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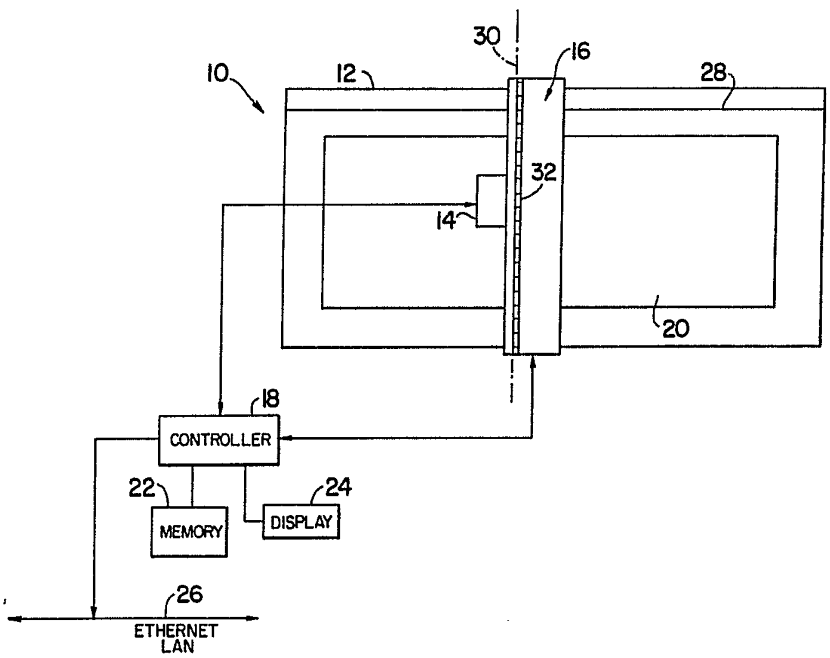

(57) Abstract

A large area scanning system (10) for use in scanning very large documents includes a table (12) and scanning mechanism (16) on which is located a scanner head (14). The scanner head includes an illumination mechanism and a camera for receiving light reflected from a document on the table. The scanning system (10) is characterized by a controller (18) which initially scans the document in a series of strips (106) and generates therefrom reformatted data in the form of a sequence of scan lines. To increase operating speed, the controller (18) provides for data compression with bilevel data.

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A LARGE AREA DIGITAL SCANNER

TECHNICAL FIELD

The present invention relates to optical scanning systems and more particularly to optical scanning systems adapted to scan large surface areas.

BACKGROUND OF THE INVENTION

In the past several years optical scanning systems have become generally known in the art. These systems are used to digitize either text or two dimensional images. The digitized signals are then stored in a computer memory for later access. Scanning systems typically are one of two types. Flatbed or sheet fed scanners are adapted for use with computer peripheral equipment and scan with a camera in a raster fashion relative to a flat image to generate corresponding digital signals. Smaller, hand held scanners are manually moved relative to an image and generate digital signals in much the same manner.

Both of these types of scanners enable photographs and documents to be digitized for use with a computer. However, known scanning systems are burden by two fundamental limitations; poor accuracy and low signal integrity. While flatbed scanning systems provide inherently greater accuracy and signal integrity, there are still limitations with respect to the quality of the image due to variations in the distance between the document being scanned and the camera. However, the most fundamental limitation is the limit and the size of the document which can be scanned accurately. For example, it is simply not possible with known systems to accurately scan blueprints having dimensions on the order of several feet.

It would be advantageous to have a scanning system which would accommodate documents of over a very broad range of sizes. It would be further advantageous to have a scanning system which would scan large documents with maximum accuracy. The present invention is drawn towards such a scanning system.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a system capable of digitally scanning a very large document.

Another object of the present invention is to provide a highly accurate large area scanning system capable of interfacing with a larger assembly of digital equipment.

Another object of the present invention is to provide a digital scanning system characterized by high optical resolution.

Still another object of the present invention is to provide a digital scanning system of the foregoing type that is characterized by software selectable optical resolution.

Another object of the present invention is to provide a digital scanning system of the foregoing type that is characterized by great depth of field.

According to an aspect of the present invention, a system for use in scanning large areas includes, a table having an upper surface with a length and a width, a scanning mechanism affixed to the surface for moving thereabout in response to control signals, and a camera attached to the scanning mechanism that includes an array of photoelectric elements each receiving an optical image from the surface and each generating signals indicative thereof. An illumination mechanism is configured with the camera for illuminating the surface optical images. A controller receives signals from the camera and includes a mechanism for generating scan signals for the scanning mechanism to move the camera across the table surface width in a sequence of scan strips each having an approximate extent equal to that of the photoelectric element array. There is both a mechanism for sampling the camera signals and a mechanism for formatting the sampled signals in signal arrays corresponding to the scan strips. The present system also includes a mechanism for configuring the sampled scan signal arrays in a sequence of scan lines extending across the table surface width and a mechanism for compressing the signals in the scan lines into a data format of reduced size.

According to another aspect of the present invention, a controller for use in controlling illumination in a scanning system having a scanning mechanism configured with a camera and a mechanism for controllably illuminating a surface, the controller controls the surface illumination in accordance with a method including the steps of providing drive signals to a lamp to increase optical intensity therefrom; measuring signals from an optical feedback device indicative of optical input to the camera; measuring camera output signals and determining the camera mechanism optical saturation. The method also has the steps of computing signals corresponding to a selected magnitude of the lamp drive signals at camera optical saturation; providing signals to the lamp to generate a known percentage of camera saturation; comparing the required lamp setting with signals from the optical feedback device and adjusting the lamp drive signals should the illumination not equal the set magnitude.

According to yet another aspect of the present invention, in a scanning system having a camera receiving light from a surface and providing output signals indicative thereof, with the camera including a plurality of photoelectric elements each having a respective signal gain, a controller for use in compensating for variations in the signal gain and surface light in accordance with a method including the steps of providing the camera elements with light having a minimum intensity; generating camera output signals indicative of the minimum light intensity, with each of the elements providing a respective minimum light intensity signal; providing the minimum light intensity signals to a signal subtracter mechanism at both signal inputs thereto for subtracting each of the elements minimum light signal from itself, thereby generating a corrected minimum light intensity signal. The method further includes the steps of generating camera output signals indicative of the maximum light intensity, which allows the camera to operate at a fixed percentage below camera saturation with each of the elements providing a respective maximum light intensity signal; subtracting, for each of the elements, the camera minimum light intensity signal from the corresponding maximum light intensity signal and generating a difference signal therefrom computing, for each of the elements, a gain adjustment factor whose magnitude is dependent on the respective element difference signal magnitude and a desired maximum signal magnitude and multiplying, for each of the elements, the selected light intensity signals by the gain adjustment factor to generate a corrected maximum signal whose magnitude corresponds to the desired maximum signal magnitude.

According to still another aspect of the present invention, a controller for use with a scanning system having a camera receiving light from a surface and generating therefrom camera output signals having a plurality of pixels, the controller includes a video processor receiving the camera signals and generating digital video signals of more than two bits per pixel; a mechanism for displaying to an operator for the purpose of optimum threshold selection a visual image on a display corresponding to the digital video signal and a mechanism for interactively changing the threshold bifurcation of the video signal while viewing the results. Once the desired threshold is achieved it is sent to the video processor to perform (during normal scanning) threshold bifurcation of the digital video signal into a bit corresponding to minimum and maximum levels of optical intensity.

According to still another aspect of the present invention, a controller for use in controlling illumination in a scanning system having a scanner configured with a camera and a surface illumination apparatus controls illumination of the surface in accordance with a method that includes the steps of providing drive signals to a lamp to increase optical intensity therefrom to a maximum value, measuring camera output signals corresponding to a saturation thereof and providing signals to the lamp corresponding to a selected reduced magnitude of the lamp drive signals at camera saturation. The method also includes the steps of measuring the camera signals at the reduced magnitude lamp drive signals and adjusting the lamp drive signals should the camera signals not be reduced in magnitude by a selected amount from the saturation magnitude.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a simplified schematic illustration of a large area scanning system provided according to the present invention.

Fig. 2 is a simplified schematic illustration of a portion of the system of Fig. 1 used for illumination.

Fig. 3 is a diagrammatic illustration of an algorithm executed by the controller of Fig. 1 in maintaining optimum illumination.

Fig. 4 is a simplified illustration showing a portion of the controller of Fig. 1 used to provide black signal compensation.

Fig. 5 is a simplified illustration showing a portion of the controller of Fig. 1 used to provide white signal compensation.

Fig. 6 diagrammatically shows the uncompensated and compensated dynamic range of the camera of Fig. 1.

Fig. 7 is a simplified illustration of a portion of the controller of Fig. 1 used in video signal processing.

Fig. 8 is a top view of the scanning system of Fig. 1 showing the relative movement of a camera across a table surface in the system of Fig. 1.

Fig. 9 is a schematic illustration showing the operation of a threshold selection mechanism in the system of Fig. 1.

Fig. 10 is a simplified diagrammatic illustration of a video processor associated with the controller provided according to the present invention.

Fig. 11 is a simplified top plan view of the table surface of Fig. 8 showing the location of several documents scanned by the system of Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Fig. 1 there is shown in simplified form a large area scanning system 10 provided according to the present invention. The system includes a scanning table 12 having an active scanning surface of approximately 48" x 148". A scanner head 14 which includes a camera and illumination optics is configured with a scanning mechanism 16 which is preferably of a gantry type. The preferred scanning system includes elements from the Gerber Model 278 Scanner. As such, it comprises a device, including motors, gears and the like for moving the scanning mechanism along the length of the table and a similar device for moving the scanning head across the table width, both in response to control signals. Both the scanning mechanism and the scanner head receive signals from controller 18, as detailed hereinafter. In sum, the controller provides signals to control the operation of the camera and illumination mechanism 23 in the scanner head. In addition, the controller generates control signals for the motors associated with the scanner mechanism for moving the scanner head relative to the table surface 20.

The controller receives signals from the scanner head indicative of the image as well as signals from a photoelectric feed back sensor used in controlling the illumination of the surface. As detailed hereinafter, the controller processes the received signals and stores them in either memory 22 associated with the controller and displays a digitized image of the scanned document on work station display 24. Further, the controller provides signals to a local area network or equivalent as indicated schematically at line 26 for use by other computer equipment. The system 10 also includes a linear encoder 28 positioned on the scanning mechanism extending along a scan axis 30. Those skilled in the art will note that some tables such as the Model 278 table sold by the assignee of the present invention typically provide a rotary linear encoder and determine the actual position of the scanner head along the scan access by mechanism of software algorithms. However, with the present invention the use of these known software algorithms to determine scanner head position along the scan access is too slow. Consequently, a linear encoder, such as encoder 32, is used to directly measure the scanner head position along the scan axis.

Unlike the prior art, the present invention provides for improved uniform illumination of the document to be scanned. The present scanner head, a portion of which is shown in Fig. 2 contains an illumination mechanism preferably comprised of a plurality of optical fiber elements extending out of the Figure. The fiber optic elements are arranged in two arrays 34 and 36 juxtaposed about a CCD camera 38, preferably a Fairchild CCD 143 linear array having 2048 13 x 13 micron elements on 13 micron centers with an approximate overall length of 1 inch.

An optical source (not shown) is remotely located from the camera to provide illumination at an intensity in accordance with received control signals. The optical source for the fiber-optic illumination mechanism of the preferred embodiment is a Tungsten halogen lamp which can be color filtered in order to improve the contrast on difficult to read documents. In the preferred embodiment the lamp is driven by a DC power supply which is modulated from the controller to select a desired image intensity. The scanner mechanism also contains the requisite drive electronics to locally control the operation of the illumination mechanism components.

The image on a document 40 is transmitted from the table through a linear graded index lens 42 such as a SELFOC lens sold by the Nippon Sheet Glass Company. The preferred lens is telecentric which makes it highly immune to the accuracy problems caused by variations in table flatness. The lens is characterized by its ability to provide to the camera only light reflected off that portion of the image which lies in registration with the camera. Secondly, the lens 42 has good depth of field to ensure image fidelity throughout the scan. The preferred lens also possesses high contrast and is extremely compact.

A photoelectric device such as diode 44 is also included to generate a feed back signal to amplifiers 46 and 48. In the preferred embodiment, the illumination intensity is selected to be approximately 90% of the CCD's element's saturation level in accordance with an algorithm 50 outlined in Fig. 3. When the system is initially energized and the scanner head positioned over a white surface (blocks 52,54), the controller will present signals to the illumination mechanism to raise the lamp intensity to its maximum (block 56). The controller measures the output of the camera elements or a subset thereof at block 58. Next, the lamp power is lowered incrementally and the camera element signal values are monitored (blocks 60,62). In the preferred embodiment, the center 2000 camera elements are monitored for an element signal decrease of at least 5 counts from the levels initially measured. The 5 count decrease corresponds to CCD element output signal levels have fallen below saturation (blocks 63, 64). Thereafter, the light intensity is measured by the photodiode (block 65) the output signal from the photodiode is used to maintain the optical output of the lamp at the computed level (block 66) by adjusting lamp drive power when necessary (block 67). This optical output level is thereafter defined to constitute "full" illumination. Although the 90% value is preferred, another value may be chosen depending on the application and on the target document.

The present system has a calibration process which is characterized by the above referenced saturation detection scheme and black and white signal level compensation detailed hereinbelow. Referring now to Figs. 4 - 6 there is schematically shown portions 68, 70 of the controller of Fig. 1 respectively used for black and white signal level compensation. With the present system there are a large number (2048) of optical elements in the preferred camera, each having various "0" or base signal levels and each with different signal gains. The present invention provides for signal compensation to ensure that signals which fall within the dynamic range of the CCD array contain information, and likewise eliminate any situation where information could lie on or beyond the dynamic range limits.

In Fig. 4 there is shown the portion 68 of the controller of Fig. 1 which generates compensation for dark or "black" signal levels. As noted above, the output of each element should be uniform for the darkest portion of the document to be scanned without illumination, that is the document portion which corresponds to a black or dark image. This is graphically represented in Fig. 6 as curve 72. However, given the various signal offsets for each of the elements, the initial signal level comparison between the different CCD elements more closely approximates curve 74 in Fig. 6.

Referring again to Fig. 4, at block 76 video signals taken from the darkest portion of the surface to be scanned are initially received. These signals are provided both to random access memory (RAM) 78 and simultaneously to subtracter 80. The output signals therefrom corresponds to a true "0" signal level as indicated by curve 72 in Fig. 6. A similar situation exists for the CCD element output signals at a selected "maximum" for the whitest image at full illumination below CCD saturation, as demonstrated by curve 81, Fig. 6.

Gain compensation by the present invention is demonstrated by reference to Fig. 5. After the saturation detection algorithm has been completed, video signals from the whitest or brightest portion of the document image with full illumination are received at block 82. These signals are provided to subtracter 84 which also receives signals from RAM 78. As noted above, these signals correspond to the video signals for the respective CCD elements from the darkest portion of the surface without illumination. The output signals from subtracter 84 correspond to the difference signal magnitudes of each of the respective elements between that element's maximum white and minimum black signals.

The controller computes a gain factor at block 86 for each element to adjust the gain of the element such that the maximum light intensity at some level below CCD staturation will yield a preselected maximum output signal. The algorithm executed by the controller ensures that the maximum signal output by the CCD element for the whitest portion of the surface at full illumination corresponds to the maximum gain available. In the preferred embodiment the algorithm computation is as follows:

$$255 + \text{video signal} = X$$

where X equals the gain factor for signal compensation for each CCD element. The gain factor signals are presented to RAM 78 to overwrite the contents thereof. The gain factor computed for each CCD element is input to multiplier 87 to generate an output signal (curve 88, Fig. 6) on line 90 corresponding to the normalized "white" output signal.

The present controller also provides for a signal threshold selection. As is known, scanning using a full 8 bit grayscale generates a substantial volume of data; a problem that is magnified by the very large documents which are to be scanned by the present scanner. As seen schematically in Fig. 7, the present controller includes a computation assembly 92 having a workstation 122 and a grayscale processor card or equivalent 94 for processing full 8 bit grayscale information from video signals 96 presented via buffer 98.

In a threshold selection mode, the controller requires the operator to select defined areas of approximately one inch square to be scanned and shown on display 24 in full grayscale. To this end, the controller includes a separate hardware path, 8 bits per pixel, as detailed hereinafter. The operator manually selects a threshold which is used by the workstation to bifurcate the 8 bit grayscale information for each pixel. This bifurcation is performed by the workstation such that, an 8 bit video pixel acts as an index into a table. The table locations are filled with values such to produce either a black or white level pixel. The operation changes the threshold by moving the bifurcation point in the look up table.

Once the operator has selected a threshold value via a keyboard entry (block 99), the workstation will directly recompute the full 8 bit grayscale information to a binary representation as detailed above. This will be displayed directly to the operator for approval or further selection. Once the operator is satisfied with the threshold selection it is down loaded to the video processor board and used for normal scanning to produce bilevel images. This provides substantial savings, in the data storage and manipulation capacity which would otherwise be needed, and improves the response speed of the present system.

As schematically shown in Fig. 8, the preferred camera 38 comprises a linear array 102 of photoelectric elements 104, such as a CCD array, extending over a length of approximately one inch. The output signals from the array then are equivalent to a one inch by 13 micron section of the scan surface. In the preferred embodiment, the length of the array is oriented to the table length, with the controller programmed to move the array across the table width at a selected rate while sampling the camera elements accordingly. Each scan 106 contains image data over approximately one inch of the table length. The surface is preferably scanned in only one direction. The controller includes an algorithm for "stitching" the signals from adjacent scans to ensure the pixels are in registration and that no image gap or overlap occur.

"Mini-raster" format is the term used to describe the present data format of the sampled camera signals. At each sample interval the video signals comprise image information for a particular strip of the surface parallel to the table edge. The signals provided to the controller, therefore, have local coordinate information pertaining to that strip in that scan. A scan comprises a sequence of strips extending the table width. This data format is different as compared to a raster format wherein each point on the table surface has a unique pair of coordinates and the camera signals are received in scan lines.

The present system is characterized by a software selectable resolution. The highest possible accuracy is delivered with the preferred system having resolution capabilities of between 200 and 1200 DPI (dots per inch). Once the user has selected the desired resolution, changes are accomplished as follows. The CCD array is advanced from right to left in Fig. 8 and from a lower to an upper portion sequentially. It is preferred that a single pass scanning technique be used. Signals from the CCD array are then provided to the controller which generates therefrom pixel data in mini raster format comprising a X and Y position vector and a value for intensity for that pixel at that scan position. Note that an effective pixel is formed by integrating the signals from a select number fractions of adjacent CCD elements in the array as determined by the selected resolution. For example, a 200 dots per inch resolution will have 6 times the number of CCD element signals integrated than will a resolution of 1200 DPI. Resolution is varied in the scan direction by varying the speed of the advance of the camera with a constant sample rate. Therefore, the camera will be advanced across the surface 6 times more quickly for a resolution of 200 DPI then for 1200 DPI.

One point of departure of the present invention over the prior art is the capability of the present system to accommodate cameras having different spatial frequency. For example, the preferred camera has 13 micron (0.00051 in.) square elements for use in a strip 1 inch in width. However, the present controller allows for conversion to an English spatial frequency by a correction in the integration computation rather than require the hardware to conform.

Referring again to Fig. 7, the camera requires a transfer clock and pixel clock signal provided by clock 108. The transfer clock signal controls the integration time of the sensor and the pixel clock signal controls the read out rate of the video data from the sensor. The sensor provides odd pixel information on Channel A and even pixel information on Channel B (lines 110 and 112). The pixel signal information is provided to the video signal buffer which amplifies and removes any DC offset from the signals provided on the CCD video channels. The two channels are also summed and digitized. The 8 bit signals are then sent to the video processor. In the preferred embodiment the video processor comprises a single VME6U board which conforms to the known VME bus specifications. In addition to performing the video threshold function noted above, the video processor performs the following functions; pixel compensation, digital resampling and integration for various resolutions, and generation of bilevel video signals after the threshold selection process. A direct memory access (DMA) controller path is provided to supply grayscale data through the CPU directly to the work station 122 only during the threshold selection process.

Fig. 9 is a simplified schematic illustration of a portion 124 of the controller used during the threshold selection process. The full grayscale data from the user defined areas reside in a controller memory portion 126 associated with the workstation. The full 8 bit wide data then has 255 states, indicated at 128. Each pixel has a signal value associated therewith, such as values 130, 132. A look up table 134 with pointer 136 is also provided. Prior to entry into the threshold selection mode, the data is provided to the look up table also in full grayscale. However, once the threshold selection mode is selected, the look up table is programmed to have all signals below the selected threshold to be output to the display as "black" and those above to be output as "white". In Fig. 9, the pointer, i.e. threshold setting is set at level 140, with "black" and "white" being indicated by "00" and "ff", respectively. The video pixels act as indexes into this table. In the preferred embodiment, a histogram of grayscale magnitudes and their occurrence frequency in the defined area are shown to the operator. Selection of an 8 bit threshold level shows the operator in real time the effect on the grayscale information stored in the work station and indicates the information content of the data of the subsequent scan.

After the threshold has been selected and sent to the video processor, the 8 bit video data signals are, as shown in Fig. 10, compared in a digital comparator 138 with the threshold level indicated at 140. Again, all those pixel signals having a value below the selected value will be processed as a "black" pixel, while all those signals whose value exceeds the threshold will be processed as "white".

A data formatter 114 is provided and is preferably comprised of a single VME6U board which conforms to the VME bus specification. The data formatter provides motion control and pixel reformatting. For motion control, a clock signal is presented on line 116 for the two axis motors in the scanner mechanism to position the scanner head. Position counters which are read by the controller indicate the actual position of the scanner head. All X axis (table length) and Y axis (table width) moves of the scanner head other than the actual scanning of the camera are performed elsewhere in the controller. The data formatter also reformats the video signals (now bilevel) to convert the CCD array scan signals into actual raster data in scan line format. An entire strip of bilevel pixel data at the commanded resolution is received and stored by the data formatter. Once the data formatter memory has been loaded with signals corresponding to a particular scan of a particular strip, the memory is read in the scan direction line by line during the scan head retrace cycle, this read operation completes the image reformatting. Data stitching is also accomplished by the data formatter. Stitching the data in the work station is an extremely involved process due to the volume of data. Consequently, bilevel data is used to simplify computation in the preferred embodiment.

A signal compressor 118 is provided and is comprised of a single VME6U board that conforms to VME bus specifications. This portion of the controller receives the raster data signals from the data formatter and performs a run length encoding data compression process (RLS) thereon before passing these compressed signals onto a central processing unit (CPU) 120. The RLS format is an efficient data compression code which minimizes the document transmission time and file size. In the preferred embodiment the central processing unit comprises a Motorola Model 147 processor on a single VME6U board. This CPU is a double high VME module with a 68030 CPU. This CPU provides a small computer system interface (SCSI) bus controller with direct memory access (DMA), floating point processor, tick timer, watch dog timer, and time of day clock calender with a battery backup. The CPU performs scanner calibration, overall scanner control and supplies the pixel data to the controller work station such as personal VAX (P-

VAX) marketed by the Digital Equipment Corporation. The reformatted data is compressed into a run length encoded short (RLS) code, blocked and transmitted to a remote computer by mechanism of a small computer system interface (SCSI) bus. Once on file in the controller work station the RLS data file can be reprocessed to alternative formats such as the CCITT Group 4 data format. The work station 122 includes a model 9700S work station with video monitor having the following functions; 1) selectable scan resolution (scanning speed is implied); 2) file naming capability; 3) CCITT format (Group 4) optional format; 4) interactive threshold setting from scanner display; and 5) storage on magnetic tape. Access to video signals for real time processing (composite video 75 ohm impedance) is provided at the scanner head.

Similarly, although the invention has been shown and described with respect to a preferred embodiment thereof, it should be understood by those skilled in the art that various other changes, omissions and additions thereto may be made therein without departing from the spirit and scope of the present invention. For example, the present system includes the capability of scanning several smaller documents in sequence as shown in Fig. 11. Documents 142 - 146 are located on the table surface. The controller determines the coordinates of the extent thereof and advances from one to the next at the completion of each scan. Further, the present invention includes the capability of software selectable zoom for display. The controller can display very large areas by the simple selection for display of selected scan lines (i.e., every third line). Zoom is accomplished by adding to the display the deleted information or a portion thereof.

Those skilled in the art will also note that the present invention encompasses scanning systems wherein the scan strips are lengthwise and those scanning systems wherein the scanner head is configured to sample the document in a bidirectional manner.

CLAIMS

1. A system for use in scanning large areas comprising:

a table having an upper surface with a length and a width;

a scanning mechanism located on the surface for moving thereabout in response to control signals;

a camera means attached to the scanning mechanism and including an array of photoelectric elements each receiving an optical image from the surface and generating signals indicative thereof;

an illumination means configured with said camera means for illuminating said surface optical images; and

a controller receiving signals from said camera means including;

a means for generating scan signals for said scanning mechanism to move the camera across the table surface width in a sequence of scan strips each having an extent equal to that of said photoelectric element array,

a means for sampling said camera means signals, a means for formatting said sampled signals in signal arrays corresponding to said scanstrips,

a means for configuring said sampled scan signal arrays in a sequence of scan lines extending across the table surface width and a means for compressing said signals in said scan lines into a data format of reduced size.

2. The system of claim 1 wherein said compressing means further compressing said data into a run length encoded short (RLS) data signal format.

3. The system of claim 1 wherein said controller further comprises a work station having a display for displaying to an operator signals corresponding to a subset of said scan lines.

4. The system of claim 3 wherein said controller further comprises a means for continuously varying the size of scan line subset displayed by said work station.

5. The system of claim 1 wherein said scan mechanism further comprises an encoder means for providing signals indicative of the position of said scan mechanism about said table surface.

6. The system of claim 1 wherein said illumination means further comprises fiber optic means for directing light on to a selected portion of said table surface.

7. The system of claim 1 wherein said camera means further comprises a linear array of camera elements.

8. The system of claim 7 wherein said camera elements comprise a charge coupled device (CCD).

9. The system of claim 1 wherein said illumination means further comprises a telecentric lens.

10. The system of claim 1 wherein said controller selects a resolution magnitude by generating integrated camera means signals comprised of integrated camera element output signals of selected adjacent ones of said camera elements.

11. The system of claim 1 wherein said controller samples said camera means output signals as said scanning mechanism moves said camera means across said table width in a single direction.

12. The system of claim 1 wherein said controller further comprises a means for sequentially scanning a plurality of documents simultaneously configured on said table surface.

13. The system of claim 1 wherein said camera further includes a plurality of photoelectric elements each having a respective signal gain, and wherein said controller further comprises a calibration means for calibrating the system including:

an illumination means controlling the illumination of said surface in accordance with a method comprising the steps of:

providing drive signals to a lamp to increase optical intensity therefrom to a maximum value;

measuring camera means output signals corresponding to a saturation thereof;

providing signals to said lamp corresponding to a selected reduced magnitude of said lamp drive signals at said camera means saturation;

measuring said camera means signals at said reduced magnitude lamp drive signals;

adjusting said lamp drive signals should said camera means signals not be reduced in magnitude by a select amount from said saturation magnitude; and

a signal compensation means for use in compensating for variations in said signal gain and surface light in accordance with a method comprising the steps of:

providing said camera elements with light having a minimum intensity;

generating camera output signals indicative of said minimum light intensity, with each of said elements providing a respective minimum light intensity signal;

providing said minimum light intensity signals to a signal subtracter means at both signal inputs thereto for subtracting each of said elements minimum light signal from itself, thereby generating a corrected minimum light intensity signal;

providing said camera elements with light having a maximum intensity;

generating camera output signals indicative of said maximum light intensity, with each of said elements providing a respective maximum light intensity signal;

subtracting, for each of said elements, said camera means maximum light intensity signal from said corresponding minimum light intensity signal and generating a difference signal therefrom;

computing, for each of said elements, a gain adjustment factor whose magnitude is dependent on the respective element difference signal magnitude and a desired maximum signal magnitude;

multiplying, for each of said elements, said maximum light intensity signals by said gain adjustment factor to generate a corrected maximum signal whose magnitude corresponds to said desired maximum signal magnitude.

14. The system of claim 13 wherein said controller further comprises a comparator means for receiving said video signals from said camera means and said threshold level signal and presenting therefrom said maximum level signal should the magnitude of said video signal exceeds said threshold signal and presenting therefrom said minimum level signal should said magnitude of said video signal not exceed said threshold signal.

15. A system for use in scanning large areas comprising:

a table having an upper surface with a length and a width;

a scanning mechanism affixed to said surface for moving thereabout in response to control signals;

a camera means attached to said scanning mechanism and including an array of photoelectric elements each receiving an optical image from said surface and generating signals indicative thereof;

an illumination means configured with said camera means for illuminating said surface optical images;

a controller receiving signals from said camera means and including a means for selecting scanner resolution by integrating signals from selectable numbers of adjacent photoelectric elements and generating scan signals for said scanning mechanism to move the camera across the table surface width in a sequence of scan strips each having an extent equal to that of said photoelectric element array with the speed of said scan selected in accordance with said selected resolution,

a means for sampling said camera means signals during said scans,

a means for formatting said sampled signals in signal arrays corresponding to said scan strips,

a means for configuring said sampled scan signal arrays in a sequence of scan lines extending across the table surface width and

a means for compressing said signals in said scan lines into a data format of reduced size.

16. The system of claim 15 wherein said compressing means further compresses said data into a run length encoded short (RLS) data signal format.

17. The system of claim 15 wherein said controller further comprises a work station having a display for displaying to an operator signals corresponding to a subset of said scan lines.

18. The system of claim 17 wherein said controller further comprises a means for continuously varying the size of scan line subset displayed by said work station.

19. The system of claim 15 wherein said scan mechanism further comprises an encoder means for providing signals indicative of the position of said scan mechanism about said table surface.

20. The system of claim 15 wherein said illumination means further comprises fiber optic means for directing light on to a selected portion of said table surface.

21. The system of claim 15 wherein said camera means further comprises a linear array of camera elements.

22. The system of claim 15 wherein said camera elements comprise a charge coupled device (CCD).

23. The system of claim 15 wherein said illumination means further comprises a telecentric lens.

24. The system of claim 15 wherein said controller selects a resolution magnitude by generating integrated camera means signals comprised of integrated camera element output signals of selected adjacent ones of said camera elements.

25. The system of claim 15 wherein said controller samples said camera means output signals as said scanning mechanism moves said camera means across said table width in a single direction.

26. The system of claim 15 wherein said controller further comprises a means for sequentially scanning a plurality of documents simultaneously configured on said table surface.

27. The system of claim 15 wherein said camera further includes a plurality of photoelectric elements each having a respective signal gain, and wherein said controller further comprises a calibration means for calibrating the system including:

an illumination means controlling the illumination of said surface in accordance with a method comprising the steps of:

providing drive signals to a lamp to increase optical intensity therefrom to a maximum value;

measuring camera means output signals corresponding to a saturation thereof;

providing signals to said lamp corresponding to a selected reduced magnitude of said lamp drive signals at said camera means saturation;

measuring said camera means signals at said reduced magnitude lamp drive signals;

adjusting said lamp drive signals should said camera means signals not be reduced in magnitude by a select amount from said saturation magnitude; and

a signal compensation means for use in compensating for variations in said signal gain and surface light in accordance with a method comprising the steps of:

providing said camera elements with light having a minimum intensity;

generating camera output signals indicative of said minimum light intensity, with each of said elements providing a respective minimum light intensity signal;

providing said minimum light intensity signals to a signal subtracter means at both signal inputs thereto for subtracting each of said elements minimum light signal from itself, thereby generating a corrected minimum light intensity signal;

providing said camera elements with light having a maximum intensity;

generating camera output signals indicative of said maximum light intensity, with each of said elements providing a respective maximum light intensity signal;

subtracting, for each of said elements, said camera means maximum light intensity signal from said corresponding minimum light intensity signal and generating a difference signal therefrom;

computing, for each of said elements, a gain adjustment factor whose magnitude is dependent on the respective element difference signal magnitude and a desired maximum signal magnitude;

multiplying, for each of said elements, said maximum light intensity signals by said gain adjustment factor to generate a corrected maximum signal whose magnitude corresponds to said desired maximum signal magnitude.

28. The system of claim 27 wherein said controller further comprises a comparator means for receiving said video signals from said camera means and said threshold level signal and presenting therefrom said maximum level signal should the magnitude of said video signal exceed said threshold signal and presenting therefrom said minimum level signal should said magnitude of said video signal not exceed said threshold signal.

29. In a scanning system having a camera receiving light from a surface and providing output signals indicative thereof, said camera including a plurality of photoelectric elements each having a respective signal gain, a controller for use in compensating for variations in said signal gain and surface light in accordance with a method comprising the steps of:

providing said camera elements with light having a minimum intensity;

generating camera output signals indicative of said minimum light intensity, with each of said elements providing a respective minimum light intensity signal;

providing said minimum light intensity signals to a signal subtracter means at both signal inputs thereto for subtracting each of said elements minimum light signal from itself, thereby generating a corrected minimum light intensity signal;

providing said camera elements with light having a maximum intensity;

generating camera output signals indicative of said maximum light intensity, with each of said elements providing a respective maximum light intensity signal;

subtracting, for each of said elements, said camera means minimum light intensity signal from said corresponding maximum light intensity signal and generating a difference signal therefrom;

computing, for each of said elements, a gain adjustment factor whose magnitude is dependent on the respective element difference signal magnitude and a desired maximum signal magnitude;

multiplying, for each of said elements, said maximum light intensity signals by said gain adjustment factor to generate a corrected maximum signal whose magnitude corresponds to said desired maximum signal magnitude.

30. A controller for use with a scanning system having a camera receiving light from a surface and generating therefrom camera output signals having a plurality of pixels, said controller comprising:

a video processor receiving said camera signals and generating digital video signals of more than two signal levels per pixel;

a means for displaying to an operator a visual image on a display corresponding to said digital video signal;

a means for generating signals to said video processor indicative of a selected one of said levels to correspond to a level threshold bifurcating said digital video signal into two levels corresponding to minimum and maximum levels of optical intensity;

a means for receiving from said operator signals indicative of one of said levels corresponding to said threshold;

a means for providing control signals to said video processor to bifurcate said received video signals in accordance with said level threshold.

31. A controller for use in controlling illumination in a scanning system having a scanning means configured with a camera means and a means for controllably illuminating a surface, said controller controlling said surface illumination in accordance with a method comprising the steps of:

providing drive signals to a lamp to increase optical intensity therefrom;

measuring signals from an optical feedback means indicative optical input to said camera means;

measuring camera means output signals;

determining optical saturation of said camera means;

computing signals corresponding to a selected portion of the magnitude of said lamp drive signals at said camera means optical saturation;

providing signals to said lamp to generate an optical output intensity therefrom corresponding to said selected portion of the optical intensity at said camera means saturation;

comparing said camera means signals with signals from an optical feedback means;

adjusting said lamp drive signals should said camera means signals not equal said selected portion of said saturation magnitude.

32. The system of claim 31 wherein said selected portion of said saturation magnitude is approximately 90% of said saturation value.

33. A controller for use in controlling illumination in a scanning system having a scanning means configured with a camera means and a means for controllably illuminating a surface, said controller controlling said surface illumination in accordance with a method comprising the steps of:

providing drive signals to a lamp to increase optical intensity therefrom to a maximum value;

measuring camera means output signals corresponding to a saturation thereof;

providing signals to said lamp corresponding to a selected reduced magnitude of said lamp drive signals at said camera means saturation;

measuring said camera means signals at said reduced magnitude lamp drive signals;

adjusting said lamp drive signals should said camera means signals not be reduced in magnitude by a select amount from said saturation magnitude.

34. The system of claim 33 wherein said selected amount from said saturation magnitude is approximately 10% of the amount needed to achieve said saturation.

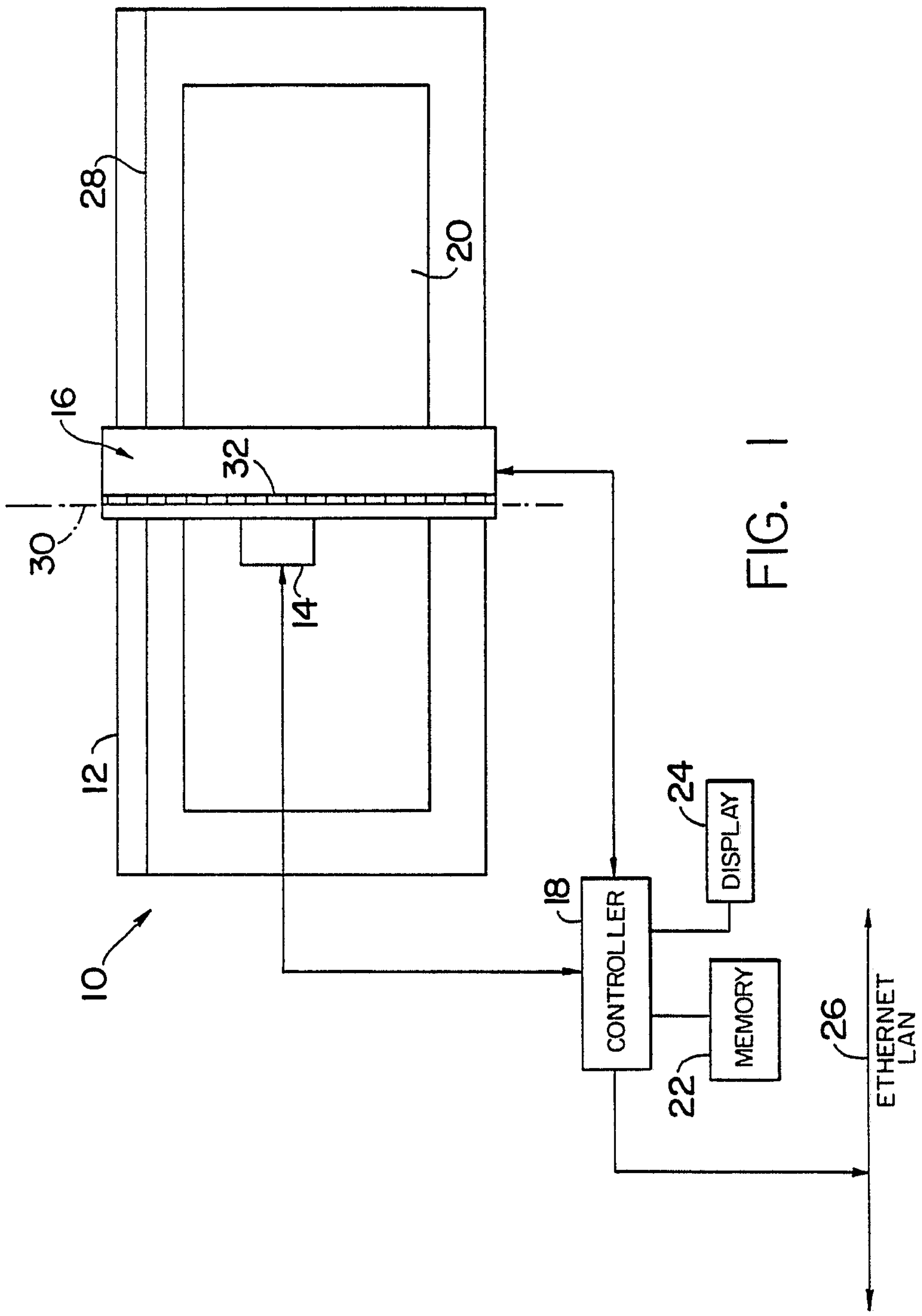
10
12
14
16
18
20
22
24
26
28
30
32
CONTROLLER
DISPLAY
MEMORY
ETHERNET
LAN

FIG. 1

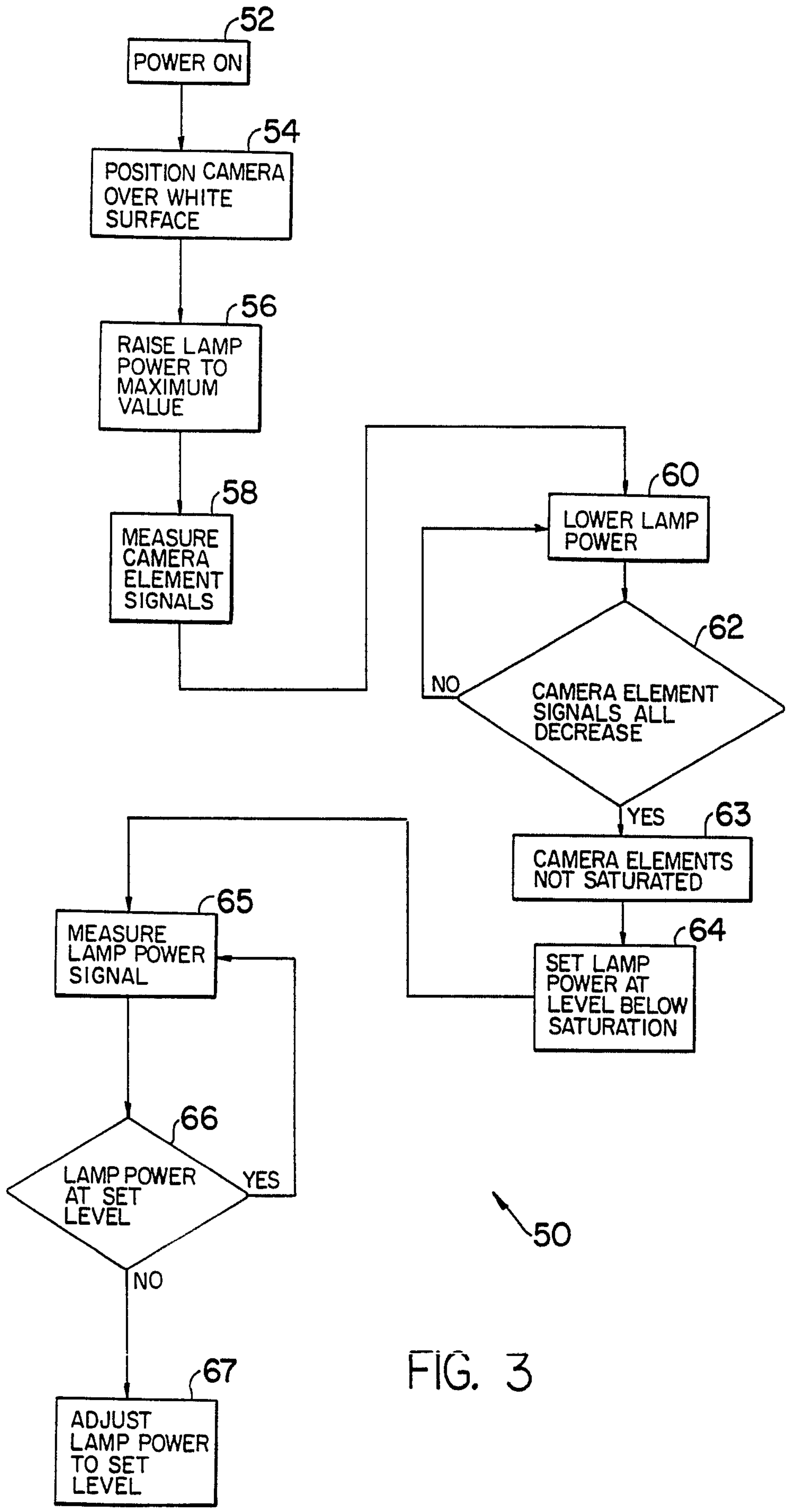
52
POWER ON
54
POSITION CAMERA OVER WHITE SURFACE
56
RAISE LAMP POWER TO MAXIMUM VALUE
58
MEASURE CAMERA ELEMENT SIGNALS
60
LOWER LAMP POWER
62
CAMERA ELEMENT SIGNALS ALL DECREASE
NO
YES
63
CAMERA ELEMENTS NOT SATURATED
64
SET LAMP POWER AT LEVEL BELOW SATURATION
65
MEASURE LAMP POWER SIGNAL
66
LAMP POWER AT SET LEVEL
YES
NO
67
ADJUST LAMP POWER TO SET LEVEL
50

FIG. 3

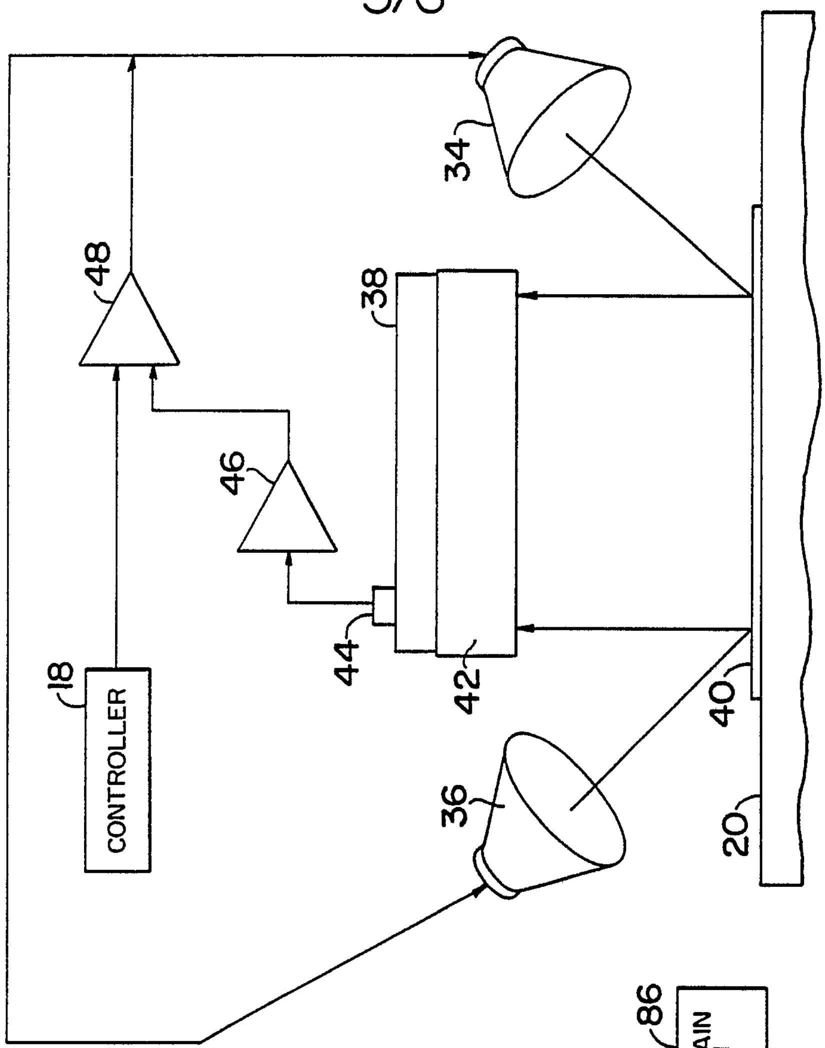

FIG. 2

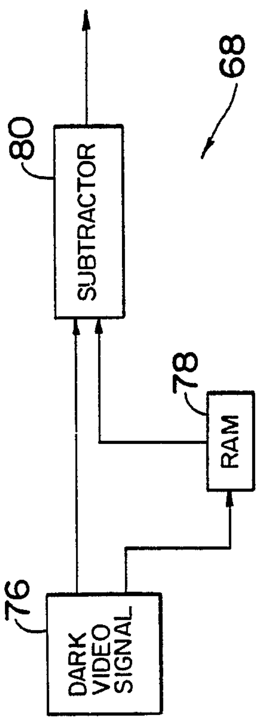

FIG. 4

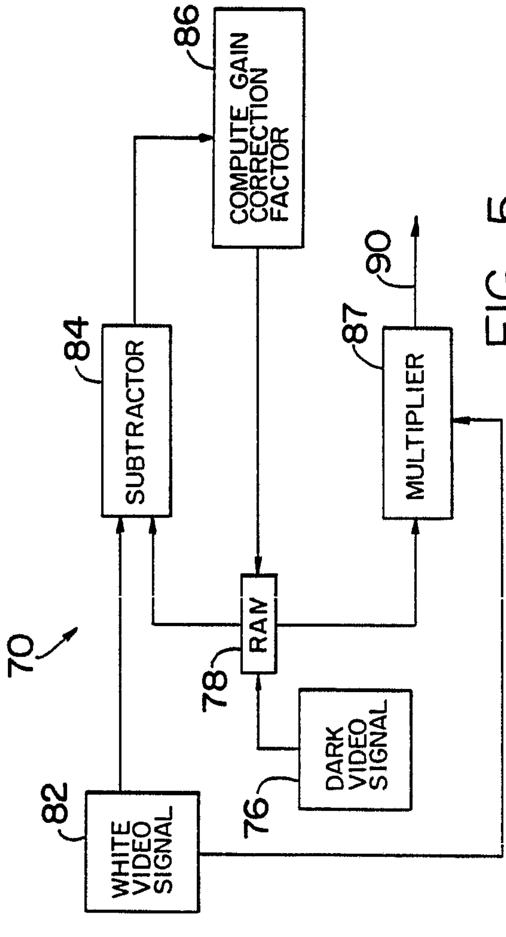

FIG. 5

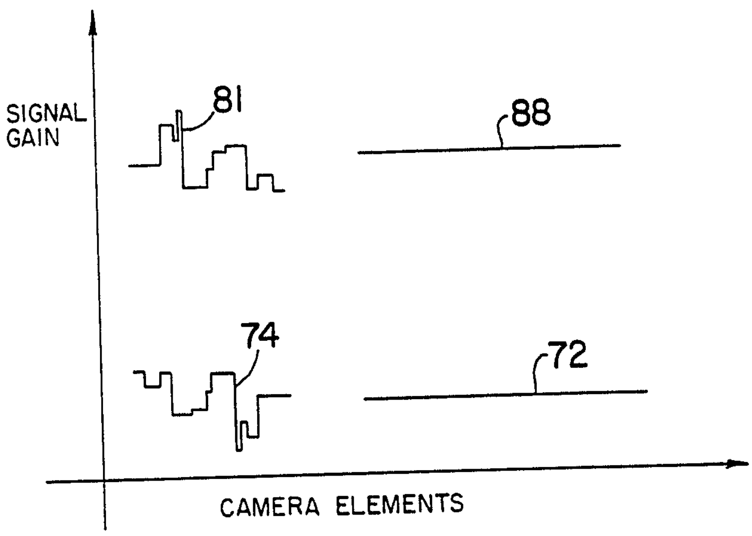
SIGNAL GAIN
81
88
74
72
CAMERA ELEMENTS

FIG. 6

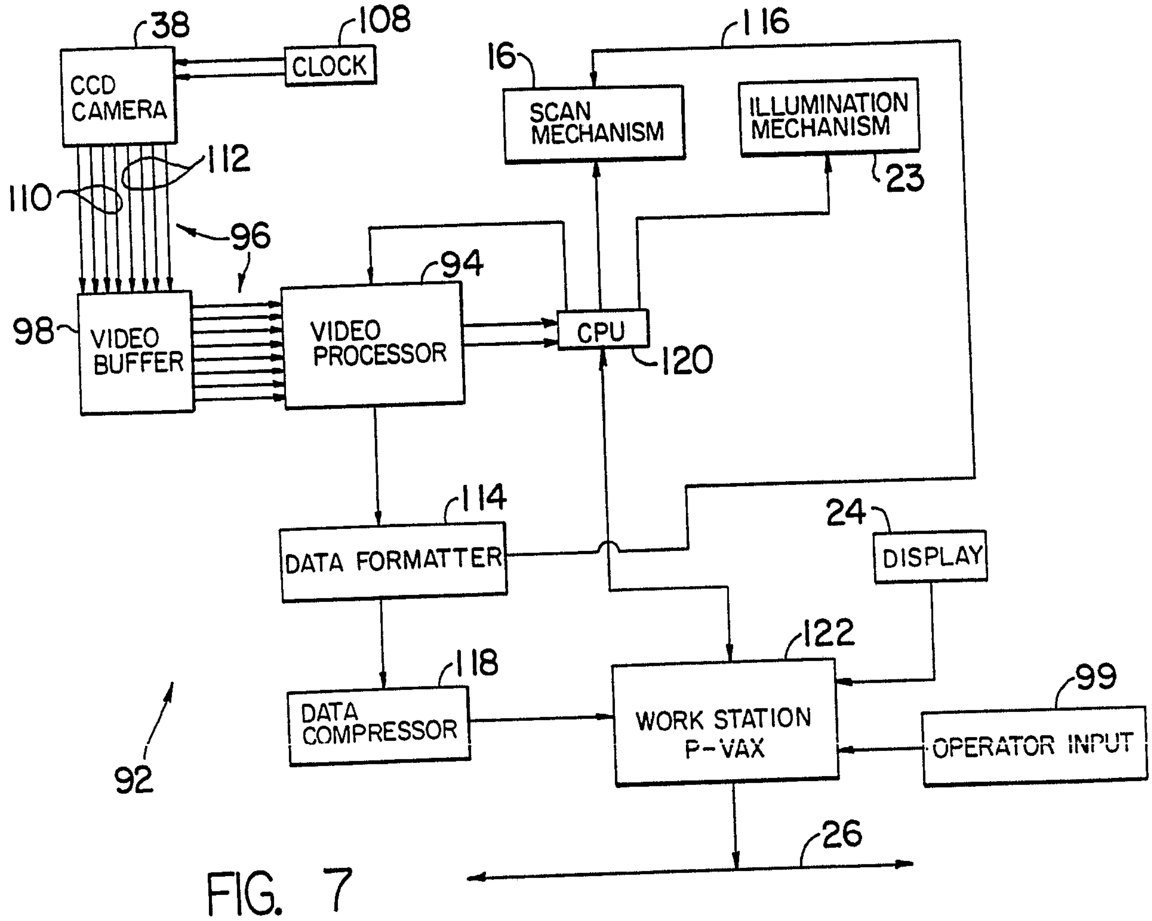
38
CCD CAMERA
108
CLOCK
16
SCAN MECHANISM
116
ILLUMINATION MECHANISM
23
110
112
96
94
98
VIDEO BUFFER
VIDEO PROCESSOR
CPU
120
114
DATA FORMATTER
24
DISPLAY
122
118
DATA COMPRESSOR
WORK STATION P-VAX
99
OPERATOR INPUT
92
26

FIG. 7

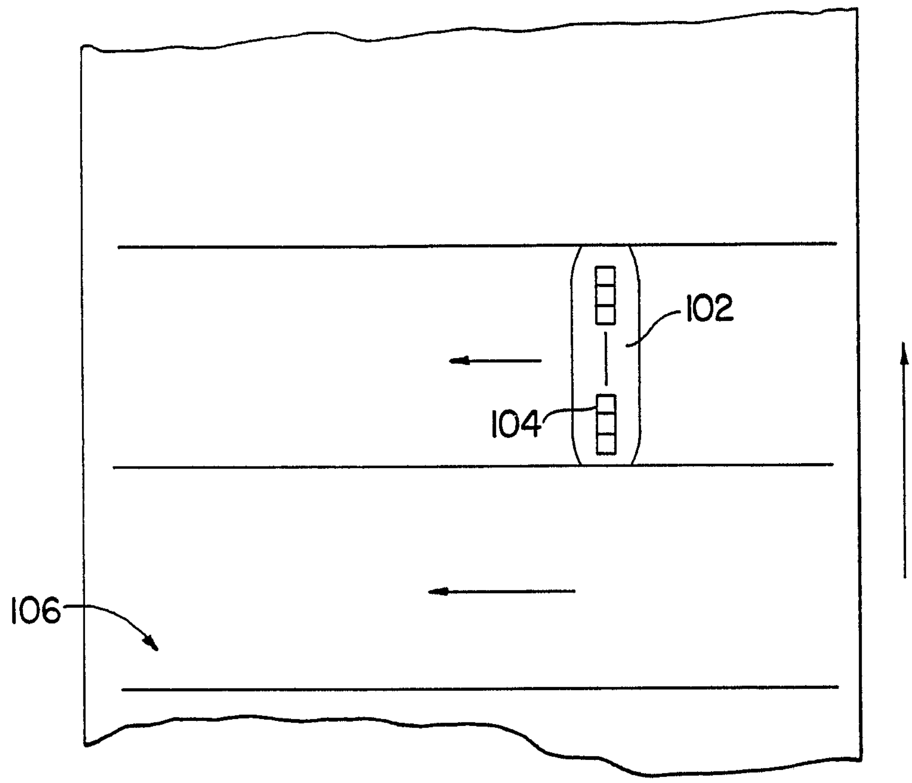
102
104
106

FIG. 8

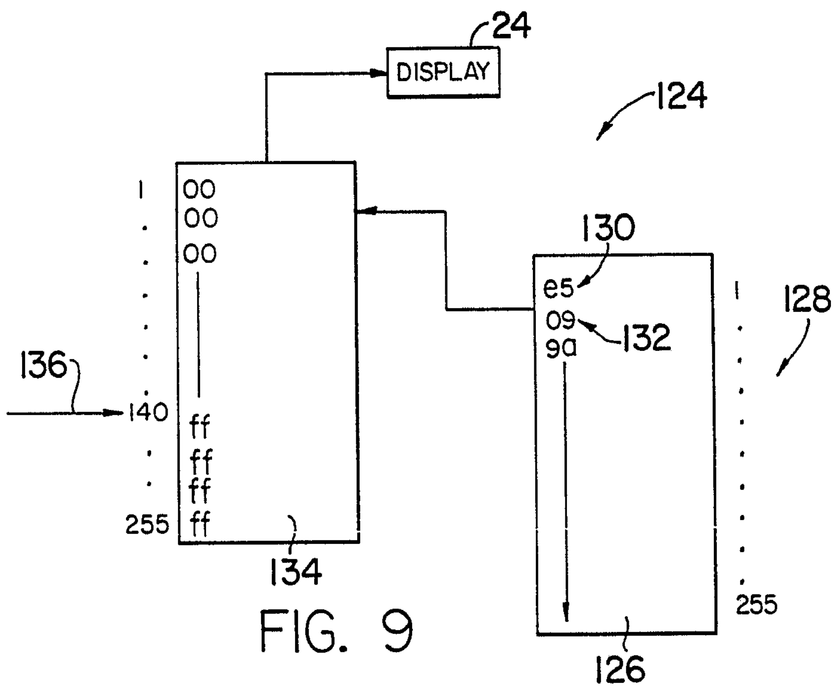
24
DISPLAY
124
1
00
00
00
136
140
ff
ff
ff
255
ff
134
130
e5
09
9a
132
1
128
255
126

FIG. 9

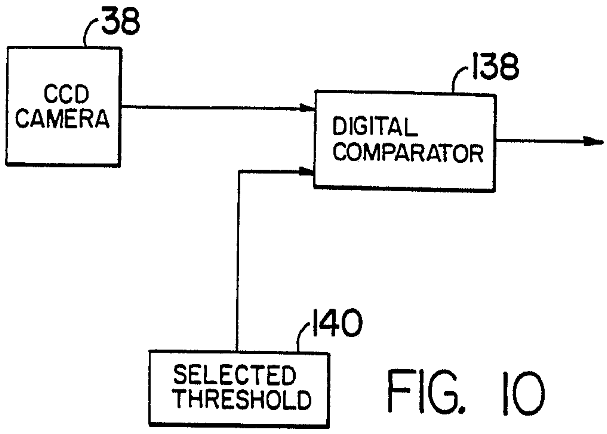
38
CCD CAMERA
138
DIGITAL COMPARATOR
140
SELECTED THRESHOLD

FIG. 10

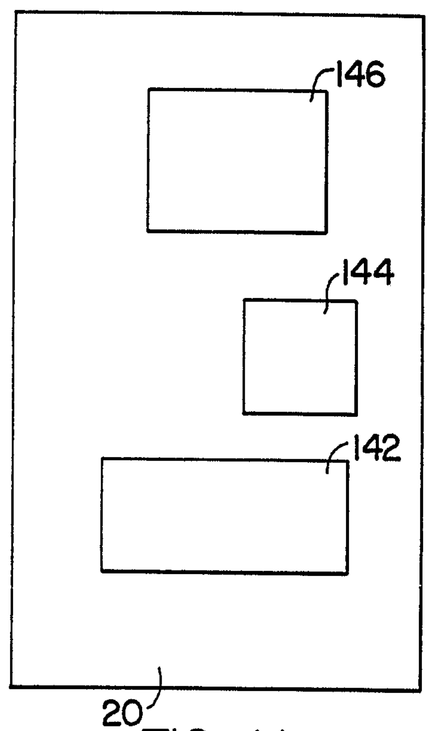
146
144
142
20

FIG. 11

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/07512

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5): H04N 1/40

U.S.CL.: 358/445,446,461,468,474,475

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.Cl.	358/445,446,450,461,468,474,475,447

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4,937,682 (DALTON) 26 June 1990 See entire document.	1-34
Y	US, A, 4,216,503 (WIGGINS) 05 August 1980 See column 5, line 33 - column 6 line 33.	13,29,31,32 33 and 34
Y	US, A, 4,554,460 (KLEIN) 19 November 1985 See column 5, lines 58-62.	13,24,31,32 33 and 34
Y	US, A, 4,916,549 (SEKIZAWD) 10 April 1990 See column 3 lines 20-27.	13,29,31,32 33 and 34
Y,P	US, A, 5,014,332 (NAKAJIMA ET AL.) 07 May 1991 See column 8 lines 6-11.	3,4,17,18
Y	US, A, 4,408,231 (BUSHAW ET AL.) 04 October 1983 See column 6, lines 1-7.	10,15,16, 20-26 17 and 18
Y,P	US, A, 4,980,778 (WITTMAN) 25 December 1990 See column 5 lines 37-53.	14,30,28

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21 December 1991	20 FEB 1992
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Thomas L. Stoll

Form PCT/ISA/210 (second sheet) (Rev.11-87)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 4,660,082 (TOMOHISA ET AL.) 21 April 1987 See entire document.	1-12, 14-26 28,30-34
A,P	US, A, 4,970,605 (FOGAROLI ET AL.) 13 November 1990 See entire document.	1-12,14-26 30-34
A	US, A, 4,803,556 (BEIKIRCH) 07 February 1989 See entire document.	1-12,14-26 30-34
A	US, A, 4,525,741 (CHAHAL ET AL.) 25 June 1985 See entire document.	1-12,14-26 28, 30-34

V. ☒ **OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE** [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☒ Claim numbers 13,27 and 29, because they relate to subject matter [12] not required to be searched by this Authority, namely:

The disclosure was non-enbling with respect to the substraction of the minimum light intensity signals from itself and the generation of a corrected minimum light intensity signal.

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

3. ☐ Claim numbers ___________, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ **OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING** [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.