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**Cooper et al.**

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(54) **COMPUTER SYSTEM AND METHOD FOR STORING VIDEO DATA**

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(52) **U.S. Cl.** ..... **709/247**; 380/217; 380/269; 704/500; 704/503

(58) **Field of Search** ..... 709/247; 380/217, 380/269; 704/500, 503

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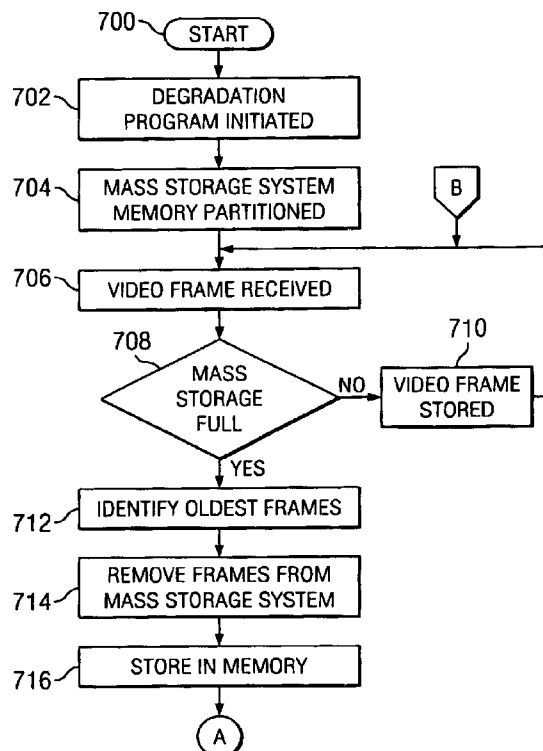
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(57) **ABSTRACT**

A computer system and method for storing video data in memory is disclosed. Memory capacity is evaluated. If the memory capacity is sufficient to allow the storing of video data in the mass storage device, then the video data is stored. If the memory capacity available is insufficient to storage the video data and the mass storage device, the oldest stored video data in the mass storage device is identified. The oldest stored video data is then removed from the mass storage device and stored in memory. The video data in memory is then modified to require less space in memory. The new video data and the modified video data are then written to the mass storage device.

**15 Claims, 8 Drawing Sheets**



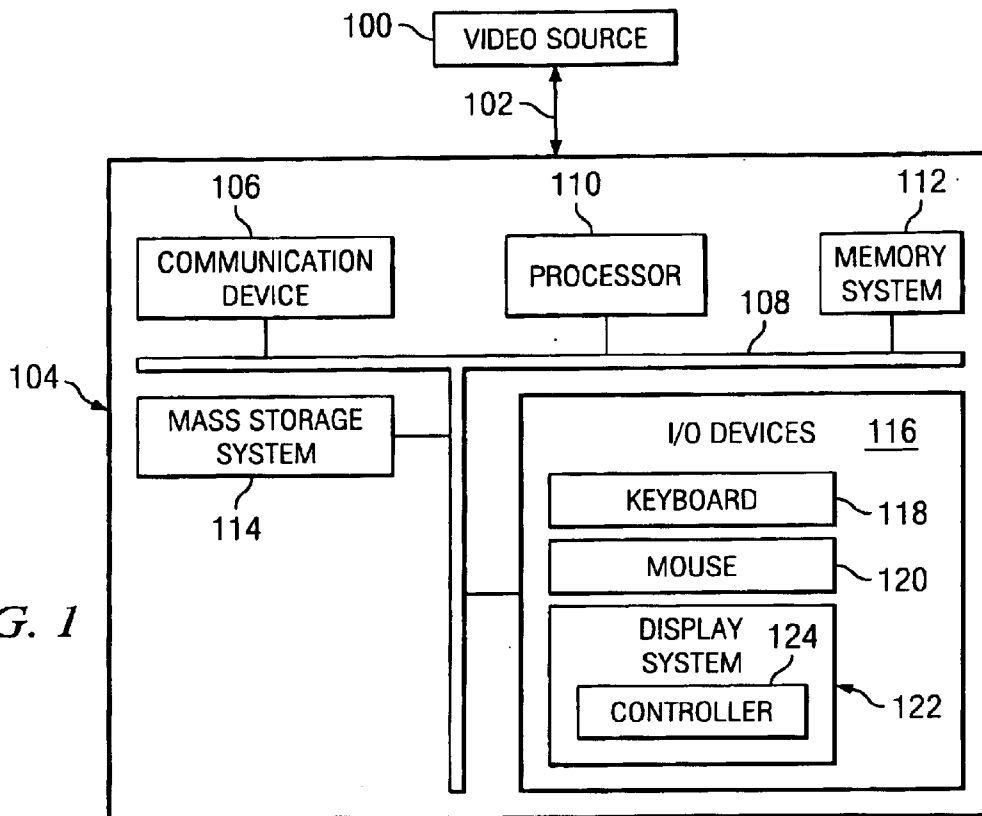


FIG. 1

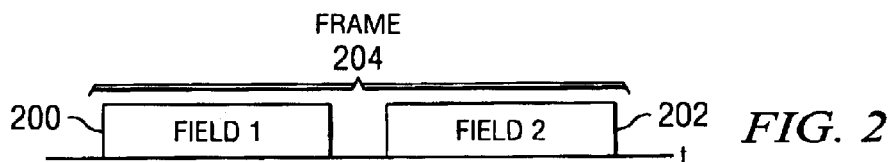


FIG. 2

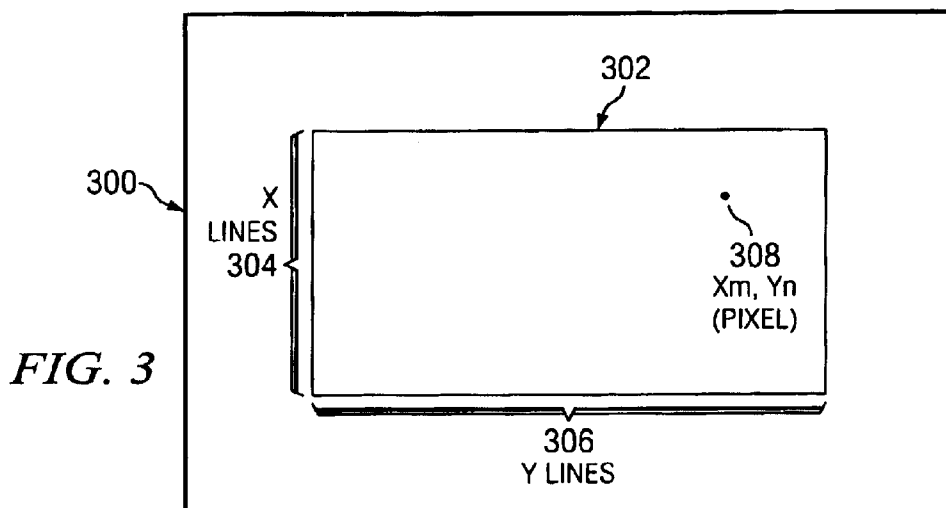


FIG. 3

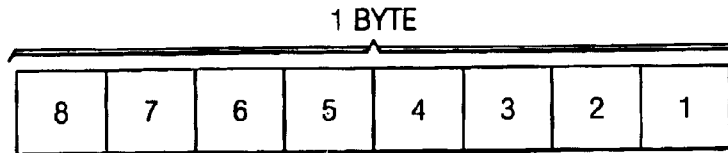


FIG. 4

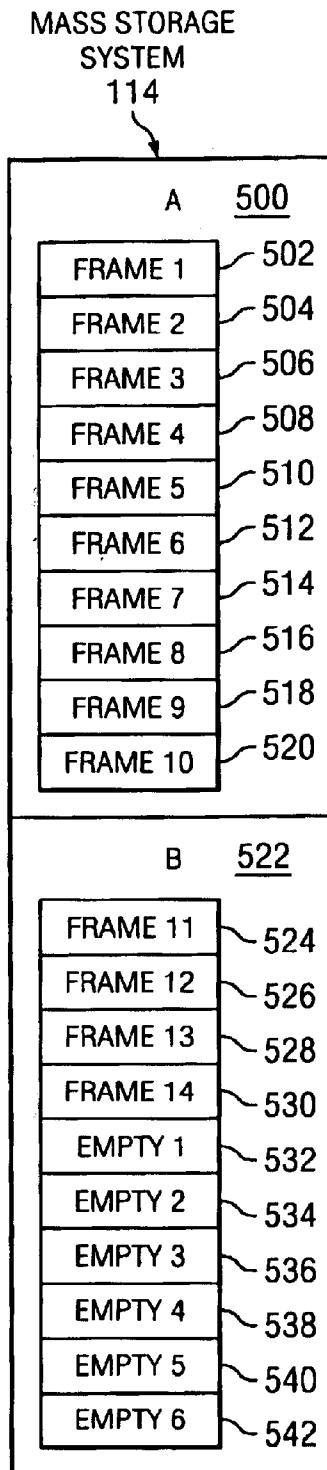


FIG. 5

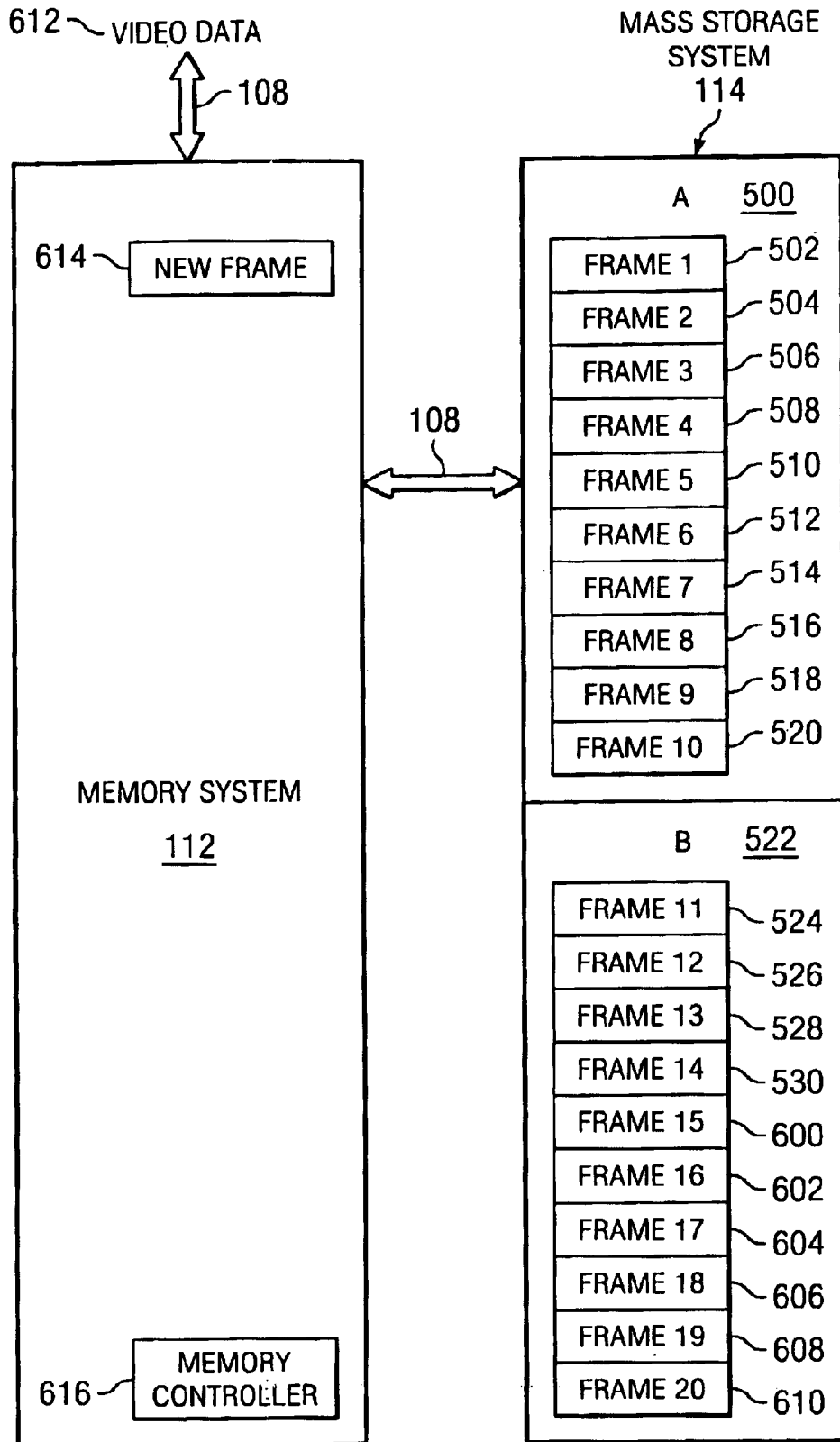


FIG. 6A

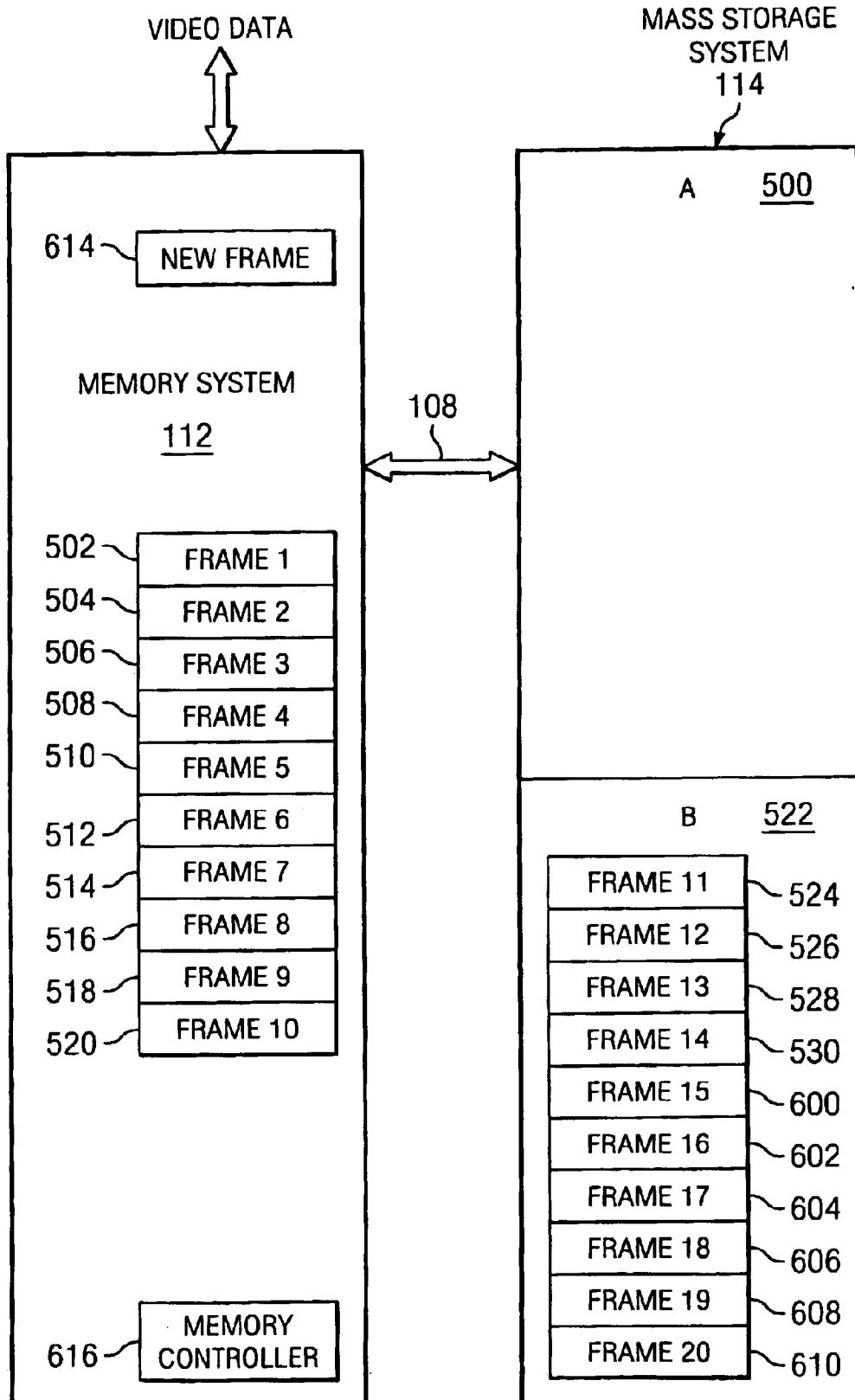


FIG. 6B

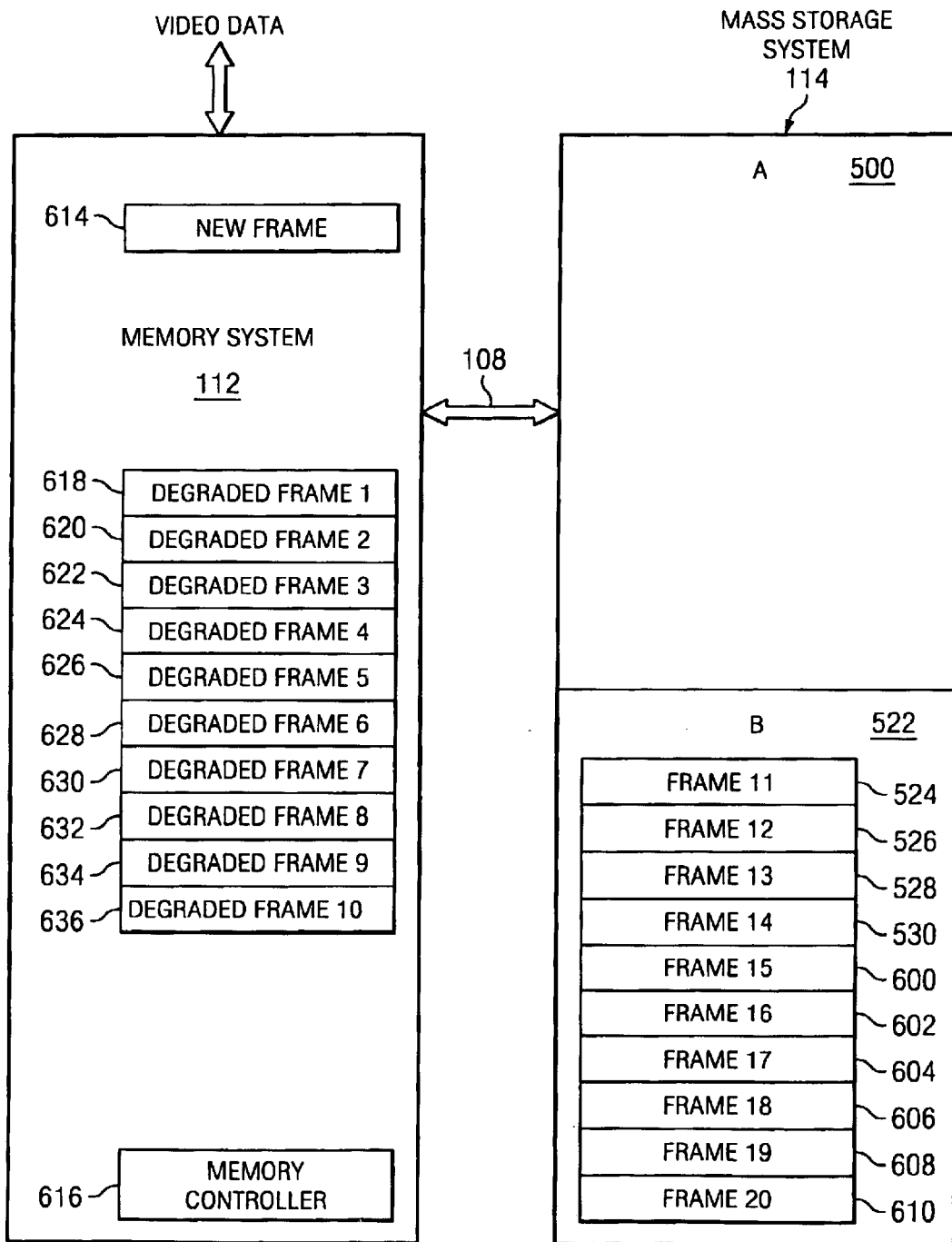


FIG. 6C

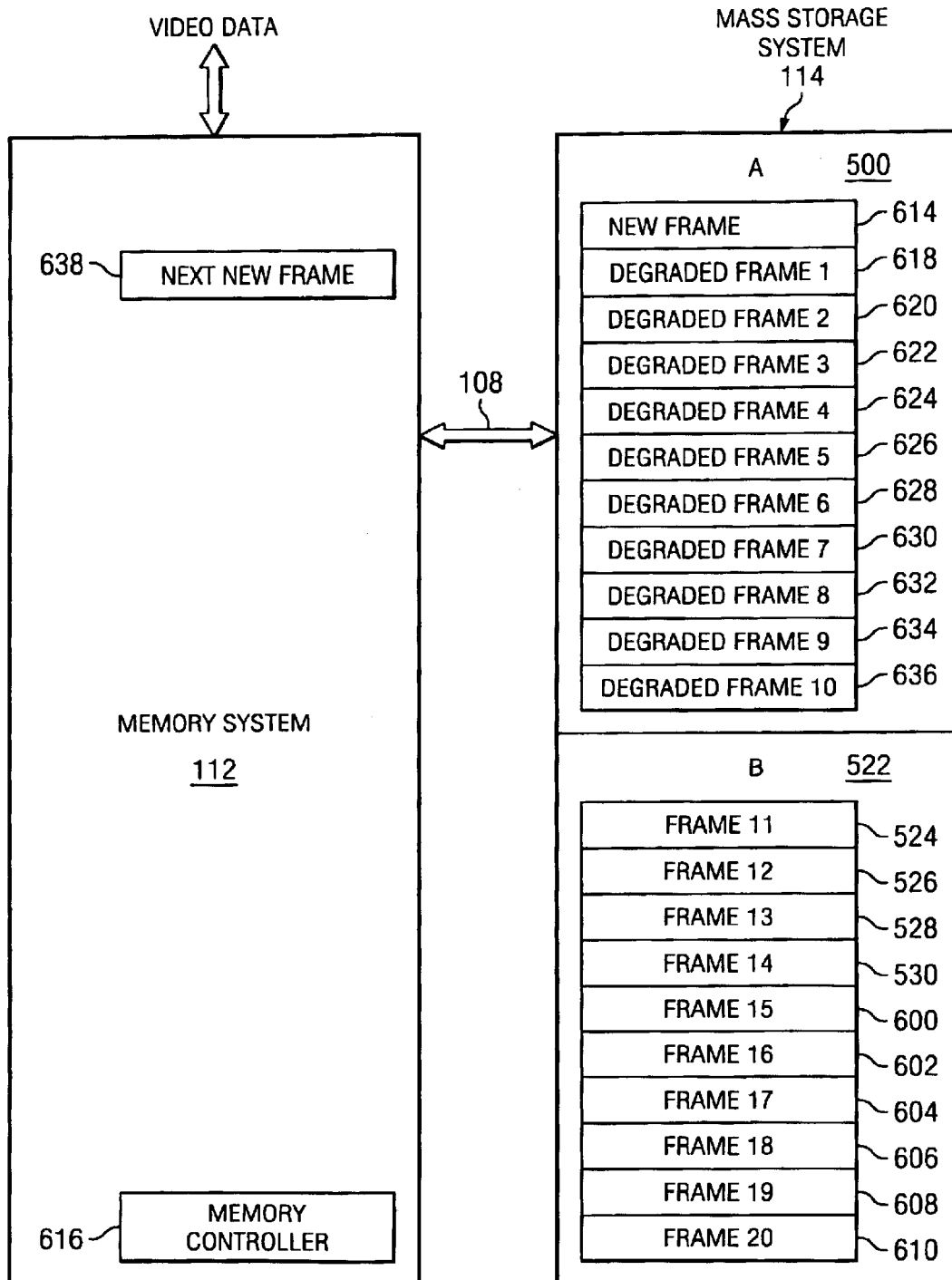


FIG. 6D

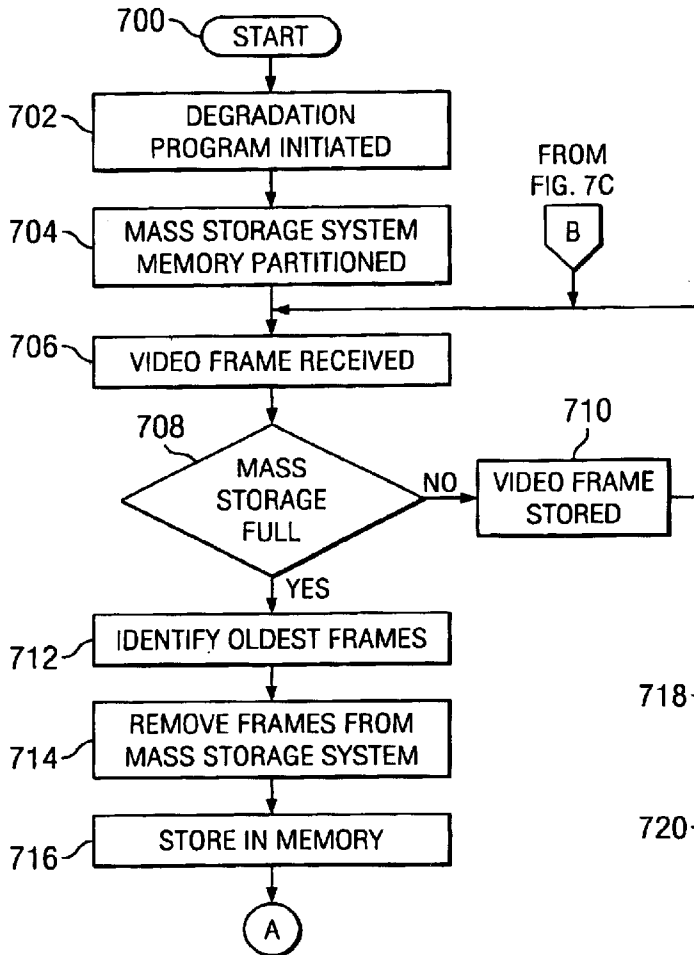


FIG. 7A

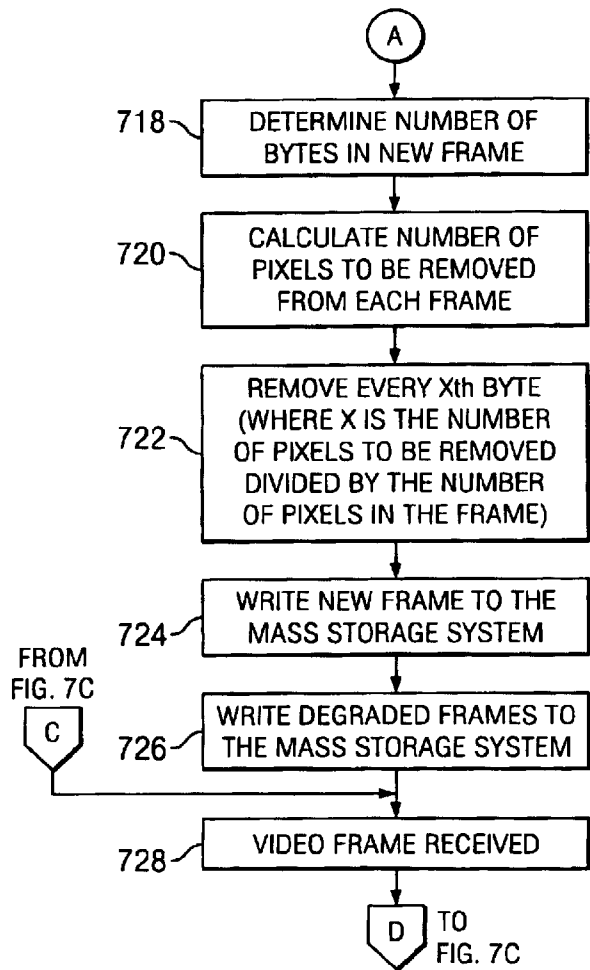


FIG. 7B



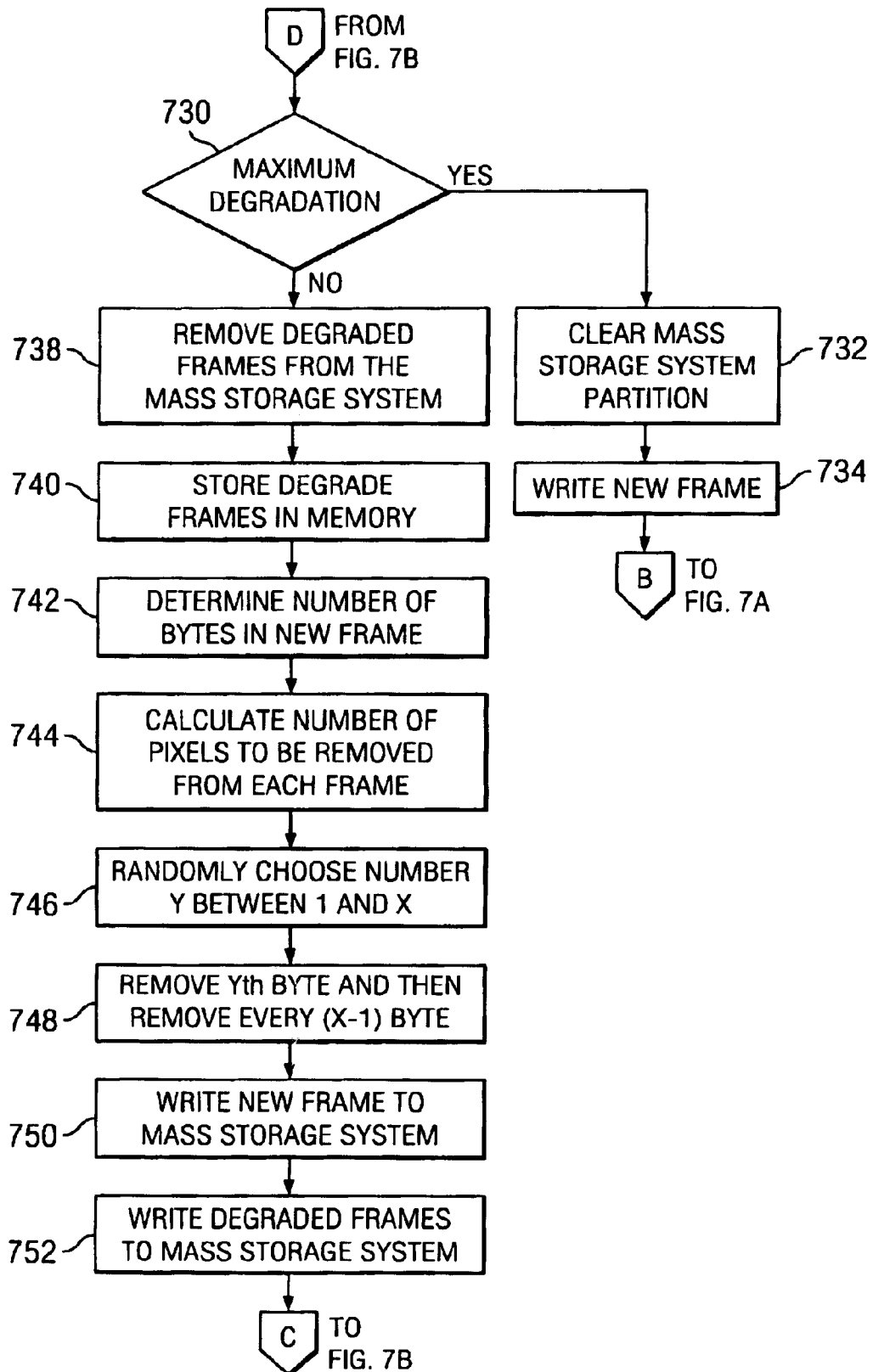


FIG. 7C

1

## COMPUTER SYSTEM AND METHOD FOR STORING VIDEO DATA

### CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable.

### STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

### FIELD OF THE INVENTION

The field of the invention relates to the storing of video data. More particularly, the invention relates to a method for storing video data in a mass storage device where once the mass storage device has reached its capacity, the oldest video data is degraded by removing random pixels from the video frame.

### BACKGROUND

For many years, software developers and users have attempted to develop processes to store data in the least amount of space required in a mass storage device. To reduce the amount of memory required in a mass storage device, compression techniques have been developed. Compression of data has become increasingly important as computer systems are now used to store vast amount of video data. Video data, which is generally sent in frames, requires a vast amount of storage capacity. Examples of video memory data compression advancements are provided in U.S. Pat. No. '1 5,184,124 issued to Molpus et al., U.S. Pat. No. 5,929,794 issued to Hayakawa et al. and U.S. Pat. No. 5,884,042 issued to Winter et al. U.S. Pat. No. 5,194,124, entitled Method and Apparatus for Compressing and Storing Pixels, discloses a method and apparatus in which 32 bit pixels (8 bits each of red, green, blue and alpha) are converted to or from 16 bit pixels (4 bits each of red, green, blue and alpha), using an ordered dithering technique. The ordered dithering technique spatially distributes the information that would otherwise be lost by truncation. This is accomplished by replacing exact pixel values with their pseudo-random average. In U.S. Pat. No. 5,929,794, entitled Digital Information Data Recording and Reproduction Apparatus, an apparatus is disclosed that subjects an initially compressed video data to a framing process which uses a fixed link format. Ineffective data is removed from the framing data of the fixed length format during the framing process and this modified data is then recorded to the mass storage device. In U.S. Pat. No. 5,884,042, entitled Data Identification in an Intelligent Video Information Management System, an apparatus which processes video data through an image analysis algorithm is disclosed. The outcome of the image analysis is then recorded on the mass storage media.

Multiple compression techniques are available however, any advancement in the ability to reproduce video data more accurately after it is stored in a mass storage device would be advantageous.

### SUMMARY OF THE INVENTION

A computer system and method for storing video data is disclosed which allows the video data to be stored in the mass storage device without standard compression techniques and still allows for efficient use of the mass storage

2

devices capacity. The capacity of the mass storage device is determined. While there remains capacity in the mass storage device, video data is stored directly in the mass storage device. Once the mass storage device has reached its capacity, the oldest video data is identified. That video data is then removed from the mass storage device and written into memory. While in memory, various pixels are removed from each frame such that when the degraded video data is stored back in the mass storage device, space is available in the mass storage device to store the recently received video data. The degraded video data is continued to be degraded by removing pixels as new video data is received until the point in which the degraded video data becomes unusable. At that point, the degraded video data is removed from the mass storage device and the new video data received is stored directly in the mass storage device.

### BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of one exemplary embodiment is considered in conjunction with the following drawings, in which:

FIG. 1 is a block diagram depicting the computer system according to the invention;

FIG. 2 is a timing diagram of the fields present in a frame;

FIG. 3 is a diagram depicting a monitor screen identifying the horizontal and vertical lines;

FIG. 4 is a diagram depicting 1 byte of data;

FIG. 5 is a block diagram of the mass storage device having storage capacity;

FIGS. 6A, 6B, 6C, and 6D show the movement and degradation of data in the mass storage device and memory;

FIGS. 7A, 7B, 7C and 7D show are flow diagrams of the method of storing video data.

### DETAILED OF DESCRIPTION OF DETAILED EMBODIMENTS

In the description which follows, like parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawing figures are not necessarily drawn to scale and certain figures may be shown in exaggerated or generalized form in the interest of clarity and conciseness.

FIG. 1 illustrates the block diagram of the computer system according to the present invention. A video source **100** is shown connected to a computer system **104** via a communication line **102**. The video source **100** provides digital video data to the computer system **104** in frames. The computer system **104** includes a communication device **106**, a processor **110**, a memory system **112**, a mass storage system **114**, a I/O device **116** which includes a keyboard **118** and a mouse **120**, and a display system **122** including a display system controller **124**, all connected via bus **108**. The video source **100** may include a video camera which is providing live digital video to the computer system **104**, a video player which is providing digital video previously recorded, or a separate computer system which has previously stored video data.

The communication device **106** includes a network communication device which allows for the computer system to be connected to the video source **100** via a network connection **102** and an Internet communication device which allows the computer system **104** to be connected to the video source **100** via any Internet connection including standard phone lines or direct connection. Further, the communica-

tion device **106** may include a device which allows for the video data to be input directly into the computer system **104**. The processor **110** includes processors commonly available from major manufacturers. The memory system **112** includes random access memory (RAM) and read-only memory (ROM). The memory system must be of sufficient capacity to allow for the storage of video data during the degradation process. In one disclosed embodiment, 128 MB of RAM are provided. The bus **108** is of the type commonly available to those skilled in the art of computer system development. The mass storage system **114** includes a hard disk drive, an optical disk, a read/write CD drive, or a tape drive. Various other mass storage systems may be implemented without detracting from the spirit of the invention. The mass storage system **114** must be a sufficient size to allow for the storage of the video data. In one embodiment, 100 GB of storage capacity is provided. The I/O device **116** allows for the input and output of data to the computer system **104**. The keyboard **118** and the mouse **120** are those commonly available from major manufacturers. The display system **122** includes a display controller **124**. The display system includes a monitor or other projection devices which are controlled by the display system controller **124** which may include a graphics video card. Software is resident in the memory system **112** or the mass storage system **114**. The software, when executed, stores and modifies the video data and is disclosed in more detail herein.

FIG. 2 is a timing diagram of a frame. Field **1200** and Field **2 202** are shown as frame **204**, over a period of time. In one embodiment, Field **1 200** contains the even horizontal lines of the frame and Field **2 202** contains the horizontal odd lines of the frame. When the data contained in Field **1 200** and Field **2 202** are displayed, the entire frame **204** is viewable.

Next in FIG. 3, the viewable screen of a computer monitor is shown. A monitor **300** is shown including a screen **302**. The screen is comprised of X lines **304** where X is the number of horizontal lines available. In one embodiment, X lines **304** can include 480 lines. The computer screen **302** is shown with Y vertical lines **306** available. The Y lines **306** in one embodiment can include 640 lines. Each intersection of an X line **304** and a Y line **306** is called a pixel or picture element. Pixel  $X_m, Y_n$  **308** is shown on computer screen **302**. The amount of data necessary to uniquely identify each pixel varies according to the number of colors to be displayed and the resolution of the monitor. In one embodiment, and as will be used throughout this description for the present invention, the amount of data necessary to describe one pixel will be one byte.

FIG. 4 shows a diagram depicting the number of bits in one byte **400**. The size of the pixel may be up to 32 bits per pixel (8 bits each of red, green, blue and alpha components) however; such variations in the amount or size of data necessary to describe each pixel may vary without detracting from the spirit of the invention.

Next in FIG. 5 a block diagram of the mass storage system **114** according to the present invention is shown. Mass storage device **114** is shown partitioned into two areas, A **500** and B **522**. The number of partitions available in mass storage system **114** may vary without detracting from the spirit of the invention. For this disclosure, two partitions are shown. The partitions A **500** and B **522** are defined upon initialization of the computer system **104**. As video data is received in the form of frames from the video source **100**, the computer system **104** stores these frames in the mass storage system **114**. The first frame received, Frame **1 502** is stored in partition A **500**. As each frame is received from the

video source **100**, the computer system continues to store the frames in the mass storage system, **114** as long as the mass storage system **114** has the capacity. Thus as is shown in FIG. 5, Frame **2 504**, Frame **3 506**, Frame **4 508**, Frame **5 510**, Frame **6 512**, Frame **7 514**, Frame **8 516**, Frame **9 518**, and Frame **10 520** are all shown stored in partition A **500**. Once all capacity of partition A has been utilized, the computer system **104** begins to store the video frames in partition B **522**. As can be seen, Frame **11 524**, Frame **12 526**, Frame **13 528** and Frame **14 530** are shown stored in the mass storage system **114** in partition B **522**. However, the mass storage system **114** still has capacity in this example and is designated as Empty **1 532**, Empty **2 534**, Empty **3 536**, Empty **4 538**, Empty **5 540** and Empty **6 542**. Therefore, in this example, the capacity of the mass storage system **114** still allows for the storage of six frames before any degradation process is necessary.

Referring now to FIGS. 6A–D, the mass storage system **114** and memory system **112** utilization is shown during the degradation method according to the present invention. In FIG. 6A, the mass storage system **114** is shown with partition A **500** and partition B **522**. Partition A **500** includes Frames **1 502** through Frames **10 520**. Partition B **522** includes Frames **11 524** through Frame **14 530**, as was shown previously in FIG. 5, however, Frames **15 600**, Frame **16 602**, Frame **17 604**, Frame **18 606**, Frame **19 608**, Frame **20 610** are shown stored in **114** partition **522**. As can be seen in this example, the capacity of the mass storage system **114** is zero. Therefore, to store a new frame in the mass storage system **114** requires that the presently stored frames be degraded. This degradation allows the frames to occupy less space in the mass storage system **114** and allows storage of the new frame. The mass storage system **114** is connected to the memory **112** via bus **108**. Video data **612** is received in the computer system **104** and is stored in the memory system **112**. The memory system **112** includes a new frame **614** which is awaiting storage in the mass storage system **114**. The memory system **112** includes a memory controller **616** which controls the input/output and the allocation of the memory available in the memory system **112**.

Referring now to FIG. 6B, the mass storage system **114** and memory system **112** are shown after the video data has been removed from the mass storage system **114**. As can be seen, partition A **500** has no data stored in the mass storage system **114**. The video data stored in partition B **522** remains unchanged. Frames **1502** through Frame **10 520** have been removed from the mass storage system **114** and have been stored in the memory system **112**. In one embodiment, the entire video data is removed from a partition and stored in the memory system **112**. However, varying amounts of video data may be removed, including only a portion of the video data stored in a partition, without detracting from the spirit of the invention.

Referring now to FIG. 6C, the mass storage system **114** and memory system **112** are shown after the video data has been degraded. Partition A **500** remains unused while partition B **522** still stores Frame **11 524** through Frame **20 610**. In the memory system **112**, Frame **1 502** through Frame **10 520** have been replaced with Degraded Frame **1 618**, Degraded Frame **2 620**, Degraded Frame **3 622**, Degraded Frame **4 624**, Degraded Frame **5 626**, Degraded Frame **6 628**, Degraded Frame **7 630**, Degraded Frame **8 632**, Degraded Frame **9 634** and Degraded Frame **10 636**. The memory utilized to store Degraded Frame **1 618** through Degraded Frame **10 636** is less than the memory necessary to store Frame **1 502** through Frame **10 520**. In one embodiment, the amount of memory that is saved after the

5

degradation process is equivalent to the size of new Frame 614. However, the amount of memory saved through the degradation process may be greater than the size of the new Frame 614, allowing multiple new frames to be stored before a second iteration of the degradation processes, without detracting from the spirit of the invention. Once the video data has been degraded, Degraded Frames 1 618 through Degraded Frame 10 636 and the new frame 614 are ready to be restored in the mass storage system 114.

Referring to FIG. 6D, the mass storage system 114 and the memory system 112 are shown after the Degraded Frames 1618 through Degraded Frame 10 636 and the new frame 614 are stored in the mass storage system 114. In the mass storage system 114, partition A 500 includes new frame 614 and Degraded Frames 1 618 through Degraded Frame 10 636. The video data stored in partition B 522 remains unchanged as Frames 11 524 through Frame 20 610 are the recently received video data and therefore remain non-degraded. The memory system 112 now includes a next new Frame 638. As the capacity of the mass storage system 114 is again zero, the process of degradation must begin again before the next new Frame 638 may be stored in partition A 500 of the memory of the mass storage system 114. Degraded Frames 1 618 through Degraded Frame 10 636 will again be removed from partition A, however new Frame 614 will remain in partition A 500. The Degraded Frames 1618 through Degraded Frame 10 636 will again be degraded to allow for the storage of the next new frame 638 and the degraded frames in partition A 500. This process will continue until the degradation of the frames is such that the video data becomes unusable. In one embodiment, the degraded video data becomes unusable when thirty percent of the pixels have been removed. However, varying the amount of pixel removed to determine when the degraded video data becomes unusable may vary without detracting from the spirit of the invention. Once the degraded video data is determined to be unusable and no further degradation can be done, then the degraded video data is removed from the mass storage system 114 and the next new frames are stored in partition A. The video data received in frames at that point will be stored in the mass storage system 114 until the capacity of the mass storage system 114 is zero. Once the capacity is zero, then partition B 522 and Frames 11 524 through Frame 20 610 will begin the degradation process allowing new Frame 614 and next new Frame 638 plus the remaining new frames stored in partition A to remain intact.

Referring now to FIGS. 7A–C, a flow chart depicting the method of storing video data is shown. The process begins with Start 700. Next in step 704, the degradation program is initiated. The degradation program can be initiated manually by a user or can initiate during the start-up of the computer system 104. Once the degradation program has been initiated, the mass storage system memory 114 is partitioned. The number of partitions of the mass storage memory can be selected manually by a user or the number of partitions can be included in the degradation program code so that the partitioning is done upon the degradation program initialization. For purposes of this example, the partitioning of the mass storage system 114 memory is shown as 2, however, multiple numbers of partitions may be implemented without detracting from the spirit of the invention. In step 706, video data in the form of a video frame is received. Next in step 708, the capacity available in the mass storage system 114 is determined. If the capacity of the mass storage system 114 is not zero. The video frame is stored in step 710. After the video frame is stored, the method awaits the next video frame to be received. If the mass storage

6

system capacity is zero, then the oldest stored frames in the memory storage system 114 are identified in step 712. Next in step 714, the oldest video frames are removed from the mass storage system 114. In one embodiment, all video frames in a partition are removed from the mass storage system 114. However, a portion or a subset of the frames may be removed from a partition without detracting from the spirit of the invention. Next is step 716, the removed video frames are stored in the memory system 112. The determination of the number of bytes in the video frame received in step 706 is determined in step 718. The requirement to determine the number of bytes in the video frame received is necessary as video data may be received of varying resolution and/or varying number of colors. Next in step 720, the number of pixels to be removed from each of the frames previously stored in the mass storage system 114 is calculated. This is done by dividing the number of bytes in the new frame received by the number of frames that were removed from the mass storage system. Once the number of pixels to be removed has been determined, that value is divided by the number of pixels in a frame which was removed from the mass storage system 114 to determine the repeating value in step 721. Once the repeating value has been calculated, then every X byte is removed from the removed video data where X equals the repeating value in Step 722. For example, if the repeating value is ten, then every tenth byte is removed from the video data stored in the memory system that was removed from the mass storage system 114. Next in step 724, the new frame is written to the mass storage system. The new frame is written as the first entry into the open or unused portion of the mass storage system 114. Next in step 726, the degraded frames are written to the mass storage system in the remaining unused memory. In one embodiment, the amount of data removed from the stored, video data is equivalent to the size in bytes of the new frame. However, an amount of memory greater than of that required by the new frame may be removed without detracting from the spirit of the invention. If an amount greater than that necessary for the new frame is removed, then the next received video frames are stored in the unused mass storage system 114 until the mass storage system 114 capacity is again zero. After the degraded frames are written to the mass storage system, the next video frame is received in step 728. Next in step 729, a determination is made regarding the amount of degradation that has occurred on the degraded frames stored in the mass storage system 114. Next in step 730, determination is made if the degradation amount is the maximum allowed. If the maximum degradation amount has been reached, the degraded video data stored in the mass storage system 114 is removed in step 732. Next in step 734, the new recently received frame is stored in the mass storage subsystem in step 734. Next, the method returns to step 706 to receive the next video frame. If the degradation amount is not the maximum allowed, the degraded frames are removed from the mass storage system 114 in step 738. Next, in step 740, the degraded frames are stored in memory system 114 in step 740. The determination of the number of bytes in the new frame is made in step 742. The calculation of the number of pixels to be removed from each frame is made in step 744. Next, in step 746 a number between one and Z where Z is the number of bytes remaining in each degraded frame is selected. Next, in step 748 the Zth byte is then removed and then every (X-1) byte is removed where X again is the number of bytes remaining in each frame that has been degraded. Next in step 750, the new frame is stored next to the previous new frame 114. In step 752, the degraded frames are stored in the mass storage

7

system. The method then runs to step 728 for the reception of the next video frame. The process will continue until the program has been stopped.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof and various changes to the size, shape, materials, components, and order may be made without departing from the spirit of the invention.

What is claimed is:

1. A method of storing video data in a memory, the method comprising the steps of:

- receiving video data from a video source;
- evaluating memory capacity available;
- if memory capacity available is sufficient, storing video data in the memory;
- if memory capacity available is insufficient, performing the following steps:
  - locating previously stored video data in the memory;
  - reading previously stored video data out of the memory;
  - modifying previously stored video data, wherein the modified previously stored video data requires less space in memory,
  - rewriting modified previously stored video data to the memory,

writing the received video data to the memory.

2. The method of claim 1, wherein the step of locating previously stored video data in the memory includes locating the oldest previously stored video data in the memory.

3. The method of claim 1, wherein the step of receiving video data includes receiving video data in frames.

4. The method of claim 3, wherein the step of receiving video data in frames includes receiving pixel data.

5. The method of claim 4, wherein the step of receiving video data includes receiving one byte of data for each pixel data in the frame.

6. The method of claim 5, wherein the step of receiving video data in frames includes receiving at least 307000 bytes per frame.

7. The method of claim 6 wherein the step of reading previously stored video data out of the memory includes reading frames out of the memory.

8. The method of claim 7 wherein the step of modifying previously stored video data includes removing pixels from the frames.

9. The method of claim 7 wherein the step of modifying previously stored video data includes removing pixels from the frames in an amount equal to the number of pixels in the received video data.

10. The method of claim 1, wherein the step of evaluating memory capacity includes determining amount of unused memory.

11. The method of claim 1 wherein the step of locating previously stored video data in the memory includes locating modified previously stored data.

8

12. The method of claim 1 wherein the step of locating previously stored data includes locating previously stored data based upon an aging protocol.

13. The method of claim 12 wherein the aging protocol includes the steps of:

- determining amount of degradation acceptable before removing modified previously stored video data from memory;
- determining amount of the memory to be allocated for modified previously stored video data;
- partitioning memory according to the allocation;
- determining amount of degradation of modified previously stored video data in partitioned memory;
- if amount of degradation is acceptable, identifying modified previously stored to video data; and
- if amount of degradation is unacceptable, removing modified previously stored video data from the memory.

14. The method of claim 13 wherein the step of determining amount of degradation acceptable includes determining the amount based upon a predetermined coefficient.

15. A system for storing video data in a memory, the system comprising:

- a video source; and
- a video storage system coupled to the video source; the video storage system comprising:
  - a processor;
  - a memory coupled to the processor;
  - a mass storage device coupled to the processor
- video storage software resident in the memory, the video storage software, when executed, performing the steps of:
  - receiving video data from the video source;
  - evaluating capacity available of the mass storage device;
  - if capacity available of the mass storage device is sufficient, storing video data in the memory;
  - if capacity available of the mass storage device is insufficient, performing the following steps:
    - locating previously stored video data in the mass storage device;
    - reading previously stored video data out of the mass storage device in to the memory;
    - modifying previously stored video data in memory, wherein the modified previously stored video data requires less space in the mass storage device;
    - rewriting the modified previously stored video data to the mass storage device,
    - writing the received video data to the mass storage device.

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