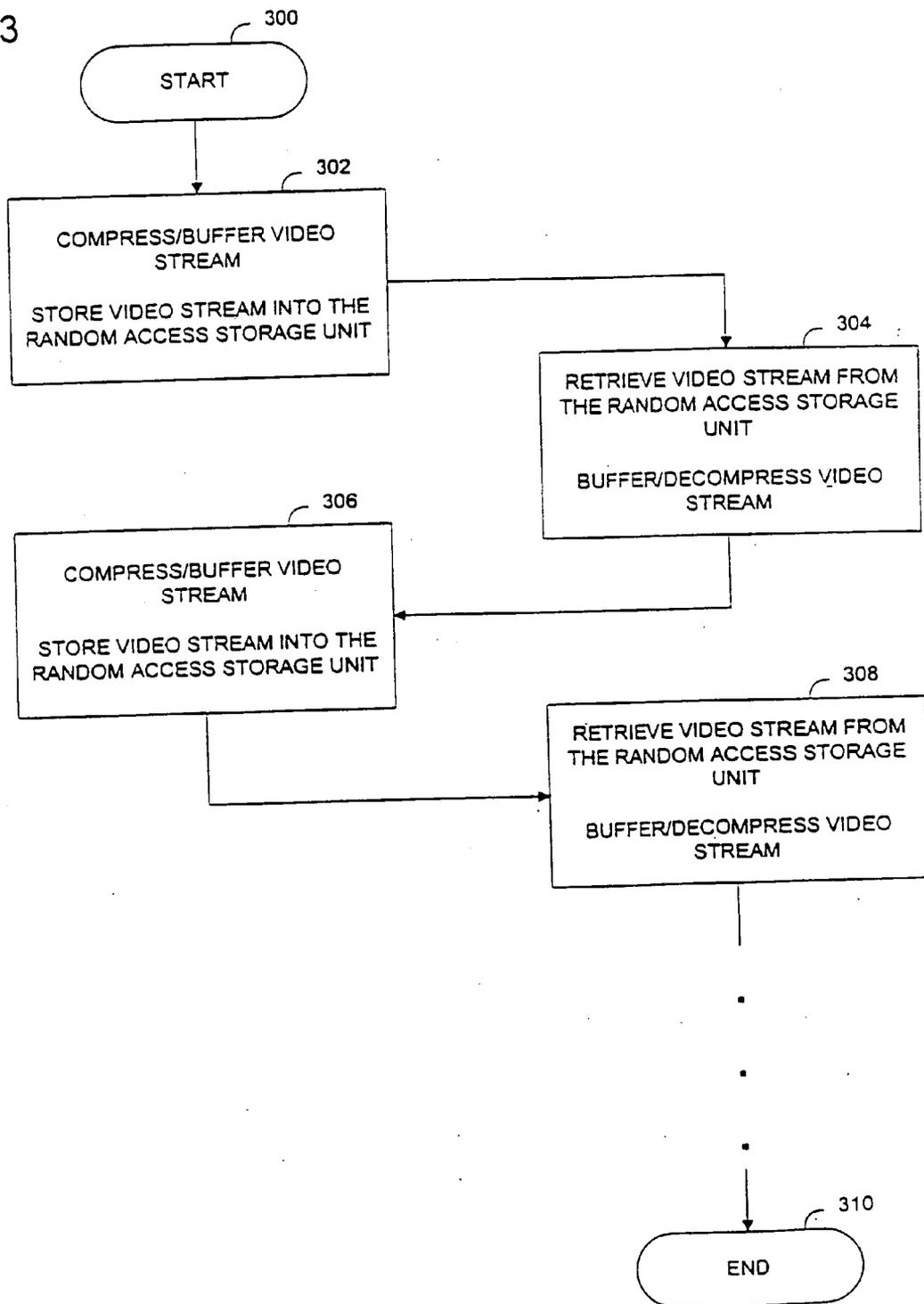


FIG. 4

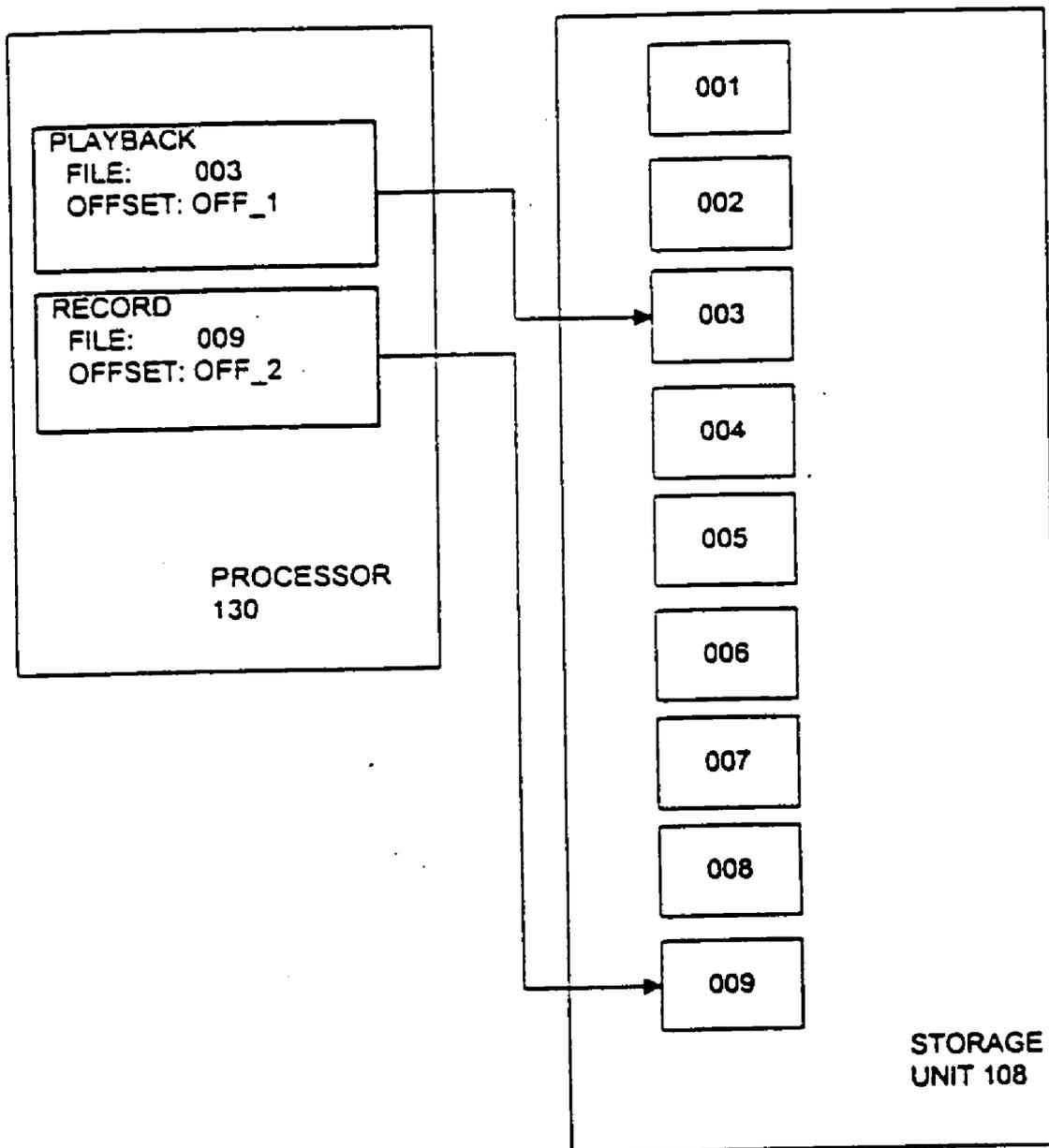


FIG. 5

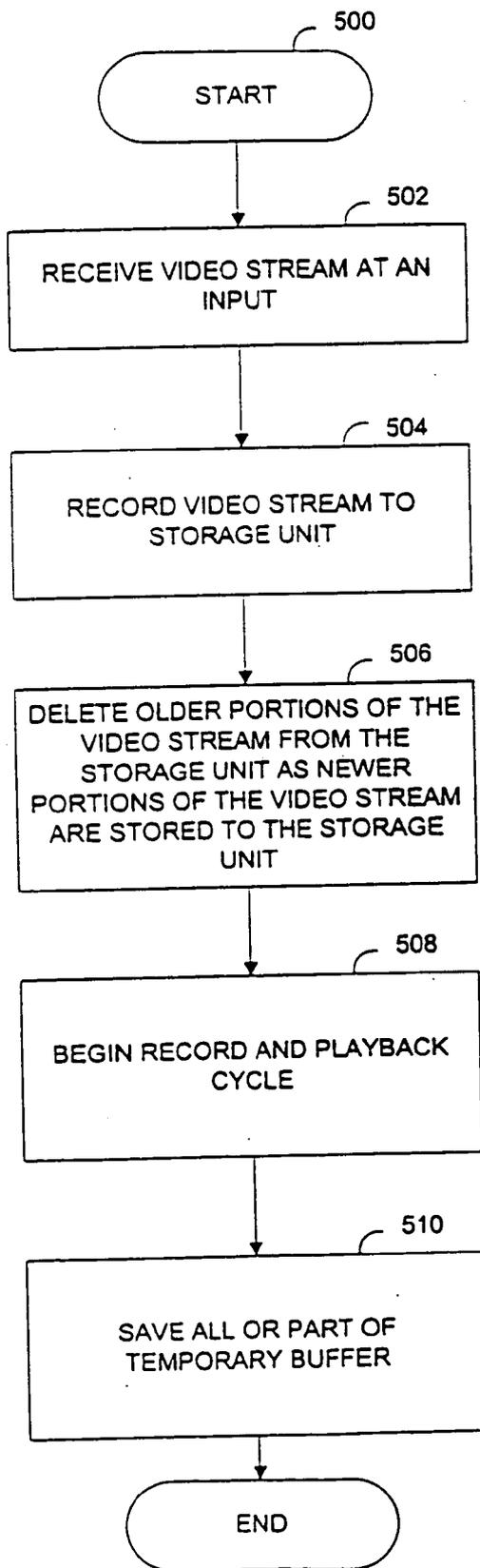


FIG. 6

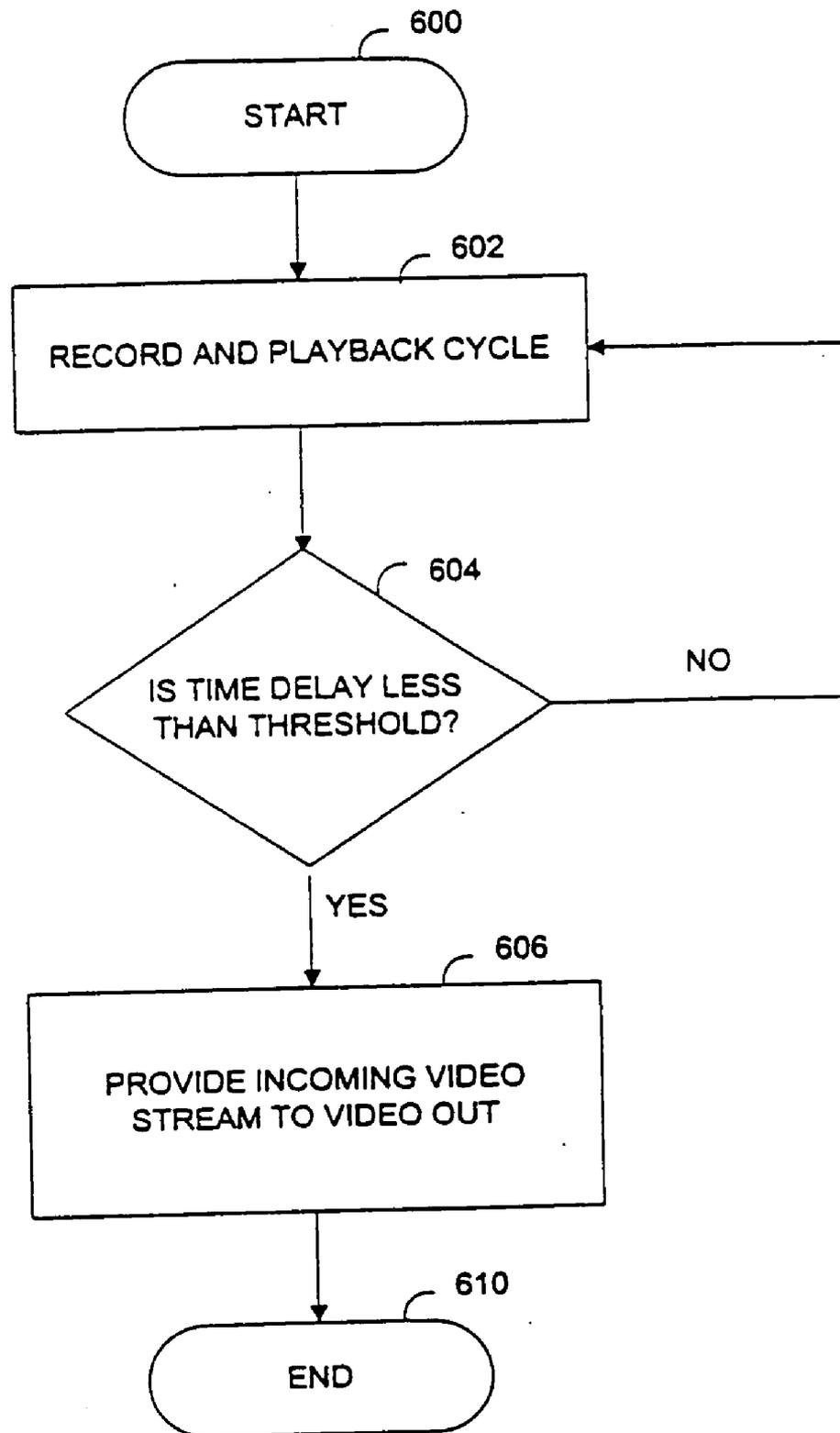


FIG. 7

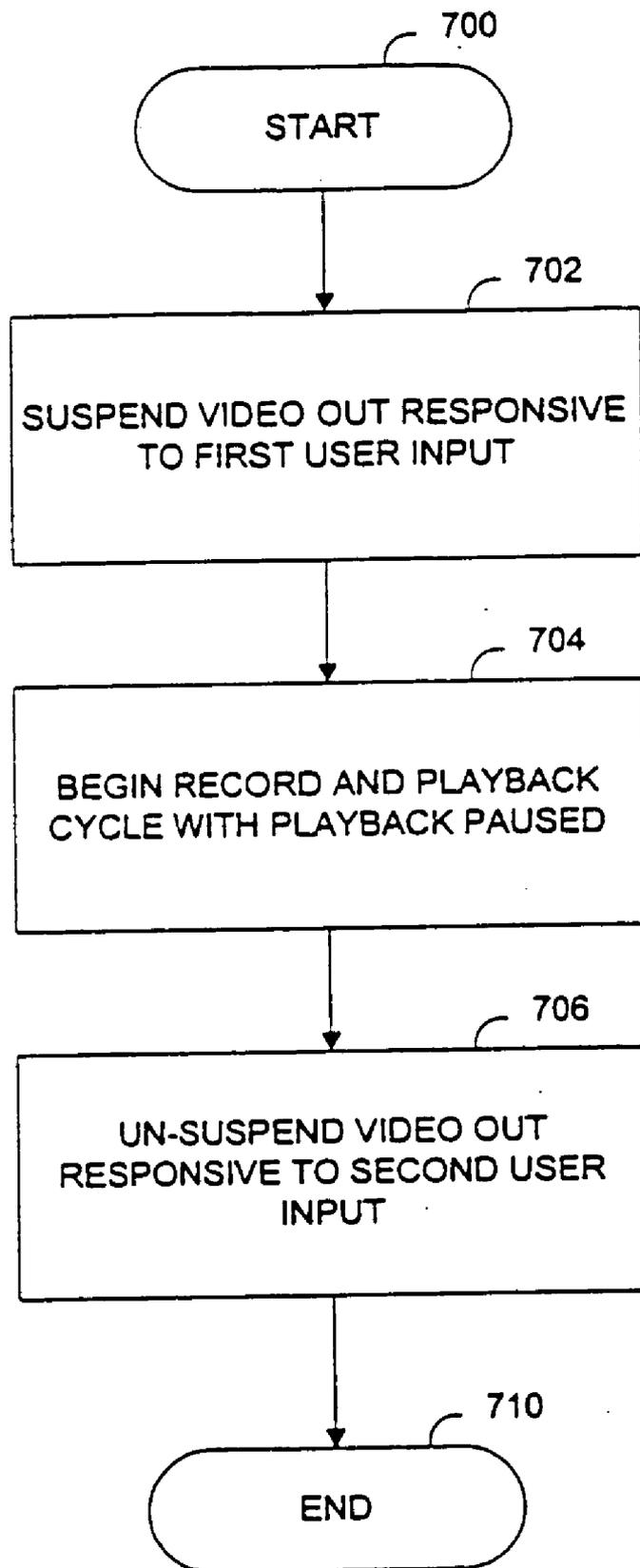
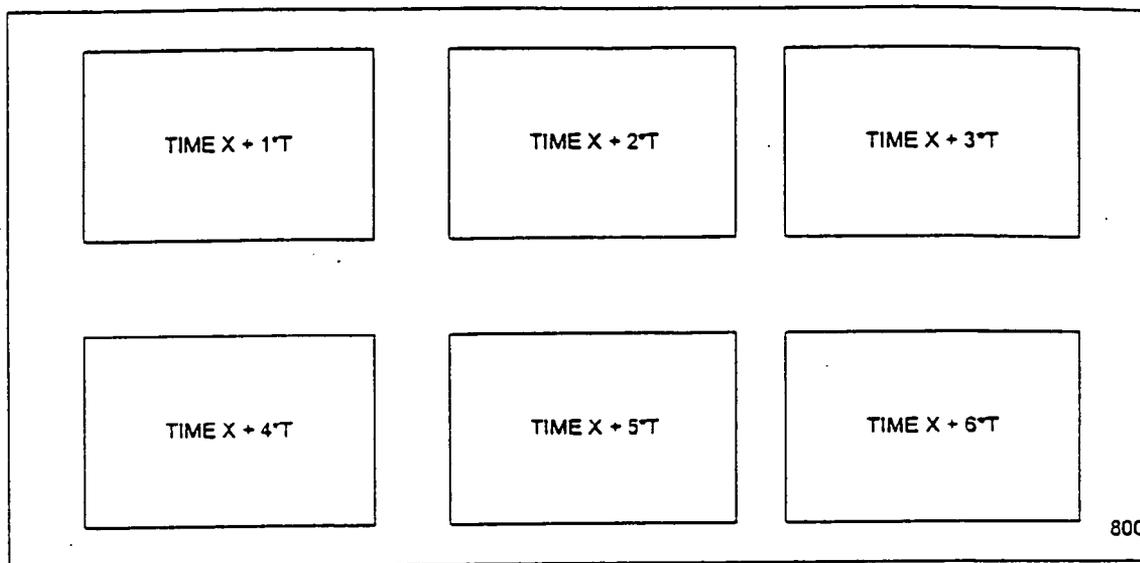


FIG. 8



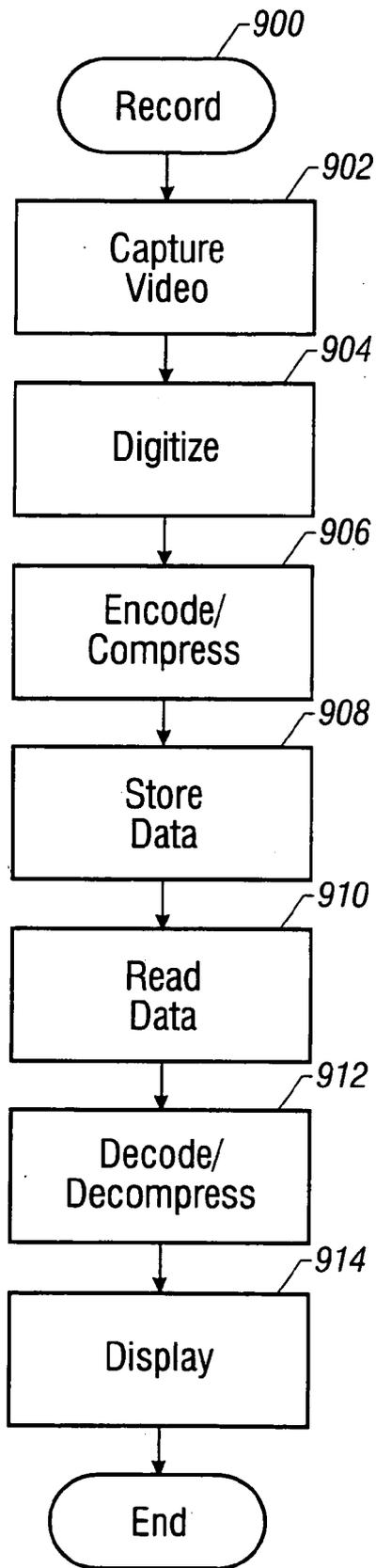


FIG. 9

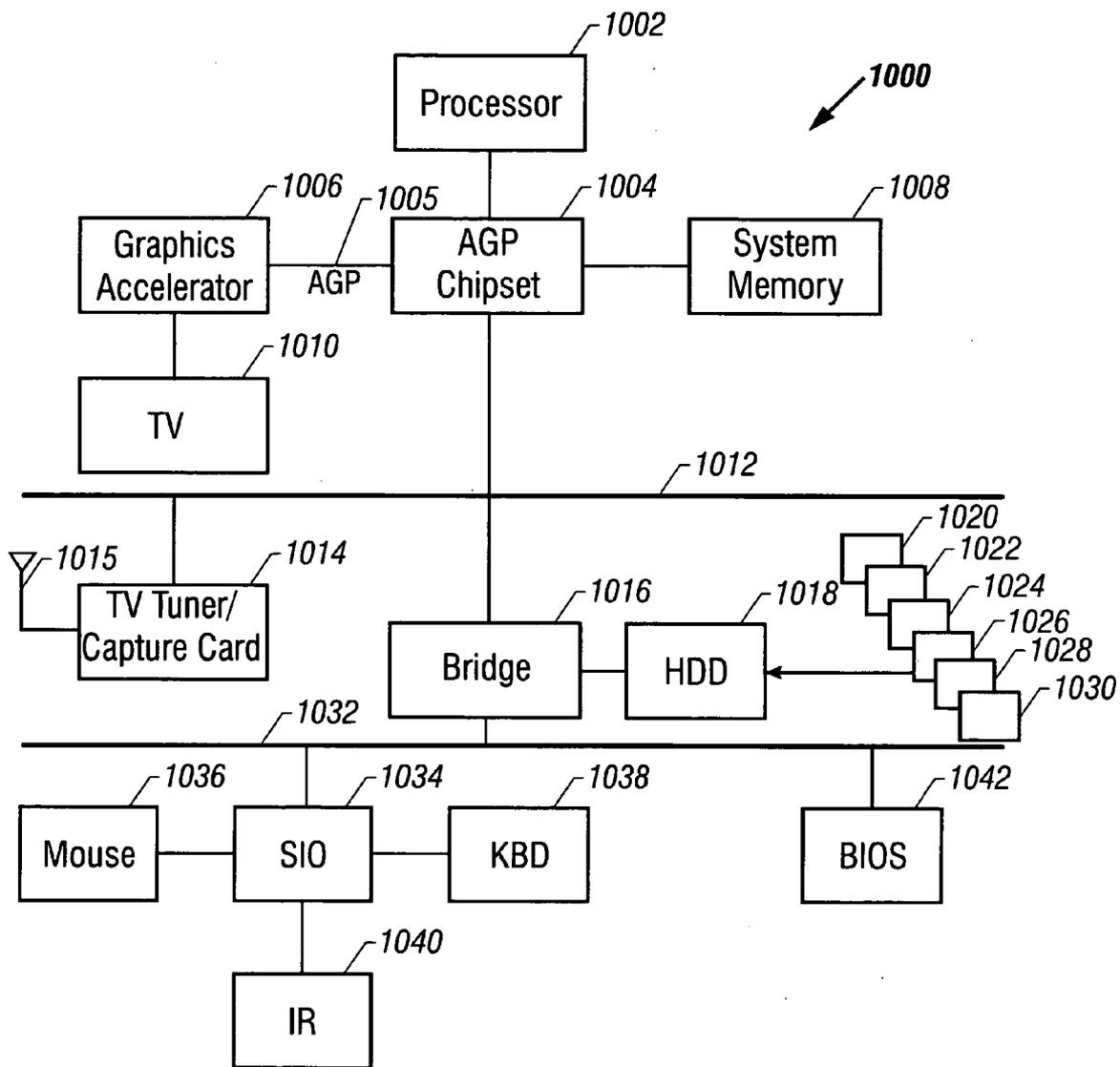


FIG. 10

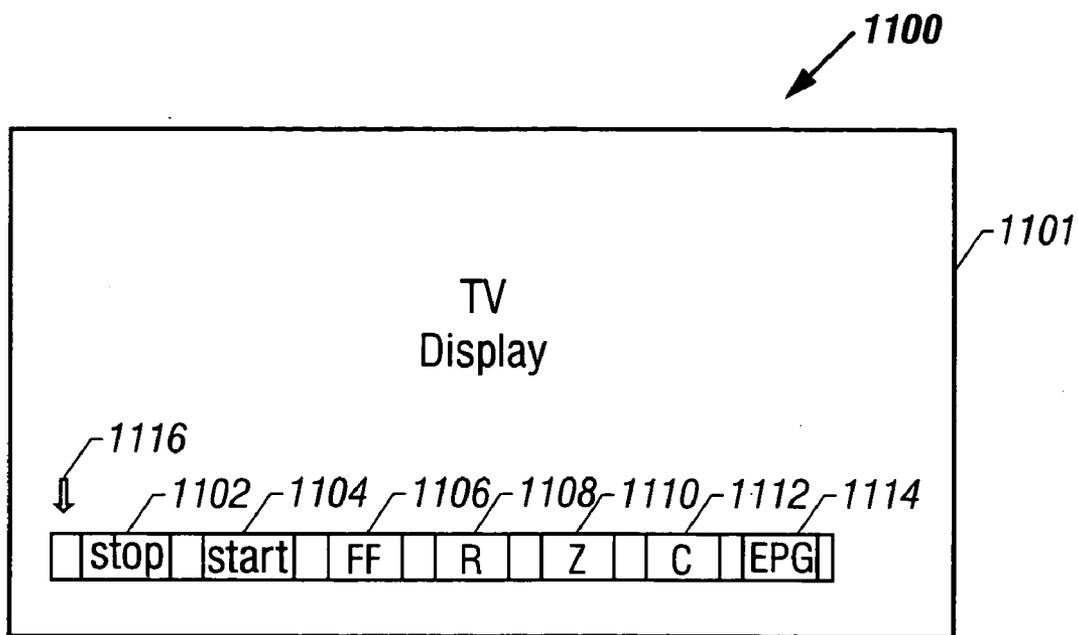


FIG. 11

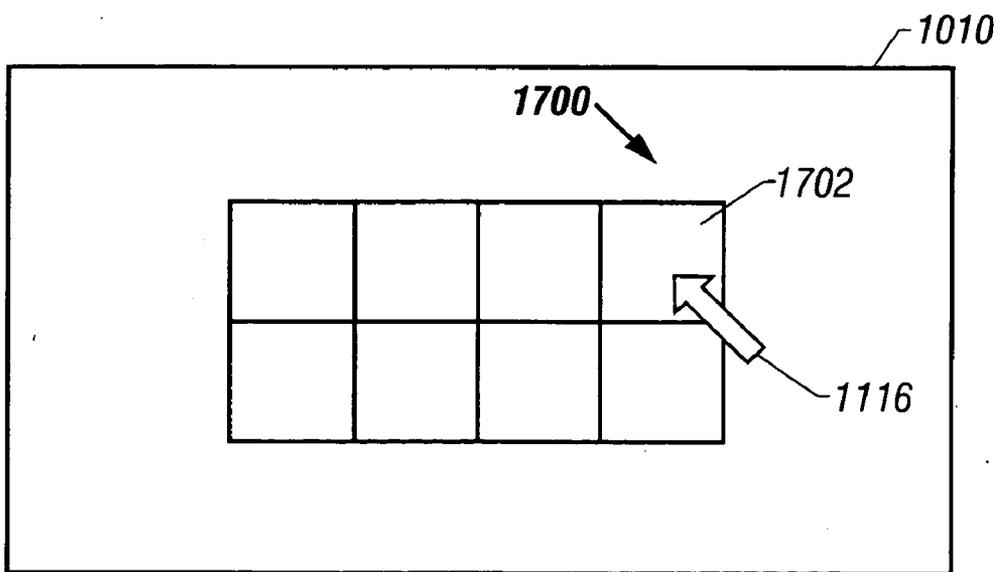


FIG. 17

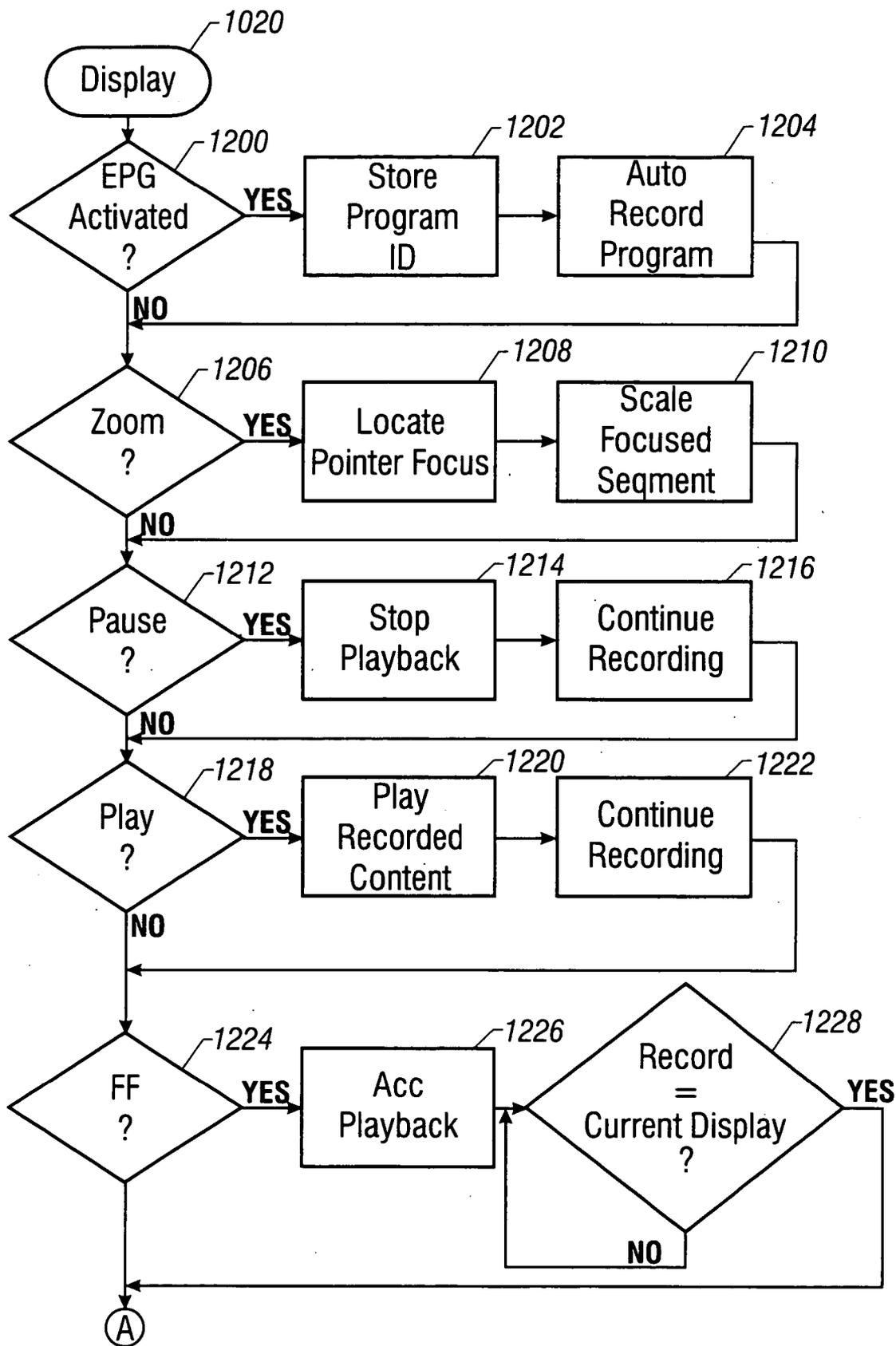


FIG. 12

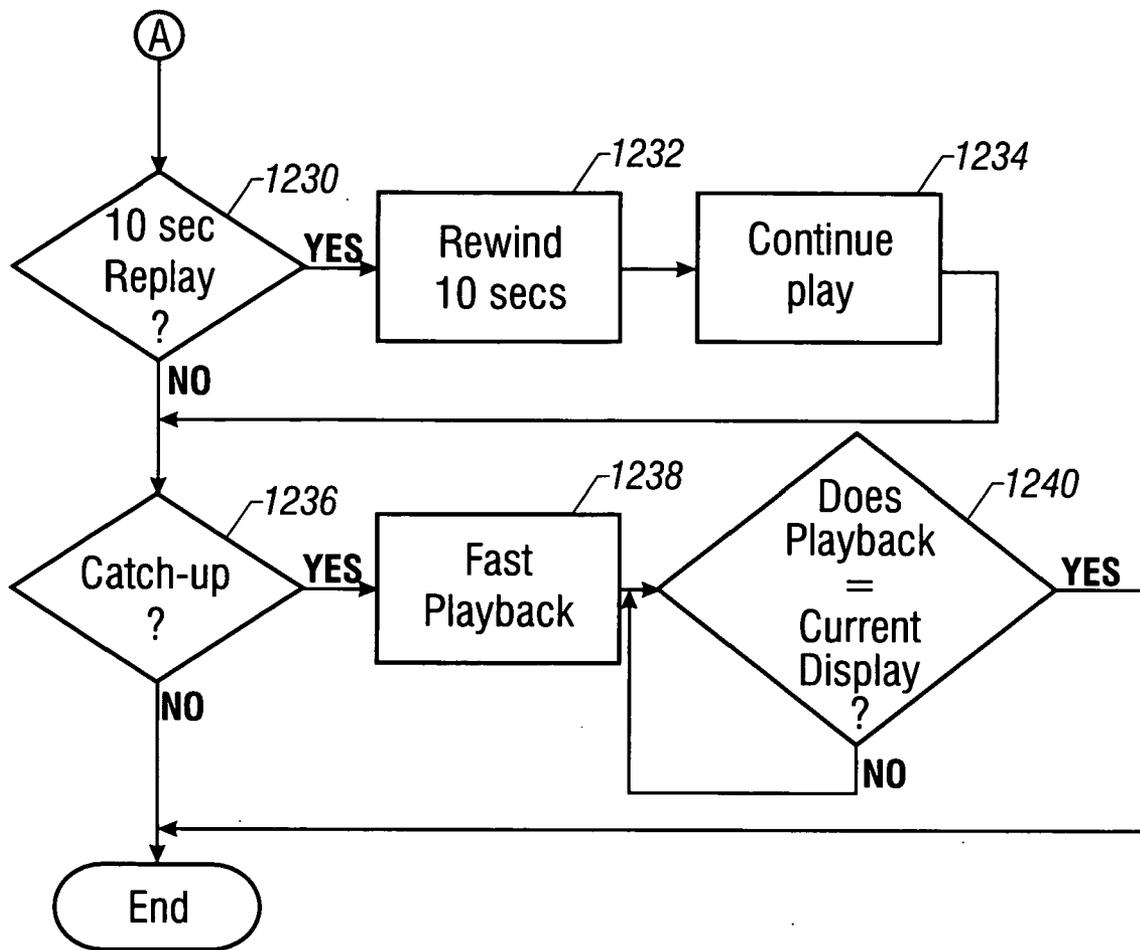


FIG. 12A

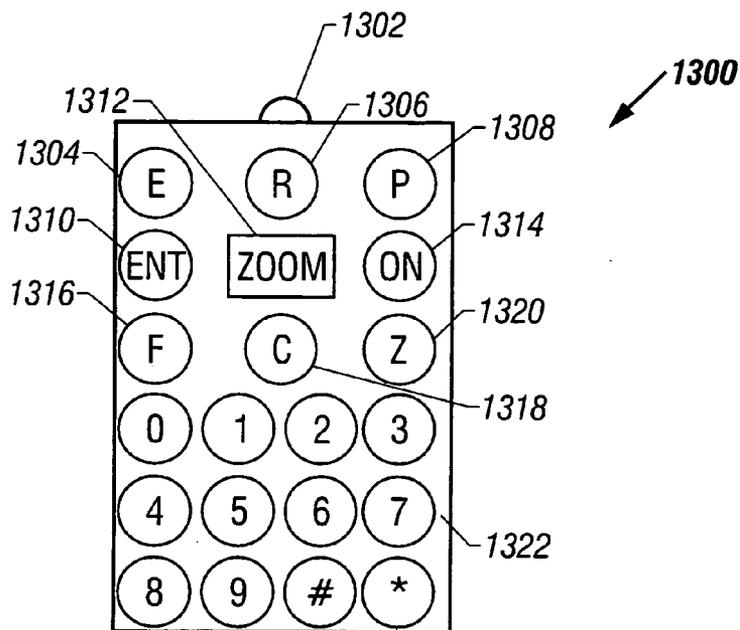


FIG. 13

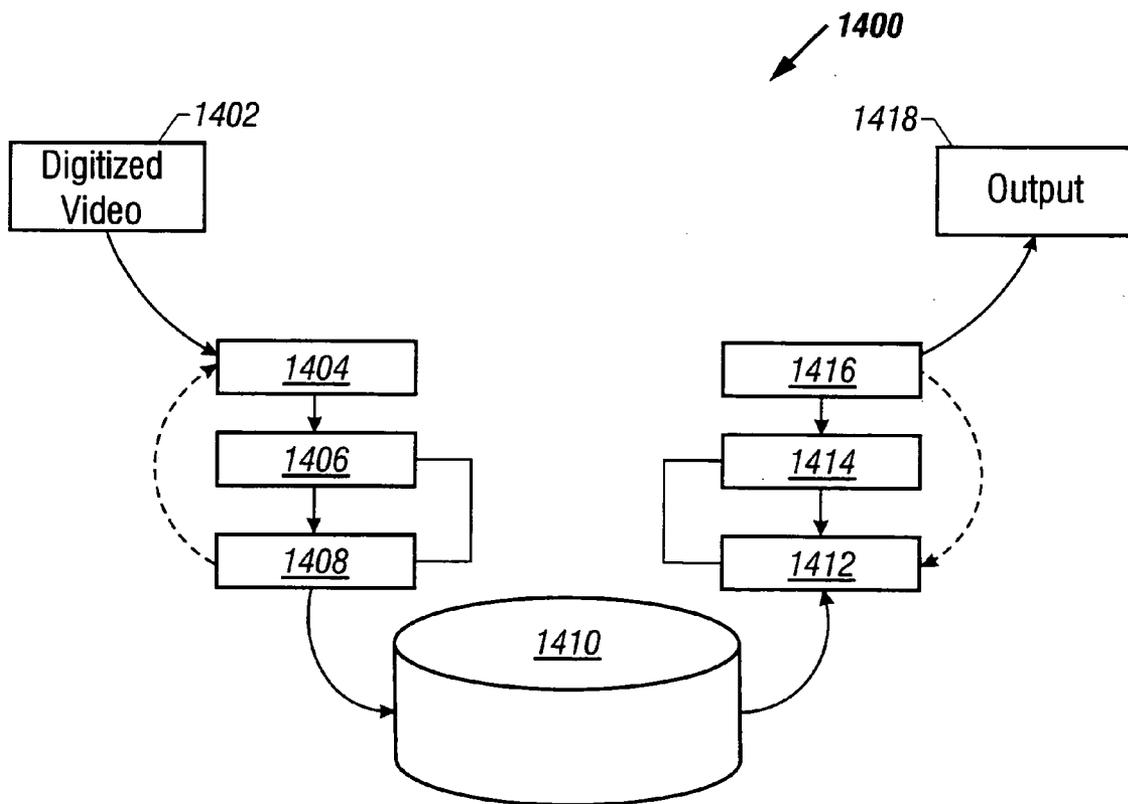


FIG. 14

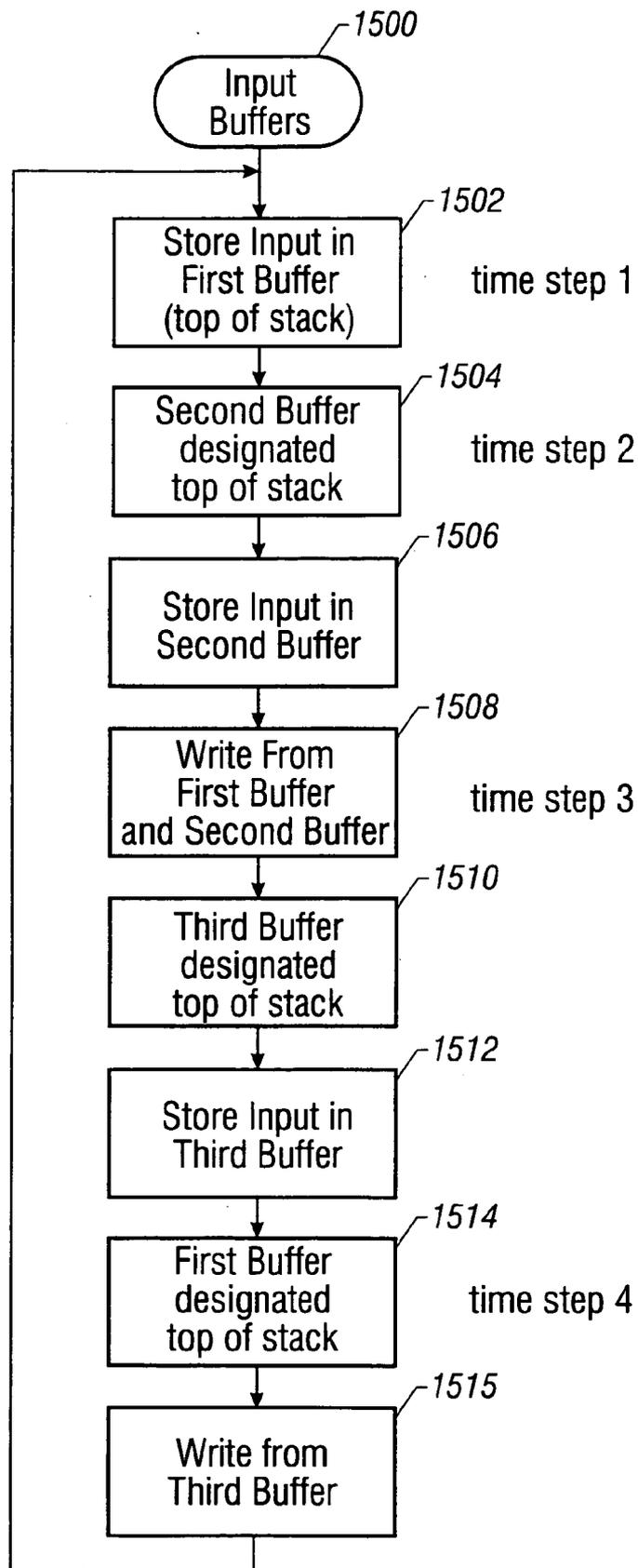


FIG. 15

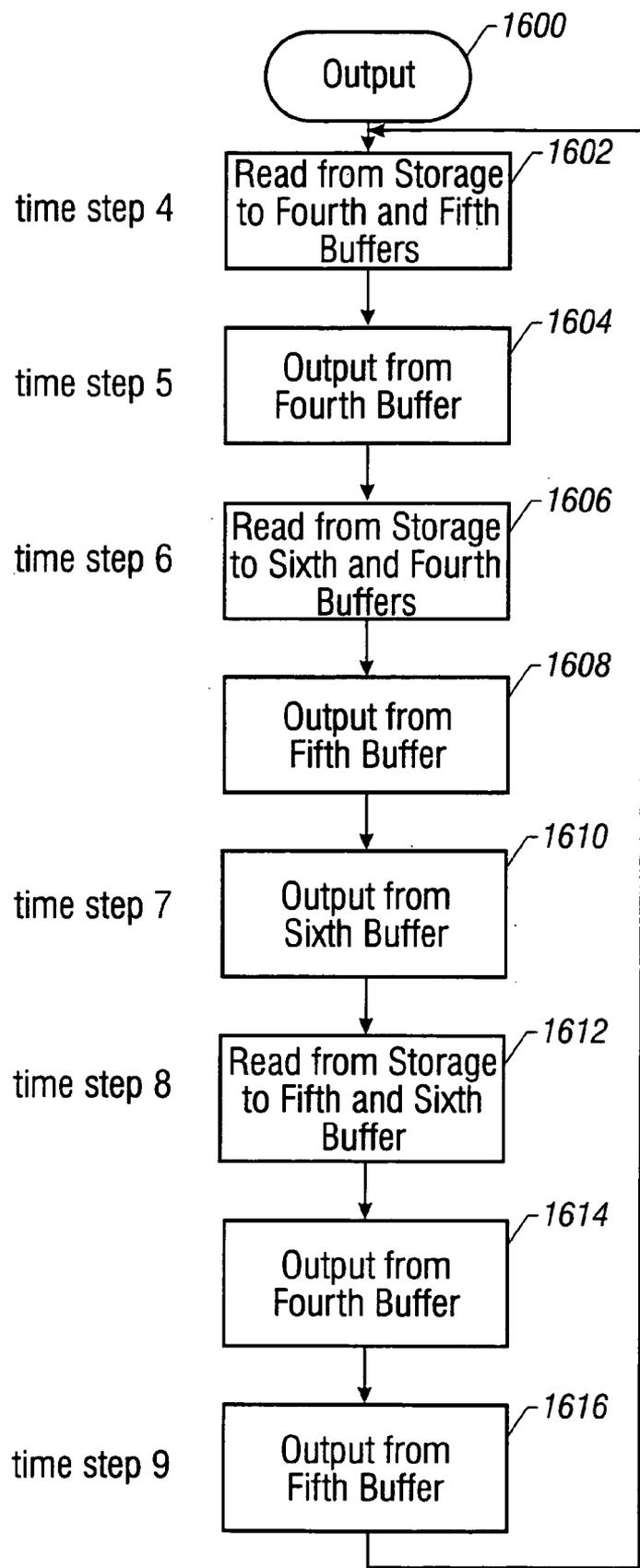


FIG. 16

TIME SHIFTING BY SIMULTANEOUSLY RECORDING AND PLAYING A DATA STREAM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This is a continuation-in-part of U.S. patent application Ser. No. 08/996,535, filed Dec. 23, 1997.

BACKGROUND

[0002] This present invention relates to the recording and playing back of a video stream. A video stream includes any combination of audio and/or video data streams.

[0003] Video streams have typically been recorded on analog media such as a video cassette. A video cassette recorder (VCR) is used to record the video stream on the video cassette. The video stream may come via a broadcast signal, via cable, via satellite signal, or from another video playback device. Once the video stream has been recorded, the VCR is used to rewind the recording medium and play what was recorded. However, due to the nature of the analog medium, once the VCR has started recording, it is not possible to play back the portion of the video stream that has already been recorded until the recording session is terminated.

[0004] For example, imagine that a person sets up a VCR for recording a one hour show because he knows that he will miss the first 15 minutes of the show. When he arrives home 15 minutes into the show, he will have to wait for the entire show to be recorded before he can start watching the program from the beginning. A way of being able to view the show from the beginning without having to wait for the recording session to terminate is desirable.

SUMMARY

[0005] A method of enabling a video stream to be stored and displayed at the same time including allowing portions of the video stream to be alternately written to and read from a storage device. The next portion to be written to the storage device is stored in a temporary buffer while another portion is being read from said storage device.

DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 shows a block diagram of a video record and playback system in accordance with one embodiment of the invention;

[0007] FIG. 2 shows a flow chart of the method of providing a time-shifted video stream;

[0008] FIG. 3 shows one embodiment of performing block 206 of FIG. 2;

[0009] FIG. 4 shows one embodiment of an apparatus for storing the video stream on a hard disk;

[0010] FIG. 5 shows an exemplary method of using the storage unit as a temporary buffer.

[0011] FIG. 6 shows a flowchart of the playback of a video stream catching up to the incoming video stream;

[0012] FIG. 7 shows another embodiment, in which the user is able to suspend the display of the incoming video stream;

[0013] FIG. 8 shows an example of a display screen with several image frames taken at different times;

[0014] FIG. 9 is a flow chart showing one system for recording and playing back a video stream;

[0015] FIG. 10 is a block diagram of a computer system useful in implementing one embodiment of the present invention;

[0016] FIG. 11 is an exemplary TV display for implementing an embodiment of the present invention;

[0017] FIG. 12 is a flow chart showing the operation of another embodiment of the present invention;

[0018] FIG. 12A is a continuation of the flow chart of FIG. 12.

[0019] FIG. 13 is a top plan view of a remote control useful in one embodiment of the present invention;

[0020] FIG. 14 is a block diagram showing how data is transferred to and from a memory device;

[0021] FIG. 15 is a flow chart showing the flow of input video information into a storage device;

[0022] FIG. 16 is a flow chart showing the flow of data from the storage device; and

[0023] FIG. 17 shows a display with an electronic program guide.

DETAILED DESCRIPTION

[0024] FIG. 1 shows a block diagram of a video record and playback system 100 in accordance with one embodiment of the invention. A video stream is received at the video input 102. The video stream may be provided by a camera, a television signal, broadcast, cable, or satellite signals, or another video playback device. In one embodiment, the video input 102 performs an analog-to-digital conversion on an analog video stream to form a digital video bit stream. In a different embodiment, the video is already in digital form. The video record and playback system 100 may be part of a computer system such that the video input 102 is a video capture card in the computer system.

[0025] The digital video stream from the video input 102 is optionally compressed at compression unit 104. In one embodiment, the video is already compressed, such as would be the case with an Moving Picture Experts Group 2 (MPEG 2) specification (available from the International Standards Organization Standard IS01172) compliant video signal, and no further compression is needed. The video stream is then stored in the storage unit 108. A buffer unit 106 may be used as temporary storage for providing larger sequential blocks of video data to the storage unit 108. In one embodiment, the storage unit 108 is a random access memory that allows relatively quick access to any portion of the stored video stream. A hard disk is an example of a random access memory.

[0026] The video stream is played back by reading the video stream from the storage unit 108. If the video stream was compressed in compression unit 104, then a decompression unit 110 decompresses the retrieved video stream. The video stream is provided from a video output port 120, to a monitor or other display device to provide sound and/or video to a user.

[0027] A removable storage unit **122** may also be included in video record and playback system **100**. Examples of removable storage units are a writeable compact disk read only memory (CD-ROM), writeable digital video disk (DVD), a flash memory, or another hard disk. The removable storage unit **122** allows a user to transfer a recording of a video stream stored in storage unit **108** to the removable storage unit **122** and then to transfer the unit **122** to another system at a different location.

[0028] In one embodiment, a processor **130** controls the operations of the video record and playback system **100**. The compression unit **104** and decompression unit **110** may be implemented in hardware, or the compression and decompression functions of units **104** and **110** may be performed by the processor **130**. Processor **130** receives instructions from firmware/memory **140**, using technology that is well known.

[0029] FIG. 2 shows a flow chart of the method of providing a time-shifted video stream. The flow chart begins at block **200**, and continues at block **202** where the video stream is received. The recording of the video stream begins at block **204**. At block **206**, playback of the recorded video stream is performed by retrieving a portion of the video stream from the random access storage unit while the recording of the incoming video stream continues. The retrieved portion of the video stream may be time-shifted from the incoming video stream by a time delay. At block **208**, the portion of the video stream retrieved from the random access storage unit is retrieved for display by a television or other display device.

[0030] In this way, the record and playback functions are decoupled from one another. The user may now begin watching a recorded TV show from the beginning, i.e., prior to the show being completely recorded.

[0031] FIG. 3 shows one method for retrieving a portion of the video stream from the random access storage unit while continuing to record the incoming video stream. In the disclosed embodiment, the simultaneous recording and playback of the video stream is performed by multiplexing or alternately storing the video stream to the random access storage unit and reading of the video stream from the random access storage unit. The multiplexed or alternated stores and reads may occur quickly enough that the user does not notice an appreciable delay in the playback of the video stream, and the incoming video stream is not lost, i.e., all of the video stream is recorded. Thus, the record and playback are simultaneous from the user's point of view.

[0032] In one embodiment, the random access storage unit is a hard disk. The retrieval of the time-shifted video signal from the hard disk is performed at a first physical location (or sector) of the hard disk, and the storing to the hard disk of the incoming video stream is performed at a different physical location (or sector) on the hard disk. Because it takes more time to jump back and forth between different sectors of the hard disk than to read and write to sequential locations in the same sector, data may be buffered to minimize the number of accesses to and from the hard disk using buffer **106**. This increases the amount of data transferred per access.

[0033] Additionally, because of time constraints for reading and writing to the hard disk, data may be compressed and decompressed to speed transfers to and from the hard disk.

[0034] In block **302**, the video stream is stored in a random access storage unit. The video stream is optionally compressed and/or buffered prior to storage. In block **304**, the video stream is retrieved from the random access storage unit. Buffering and/or decompression may be performed before providing the retrieved video stream to the video output port **120**.

[0035] The next portion of the video stream is stored (block **306**) as described in block **302**. At block **308**, the next portion of the video stream is retrieved as described in block **304**. This process is repeated until either the recording or playback cycle is terminated.

[0036] FIG. 4 shows one embodiment of an apparatus for storing the video stream in the storage unit **108**. In this embodiment, the video stream is stored as separate files **001** and **009** on a hard disk, for example. The processor **130** keeps track of the file and offset into the file of the data being played back, as well as the file and offset into the file of the data being recorded. If the random access storage unit is fast enough, more than one video stream can be recorded and played back at the same time.

[0037] Due to the nature of the random access storage unit being capable of easily recording over itself, the random access storage unit may act as a temporary buffer for recording the latest portion, or X number of minutes, of an incoming video stream, where X is set up based upon the size of the storage unit. In one embodiment, X could be set up to be the entire storage unit. As newer portions of the video stream are received, they overwrite the older portions of the video stream saved in the random access storage unit. In this manner, the temporary buffering of the video stream acts as a circular buffer. In one embodiment, the processor **130** maintains pointers to the beginning and ending points of the temporary buffer. The processor **130** reassigns the pointers as newer portions of the video stream are received and/or older portions of the video stream are overwritten.

[0038] FIG. 5 shows a flow chart **500** of one method for using the storage unit as a temporary buffer. At block **502**, the video stream is received at an input. Recording of the video stream to the storage unit begins at block **504**. At block **506**, older portions of the video stream are deleted as newer portions of the video stream are stored to the storage unit.

[0039] A user may initiate a playback cycle following block **506**. For example, this may occur when the user wishes to re-view a video clip that he just saw. In one embodiment, the user stops recording to the temporary buffer and plays back the last portion of the temporary buffer.

[0040] However, it may be more desirable to the user to be able to continue recording as shown at block **508**. A record and playback cycle (as described with respect to FIG. 2) is started, in which the incoming video stream is recorded while the user re-views the last portion of the temporary buffer. In this manner, after re-viewing the desired video clip, the user can resume sequentially watching the video stream from the point of the video clip.

[0041] At block **510**, after the record and playback cycle is completed, all or part of the temporary buffer may be saved. Since the temporary buffer stores the latest X minutes of the video stream prior to the record and playback cycle, all or part of the temporary buffer may be allocated to the

portion of the video stream saved during the record and playback cycle. Other portions of the video stream may then be deleted from the storage unit, or they may be marked as overwriteable and used as a new temporary buffer.

[0042] FIG. 6 illustrates a method for playing back a video stream to allow the playback to catch up to the incoming video stream. Usually, during simultaneous playback and recording of the same video stream, the playback of the video stream is time-shifted from the incoming video stream by a time delay. However, if the playback is performed at an overall rate faster than the rate at which the incoming video stream is received, then the playback will catch up to the incoming video stream.

[0043] For example, playback of the video stream may have an overall rate faster than the rate of the incoming video stream if the playback is fast forwarded, or if segments of the playback are skipped altogether. When the time delay of the time-shifted video stream being played back falls below a certain threshold, the video and playback system 100 will cease providing the time-shifted video stream from the storage unit. Instead, the incoming video stream will be provided to the video output port 120 directly. In one embodiment, a bypass 142, as shown in FIG. 1, allows the incoming video stream to be provided to the video output port 120 directly.

[0044] When this happens, the user has caught up to the "live" broadcast, i.e., the incoming video stream. The user may terminate the recording cycle, if he wishes. Alternatively, the user can put the video record and playback system 100 back into the temporary buffering mode in which only the latest portion of the video stream is stored.

[0045] FIG. 7 shows an embodiment in which the user is able to suspend the display of the incoming video stream. This can be used for example, when the user is interrupted, and wishes to continue viewing the video stream after the interruption. When interrupted, the user signals to the video stream and playback system 100 to suspend the display of incoming video stream. This can be done via a remote control, for example. At block 702, the video output is suspended. In one embodiment, the video output continues to provide a still image of the image present at the instance when the suspend was encountered.

[0046] At block 704 the incoming video stream is recorded but is not displayed to the monitor. Instead the playback is paused at the point at which the user indicated that the incoming video stream be suspended. When the user is ready to view the video stream again, he can signal the video record and playback system 100 to un-suspend the video stream so that it plays back from the point at which the video stream was suspended, as shown in block 706.

[0047] The user may then view the video stream time shifted by the amount of time that he suspended the incoming video stream, or he may fast forward (or rewind) through the time-shifted video stream. When playback of the time-shifted video stream catches up to the point at which the incoming video stream is being recorded, the record and playback system 100 may display the incoming video stream directly from incoming video stream without retrieving the video stream from the storage unit, as described with respect to FIG. 6. The recording of the video stream may then be terminated by the user, if desired.

[0048] Employing a random access storage unit for storage of the video stream facilitates jumping to various points within the video stream. One way of jumping is by retrieving different time slices of the video stream. For example, an image frame from the video stream can be retrieved from the storage unit at 1 minute intervals from a current position of the video stream. In one embodiment, an image frame at the current playback position+1 minute, current playback position+2 minutes, and so forth are retrieved and displayed on the TV screen.

[0049] FIG. 8 shows an example of a display screen 800 which displays several image frames taken from the video stream at different times. In FIG. 8, the current playback position is designated as X. In one embodiment, the time interval, T, is user programmable. The intervals may be multiples of the time interval, as shown. A small interval may be used if the user wishes to skip a commercial, which usually lasts only a few minutes. Longer intervals such as a half hour may be useful for determining which movies are recorded on a storage unit.

[0050] After the image frames are displayed, the user is able to select one of the frames as a new starting point to which to begin an operation, such as a playback or record operation. By using such a story boarding method, it is easy for a user to quickly jump to a desired location within the video stream.

[0051] In one embodiment, the record and playback system 100 is able to detect a black screen or fade out, such as those which accompany the beginning or end of a commercial. This is useful in editing a video stream.

[0052] Having the video stream stored on a random access storage unit such as a hard disk allows for easy editing of the video stream. Individual frames of the video stream may be deleted or replaced. For example, a commercial may be replaced by a fade-to-black sequence.

[0053] Once the video stream on the storage unit has been edited, it can be stored to a more permanent medium such as a writable CD-ROM, flash memory, or another hard disk via the removable storage unit 122.

[0054] Referring now to the embodiment shown in FIG. 9, a flow 900 for digitally recording a video stream begins by capturing the video stream as indicated in block 902. If the stream is an analog stream, it may be digitized in an analog-to-digital conversion process as indicated at block 904. Next the digital stream may be encoded and compressed, for example using the MPEG2 compression scheme, as indicated in block 906. The stream is alternately read, as indicated at block 910, and stored, as indicated in block 908, in a conventional storage device such as a hard disk drive, a digital video disk or a flash memory. Data that is read from the storage device is decoded and decompressed using conventional technology, as indicated in block 912, for display as indicated in block 914.

[0055] A computer system 1000 in accordance with one embodiment of the present invention, shown in FIG. 10, includes a processor 1002. In one embodiment, the processor may be coupled to an accelerated graphics port (AGP) chipset 1004 for implementing an accelerated graphics port embodiment. The chipset 1004 communicates with the AGP port 1005 and the graphics accelerator 1006. The television 1010 may be coupled to the video output of the graphics

accelerator **1006**. The chipset **1004** accommodates the system memory **1008**. The chipset **1004** is also coupled to a bus **1012** which may be, for example, a peripheral component interconnect (PCI) bus. The bus **1012** connects to TV tuner/capture card **1014** which is coupled to an antenna **1015** or other video input, such as a cable input, a satellite receiver/antenna or the like. The TV tuner and capture card **1014** selects of a desired television channel and also performs the video capture function (block **902**, FIG. 9). One exemplary video capture card is the ISVR-III video capture card available from Intel Corporation.

[0056] The bus **1012** is also coupled to a bridge **1016** which couples a hard disk drive **1018**. The software **1020**, **1022**, **1024**, **1026**, **1028**, and **1030** may be stored on the hard disk **1018**. The bridge **1016** is also coupled to another bus **1032**. The bus **1032** may be coupled to a serial input/output (SIO) device **1034**. The device **1034** is in turn coupled to conventional components such as a mouse **1036**, a keyboard **1038**, and an infrared interface **1040**. Also connected to the bus **1032** is a basic input/output system (BIOS) **1042**.

[0057] An exemplary display **1100**, shown in FIG. 11, for the television **1010** may display a conventional television picture or program **1101** and, in addition, may have superimposed over the screen, in a discrete fashion, a mouse selectable series of icons, such as the icons **1102** through **1114**. When the mouse cursor **1116** selects the appropriate one of the icons, a corresponding feature may be implemented. Among the features that may be implemented in this fashion include a pause or stop function **1102**, a start record function **1104**, a fast forward function **1106**, a rewind function **1108**, and a 10 second reply function **1110** which winds back 10 seconds and replays, and a catchup function **1112** that begins playing back recorded content at a faster than normal rate until the display catches up with a live broadcast and an electronic program guide **1114**.

[0058] Referring next to FIG. 12, a program **1020** called display is used to control various features implemented by the computer **1000**. Initially a check is made at diamond **1200** to determine if an electronic programming guide (EPG) is implemented. An electronic programming guide is an electronic depiction of the various programs that are available at different times. The electronic programming guide can be provided on a disk, over a modem, by an Internet connection and using an interactive broadcasting transmission such as InterCast® 2.0 interactive broadcasting software available from Intel Corporation.

[0059] If a particular television program is selected (even if the program is only selected for viewing) on the EPG, an identifier for that particular program is stored, as indicated at block **1202**, and automatic recording of the program begins (block **1204**). In this way the stored version of the program is available to implement the various features described herein even if the storage function was not particularly requested. Because the information is stored in an overwriting fashion, no harm is done by recording the information even if the information turns out not to be useful.

[0060] Referring to FIG. 17, an electronic program guide user interface **1700** may be deployed on the television **1010**. When the user mouse clicks a box image **1702**, representing a given television program, using the cursor **1116**, that program is automatically recorded.

[0061] Continuing in FIG. 12, an inquiry (diamond **1206**) checks whether the user has selected the zoom feature for playback. If the user presses a zoom button during playback, a zoom feature is implemented. In one embodiment, five predefined quadrants in the television display may be defined including four quadrants located peripherally around a central quadrant. When the user selects the zoom feature the user indicates the appropriate quadrant for the zoom (block **1208**). The selected quadrant is scaled (block **1210**) to produce a larger (zoom) picture.

[0062] Referring to block **1208**, the pointer focus is identified to determine which quadrant will be zoomed. That quadrant is then scaled as indicated at block **1210**. Because the television program is continually being stored, the scaling can be implemented without any loss of continuity of the television picture. After the user has completed looking at the zoomed depiction, the user can return to the program at the point where he or she departed to view the zoomed depiction. Thereafter the displayed depiction viewed by the user may be time delayed from the actually broadcast program. However the user is able to view the program in its entirety even if slightly time delayed.

[0063] Next a query is made at diamond **1212** to determine whether a pause function has been selected. If so, the playback is stopped as indicated at block **1214** but recording continues unabated as shown in block **1216**.

[0064] The next check determines whether the play feature has been selected (block **1218**). If so the recorded content is played thereby terminating the live display. However, while the recorded content is displayed, recording continues as indicated in block **1222** so that the recorded content may be eventually displayed without disrupting the continuity of the program.

[0065] A query finds out if the fast forward feature has been implemented as indicated in diamond **1224**. If so, a fast playback is implemented as shown in block **1226**. Once the playback equals the current broadcast or program content (diamond **1228**), the flow returns to display current broadcast or program content. The fast forward may progress at 300 to 400% of normal playback speed.

[0066] Moving on to FIG. 12A, at diamond **1230** a check is done to see if the 10 second replay feature has been activated. If so, the storage device is operated to find the content which was recorded 10 seconds ago (block **1232**). The recorded content is then played (block **1234**) from the 10 second period back to present. This would correspond to the replay feature implemented with broadcast television sporting events. After the "rewind" and playback of 10 seconds has been completed, the system is automatically transferred to automatic play and the recorded content that was displayed during the replay is displayed so the user does not lose any continuity in the show. Of course, the user can set the amount of time for the replay to be something other than 10 seconds.

[0067] A catchup feature is checked (diamond **1230**) and, if this feature has been selected, an accelerated playback option is implemented (as indicated in block **1238**). In the accelerated playback, the playback may be slightly increased in speed, for example from 105 to 115% of actual speed, so the user can easily follow the program but can make up for lost time to get back into the program as

broadcast. Once the recorded program catches up to the real-time program as indicated in diamond **1240**, the catchup feature is completed and the user returns to real-time display.

[0068] Control over the record and playback functions may be implemented through a normal mouse function, for example by clicking on icons as indicated in **FIG. 11**. In addition, the record and playback features may be controlled remotely even when the user is not proximate to a keyboard or mouse. This may be done using a conventional remote control operator which may, for example, utilize infrared radiation.

[0069] As indicated in the depiction of an exemplary computer system **1000** (**FIG. 10**), an infrared adapter **1040** may be provided, for example in compliance with the standards and specifications (such as Infrared Data Association Serial Infrared Link Access Protocol Version 1.0, Jun. 23, 1994) of the Infrared Data Association (which can be found at {www.irda.org}). The remote control **1300**, as shown in **FIG. 3**, may be utilized as a separate stand alone remote control or its features may be incorporated into a global remote control. The illustrated control **1300** is a stand alone control for controlling the record and broadcast features. It includes an infrared transmission port **1302** and a plurality of buttons to control the various features. For example a zoom function **1312** may be implemented as a four-way rocker switch. A zoom is implemented for the top quadrant of a display by pressing the upper edge of the button. If the button is pressed in the middle, the center quadrant is chosen for zoom. Likewise any of the remaining three edges of the zoom button can be operated to select a desired quadrant for zoom features.

[0070] A button **1306** is provided to implement the replay function, a button **1308** may implement the pause feature, and an enter button **1310** may be provided to allow entry of various information including a particular television program station. An on/off button **1314** may also be provided. Fast forward may be implemented by button **1316**, an electronic program guide may be called by pressing button **1304**. The catch up feature may be called by the button **1318**, and a 10 second reply may be implemented by the button **1320**. A conventional numeric keyboard **1322** may be provided to input additional information including selected television channels.

[0071] Techniques for storing the video stream onto the storage device **1410** and for reading the information out of the storage device are summarized in Table 1 below and illustrated in **FIGS. 14, 15, and 16**. In **FIG. 14**, a schematic depiction of the storage system **1400** includes a digital storage device such as a hard disk drive **1410**. The digitized video **1402** is initially stored in a buffer which is designated as being currently on the top of the memory stack. The transfer of information between the buffers and the storage device **1410** may be done in discrete time

TABLE 1

Buffers	Time Steps								
	1	2	3	4	5	6	7	8	9
Input Storage	1404	1408	1406	1404	1408	1406	1404	1408	1406
Read	X	X	X	1412 1414	X	1414 1416	X	1412 1416	X

TABLE 1-continued

Buffers	Time Steps								
	1	2	3	4	5	6	7	8	9
Write	X	X	1404 1408	X	1404 1406	X	1406 1408	X	1404 1408
Output	X	X	X	X	1414	1412	1416	1414	1412

(X = no action)

[0072] periods referred to herein as time steps. In a first time step, shown in **FIG. 15**, the digitized video **1402** (**FIG. 14**) is stored in memory buffer **1404** because that buffer is currently at the top of the memory stack, as indicated in block **1502** in **FIG. 15**.

[0073] As the buffer **1404** fills up, the buffer **1408** moves to the top of the stack (as indicated by the dashed arrow) and incoming video is stored in buffer **1408**. As indicated in block **1504** in **FIG. 15** in time step 2, the buffer **1408** replaces the buffer **1404** as the designated top of the stack buffer. The next input video is then stored in the new buffer (**1408**) as indicated in block **1506**.

[0074] In time step 3 the buffer **1408** has filled up and the contents of buffers **1404** and **1408** are written to the storage device **1410** in a single write operation. During the same time step, buffer **1406** moves to the top of the stack and becomes the storage buffer for incoming video. This is illustrated in blocks **1508, 1510** and **1512** in **FIG. 15**.

[0075] In time step 4, the buffer **1404** moves back to the top of the stack to store incoming video since its previous content has already been saved in the storage device **1410**. This is indicated in block **1514** of **FIG. 15**, and in **FIG. 16** in block **1602**. The storing of incoming information, as illustrated in **FIG. 15** then cycles back to the top of the flow in **FIG. 15** and continues in the same fashion thereafter.

[0076] The content from the storage device **1412** is then read into buffers **1412** and **1414**.

[0077] In time step 5, the buffer **1408** moves to the top of the stack to store incoming video, and buffer **1414** moves to the top of the output stack and transfers data to the video output **1418**. The contents of the buffers **1404** and **1406** are then written to the storage device **1410**.

[0078] The time steps 1 to 5 illustrate a complete cycle from input to output. The remaining sequence of steps repeat starting at step 5 for the input of data and time steps 6 through 9 repeat for the output of data.

[0079] Referring now solely to **FIGS. 14 and 16**, in time step 6, information stored in the storage device is read to the sixth and fourth buffers (i.e., buffers **1414** and **1416**) as indicated in block **1606**. The contents of the fifth buffer (**1412**) are sent to the output **1418**.

[0080] In time step 7, the contents of the sixth buffer (which is buffer **1416**) are sent to the output **1418**. No other output operations occur.

[0081] In time step 8, the contents from the storage device **1410** are read into the fifth and sixth buffers (buffers **1412** and **1416**) as indicated in block **1612**. Also the contents of the fourth buffer (buffer **1414**) are passed to the output **1418** as indicated in block **1614**.

[0082] Finally, during time step 9 the contents of the fourth buffer (buffer 1412) are passed to the output 1418, completing the cycle.

[0083] Using these algorithms, the storage device is provided with enough time, through the operation of the buffers, to write the incoming video while supplying enough data simultaneously to the output display. Since the memory is used to make sure no content is dropped at the input end and the display is never starved at the output end, continuous, even display can be provided without losing information. In addition reading and writing larger chunks of data at one time minimizes the amount of storage device head movement, thereby allowing the storage device to keep up with the read and write requests.

[0084] The minimum size of the individual buffers 1404 to 1408 and 1412 to 1416 (“B”) is dependent on a number of factors including the input/output data rate “D”, for example in megabytes per second, the effective bandwidth of the storage device when reading or writing “S”, for example in megabytes per second, and the average seek time for the storage device per transaction “t”, in microseconds. The time that it takes to fill up one memory buffer (B divided by D) is advantageously greater than the time it takes to read or write two memory buffers (2B divided by S) plus the average seek time (t):

$$\left(\frac{B}{D}\right) \geq \left(\frac{2B}{S}\right) + \left(\frac{t}{1000}\right)$$

[0085] Solving for the minimum buffer size in the above equation yields the following equation which gives the minimum buffer size:

$$B \geq ((DS)/(S-2D))(t/1000)$$

[0086] A viewer can pause a season premier of a television while the station is still broadcasting in order to get up and answer the telephone. The user can resume watching the show after interruption as if the program were on video tape. In addition, while watching a sports event the user can rewind back to a controversial pass, replay the play in slow motion, stop at the exact instance when the catch was made and zoom in on the receiver. Also, the user can apply an image sharpening filter to see if both of the receiver’s feet touched the ground before the receiver went out of bounds.

[0087] Timeshifting by simultaneously recording and playing back a data stream enables the following type of benefits/features for an end-user. While watching the season premiere of a television show, the viewer can literally “pause” the program in order to get up and answer the phone or get a snack from the refrigerator. After the interruption, the viewer can resume watching again without having missed anything. If the viewer came home 15 minutes late for the show but had started recording the program from the beginning, the viewer can begin watching right away instead of waiting for the show to be over and then rewinding the cassette tape. Also the viewer can replay scenes during a “live” broadcast (e.g. season premiere of a show or sporting event) in case the viewer missed a line or an exciting play. In addition, while watching a sports event the user can rewind back to a controversial play, replay the play in slow motion, and stop at the exact instance when the catch was

made. To get a better view, the viewer can zoom in on a portion of the screen and apply image sharpening filters to magnify one part of the screen.

[0088] Thus, a method of simultaneously recording and playing back a time-shifted video stream is disclosed. The specific arrangements and methods described herein are merely illustrative of the principles of this invention. For example, the same method may be used to store and retrieve other types of data streams besides video streams. Numerous modifications in form and detail may be made without departing from the scope of the described invention. Although this invention has been shown in relation to a particular embodiment, it should not be considered so limited. Rather, the described invention is limited only by the scope of the appended claims.

What is claimed is:

1-25. (canceled)

26. A method comprising:

selectively displaying a video stream from storage or without storing said video stream, depending on a time delay.

27. The method of claim 26 including:

when the time delay is greater than a threshold, displaying a video stream from the storage; and

when the time delay is less than the threshold, displaying the video stream without storing said stream.

28. The method of claim 26 including allowing portions of the video stream to be alternately written to and read from the storage device and storing in a temporary buffer the next portion to be written to the storage device while another portion is being read from the storage device.

29. The method of claim 26 further including allowing one or more portions of the video stream to be read from the storage device to retrieve the video stream with one or more time delays that are user-specified.

30. The method of claim 26 wherein storing the video stream further comprises allowing the video stream to be compressed prior to writing the video stream to the storage device.

31. The method of claim 28 wherein displaying the video stream from the storage device when the time delay is greater than the predetermined threshold comprises decompressing the video stream after retrieving the video stream from the storage device.

32. An article comprising a medium storing instructions that, if executed, enable a computer to:

selectively display a video stream from storage or without storing said video stream, depending on a time delay.

33. The article of claim 32 further storing instructions that, if executed, enable the computer to:

when the time delay is greater than a threshold, display the video stream from the storage; and

when the time delay is less than the threshold, display the video stream without storing said stream.

34. The article of claim 33 further storing instructions that, if executed, enable the computer to allow portions of the video stream to be alternately written to and read from the storage device and storing in a temporary buffer the next portion to be written to the storage device while another portion is being read from the storage device.

35. The article of claim 33 further storing instructions that, if executed, enable the computer to allow one or more portions of the video stream to be read from the storage device to retrieve the video stream with one or more time delays that are user-specified.

36. The article of claim 33 further storing instructions that, if executed, enable the computer to compress the video stream prior to writing the video stream to the storage device.

37. The article of claim 34 further storing instructions that, if executed, enable the computer to allow portions of the video stream to be displayed from the storage device when the time delay is greater than the predetermined threshold comprises decompressing the video stream after retrieving the video stream from the storage device.

38. A system comprising:

a storage to store a video stream;

a controller to selectively display a video stream from said storage or without storing said video stream, depending on a time delay.

39. The system of claim 38 said controller to display the video stream from the storage when the time delay is greater than a threshold, and when the time delay is less than a

threshold, said controller to display the video stream without storing said stream

40. The system of claim 38 including a display.

41. The system of claim 38, said controller including a temporary buffer and wherein said storage stores instructions that enable the controller to allow portions of the video stream to be alternately written to and read from the storage and store in its temporary buffer the next portion to be written to the storage while another portion is being read from the storage.

42. The system of claim 40 including said controller to allow one or more portions of the video stream to be read from the storage to retrieve the video stream with one or more time delays that are user specified.

43. The system of claim 41 wherein said controller to allow the video stream to be compressed prior to writing the video stream to the storage.

44. The system of claim 41 wherein said storage decompresses the video stream after retrieving the video stream from the storage when the time delay is greater than the predetermined threshold.

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