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Hamel et al.

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(54) **METHOD AND SYSTEM FOR VIDEO BASED IMAGE DETECTION/IDENTIFICATION ANALYSIS FOR FLUID AND VISUALIZATION CONTROL**

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(58) **Field of Classification Search**
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USPC 600/103, 117, 118, 157, 158, 159
See application file for complete search history.

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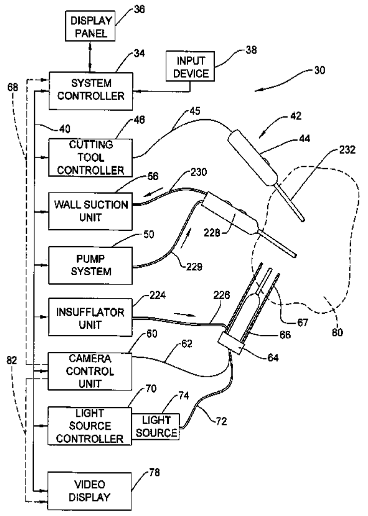
(57) **ABSTRACT**

In a surgical system, a system controller executes a video signature identification and image control routine to maintain quality of a video image taken by a video camera located at a surgical site and provided on a video display. The system includes a video camera/light source handpiece for insertion into a patient body. A tool is inserted separately into the surgical site. Fluid input into the surgical site is provided by a liquid pump or by an insufflator. Video signals are analyzed and fluid input/output, fluid pressure, and/or tool operation is automatically controlled to maintain image quality of the surgical site without manual adjustments.

21 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

G06F 19/00	(2011.01)
A61B 1/12	(2006.01)
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A61B 17/32	(2006.01)
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A61B 17/00	(2006.01)
A61B 18/00	(2006.01)

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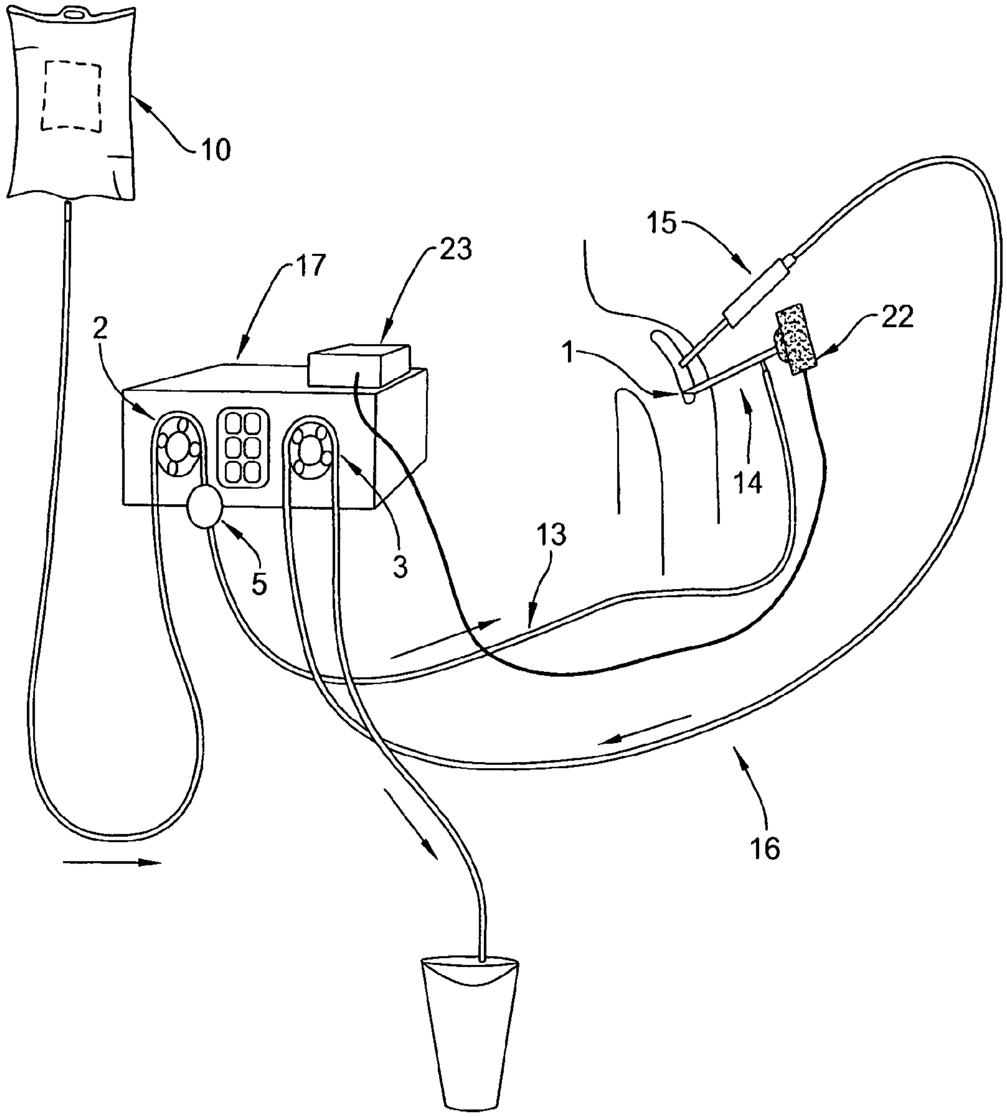


FIG. 1 (PRIOR ART)

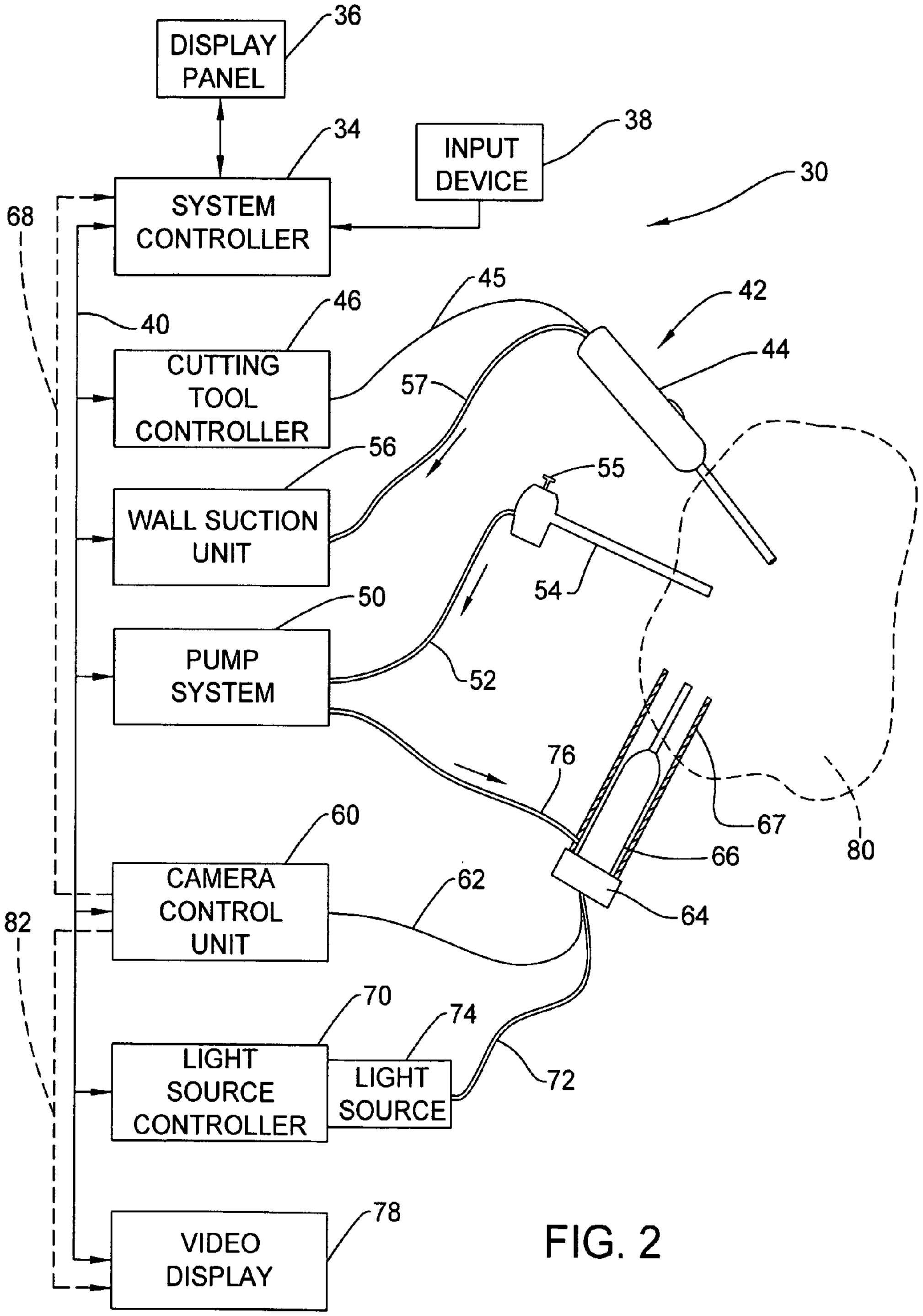

36
DISPLAY PANEL
34
SYSTEM CONTROLLER
38
INPUT DEVICE
30
68
40
45
42
46
CUTTING TOOL CONTROLLER
44
57
56
WALL SUCTION UNIT
55
54
50
PUMP SYSTEM
52
76
67
66
80
60
CAMERA CONTROL UNIT
62
64
82
70
LIGHT SOURCE CONTROLLER
74
LIGHT SOURCE
72
78
VIDEO DISPLAY

FIG. 2

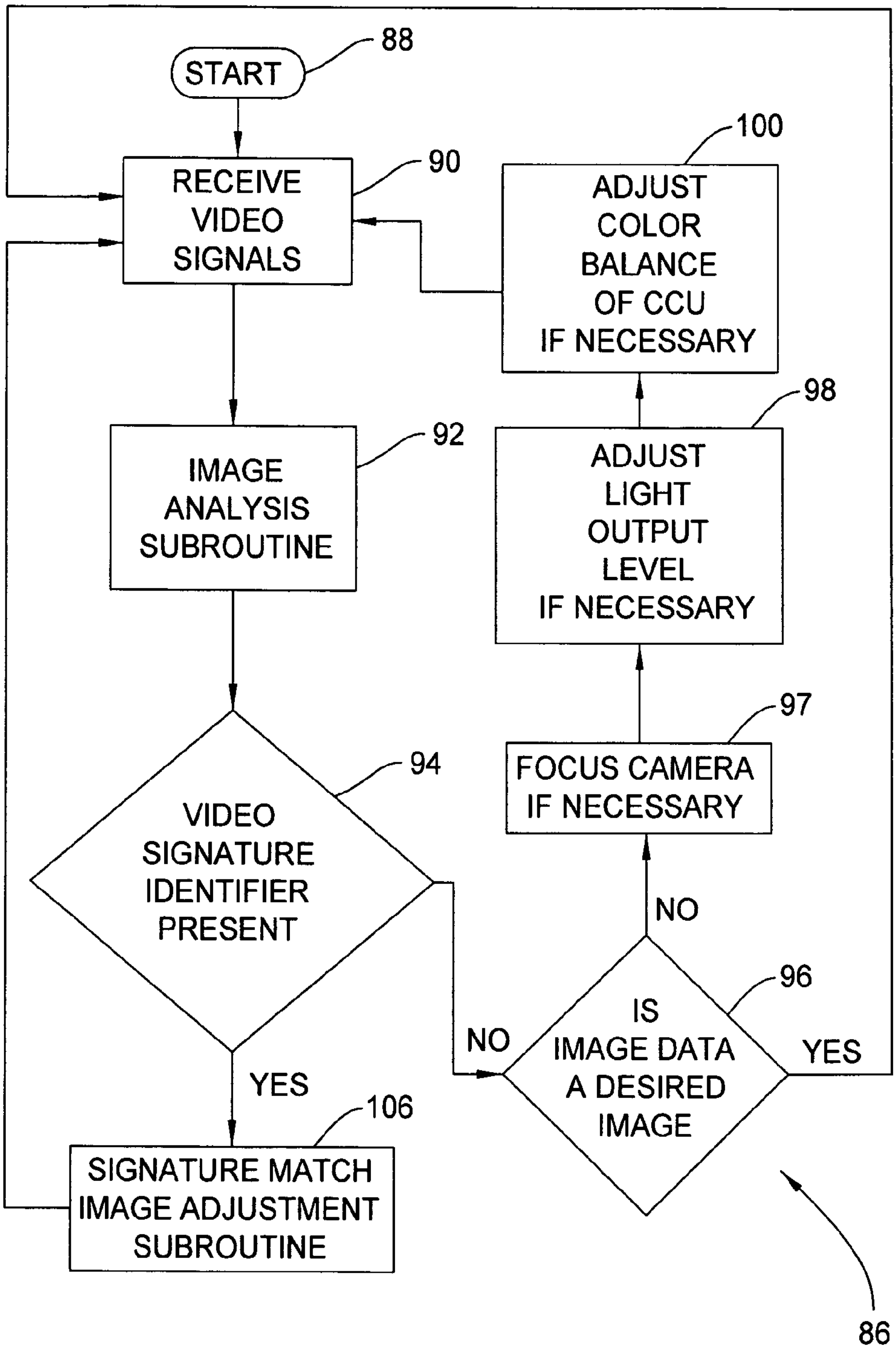

START
88
RECEIVE VIDEO SIGNALS
90
ADJUST COLOR BALANCE OF CCU IF NECESSARY
100
IMAGE ANALYSIS SUBROUTINE
92
ADJUST LIGHT OUTPUT LEVEL IF NECESSARY
98
FOCUS CAMERA IF NECESSARY
97
VIDEO SIGNATURE IDENTIFIER PRESENT
94
NO
NO
IS IMAGE DATA A DESIRED IMAGE
96
YES
YES
106
SIGNATURE MATCH IMAGE ADJUSTMENT SUBROUTINE
86

FIG. 3

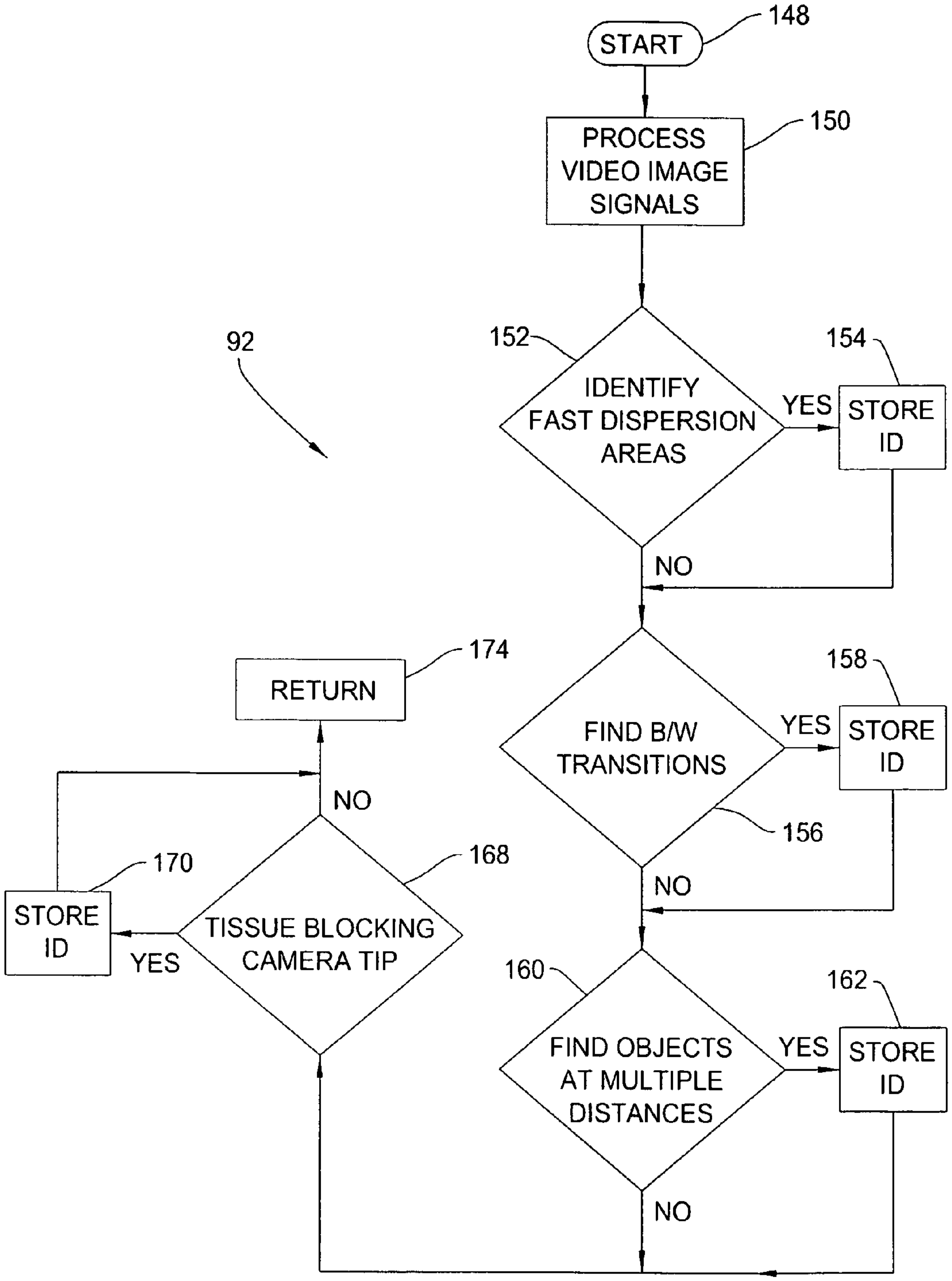

START
148
PROCESS VIDEO IMAGE SIGNALS
150
152
IDENTIFY FAST DISPERSION AREAS
YES
STORE ID
154
NO
92
FIND B/W TRANSITIONS
156
YES
STORE ID
158
NO
160
FIND OBJECTS AT MULTIPLE DISTANCES
YES
STORE ID
162
NO
RETURN
174
NO
TISSUE BLOCKING CAMERA TIP
168
YES
STORE ID
170

FIG. 4

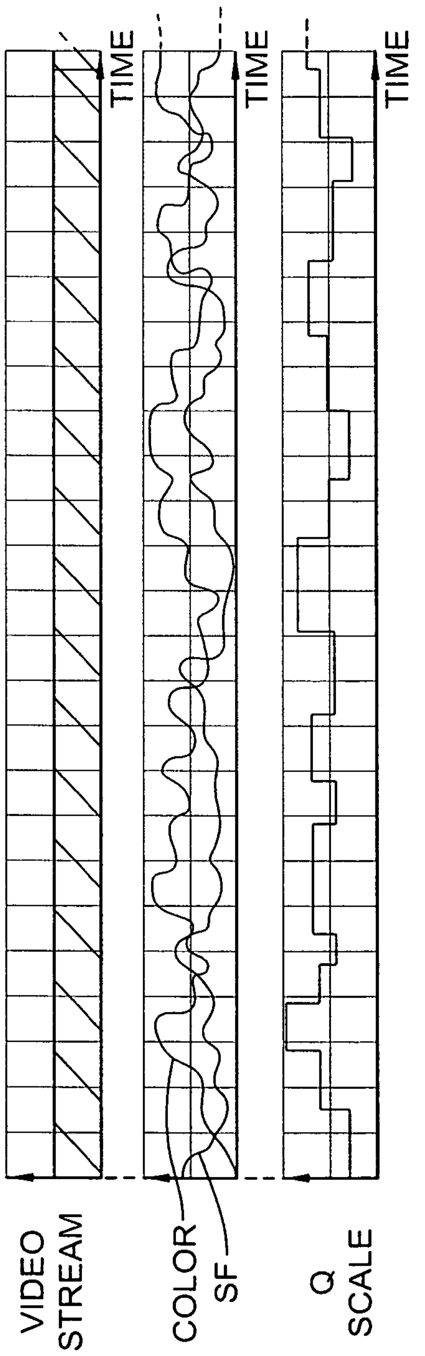


FIG. 5

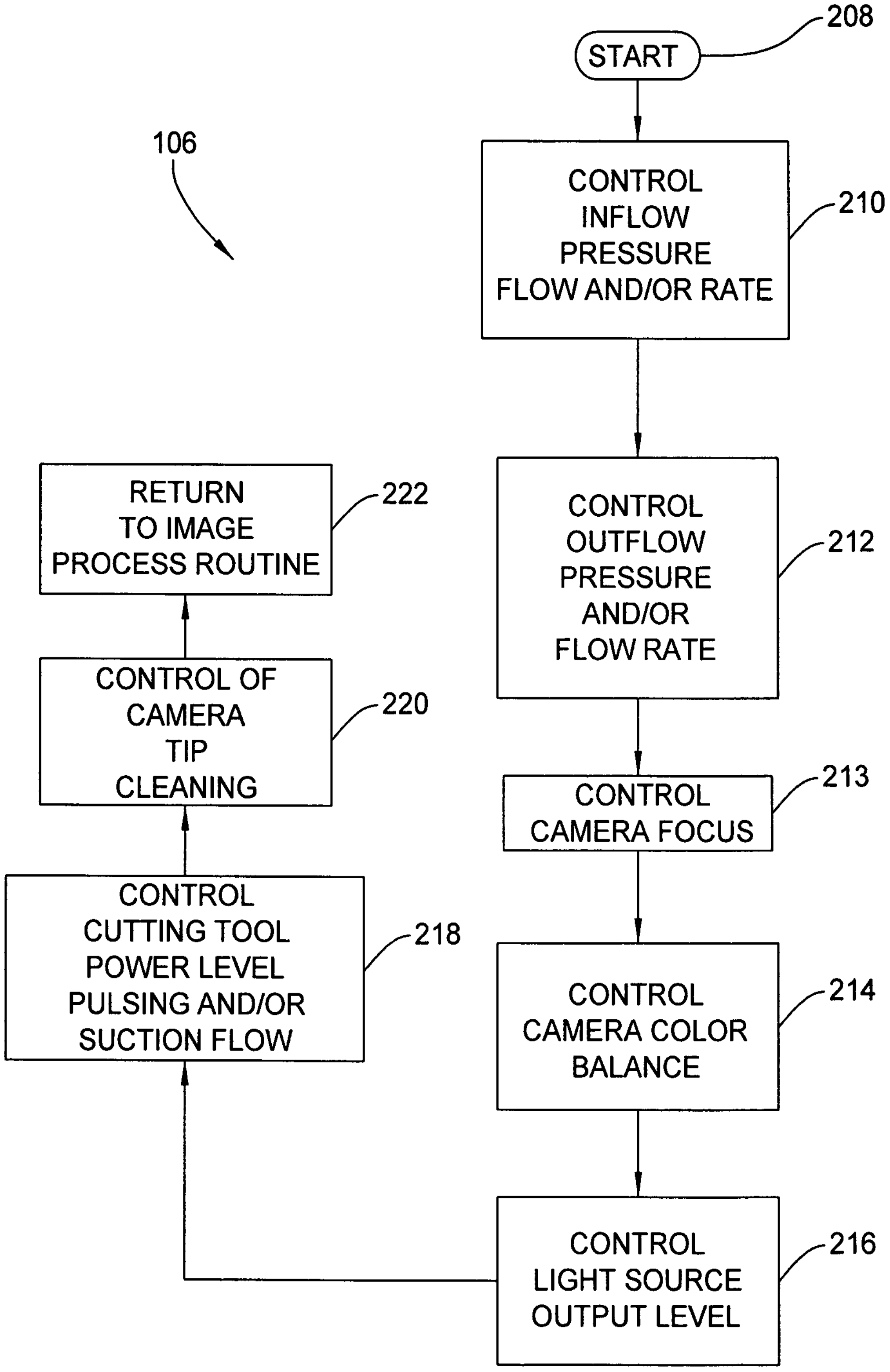

208
START
106
CONTROL INFLOW PRESSURE FLOW AND/OR RATE
210
CONTROL OUTFLOW PRESSURE AND/OR FLOW RATE
212
CONTROL CAMERA FOCUS
213
CONTROL CAMERA COLOR BALANCE
214
CONTROL LIGHT SOURCE OUTPUT LEVEL
216
CONTROL CUTTING TOOL POWER LEVEL PULSING AND/OR SUCTION FLOW
218
CONTROL OF CAMERA TIP CLEANING
220
RETURN TO IMAGE PROCESS ROUTINE
222

FIG. 6

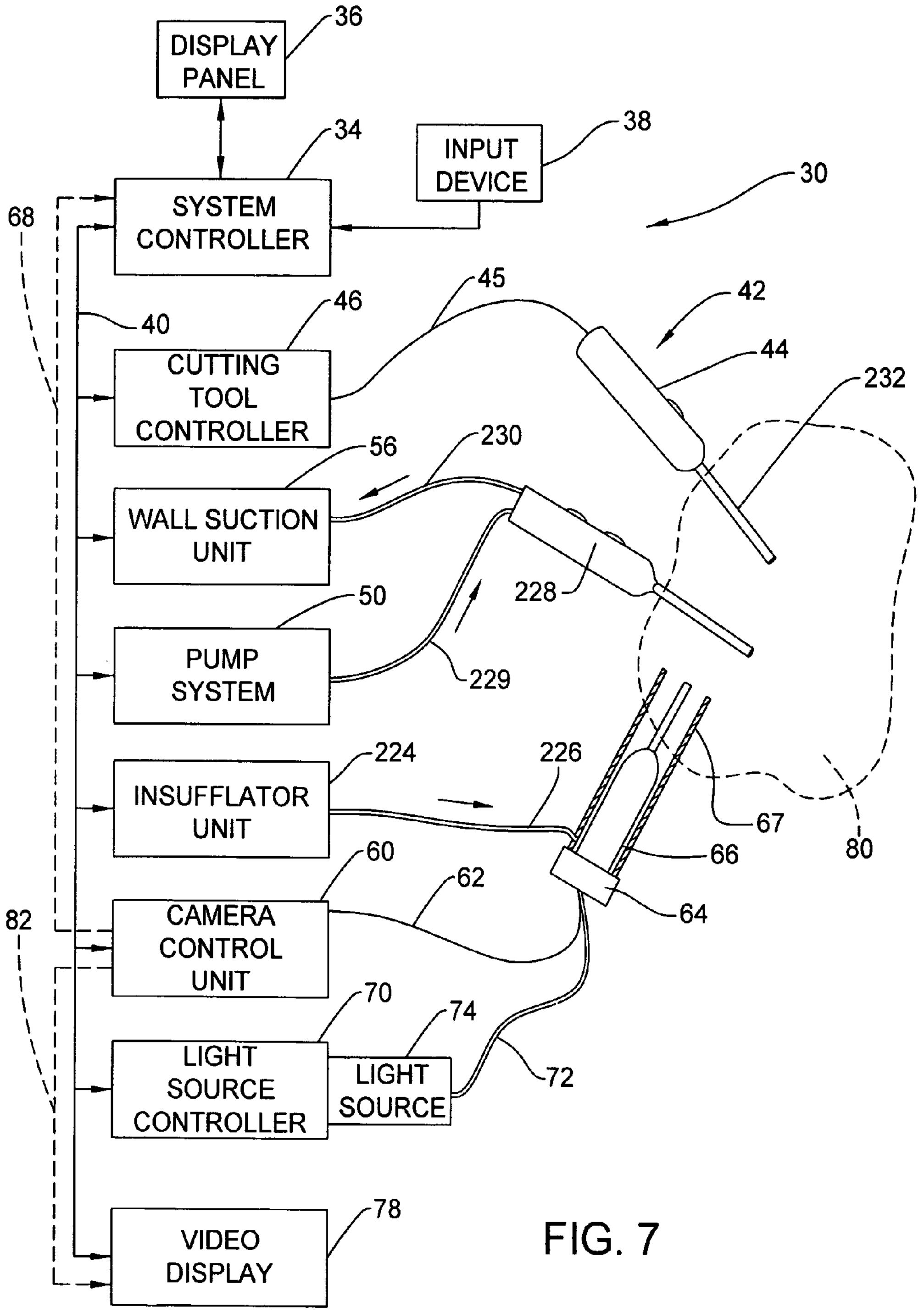

DISPLAY PANEL
36
34
SYSTEM CONTROLLER
INPUT DEVICE
38
30
68
40
46
45
42
CUTTING TOOL CONTROLLER
44
232
56
230
WALL SUCTION UNIT
228
50
PUMP SYSTEM
229
224
226
INSUFFLATOR UNIT
67
66
80
60
62
64
82
CAMERA CONTROL UNIT
70
74
LIGHT SOURCE CONTROLLER
LIGHT SOURCE
72
78
VIDEO DISPLAY

FIG. 7

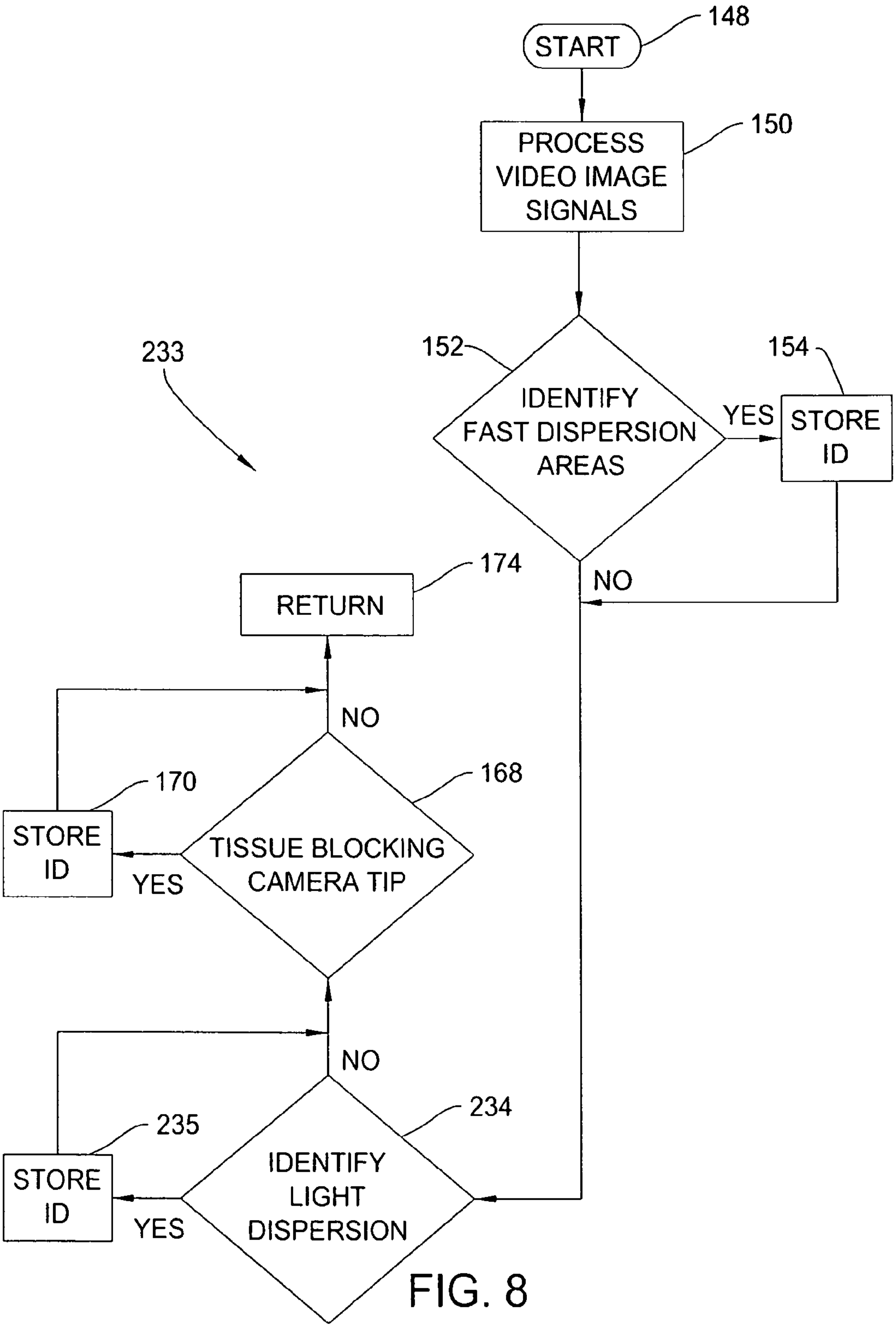

148
START
150
PROCESS VIDEO IMAGE SIGNALS
152
IDENTIFY FAST DISPERSION AREAS
YES
154
STORE ID
NO
233
174
RETURN
NO
170
STORE ID
YES
168
TISSUE BLOCKING CAMERA TIP
NO
235
STORE ID
YES
234
IDENTIFY LIGHT DISPERSION

FIG. 8

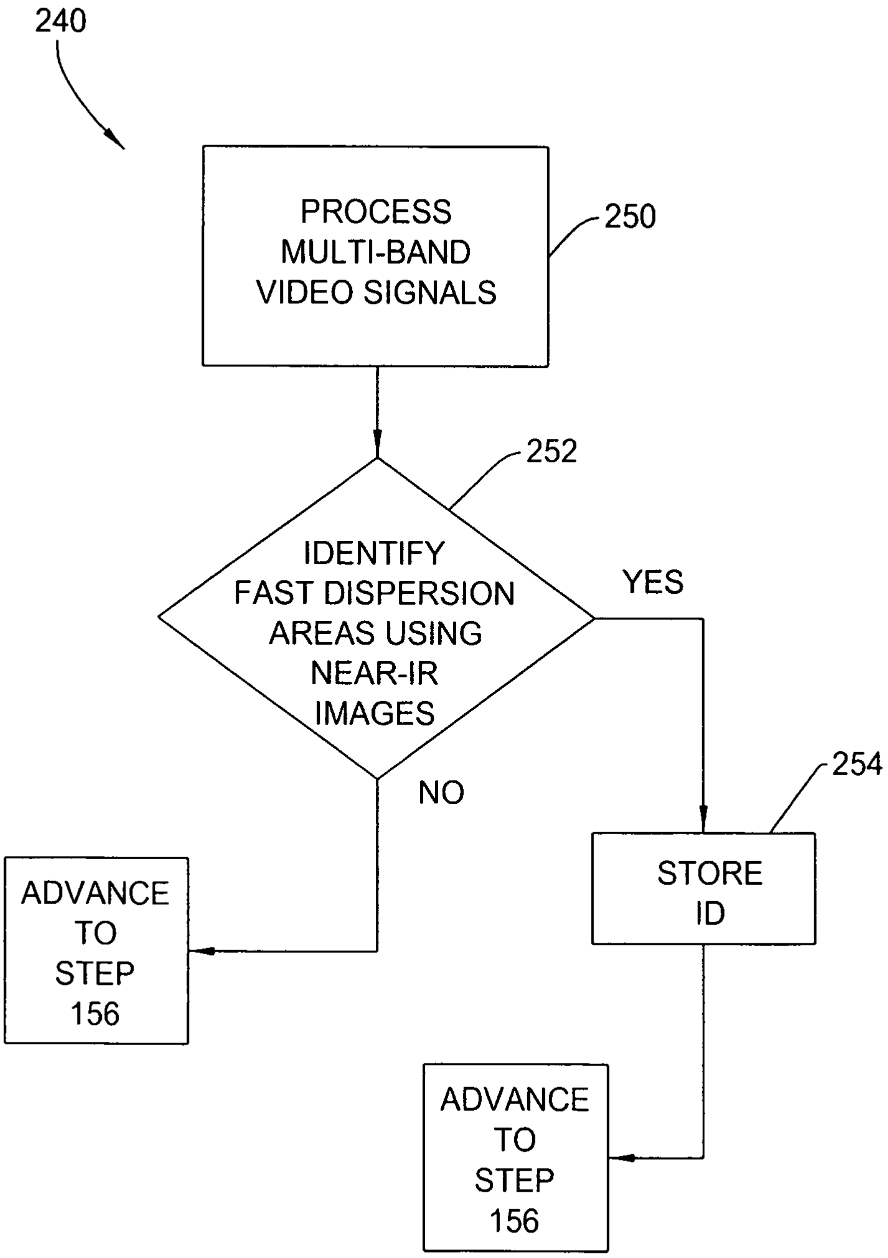
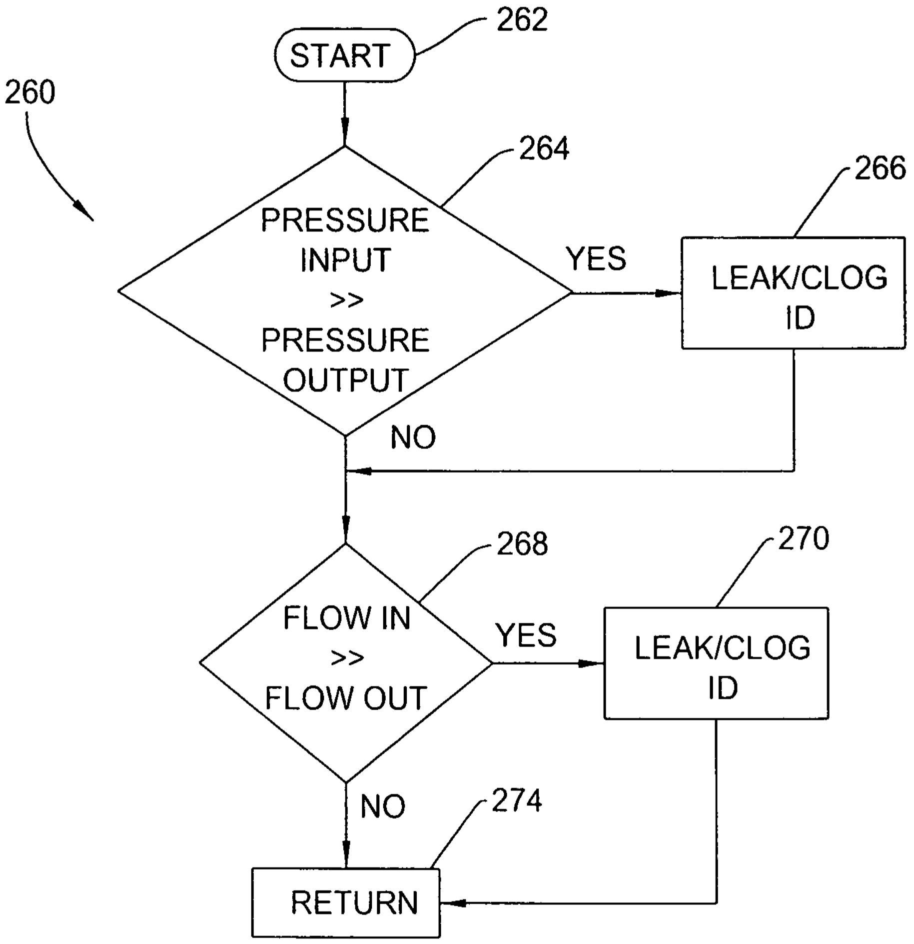

240
PROCESS MULTI-BAND VIDEO SIGNALS
250
IDENTIFY FAST DISPERSION AREAS USING NEAR-IR IMAGES
252
YES
NO
STORE ID
254
ADVANCE TO STEP 156
ADVANCE TO STEP 156

FIG. 9



260
START
262
PRESSURE INPUT >> PRESSURE OUTPUT
264
YES
LEAK/CLOG ID
266
NO
FLOW IN >> FLOW OUT
268
YES
LEAK/CLOG ID
270
NO
RETURN
274

FIG. 10

METHOD AND SYSTEM FOR VIDEO BASED IMAGE DETECTION/IDENTIFICATION ANALYSIS FOR FLUID AND VISUALIZATION CONTROL

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 61/340,805, filed Mar. 23, 2010, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

This invention is directed to a method and system for analyzing video images to obtain an acceptable image of a surgical site for display and use in a surgical procedure.

BACKGROUND OF THE INVENTION

In a typical arthroscopic surgical procedure, fluid is pumped into a surgical field to create a positive pressure in a joint to provide space to perform the procedure and to reduce bleeding by creating a tamponade effect. Fluid is pumped into and out of the joint to remove debris and blood from the surgical site. A video sensing device typically provides images of the surgical site. A surgeon manually controls the inflow and outflow of fluid from the surgical site to prevent debris, blood or other particulates from degrading the image that is necessary to perform the procedure. This manual task can be difficult and lead to additional time for conducting a surgery and potentially compromise the surgery if the images are not acceptable.

Prior art U.S. Patent Pub. No. 2008/0243054 A1 discloses a known arrangement, as shown in prior art FIG. **1**, for detecting and distinguishing blood and debris disposed within a shoulder joint during an arthroscopic procedure. The pressure in the shoulder joint, and the liquid flow from an irrigation system, is controlled to attempt to provide good viewing with the arthroscope by keeping video camera images free from blood and debris.

In prior art FIG. **1**, the arrangement includes an operating control device **17** and a saline bag **10** connected to a liquid inflow pump **2** that pressurizes feed tubing **13**. The arrangement includes a pressure sensor **5** joined to the feed tubing **13**. The feed tubing **13** connects to an arthroscope **14** that includes a video camera **22**. A shaver **15** connects to an outflow tubing **16** that is in fluid communication with an outflow pump **3**. During flow, the pressure drops all the way from the inflow liquid pump **2** to the outflow pump **3**. In prior art FIG. **1**, a video signal processor **23** is shown adjacent the operating control device **17**.

In prior art FIG. **1**, the detection of hemoglobin is obtained by use of light reflected from the hemoglobin in blood disposed in the joint **1**. The light reflected is that which is radiated by a light source (not illustrated) known in the art of endoscopy. The light is introduced in a designated channel in the arthroscope **14** that is placed in the shoulder. The reflection of white light is detected by the video camera **22**, which is fitted on the arthroscope **14**. The video signal that is output from the video camera **22** is provided to a video signal processor **23**.

The video signal is composed of separate red, blue and green video signal components that, in combination, compose the video color information. The video signal from the camera **22** is fed to the signal processor **23** that divides every video line signal into 0.64 microsecond time slots. This arrangement corresponds to 100 time slots for every video signal line, where a picture frame is made up of 625 lines (PAL). The signal levels of red, blue and green are nearly the same for the images common in the view field of the arthroscope, meaning that it is generally ranging from white to black. If the signal level of red is >20% of either the blue or green during a time slot, a score of one is registered in a first frame memory in the signal processor **23**. If the whole image is red, 62,500 score points would be registered. Every picture frame has its own score. The first frame memory in the signal processor **23** has a rolling register function that has the capacity of scoring points from 10 frames. The frame memory is updated as every frame is completed and delivered by the camera. At every new frame, the score value of the oldest frame is discarded. A score sum for the ten frames is calculated every time a new frame is delivered by the camera, thus introducing an averaging function.

If, during a period of 10 frames, the score sum is >30,000, blood is considered present, and if the score sum is >70,000, much blood is considered present.

If the score sum is >30,000, the video signal processor **23** will signal to the operating control device **17** which will react by increasing the flow of the aspiration pump to a higher level to rinse the shoulder. This higher level is preselected in the menu of the pump system, and is in this case 300 ml/min. If the score sum is >70,000, the flow will increase to 450 ml/min. When the blood detection determines that the increased flow has rinsed the shoulder as the signal level has returned to a low level, the aspiration pump will return to the intrinsic flow of 150 ml/min after a timeout of 30 seconds. Also, to stop bleeding of a ruptured blood vessel in the shoulder joint **1**, the pressure in the joint is increased by a pressure control for the same time that flow is elevated. This pressure increase is predetermined in menu settings of the pump, and is in this example 40 mm Hg. Also other picture analysis techniques as known in the art could be used.

To detect debris, the signal processor **23** divides every video frame into 128×128 pixel elements. Every such pixel has a signal level that corresponds to the whiteness of the object that is visualized by the camera. This whiteness is nearly the same from video image frame to video image frame. The signal processor stores a value from 0 to 15 as this intensity value of the video signal of each pixel in a second frame memory. The pixel values are stored in a matrix fashion. For each video image frame **25** consecutive frame matrixes are stored. The second memory in the signal processor has a rolling register function that rolls the 25 frames in a first in-first out fashion. The second memory is updated as every video image frame is completed and delivered by the camera. As a new frame is developed by the camera, the oldest frame is discarded. A variation in the pattern in the second stored matrix is detected by the signal processing unit. This variation is identified as pixel intensities that are recognized as moving from one adjacent pixel to another in an identifiable fashion. As every pixel has a location in the matrix that corresponds to the physical image, a movement of intensity in the matrix location from image frame to image frame is a movement in relation to the surrounding, of a single object, in this case debris that float in the shoulder joint. Movement can be in any direction in the matrix. If 10 such movements are detected during one frame, a first score value is incremented by one in a memory cell representing a first score value. This score value is incremented for each detection, and is decremented down to 0 for every frame there is no such detection. If there are over 500 detections in one frame, the camera is moved, and no score values are given. Also, other picture analysis techniques as known in the art could be used.

Every second a frame matrix is stored in a third frame memory. This memory also has a rolling register function that rolls the 25 frames in a first in-first out fashion. If predominant consistently low signal levels are occurring in the third frame memory, dark areas are identified. If these dark areas are elevated to a consistent signal >25% level over a time of 5 seconds, homogeneous debris is identified as being present in the shoulder joint. Such occurrence increases the value of a second score value by 10. If there is no such occurrence, this second score value will be decremented by 10 down to 0.

If either the first or second score values are >50, debris is considered present, and the video signal processor **23** will signal to the operating control device **17** which will react by increasing the flow of the aspiration pump to a higher level to rinse the shoulder. This higher level is preselected in the menu of the pump system, and is in this case 300 ml/min. When the debris detection determines that the increased flow has rinsed the shoulder as the score value has returned to <50, the aspiration pump will return to the intrinsic flow of 150 m./min after a timeout of 5 seconds, and both score values are reset.

The system described above, however, is limited to an operating control device **17** for a pump that only controls liquid inflow for the arthroscope **14** and liquid outflow from a separate shaver **15**. In this system, there is no control of any functions other than the liquid inflow pump **2** and liquid outflow pump **3**. Further, the prior art system is limited to processing red, blue and green video signal components. Finally, the FIG. **1** system is limited to controlling flow pressure/inflow and outflow rates in order to obtain a desired video image.

SUMMARY OF THE INVENTION

The present invention provides an enhanced video image for a surgical site by determining one or more of a plurality of conditions that degrade the quality of at least portions of the video image of a surgical site, and automatically selecting from a plurality of system control arrangements the optimal functions to be controlled in order to maximize the quality of the video image provided on a display for a surgeon during a medical procedure.

In one embodiment of the invention, a video based image detection/identification system for sensing fluid and for visualization control is provided with a surgical system including a cutting tool for manipulating tissue, a pump system for providing fluid, a light source, and a video sensing device for obtaining video signals of images at a surgical site for display. A system controller controls at least one of the cutting tool, the pump system, and the video sensing device to maintain image quality of the images obtained by the video sensing device for display. The controller receives and processes video signals from the video sensing device to determine video signatures that correspond to specific conditions at a surgical site that interfere with image quality. In response to an identified condition at the surgical site that degrades the video image, the controller controls the cutting tool, pump system, light source and/or video sensor device so that the images from the video signals return to an acceptable quality automatically, so as to free a user from the task of manually controlling the devices to maintain a desired video image. The video signatures determined by the controller include one or more of bubbles, debris and bleeders located at a surgical site as viewed by the video sensing device of an endoscopic system. Another video signature determined by the controller determines the presence of debris located at a distal tip of a housing of a handpiece associated with a video sensing device.

In one embodiment, the invention is provided with a laparoscopic system that utilizes an insufflator as a pump to provide gas to a surgical site. In this embodiment, the video signatures are provided to detect smoke, debris and other conditions.

In some embodiments, predetermined wavelengths of energy are provided from the light source to the surgical site. The energy for determining the conditions at the surgical site can be emitted at wavelengths that are out of the visible light range.

In response to the various video signatures, the system controller of one embodiment of the invention controls at least one of suction pressure, a suction valve position, input pressure, an input flow valve, color imaging processing of the camera control unit, light source intensity, and color balance of the video sensing device to improve the video image for display.

By directly comparing video images for quality and directly operating various devices in response to image quality issues, the invention operates as a closed system. More specifically, the quality of the image is not obtained or improved by sensing pressure values or other conditions that do not have a direct effect on the image. Instead, the controller acts as a closed system by receiving direct video information as to the quality of an image and then controlling devices to maintain image quality.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a prior art arthroscopic system.

FIG. **2** depicts a block diagram of an integrated surgical control system, along with surgical tools disposed at a surgical site.

FIG. **3** is a flow chart showing steps for a video signature identification and image control routine that operates to provide an enhanced image of a surgical site.

FIG. **4** is a flow chart of a video image analysis subroutine for analyzing video images from a surgical site.

FIG. **5** is a graph of a video signal stream, color signals, spatial frequency and a Q scale.

FIG. **6** is a signature match image adjustment subroutine for controlling devices to improve the video image.

FIG. **7** depicts a block diagram of a laparoscopic integrated surgical control system, along with surgical tools disposed at a surgical site.

FIG. **8** is a flow chart of a video image analysis subroutine for analyzing video images from a surgical site.

FIG. **9** is a flow chart for a multi-band light source control image analysis subroutine.

FIG. **10** is a flow chart of a leak/clog subroutine of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **2** illustrates an integrated surgical control system **30** that includes a system controller **34** having a display panel **36** and an input device **38**. The system controller **34** is connected by a computer network **40** to communicate with a plurality of surgical devices. The devices may include a cutting tool **42**, such as a surgical shaver, having a handpiece **44** connected by a signal line **45** to a cutting tool controller **46** that communicates with the system controller **34** over the network **40**. The surgical control system **30** can be an arthroscopic surgical control system.

The surgical control system **30** includes a pump system **50** connected to suction tubing **52** for providing suction to a cannula **54** having a stop cock **55**. In some embodiments, the pump system **50** includes a peristaltic pump. While the cannula **54** is only shown as providing a suction flow path, in some embodiments, the cannula **54** can be used to define a portal into the surgical site into which other types of tools or devices can be placed. Such devices include cutting tools, irrigation devices and other surgical instruments. The pump system **50** communicates with the system controller **34** via the network **40**. While a single suction tubing **52** is shown connected to the pump system **50**, in some embodiments a plurality of suction tubings from different devices may connect to the pump system.

The surgical control system **30** includes a wall suction unit **56** and suction tubing **57** which connects the suction unit to the cutting tool **42** via the cutting tool handpiece **44** to provide suction for removing debris resulting from tool operation. The wall suction unit **56** includes an adjustment valve (not shown) for controlling the suction for tubing **57**. In some embodiments, the valve is automatically adjusted by the controller **34** to automatically vary the pressure within tubing **57**. While pump system **50** provides suction for tubing **52**, in some embodiments the pump system **50** does not provide suction. Instead, wall suction unit **56** provides suction to tubing **52** and additional tubing. The wall suction unit **56** can have control valves to control suction separately for each tubing connected thereto. In some embodiments, a portable suction unit is provided when a wall suction unit is not available.

The surgical control system **30** also includes a camera control unit (CCU) **60** that communicates via the network **40** with the system controller **34**. The camera control unit **60** connects via video signal line **62** to a video camera **64** that is mounted onto or is integral with a video camera/light source handpiece **66** disposed within a cannula **67** providing access to a surgical site as shown in FIG. **2**. The handpiece **66** is configured to output light to a surgical site. In some embodiments, a separate connection **68** (shown in broken line in FIG. **2**) is provided to transfer the video signal from the camera control unit **60** directly to the system controller **34**. In some embodiments, the handpiece **66** includes a C-mount endoscope having a focus ring and a camera head with a video camera that is attached to the proximal end thereof.

A light source controller **70** communicates with the system controller **34** via the network **40** and controls power to a light source **74** that provides light to the handpiece **66** via light source optical fiber **72**. In other embodiments, the optical fiber **72** is replaced by a power line that provides power to a light source mounted in the handpiece **66**. In some embodiments, the video camera/light source handpiece **66** has a video camera (not shown) provided at the distal end of the handpiece, instead of the video camera **64** located at a proximal end of the handpiece.

Irrigation tubing **76** connects the pump system **50** to the cannula **67** to provide irrigation fluid to the handpiece **66**. The fluid is output to irrigate surgical site **80**. A stop cock or valve (not shown) controls irrigation fluid into the cannula **67**. The irrigation fluid follows a path between the inner wall of the cannula **67** and about the outer periphery of the video camera/light source handpiece **66** to the surgical site **80** at the distal end of the cannula. The video camera/light source handpiece **66** both projects light outwardly at the distal end thereof and senses video images with the video camera **64**.

Video display **78** shown in FIG. **2** communicates with the system controller **34** over the network **40**. The video display **78** displays the video image taken at a surgical site **80** by the video camera **64**. In some embodiments, a video display signal line **82** (shown in dotted lines in FIG. **2**) is provided for directly connecting the camera control unit **60** to the video display **78**.

In FIG. **2**, the handpieces **44**, **66** and cannulas **54**, **67** are oriented within surgical site **80** for conducting a surgical procedure.

In the surgical control system **30**, the system controller **34** receives inputs from the cutting tool controller **46**, pump system **50**, video camera control unit **60** and the light source controller **70**. The video display **78** typically is a high definition LCD display whereat the image taken by the video camera **64** of the handpiece **66** is displayed continuously.

The input device **38** of the system controller **34** in some embodiments is a touch screen, while in other embodiments the input device is a set of contact switches or the like. Further, the input device **38** may include a voice recognition system for processing voice commands to provide control signals to the system controller **34**.

In one embodiment, video signals from the camera control unit **60** are, instead of being provided over the network **40**, simply sent separately and wirelessly to the system controller **34** and to the video display **78**.

While pump system **50** is shown in FIG. **2** as having one suction input and one irrigation output, it is contemplated that the pump system may have a plurality of suction inputs. Wall suction unit **56** with valve control can connect to the suction tubing **52** as well as other tubing, so that the pump system **50** only comprises an irrigation pump. A portable pump system for providing irrigation is also contemplated.

Video Signature Identification and Image Control Routine

FIG. **3** is a flow chart representing a video signature identification and image control routine **86** for the system controller **34** that controls the devices of the surgical control system **30**. The video signature identification and image control routine **86** begins at start **88**. From start **88**, the video signature identification and image control routine **86** advances to signal receiving step **90** wherein the system controller **34** receives video signals from the camera control unit **60** and advances to image analysis subroutine **92**. In other embodiments, the camera control unit **60** performs the image analysis. In some embodiments, the camera control unit **60** is mounted with the camera **64** that is located at the proximal end of the video camera/light source handpiece **66**.

At image analysis subroutine **92**, the system controller **34** analyzes image data taken from the video signals for determining the presence of video signatures and stores identifiers in response to matches as shown in the flow chart of FIG. **4** discussed in detail later herein.

Returning to FIG. **3**, the image control routine **86** then advances from image analysis subroutine **92** to video signature match step **94**. At decision step **94**, system controller **34** looks for the presence of stored identifiers corresponding to the various video signatures as determined by and stored in the controller during operation of the image analysis subroutine **92**.

In instances where the image analysis subroutine **92** does not find a video signature that matches with a predetermined stored video signature, no identifier is present at decision step **94**, and the identification and image control routine **86** advances to image data decision step **96**.

At decision step **96**, at least a portion of the image data previously analyzed at subroutine **92** is compared with optimal desired image data properties. If the analyzed image is considered appropriate, the routine **86** advances from step **96** by returning to step **90** to receive new video signals. The routine **86** is then repeated.

At step **96**, when the video image is not at a maximized quality level, the system controller **34** advances to camera focus step **97**. At step **97**, focus of a lens (not shown) or the like provided with the video camera/light source handpiece **66** is automatically controlled to maximize the clarity of the video images. The system controller **34** then advances to light adjustment step **98**. At step **98**, the output level of the light source **74** is either increased or decreased depending on the amount of light necessary to maximize the quality of the video image taken by video camera **64** for display on the video display **78**. After light adjustment step **98**, the image control routine **86** advances to color balance adjustment step **100**.

At color balance adjustment step **100**, the system controller **34** adjusts, if necessary, the color balance of the camera control unit **60** for the video images provided by the video camera **64**. After color balance adjustment step **100**, the image control routine **86** advances to video signal receiving step **90** and repeats the video signature identification and image control routine **86**.

In some embodiments, the color balance is adjusted internally by the camera control unit **60** before a signal is output by the camera control unit **60**. In other embodiments, the system controller **34** performs calculations and provides an output to control the camera control unit **60**.

The order of adjustment steps **97**, **98**, **100** as shown in FIG. **3** is for purposes of illustration only. The steps **97**, **98**, **100** may be performed in any order or performed essentially simultaneously by the system controller **34**.

Returning to video signature identifier present step **94**, in an instance wherein a video signature identifier is stored in the controller **34**, the controller advances the routine **86** to the signature match adjustment subroutine **106** as shown in the flow chart of FIG. **6** and discussed later herein. Upon adjustment of the video image at subroutine **106**, the controller **34** returns to step **90** of the video signature identification and image control routine **86** as shown in FIG. **3**, to receive new video signals and to repeat execution of the video signature identification and image control routine **86**.

Image Analysis Subroutine

The image analysis subroutine **92** shown in FIG. **4** operates as follows. The subroutine **92** begins at start **148** and advances to process video image signals step **150** to obtain video signature information from received video images. At step **150**, the system controller **34** may conduct a plurality of subcalculations or signature identification type operations on a video image, including comparisons with a sequence of previously stored video images.

Image analysis subroutine **92** then advances to identify fast dispersion areas step **152**. At step **152**, processed video signals are compared with previously received and stored processed video signals to identify the presence of video signatures for fast dispersion red areas (bleeders) within subsequent video images whereat blood is spreading at at least a predetermined minimum rate. If a bleeder is occurring, the subroutine **92** advances to store identifier (ID) step **154**. At step **154**, the system controller **34** then stores an identifier or identification code identifying the presence of a bleeder in the video images for later control purposes.

The controller **34** then advances the subroutine **92** to find black/white (B/W) transitions decision step **156**. If an identification of a video signature for fast dispersion red areas is not matched at step **152**, the image analysis subroutine **92** advances directly to decision step **156**.

At black/white transitions decision step **156**, processed video signals are compared with a sequence of previously processed video signals to determine, over time, the presence of a video signature match for fast upwardly moving black/white transition, which correspond to upward movement of air bubbles within a liquid. The air bubbles can be generated by operation of an RF cutting tool. If there is a signature match, or in some instances close to a complete signature match, the subroutine **92** advances to storing identifier step **158**.

At step **158**, the controller **34** stores an identifier indicating the presence of air bubbles in the video image. The controller **34** then advances the subroutine **92** to find objects at multiple distances step **160**. If there is not a signature match at step **156**, the subroutine **92** immediately advances to find objects at multiple distances step **160**.

At find objects at multiple distances step **160**, video images are compared to determine the presence of video signatures for multiple small objects at different focal distances within a video image. This signature matching determines the presence of particulates in the fluid at the viewed surgical site **80**. If the processed video images result in a video signature or signatures that match a stored video signature or signatures for the presence of particulates, the video image analysis subroutine **92** advances to storing identifier (ID) step **162**. The particulates can be debris generated by a burr or other cutting tool.

At storing identifier step **162**, a particulate identifier or identifier code is stored in the system controller **34**. The subroutine **92** then advances to identify light dispersion step **164**.

If there is not a video signature match for the identification of particulates at decision step **160**, the subroutine **92** immediately advances to identify light dispersion step **164**.

At tissue blocking camera step **168**, the controller **34** analyzes the processed video image signal to determine the presence of tissue or like material blocking the distal tip of the video camera/light source handpiece **66** by comparing processed video images with a video signature for the presence of tissue blocking the distal end of the handpiece **66**.

If a processed video image has a signature that matches with a stored video signature corresponding to the presence of tissue blocking the camera view, the controller **34** advances the subroutine **92** to store identifier (ID) step **170**.

At step **170**, a camera tip blocked identifier is stored in the system controller **34** and the subroutine **92** advances to return step **174**. If a blocked distal tip for the camera/light source handpiece **66** is not detected at step **168**, the controller **34** immediately advances the image analysis subroutine **92** to return step **174**.

The order of identification steps **152**, **156**, **160**, **168** as shown in FIG. **4**, is for purposes of illustration only. The steps **152**, **156**, **160**, **168** in subroutine **92** can be performed in any order, or executed essentially simultaneously.

Upon completion of the identification of the various conditions that can degrade a video image taken at a surgical site **80**, the controller **34** advances from return step **174** of the video image analysis subroutine **92** to the video signature identifier present step **94** of the video signature identification and image control routine **86** shown in FIG. **3**.

With respect to video image signal processing or video image stream analysis for the image analysis subroutine **92** discussed above, information can be extracted specifically by using color imaging processing algorithms. For instance, bleeders can be determined by using a color image processing algorithm coupled with 2-D spatial information from the sensed video image. For example, close pixels that look like blood can be detected in the video RGB color space by using a simple distance formula. The closer that the pixel distance is to the desired pixel point in the color space, the more likely that the pixel belongs to a digital representation of a bleeder.

While determining and adjusting light output level and color balance is separate from the image analysis subroutine **92** shown in FIG. **3**, in some embodiments one or both of the light output level and the color balance of the camera control unit **60** are provided with decision blocks as shown in FIG. **4** and compared with various video signatures in the image analysis subroutine **92**.

In some embodiments, swelling/distention of joints can reduce quality of a video image. This situation can be determined by video image analysis and pressure/fluid flow may be controlled to minimize the condition and any negative effect on the video image.

In image analysis subroutine **92**, color image processing may also be coupled with other information and techniques, such as fast fourier transform (FFT) spatial frequency information, image segmentation and weighting techniques to weight the different processing quantitative indicators to make automated decisions about the existence of obstructions, such as bleeders, along with particulates and bubbles.

FIG. **5** illustrates an embodiment wherein a video stream that represents a plurality of sequential video images is analyzed to determine the presence of video signatures. In FIG. **5**, color (RED color) and spatial frequency (SF) are determined and shown over time for a stream of video signals. A subjective image quality evaluation provides scaled scores as shown over time on a Q scale as illustrated in FIG. **5**. The Q scale values can be used to determine the presence of a video signature or other anomaly. Low spatial frequency values may indicate the presence of blood and high spatial frequencies may indicate the presence of debris. The presence of bubbles may have a unique signature spatial frequency. In response to a video signature match or the like, the controller **34** then stores a predetermined identifier as discussed above.

Additional image analysis techniques are disclosed in U.S. Patent Pub. 2008/0243054, the disclosure of which is hereby incorporated by reference. The '054 patent publication discloses an arthroscopic video camera and video signal processor.

Signature Match Image Adjustment Subroutine

If, at the video signature identifier present decision step **94** in FIG. **3**, the controller **34** finds at least one stored identifier present, the controller advances to signature match adjustment subroutine **106**. Detailed operation of the signature match image adjustment subroutine **106** is illustrated in FIG. **6**.

From start **208** in FIG. **6**, the controller **34** advances the subroutine **106** to control inflow pressure flow and/or flow rate control step **210**.

At control step **210**, the system controller **34** obtains information on the inflow pressure from a sensor (not shown) associated with the irrigation tubing **76** from the pump system **50** or from a sensor disposed in the handpiece **66**. Further, in some embodiments the system controller **34** is provided with gas or liquid pressure sensed within the surgical site **80**, as well as the flow rate through return suction tubing **52**, **57** and the pressure values thereat. Depending on the measured pressure/flow conditions, and especially the type of condition at the surgical site **80** determined by the matched video signature(s) and provided by the stored identifiers, the controller **34** adjusts inflow pressure and/or flow rate provided to the surgical site at step **210** to improve the quality of the video image taken by video camera **64**. The controller **34** then advances the signature match image adjustment subroutine **106** to control outflow pressure and/or flow rate step **212**.

At step **212**, depending on the video signatures matched, the system controller **34** selectively controls the outflow pressure and/or flow rate through the suction tubing **52**, **57**. The outflow pressure/flow rate control is dependent in part on the input pressure/flow rate values, and the type of identifiers. For example, in the case of a quantity of increasing blood areas detected by a video signature and provided with an identifier at step **154** as shown in FIG. **4**, the inflow/outflow and pressure values can be operated in a manner to flush blood from the surgical site **80** in a timely and effective manner. In some embodiments, pulsing of irrigation fluid entering a surgical site **80** removes the blood and provides a quality video image. The position of the stop cock **55** of the cannula **54** or the valve of wall suction unit **56** can automatically be adjusted by controller **34** to maximize the video image.

While steps **210**, **212** are illustrated as separate steps in FIG. **6** for convenience, in some embodiments the steps **210**, **212** represent a single step as inflow/outflow control of fluid acts as a single response to correct a sensed undesired condition or plurality of undesired conditions identified by a comparison with one or more video signatures from subroutine **92**. The controller **34** then advances the subroutine **106** to camera color balance step **214**.

Depending on the properties of the one or more video signature(s) that are determined, selective control of lens focus for the video camera is provided at camera focus step **213**. In some instances, the system controller **34** takes no action at step **213** and advances to step **214**.

Depending on the properties of the one or more video signature(s) that are matched or determined, selective control of camera color balance occurs in some embodiments at camera color balance step **214**. In some instances, especially depending on the type of video signature identifier obtained by the system controller **34**, the controller takes no action at step **214** and advances to light source output control level step **216**.

At light output control level step **216**, the controller **34** signals the light source controller **70** for operating the light source **74** to output more or less light, as necessary, to maximize the video image output by the camera control unit **60**. More specifically, the system controller **34** calculates the need for changes or adjustments in the light output level, and then the controller **34** provides signals to the light source controller **70** to carry out the light output level changes. In some instances, the light output level does not change as video image quality with respect to the light level is already maximized.

In some embodiments, the image adjustment subroutine **106** then advances to step **218**. Depending on the video signature identifiers that have been determined and stored, the controller **34** may automatically control, for example, operation of the cutting tool **42** (on/off state or rotational/reciprocating speed) and also may control the inflow pressure/flow rate and/or outflow pressure/flow rate essentially simultaneously to unclog the cutting tool **42**, or to otherwise improve the video image taken of the surgical site **80** by camera **64**. In some embodiments, a pulsing pressure and/or liquid flow is also applied to clean or unplug material at or near a cutting tool. In some embodiments, if bubbles are detected by image analysis, an RF cutting tool that presumably is generating the bubbles is controlled by the controller **34** to operate in a different power mode or powered off to minimize the formation of bubbles.

In instances where the cutting tool **42** is not in operation, or no identifier requires an action thereby, control of the cutting tool does not occur, and the image adjustment subroutine **104** simply advances the subroutine **106** to control of camera tip cleaning step **220**. In some embodiments, cutting tool control step **218** is not provided in the image adjustment subroutine **106**.

At step **220**, if the controller **34** stores a camera cleaning identifier that corresponds to a video signature caused by material or tissue disposed at the distal end of the video camera/light source handpiece **66** shown in FIG. **2**, then the controller **34** controls an apparatus known in the art to clean the distal tip of the handpiece **66** to obtain a desired improved image.

In some embodiments, the inflow of irrigation liquid is redirected by a structure adjacent or near the distal end of the handpiece to remove the tissue. In other embodiments, when a tip cleaning identifier is provided, the other control steps, such as camera color balance and light output level control are by-passed. The controller **34** advances the image adjustment subroutine **106** directly to tip cleaning step **220** and then to return step **222**.

At return step **222**, the system controller **34** returns to the video signature identification routine **86** shown in FIG. **3** to receive video signals at step **90** and repeat execution of the routine **86** to again determine the presence of video signature matches.

In some embodiments, the operating status of output devices or tools are either monitored by or input to the system controller **34**. In response to the status of the devices or tools, the controller **34** can control pressure and/or suction values, as well as control tool operation, to maintain a quality image free from video signatures. For example, in some embodiments the system controller **34** provides output signals to drive the various cutting devices or receives input signals when a tool is manually operated. Thus, the system controller **34** is capable of controlling inflow pressure flow and/or flow rate, as well as outflow suction and/or flow rate, depending on the tools being operated. This arrangement enables the system controller **34** to initially prevent the degradation of picture quality and thus avoid requiring a later action in response to a video signature to improve the picture quality.

For example, when a burr or other cutting device is operating, the system controller **34** can immediately control suction and/or irrigation to remove debris before video image quality is degraded.

Laparoscopic System

The surgical control system **30** illustrated in FIG. **7** generally corresponds to the system illustrated in FIG. **2** (like numbers utilized for the same parts), except the system is a laparoscopic surgical system.

The surgical system **30** includes an insufflator unit **224** having air supply tubing **226** for supplying air, preferably carbon dioxide, to a trocar **267** that receives the video camera/light source handpiece **66**. Thus rather than supplying irrigation to surgical site **80**, the trocar **267** receives fluid, such as air or CO_2, between an inner wall of the trocar and the periphery of the handpiece **66** that flows outwardly from the distal end of the trocar to expand a peritoneal cavity to enable access to a surgical site **80**.

The pump system **50** and wall suction unit **56** shown in FIG. **7** connect to a suction/irrigation tool **228**. The pump system **50** provides fluid to the tool **228** via irrigation tubing **229**. The wall suction unit **56** provides suction to the suction/irrigation tool **228** via suction tubing **230**. The suction/irrigation tool **228** selectively irrigates and suctions the surgical site **80**. In some embodiments, the wall suction unit **56** is replaced by a portable suction unit.

The cutting tool **42** shown in FIG. **7** includes the handpiece **44** receiving an electrode **232**. In some embodiments, the cutting tool **42** typically is an electrocautery device with the electrode **232** being capable of cutting tissue and a coagulation function.

In some embodiments, the video camera/light source handpiece **66** comprises an endoscope having an eyepiece that is joined at a proximal end to a camera head having a coupler.

The arrangement shown in FIG. **7** operates in a similar manner to the arrangement shown in FIG. **2**. The suction/irrigation tool **228** typically is only manually controlled for irrigating surgical site **80** and for withdrawing irrigation fluid as necessary.

The system controller **34** and network **40** communicate with and operate the various devices in essentially the same manner as shown in FIG. **3** and discussed above.

FIG. **8** shows a video image analysis subroutine **233** similar to the arrangement described above with respect to FIG. **4** (same numbers perform the same function).

In the video image analysis subroutine **233**, steps **150**, **152**, **154** function in the same manner as set forth above. After comparing video signatures for fast dispersion areas (bleeders) at step **152**, and if found, storing a bleeder identifier at step **154**, the controller **34** advances the video image analysis subroutine **233** to light dispersion identification step **234**.

At light dispersion identification step **234**, the system controller **34** operates to compare a sequence of processed video signals with predetermined and stored light dispersion video signatures to determine the presence of smoke. If there is a signature match between the processed video signal and a stored video signature for the presence of smoke, the controller **34** advances the subroutine **92** to store identifier (ID) step **235**.

At store identifier step **235**, a smoke presence identifier is stored in the system controller **34**. Then, the controller **34** advances the subroutine **233** to tissue blocking camera tip decision step **168**.

If a video signature for the presence of smoke is not identified by the controller **34** at step **235**, the controller **34** immediately advances the subroutine **233** to decision step **168**.

At tissue blocking camera tip decision step **168**, besides the possibility of tissue on the lens of the camera/light source handpiece **66**, the presence of blood or the like on a lens and thus blocking the image for the video camera **64** can be determined as a video signature match. If a match is formed, the controller **34** advances to store identifier (ID) step **170** and thus stores an identifier.

After store identifier step **170**, the controller **34** advances to return **174** and returns to the video signature identification and image control routine **86** shown in FIG. **3**. If there is no detection of tissue blocking of the camera **64** at decision step **168**, the controller **34** immediately advances to return step **174** and returns to routine **86**.

The order of steps **152**, **234**, **168** in subroutine **233** is provided for purposes of illustration only. The steps can be performed in any order, or essentially simultaneously.

In the laparoscopic surgical system, the signature match adjustment subroutine therefore is similar to the signature match adjustment subroutine **106** shown in FIG. **6**. A main difference is that the control of pressure steps **210**, **212** are limited. In the laparoscopic surgical system, in the event that smoke is detected by the video images from the surgical site, the suction/irrigation tool **228** can automatically operate to remove smoke with the wall suction unit **56** via tubing **230**. At the same time, the insufflator unit **224** provides additional gas via the handpiece **66** to the surgical site **80** for preventing the peritoneal cavity from collapsing. Further, power to the electrode **232** of an electrocautery device can be reduced or interrupted, if necessary, to limit the production of additional smoke.

With respect to both arthroscopic and laparoscopic surgical systems, the cause of bleeding is less certain than other conditions resulting in degraded image quality. Therefore, in some embodiments, when a bleeder is detected and none of the tool devices are operating, the system controller **34** determines the tool device or devices that were most recently operated. The system controller **34** can utilize this information to assist in determining what operations of fluid input/output, fluid pressure, or even which of plural fluid input/output devices to select for removing the bleeder from the video image.

Multi-Band Light Source Control Image Analysis Subroutine

Multi-band light source control image analysis subroutine **240** shown in FIG. **9** includes steps **250**, **252**, **254**. The steps **250**, **252**, **254** are a substitute for steps **150**, **152**, **154** in the video image analysis subroutine **92** shown in FIG. **4** and discussed above.

In multi-band light source control image analysis subroutine **240**, the light source controller **70** additionally controls the light source **74** to periodically strobe or pulse the light source **74** to output additional non-visible near-infrared (IR) light at predetermined intervals. Since the additional near-infrared light is outside of the visible spectrum, the additional light is not viewable by a surgeon. Further, one or more bands or wavelengths of non-visible light can be provided at short time intervals, such as milliseconds. Finally, in some embodiments, various wavelengths of non-visible light are output simultaneously.

Since hemoglobin absorbs light in the 800 nm-1,000 nm (near-infrared) range, blood is visible as distinct dark points when reflected near-IR light images are received by video camera **64**. The dark points provide more detailed information for an image processing algorithm to determine the presence of blood in an image, as compared to analyzing colors. Thus, instead of identification of fast dispersion areas at step **152** in FIG. **4** as discussed above, pulsed or strobed near-infrared signals, not viewable by the surgeon, are included with visible light and utilized to better determine the presence of fast dispersion red areas corresponding to bleeders within the video image obtained by the video camera **64**.

To execute the multi-band light source control image analysis subroutine **240** shown in FIG. **9**, the light source **74** is controlled by light source controller **70** to provide multi-band light source outputs to illuminate a surgical site **80**, including providing near-infrared or other non-visible light at predetermined intervals. At processing multi-band video signals step **256** shown in FIG. **7**, the controller **34** processes video image signals that include the periodic reflected IR signals received by the video camera **64**. Thus, step **250** essentially corresponds to step **150** shown in FIG. **4**, except the additional periodic IR signals are also processed.

The light source control image analysis subroutine **240** then is advanced by the controller **34** to step **252** shown in FIG. **9**. At step **252**, the controller **34** identifies the presence of bleeders in view of the IR signals sensed by the video camera **64** in comparison with corresponding non-visible video signatures for a video signal. Thus, step **252** corresponds in part to step **152** shown in FIG. **4**, except IR signals are processed instead of, or in addition to, visible color signals.

If a dispersion area is found at identify fast dispersion areas decision step **252**, the controller **34** advances to stop identifier (ID) step **254**. At step **254**, the controller **34** stores an identifier corresponding to the presence of bleeders. Thus, step **254** is essentially identical to step **154** shown in FIG. **4**.

Regardless of the identification of a bleeder, the light source control image analysis subroutine **240** shown in FIG. **9** advances to step **156** as shown in the subroutine **92** of FIG. **4**.

In conclusion, the multiband light source control image analysis subroutine **240** corresponds to and replaces flowchart blocks **150**, **152**, **154** shown in FIG. **4**. The main difference between the flow chart shown in FIG. **9** from the corresponding portion of the flow chart illustrated in FIG. **4**, is the use of IR light to determine the presence of dispersion areas, rather than color analysis.

Leak/Clog Detection Subroutine

In another embodiment of the invention, a leak/clog detection subroutine **260** shown in FIG. **10** is also provided for use with the routine **86** shown in FIG. **3**. The subroutine **260** operates to determine the presence of greater than expected fluid leakage at the operating site **80** or greater than expected fluid pressure in the flow paths.

In FIG. **10**, the subroutine **260** begins at start **262** and advances to step **264**. At pressure comparison step **264** the input pressure, typically determined from the pump system **50** or from a sensor associated with irrigation tubing **76** is measured and compared with an output pressure (suction) determined by a pressure sensor provided with a suction port of pump system **50** or otherwise pressure sensors disposed in suction flow paths of tubing **52**, **57** or within the cutting tool handpiece **44**. When the system controller **34** determines that the pressure input and pressure output differ by a predetermined amount, the subroutine **260** advances to leak/clog store identifier (ID) step **266** and stores a clog identifier in the system controller **34**. Thereafter, whether or not a clog is identified, the system controller **34** advances the subroutine **260** to decision step **268**.

At flow decision step **268**, the system controller **34** determines whether the measured fluid flow through the irrigation tubing **76** that enters the cannula **67** between the inner wall thereof and the periphery of the camera/light source handpiece **66** and advances to the distal end of the cannula and enters the peritoneal cavity exceeds the fluid flow through the suction tubing **52**, **57** by a significant amount. If the flow difference is significant enough to determine that an issue exists at the surgical site **80**, such as significant leakage of fluid into the body of a patient, a leak identifier is stored in the system controller **34** at step **270**. Whether or not a leak is discovered at step **268**, the routine **260** advances to return step **274** as shown in FIG. **10**.

As a result of the sensing of a clog, the fluid input and/or the fluid output can be automatically pulsed or varied by the controller **34**. Further, the driving of the cutting tool **42** can be automatically pulsed/stopped by the controller **34** in an attempt to unclog the suction path of the handpiece.

In some embodiments, the leak/clog detection subroutine **260** is operated periodically by the system controller **34** as a part of a routine that is different from the routine **86** illustrated in FIG. **3**.

Although a particular preferred embodiment of the invention has been disclosed in detail for illustrative purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.

What is claimed is:

1. A video based image detection/identification system for fluid and visualization control of a laparoscopic surgical system for providing an acceptable video image of a surgical site, comprising:

a cauterizing tool for manipulating tissue at the surgical site;

an insufflator for providing gas to the surgical site;

an adjustable suction system for providing suction at the surgical site for controlling removal of gas from the surgical site;

a light source for providing light to the surgical site;

a video sensing device for obtaining video signals of video images at the surgical site;

an image display for displaying the video images; and

a system controller configured to maintain quality of the video images obtained by the video sensing device and provided to the image display, wherein the system controller receives and processes the video signals to identify a video signature corresponding to a condition that interferes with a quality of the video images;

the system controller interacting with the cauterizing tool, the insufflator and the adjustable suction system and controlling at least one of the cauterizing tool, the insufflator and the adjustable suction system to address the condition of the surgical site to return the video images from the video signals to an acceptable quality for viewing so that a user is free from having to manually control any of the cauterizing tool, the insufflator, the adjustable suction system, and the video sensing device to obtain the acceptable video image of the surgical site for viewing on the image display;

wherein the video signature to be identified comprises smoke, and the system controller operates at least one of the cauterizing tool, the insufflator and the adjustable suction system in response to an amount of smoke sensed.

2. The system according to claim **1**, wherein the system controller adjusts a power output of the cauterizing tool between a low power output level and a high power output level.

3. The system according to claim **1**, wherein the system controller analyzes the video signals to determine a second video signature corresponding to debris on a tip at a distal end of a housing of the video sensing device, the system controller controlling a tip cleaning device in response to the sensing of debris at the tip of the housing.

4. The system according to claim **1**, wherein the system controller uses color image processing comprising a FFT spatial frequency information technique to process the video signals.

5. A method for controlling a surgical system to provide an acceptable image of a surgical site for display during laparoscopic surgery, comprising:

manipulating tissue at the surgical site with a cauterizing tool;

providing gas to the surgical site from an insufflator;

suctioning the surgical site with an adjustable suction system to controllably remove gas from the surgical site;

providing light energy to the surgical site so that the surgical site is viewable;

obtaining video image signals at the surgical site with a video sensing device for use in displaying video images on a video display;

analyzing the video image signals to determine the presence of smoke that reduces visibility or clarity of the video image signals;

configuring a system controller to control the cauterizing tool, the insufflator and the adjustable suction system;

in response to sensing a lack of quality and clarity of the video images because of the smoke, controlling at least one of the cauterizing tool, the insufflator and the adjustable suction system with the system controller to provide an acceptable video image quality for viewing without any manual control or manual input from a tool operator; and

displaying the video images on the video display.

6. The method according to claim **5**, wherein the step of analyzing the video image signals includes comparing portions of the video image signals to stored video signatures corresponding to conditions that interfere with the quality of the video image signals.

7. A video based image detection/identification system for fluid and visualization control of an arthroscopic surgical system for providing an acceptable video image of a surgical site, comprising:

a cutting tool for manipulating tissue at the surgical site;

a liquid pump system for providing fluid to the surgical site;

a first adjustable suction system providing suction from the cutting tool through first suction tubing for controlling removal of fluid from the surgical site;

a second adjustable suction system providing suction at the surgical site through second suction tubing also for controlling removal of fluid from the surgical site;

a light source for providing light to the surgical site;

a video sensing device for obtaining video signals of video images at the surgical site;

an image display for displaying the video images; and

a system controller maintaining quality of video images obtained by the video sensing device and provided to the image display, wherein the system controller receives and processes the video signals to determine a video signature corresponding to a condition that interferes with the quality of the video images, wherein the system controller independently controls a first suction of the first adjustable suction system, a second suction of the second adjustable suction system and an output of the cutting tool between a low cutting level and a high cutting level to address a condition of the fluid at the surgical site to return the video images from the video signals to an acceptable quality for viewing so that a user is free from having to manually control any of the cutting tool, the liquid pump system, the light source, and the video sensing device to obtain the acceptable video image of the surgical site for viewing on the image display.

8. The system according to claim **7**, wherein the video signature to be determined corresponds to at least one of bubbles, debris, particles, and bleeders.

9. The system according to claim **8**, wherein the cutting tool comprises an RE cutting tool, and wherein the system controller controls the RF cutting tool in response to bubbles identified from the video signals by the system controller to return the video images of the video signals to the acceptable quality for viewing.

10. The system according to claim **9**, wherein the system controller analyzes the video signals to determine a video signature corresponding to debris on a tip at a distal end of a housing of the video sensing device, the system controller controlling a tip cleaning device in response to the sensing of debris at the tip of the housing.

11. The system according to claim **7**, wherein the system controller controls the light source to adjust an output of predetermined wavelengths of energy to different predetermined output levels for sensing preselected conditions.

12. The system according to claim **11**, wherein the predetermined wavelengths of energy are output intermittently.

13. The system according to claim **11**, wherein the predetermined wavelengths of energy include near infrared energy for at least assisting in determining the presence of a bleeder or of blood in the video images of the video signals.

14. The system according to claim **7**, wherein the system controller uses color image processing comprising a FFT spatial frequency information technique to process the video signals.

15. The system according to claim **7**, wherein the cutting tool is a mechanical cutting tool.

16. A method for controlling an arthroscopic surgical system to provide an acceptable image of a surgical site for display, comprising:

manipulating tissue at the surgical site with a cutting tool;

outputting fluid to the surgical site from a liquid pump system;

providing a first adjustable suction system providing suction from the cutting tool through first suction tubing for controlling removal of fluid from the surgical site;

providing a second adjustable suction system providing suction at the surgical site through second suction tubing also for controlling removal of fluid from the surgical site;

providing light energy to the surgical site so that the surgical site is viewable;

obtaining video image signals at the surgical site with a video sensing device for use in displaying video images on a video display;

analyzing the video image signals to determine presence of factors that reduce visibility or clarity of the video image signals;

in response to sensing a lack of quality and clarity of the video images, independently controlling a first suction of the first adjustable suction system, a second suction of the second adjustable suction system and a cutting level of the cutting tool between a low cutting level and a high cutting level so that the video images detected by the video image signals is controlled to provide an acceptable image quality for viewing without any manual control or manual input from a cutting tool operator; and

displaying the video images on the video display.

17. The method according to claim **16**, wherein a camera/light source handpiece includes a camera and a light source, the camera/light source handpiece being disposed within a cannula that provides access to the surgical site, and further comprising controlling a flow of irrigation fluid between an outer periphery of the camera/light source handpiece and an inner wall of the cannula, wherein the fluid enters the surgical site via a distal end of the cannula.

18. The method according to claim **16**, wherein the step of analyzing the video image signals includes comparing portions of the video image signals to stored video signatures corresponding to conditions that interfere with the quality of the video image signals.

19. The method according to claim **18**, wherein the surgical system comprises an endoscopic system, and the video signatures are provided for bubbles, debris, particles and bleeders.

20. The method according to claim **16**, including providing the light energy to the surgical site so that the surgical site is viewable for the video sensing device and providing non-visible light at one or more predetermined wavelengths for assisting the analyzing step in determining the presence of bleeders within the video images.

21. The method according to claim **16**, wherein the cutting tool is a mechanical cutting tool.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

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Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the claims

Column 16, line 60, Claim 9; change "RE cutting tool" to ---RF cutting tool---.

Signed and Sealed this
First Day of December, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

专利名称(译)	用于流体和可视化控制的基于视频的图像检测/识别分析的方法和系统		
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CPC分类号	A61B1/015 A61B1/00009 A61B1/045 G06F19/3437 A61B1/126 A61B1/3132 A61B17/32002 A61B18/1482 A61B2017/00296 A61B2018/00773 A61B2018/00863 A61B2218/001 G16H50/50		
优先权	61/340805 2010-03-23 US		
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摘要(译)

在外科手术系统中，系统控制器执行视频签名识别和图像控制例程，以维持由位于手术部位并设置在视频显示器上的摄像机拍摄的视频图像的质量。该系统包括用于插入患者体内的摄像机/光源手机。将工具分别插入手术部位。输入手术部位的流体由液体泵或吹入器提供。分析视频信号并自动控制流体输入/输出，流体压力和/或工具操作以保持手术部位的图像质量而无需手动调整。