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(54) **IMAGING SYSTEM**

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SYSTEME D'IMAGERIE

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Description

The invention relates to an imaging system. The invention relates particularly, but not exclusively, to the imaging and analysis of electric arcs formed during the operation of a miniature circuit breaker.

Miniature circuit breakers (MCB's) are in widespread use for overload and short circuit protection in domestic, commercial and industrial installations. When a miniature circuit breaker is activated under short circuit conditions an electric arc is drawn between the contacts. Modern miniature circuit breaker design relies on the control of the arc to limit fault currents thus reducing damage to both the circuit breaker and the installation which it is protecting. To achieve a better understanding of the arc behaviour leading to more efficient and economical circuit breaker design more detailed information on arc motion and the factors that influence it is required.

The small enclosed construction of these devices, the hostile environment in the arc chamber and the rapidity of the circuit breaking event, have made it difficult to obtain detailed information on the behaviour of the arc. The very high intensity of the light emission from the arc make direct visualisation methods (e.g. high speed photography) of limited use. Several recent approaches have employed electronic means to detect the arc position by virtue of its magnetic properties (see M. Mercier et. al., "Study of the Movement of an Electric Breaking Arc at Low Voltage", Journal of Physics D: Applied Physics, Vol. 24, pages 681-684 (1991)) while recent advances in optical fibre technology have opened up new possibilities for studying the light emission of the arc by positioning an array of optical fibres in the arc chamber (M. Delaplace, "Observations sur écran vidéo du comportement de l'arc dans une chambre de coupure" Revue Generale de l'Electricite, No. 1, January 1987, pages 26-32 (1987); J. Wassermann et. al., "Quantitative Recording of Arc Motion and Structure through Opaque Walls Employing Optoelectronic Sensors", Journal of Physics. E: Scientific Instruments, Vol. 21 pages 155-158 (1988); J Leemans et. al., "Fiber Optic Sensor Applied in Circuit Breaker Design", Australasian Instrumentation and Measurement Conference, Adelaide 1989, pages 293-295 (1989); and FR-A-2,571,888). The advantages of such techniques include rapid response times of the order of microseconds, immediate access to data in electronic form for storage and analysis by computer and the fact that electronic equipment is electrically isolated from and physically removed from the vicinity of the arc and the breaking circuit, thus reducing the possibilities of electromagnetic interference or physical damage.

There is known from "Observation sur écran vidéo du comportement de l'arc dans une chambre de coupure" an imaging system for two-dimensional imaging of an event, the imaging system comprising an array of sensors for sampling event parameters at an array of event locations, each sensor being responsive to an

event parameter at a respective event location, the system comprising memory means for recording sampled event parameters.

Furthermore, a group of event locations is identified at which the sampled event parameter exceeds a predetermined threshold value.

However, the prior techniques have only provided simple representations of the arc movement which do not faithfully represent the complexities of the circuit breaking event. The difficulties which have been encountered result from the high sampling frequencies which are needed, as a result of which only poor resolution images can be generated based on a relatively small number of samples (or pixels) per image, compared to conventional high definition imaging techniques.

The object of the invention is to provide an imaging system which is able to provide improved imaging of events even when the imaging is based on a relatively small number of image samples taken at very high sampling rates.

In accordance with a first aspect of the invention we provide an imaging system for two dimensional imaging of an event, the imaging system comprising a array of sensors for sampling event parameters at an array of event locations, each sensor being responsive to an event parameter at a respective event location, the system further comprising memory means for recording sampled event parameters, and first means responsive to the recorded event parameter values for identifying a collection of groups of event locations, each event location within the thus identified groups having an event parameter value exceeding a predetermined event parameter threshold value, characterised by the provision of

- a) second means for identifying, for each group of event locations, event locations at the boundary of an area encompassing the group, and
- b) third means responsive to the identified boundary event locations to plot, for each group, at a distance from points indicative of the centres of the identified event locations lying on the edge of the area, a line around the area of the identified locations representing a contour dividing the identified event locations with an associated event parameter value exceeding the threshold value from event locations with an associated event parameter value smaller than the threshold value.

An imaging system in accordance with the invention enables a plurality of ranges of sensed event parameter values to be imaged in a reliable and effective manner even for a low resolution imaging system where conventional image processing techniques (e.g. interpolation techniques) could not be employed to reliably represent the sensed event parameters. Such low resolution systems are of particular use where very high sampling

rates are required, for example where the event is of short duration, so that bandwidth requirements prevent the use of high sampling resolutions. The improved image enables more effective analysis of imaged events.

Where each sensor is responsive to the value of the event parameter over a predetermined field centred on an event location, the third means preferably plots a contour line at a distance from the event location indicative of the field to which the sensor responds. This enables the contours to reflect the line of constant event parameter value as sensed by the sensors.

Preferably, also, the third means plots contour lines at distances from the event location which reduce for groups representative of higher threshold values. This enables nesting of the threshold levels to be achieved which provides for easier analysis of the images. The images are preferably displayed on a display with area-filling between contour lines with respective colours and/or textures. In order to indicate the relationship of the event to the environment in which it takes place, the contour lines are preferably superimposed on a representation of the environment, including the event locations.

Where the event parameter is a luminance value, each sensor comprises a photosensitive element and a polymer optical fibre for guiding light from an event location to the photosensitive element.

The use of polymer optical fibres enable the photosensitive elements to be located away from the event to be sampled in a flexible and cost effective manner. In particular, by means of a positioning block defining an array of holes with each hole aligned, in use, with a respective event location, and with each polymer optical fibre located in a respective hole, the polymer optical fibres can be arranged to form a friction fit within the holes so that the position of the optical fibres is slidably adjustable along the holes. This enables the polymer optical fibres to be located to give a desired response to a desired field surrounding the event location.

Preferably, the photosensitive element comprises a photodiode operated in a reverse bias configuration whereby a current through the photodiode proportional to the light intensity generates a voltage across a load resistor. By adjusting the value of the load resistor the optical sensitivity can be adjusted without significantly altering the time required to sample a current luminance value.

In a preferred embodiment of the invention, each sensor comprises an amplifier for amplifying the sensed luminance signal and the system comprises multiplexer means for multiplexing the signals from a plurality of sensors, flash analogue to digital converter means connected to the multiplexer means for converting successive signals from the multiplexer means into digital values, successive digital values output from the analogue to digital converter being written to respective locations in the memory means. High sample rates can be achieved by controlling the multiplexer means, the analogue to digital converter means and write operations

for the memory means by a common system clock with one event parameter sample value being stored in the memory means per clock cycle.

An embodiment of the invention is therefore particularly suitable for imaging an event for which the event parameter values change with time, wherein event parameter values for the plurality of event locations are sampled at successive event timings, a set of event parameter samples being recorded for each the event timing. An embodiment of the invention enables very high sample rates to be achieved. Indeed, embodiments of the invention have been able to sample images at a sample rate of 1 million images per second.

As a result of the very high sample rates, an embodiment of the invention is ideally suited for applications where the event is the motion of an electric arc in an electric component, the array of event locations being an array of positions in an arcing chamber.

A particular embodiment of the invention to be described hereinafter is particularly adapted to image the motion of an electric arc in a miniature circuit breaker. In this embodiment, in order that the electric arc can be viewed within a closed housing, a transparent window is provided for viewing the motion of the electric arc.

In accordance with a second aspect of the invention there is provided a method of two-dimensional imaging of an event comprising sampling event parameters at an array of event locations using an array of sensors each sensor being associated with a respective event location, recording a set of sampled event parameter values associated with each event timing in real time in memory means and subsequently imaging the set of recorded event parameter values, the method comprising the steps of

- a) identifying a group of event locations at which the event parameter sample value exceeds a predetermined threshold value;
- b) identifying event locations at the boundary of an area encompassing the group;
- c) responding to the identified boundary event locations to plot, at a distance from points indicative of the centres of the identified event locations lying on the edge of the area, a line around the area of identified event locations, the line representing a contour dividing the identified event locations with an associated event parameter value exceeding the threshold value from event locations with an associated event parameter value smaller than the threshold value; and
- d) increasing the predetermined threshold and repeating steps (a), (b) and (c) for the increased threshold until a predetermined plurality of contour lines for respective event parameter threshold values have been generated.

An embodiment of the invention is described by way of example hereinafter with reference to the accompa-

nying drawings in which:

Figure 1 is a schematic block diagram of the imaging system in accordance with the invention;
 Figure 2 is a perspective view of the mounting of a plurality of optical fibres;
 Figure 3 is a cross section illustrating the mounting of an optical fibre;
 Figure 4 is a schematic diagram illustrating the positioning of a set of optical fibres in a MCB;
 Figure 5 illustrates a circuit forming an optical sensor for the system of Figure 1;
 Figure 6 is a timing diagram for explaining the operation of part of the optical sensor;
 Figure 7 is a schematic block diagram of part of the system of Figure 1;
 Figure 8 illustrates timing circuitry for the system of Figure 1;
 Figure 9 illustrates a data buffer between a RAM and a computer forming part of the system of Figure 1;
 Figure 10 is a flow diagram of an imaging process;
 Figures 11 to 16 are illustrations for explaining the operation of the imaging process;
 Figure 17 illustrates an example of a current response of a short circuit and a miniature circuit breaker; and
 Figures 18A and 18B are representations of images produced at two timings during an event.

Figure 1 is a schematic block diagram of an embodiment of the invention. In this embodiment an array of up to 45 optical fibres 12 is positioned with optical access to the arc chamber of a circuit breaker 10. Optical detector circuitry 14 comprises photosensors for converting the light from each fibre into an analogue signal. A multiplexer 16 switches the output from respective photosensor channels to produce a sequence of voltage levels each corresponding to the signal for a particular fibre. This permits use of a single A-D converter 18 and digital data path per group of fibres, thereby significantly reducing cost and circuit complexity. Only one A-D converter for a group of eight fibres is shown for ease of illustration. In practice one A-D converter for each group of eight fibres would be provided. The A-D converter 18 converts analogue voltage levels to 6-bit binary numbers which are then stored at sequential locations in a random access memory (RAM) 20 in real time during the operation of the circuit breaker. Sampling and writing are synchronised with the multiplexer switching so that sequences of 8 digital numbers are written to successive RAM locations so that the RAM location for a particular channel at a particular time is well defined. After the experiment the data are transferred from the RAM 20 to a computer 22 via a digital I/O card 24 for permanent storage and analysis.

The optical fibres 12 are each about 1 metre long polymer optical fibres with a 1mm core diameter. Poly-

mer fibres have been used under the arduous conditions encountered in EHV (70 kA at 420 kV) circuit breakers operating at high power. There is apparently no degradation of the fibres under these conditions. Attenuation in polymer fibre is higher than in glass - typically 200 dB km⁻¹ at 665nm, but over relatively short transmission distances required for an embodiment of the invention, attenuation or dispersion do not impose serious limitations. The main advantages of polymer fibres lie in the ease of manipulation and an aperture comparable with the resolution required. Polymer fibres are robust and inexpensive and their use greatly simplifies construction of the optical fibre array, and requires no specialised equipment.

Figure 2 illustrates the mounting of the optical fibres 12. The optical fibres are mounted in an array of holes 11 within a fibre positioning block 13 with the fibres withdrawn somewhat into the holes adjacent a perspex window 15 in the side of the circuit breaker 10. The optical fibres 12 form a friction fit within the holes 11 so that the position of the fibres can be slidably adjusted within the holes to restrict the field of view of each fibre to a desired portion of the test volume and to enable a desired intensity of light to be incident on the fibre end.

Figure 3 illustrates how the position of the end of the fibre within the hole determines the field of view of the fibre. The radius view of each fibre at the rear of the arc chamber is calculated by:

$$r = t (0.5 + d/a)$$

where t is the fibre diameter (1mm), d is the depth of the arc chamber (typically 15mm), a is the distance of the end of the fibre from the window and r the radius of view at the rear of the arc chamber. The optimum fibre recess distance for the present embodiment was found to be 25mm giving an estimated radius of view of 1.1mm, slightly smaller than the spacing of the fibres (4mm in the contact region). This gave a reasonable definition of the fibre viewing area and light levels acceptable to the electronic detectors.

The possible fibre positions relative to the interior components of the circuit breaker are shown in Figure 4. In Figure 4, 24 represents the moving contact of the circuit breaker, 26 is the fixed contact of the circuit breaker, 28 is the arc runner and 30 is the arc splitter stack. The small circles such as 25 represent the event locations, which are to be sampled, that is the positioning of the ends of the optical fibres.

Figure 5 is a circuit diagram for an optical sensor for sensing the light transmitted along an optical fibre from an event location. A photodiode 'PD' is used to convert the light transmitted through the optical fibre into an electronic signal. The photodiode 'PD' is operated in a reverse bias (photoconductive) configuration whereby the current through the photodiode (proportional to the incident light intensity) generates a voltage across a

load resistor R_b .

A lower resistance R_b gives a reduced voltage and a faster response time. However as long as the response time is not longer than that of the amplifier stage ($\approx 2.5\mu\text{s}$) there is nothing to be gained by changing the value of R_b to improve response time. The value of R_b can therefore be optimised to give signals that, after amplification, provide a suitable level for the A-D converter 18. A high resistance (e.g. 100k Ω) would therefore give detailed information at low light levels but would produce overload throughout much of the circuit breaking event while a low value (e.g. 1k Ω) would only register the very highest intensity light emission and much of the detail of the arc motion would be lost. A value of 10k Ω has been found to give good definition of arc motion throughout the circuit breaking event in the particular embodiment and at the short circuit current levels employed (3kA).

The signal across the load resistor R_b is detected by an amplifier stage 'A' based around an LF351 J-F.E.T operational amplifier which provides a high input impedance and fast response at a low cost. This is used in a non-inverting configuration with a gain of 2. The gain prevents instability caused by rapid changes in load from switching in the multiplexer stage.

A 4.7v Zener diode 'ZD' is placed across the amplifier output to limit the voltage to less than 5v which is the limit for the operation of subsequent stages.

The amplifier 'A' responds to a step input signal with a rise time of 2.5 μs as illustrated in Figure 6.

Figure 7 illustrates the interconnection of the multiplexer 16, the A/D converter 18 and the RAM 20 in more detail. As illustrated in Figure 7, sets of 8 analogue inputs from respective sensors (Figure 5) are each fed through an analogue multiplexer 16 which switches the output between successive analogue channels (0-7) on the rising edge of a clock signal CLK in response to the count output of a counter 32. A single clock signal CLK and its inverse are used to control the entire digital recording process.

At the switching speeds used here (8MHz), residual charge on the switching capacitance could disturb the operation of the amplifier circuit and cause crossover of the signal from one channel onto the next. Accordingly, a 220 Ω resistor is placed between the multiplexer output and ground to rapidly discharge the switching capacitance between channels. Some reduction in signal levels and some nonlinearity in the signal is an acceptable consequence of this measure which, along with a stable amplifier configuration and limiting the signals to less than 5v, reduces crosstalk between channels to an acceptable level of about 1 least significant bit of the A-D conversion.

The analogue signal is digitised by a 6-bit flash A-D converter 18 on the falling edge of the inverted clock signal. The 6-bit (plus one overflow bit) digital number is presented at the output of the A-D converter 18 on the next rising edge of the inverted clock signal. The over-

flow bit is designed for use in cascading converters to obtain a higher bit resolution. It is not essential for the present application although it is included in the binary number written to the 32k*8bit RAM 20. The RAM memory location is defined by a 15 bit address generated by four 4-bit synchronous counters (not shown). The count is increased by one on the rising edge of the inverted clock signal. The RAM address uses only 15 bits. The 16th bit is used as a STOP signal so that when all RAM locations have been written to the recording can be halted.

The timing of the multiplexer switching, a-d conversion and RAM write operations are synchronised so that one sample can be made every clock cycle. The rising edge of the clock signal CLK initiates switching of the analogue sensor channel (from say channel 2 to 3). The sampling aperture time is 25ns - significantly less than the time taken for the multiplexer output to change so that the channel 2 can be sampled on the same rising edge of the clock signal before the analogue signal starts to change. During this high phase of the clock signal channel 1 is being written to the RAM 20. On the falling edge of the clock signal the write pulse to the RAM 20 is removed and, after a short delay (20ns), converted data for channel 2 are presented to the RAM data ports (but not written). The RAM address counters are also clocked on this edge. By the next rising clock edge the analogue signal for channel 3, the digital data for channel 2 and the RAM address signals have had sufficient time to stabilise in order to repeat the cycle for the next channel.

The critical time is the write pulse for the RAM 20 which must be at least 70ns, giving a minimum clock period of 140ns and therefore a theoretical maximum clocking frequency of nearly 8MHz. This provided a recording time of 4.096ms which is usually sufficient to record the entire circuit breaking operation.

The circuit shown in Figure 8, including a buffer 36, produces the control signals for operation of the counters, A-D conversion and writing to RAM. The data acquisition system is organised around pairs of RAMs each sharing common RAM location counters, multiplexer counters and clock signals. This pairing greatly reduces the circuit complexity and size thereby reducing the cost and construction time.

The elements of the imaging system described above permit the real-time sampling and storage in the RAM(s) 20 of the light intensities experienced during a circuit breaking event, the light intensities forming event parameters representative of that event.

Once the event has been sampled, and recorded in the RAM 20, the recorded results can then be transferred to a computer to complete the imaging process off-line.

For transfer of data to the computer, each RAM 20 is addressed separately by a 4-bit address. When GO is low the output buffers of the A-D converter are disabled. The address decoding circuitry can then produce

a low output enable signal to the relevant RAM and buffer when the correct address is presented. This allows transfer of the data to the computer by re-counting through the memory locations using a computer generated clock signal CLK.

The independent clock signal and interface to the computer are shown schematically in Figure 9. The independent clock CLK is generated by a clock integrated circuit 40 which is programmable by a 3-bit number of 8MHz down to 62.5kHz in factors of 2. This number is held by a latch 41 until the clock is addressed whereupon the address decode circuitry 42 opens the latch 41 allowing the 3-bit number to be read from the lowest 3 bits of the data line. When the address is changed the latch 41 holds the 3 bit clock speed number even if the data lines change. At the start of the run all counters have been re-set so the STOP signal (bit 16 of the RAM location counters) is low. When GO becomes high the independent clock signal is transmitted by the three-input NAND. If CCLK is held low the independent clock signal CLK is admitted to the data acquisition cards 24 via the 2 input NAND. Data acquisition then proceeds automatically and stops automatically when all RAM locations have been written to. The GO signal is also buffered to an external connector for use in triggering external equipment such as a digital storage oscilloscope and the capacitor discharge used to test the MCB, thus allowing accurate synchronisation of different recording instruments.

The direction of the tri-state data buffers 48, 50 is controlled by the READ signal with a high on this line allowing data transfer to the computer (for reading RAM data) and a low allowing transfer from the computer (for setting clock speed). (Data buffers 44 and 46 are fixed and unidirectional). All other signals are simply buffered and are therefore directly under computer control.

The computer end of the interface between the RAM 20 and the computer 22 is a 24 channel programmable digital I/O card 24. This allows configuration of the 24 channels as inputs or outputs and transfer of data to/from imaging software via the card. The data from each RAM 20 are read into the computer in the order in which they were recorded by addressing the RAM 20 then, with GO held low and READ held high, re-counted under computer control. The data are then stored on a disc or other mass storage device.

There now follows a description of image construction which, in the present invention, is performed by computer software running on a general purpose computer 22 of conventional construction.

The image construction software was developed to analyse the large quantity of optical fibre data and to present these data as an image of the arc alongside other important information such as voltage, current and estimated contact position.

In this example of the invention the image of the arc is presented as a plot of 5 light intensity contours although it will be appreciated that the number of intensity

contours can be adapted to the particular imaging requirements of a specific application. It is a relatively straightforward process in conventional image processing to form contour plots for a continuous function by joining points of constant intensity to form a line. Also, with a conventional, high resolution image, it is possible to simply plot the points and a line will be built up. However, such conventional approaches are not possible in the present case because the available sample points are so few so that at a given time the number of points within any narrow intensity band would probably be close to zero. In the present situation the contour line needs to be explicitly drawn because of the low resolution.

Each contour line is associated with a different intensity threshold. All the sensor channels giving an intensity greater than or equal to a threshold level are considered to lie inside the contour and are marked "in"; all those giving values lower than the threshold are considered to lie outside the contour and are marked "out". In general the "in" channels will form 2-D areas where light from the arc is above the intensity threshold.

Figure 10 represents the process of generating the contours.

Firstly, in step S0, a first threshold is set and then, in step 1, the sensor channels giving an intensity value greater than or equal to a first threshold are identified.

Then, in step S2 the sensor channels that lie on the edge of an area of "in" channels are identified. These channels constitute what will be referred to as a "boundary" and the centre points of the optical fibres as "boundary points". On a map of the circuit breaker this would produce a series of points at the centre of the optical fibre positions at the edge of a region. These can be joined to make a line, represented by the solid line in Figure 11. However, it will be noted that for a spur or an area encompassing only two fibre positions no area would be enclosed by a line joining the boundary points. Accordingly, the image would not faithfully represent the spatial distribution of intensity.

Accordingly, in step S3 a contour line is drawn around the area of "in" channels at a distance from the centre of each boundary point that is indicative of the area over which the optical fibres are sensitive or representative. This line will be referred to as a "contour" and is represented by the dotted line in Figure 11.

If, in step S4 it is determined that further contours need to be defined for further thresholds, then, in step S5, the next threshold is taken and steps S1, S2 and S3 are repeated for the next threshold. This process repeats until contours for all the thresholds have been plotted (in the present example 5 thresholds are processed).

When plotting the contours in step S3, it has been found advantageous to slightly reduce the distance between the boundary point and the contour line for contours of increasing intensity thresholds as this permits nesting of the contours to given an easily readable rep-

resentation of the contours.

Step S2 for boundary tracing will now be described in more detail. The boundary is traced by examining each point of the optical fibre array in turn. For this purpose the fibre identifications are held in an array that records which channels are adjacent to which, but does not represent the actual positions of the optical fibres in the arc chamber. Each channel is checked in turn starting at the upper left corner of the array and moving from left to right. If a particular channel is marked "in" then it may be a new boundary point unless it is already part of a previous boundary in which case it is ignored (for a given threshold there may be more than one illuminated area and therefore more than one boundary). When a new boundary point is found the program steps clockwise around adjacent array elements until the next "in" point is found. This is achieved in the following way. The optical fibre array coordinates (Row, Column in Figure 12) for the next point to be checked (R_1 , C_1) are calculated in turn by adding a displacement angle, θ , of $\pi/4$ to the array vector of the previously checked point (R_0 , C_0):

$$R_1 = R_0 \cos \theta + C_0 \sin \theta$$

$$C_1 = C_0 \cos \theta - R_0 \sin \theta$$

where R and C are rounded to the nearest integer. In this manner all adjacent points can be checked.

When an adjacent boundary point is located, the process is repeated around the new point starting at a displacement $\pi/2$ clockwise from the line (in array space) joining the new point to the previous point. This minimises overlap in the searches of adjacent points whilst ensuring that no neighbours are left unchecked. Each new boundary point is added to an array containing identifiers in sequence for all the optical fibre channels on the boundary. The process is then repeated. In this manner the program "walks" around the edge of the boundary until the start point is returned to at which point the boundary is complete.

The program is prevented from analysing points inside a boundary by a flag which is set when an existing boundary is reached and not re-set until an "out" point or the end of a row is reached. This scheme may be upset by the presence of a "hole" (see Figure 13). Figure 13 is a schematic illustration of different types of boundary configurations. Figure 13a represents a multiple boundary. Figure 13b represents a boundary with a "hole" and Figure 13c represents a boundary with an "island".

The presence of a "hole" can result certain difficulties. A spurious boundary can start inside another boundary and break through to the exterior so that it never returns to its starting point. This can be overcome, however, by aborting the current boundary when the

number of points in it exceeds the number of available channels. A spurious interior boundary can be formed consisting of usually four interior points. This can be overcome by marking this as a boundary but eliminating it in the contour plotting routine. A complex hole or an island can be recorded as a boundary. This can be overcome by marking and eliminating as described above. However, even if it were to be recorded, it is not likely to cause serious problems and may even be useful.

Thus step S2 enables a sequence of optical fibre identifiers that form the boundary of a region of "in" channels to be identified. It is now necessary to draw a contour around the boundary on the 2-D map of the circuit breaker arc chamber.

Initially this involves drawing a line parallel to and displaced outwards from the line joining the centre points of two adjacent boundary points. The centre point co-ordinates are obtained from a look-up table using the optical fibre identifier held by the boundary array.

The co-ordinate system used for calculating the parameters of these lines is shown in Figure 14. To calculate the parameters of the contour line, the angle Φ of the line joining the two centre points is first calculated from their co-ordinates. The end points of the contour line lie at a fixed distance along a line at right angles to line joining the centre points of the boundary i.e. at an angle θ :

$$\theta = \Phi + \pi/2$$

Using $+\pi/2$ ($-\pi/2$ also gives a line at right angles) always produces a contour lying outside the boundary when plotting in a clockwise direction.

Simple lines thus constructed will fail to meet on outward pointing corners and will intersect on inward pointing corners. These two cases require different handling and therefore it is necessary to distinguish between inward pointing and outward pointing corners as illustrated in Figures 15A and 15B, respectively. Intuitively, outward corners have an angle of $> \pi$ between the two boundary (centre point) lines that form the corner whereas inward corners have $< \pi$. However, the multi-valued nature of the angular co-ordinates and the fact that shapes can appear in any orientation relative to the co-ordinate system means that the criteria have to be defined more carefully.

The angular displacement of the line from the previous centre point (-1) to the current centre point (0) is Φ_i , and that for the next centre point in the boundary is Φ_0 (Figure 16). Both angles are calculated from the optical fibre position co-ordinates. For an outward pointing corner

$$0 < \Phi_i - \Phi_0 < \pi$$

or

$$-2\pi < \Phi_i - \Phi_0 < -\pi$$

The pairs of contour lines forming inward pointing corners are drawn by plotting to the intersection of the two contour lines. At outward pointing corners the two contour lines are drawn fully then joined by a geometrical arc.

By taking each boundary point in turn a continuous contour is plotted around the outside of each boundary. When all contours are complete the entire process is repeated for the next threshold level. The contours may be plotted as lines or filled with colours using a conventional area-fill technique to provide a more "solid" image.

An example of the use of the present invention for testing a miniature circuit breaker will now be described. Short circuit currents of up to 10kA have been generated by the discharge of a bank of capacitors charged from a rectified mains source to a maximum D.C. voltage of 380 volts. The discharge was initiated electronically by the triggering of an silicon controlled rectifier (SCR). A four channel digital storage oscilloscope was operated at a sample rate of IMs/s (giving a duration of 10ms) to record the arc current and voltage. The SCR and the oscilloscope were both triggered by the GO signal from the imaging system described above. A typical short circuit current pulse with a peak of 3.4kA and duration of 6.3ms is shown in Figure 17. A typical current recording for discharge through a miniature circuit breaker is also shown in Figure 17.

Two images for respective timings during a circuit breaker event are illustrated in Figures 18A and 18B, respectively. Figure 18A represents an image generated 1430 μ s into a specific circuit breaker event when the moving contact 24 has just opened. At the time a current of 2888 Amps at 32 volts was recorded. The arc is represented by 4 concentric arc contours C1, C2, C3 and C4. The dashed lines represent the internal components of the circuit breaker 24, 26, 28 and 30 (compare Figure 4) and the dashed circles represent the fibre positions 25. Figure 18B represents a later stage 1980 μ s into the event when the moving contact 24 is more fully open. At this time a current of 3240 Amps at 116 Volts was recorded. At this stage the arc is represented by five contours C1, C2, C3, C4 and C5.

Each series of contours in the order C1 to C4 and C1 to C5 represents thresholds of increasing brightness. In a real image the contours would be displayed in colour and the spaces inside the contours would preferably be filled-in with a colour or pattern by conventional area-fill software to aid evaluation of the image. The effect of nesting the contours by reducing the distance from the centres of the event locations (i.e. the fibre centres) in accordance with the increasing threshold values can clearly be seen.

There has been described an embodiment of an imaging system for imaging an event which occurs at high speed with a very high sample rate. A specific embodi-

ment of the invention permits the study the motion of the electric arc formed during the breaking operation of a miniature circuit breaker under short circuit conditions. Over 4000 images can be captured at a rate of 1 image per μ s. A computer program uses the optical information to display an image of the arc on the screen. Although a specific example of the invention has been described, it will be appreciated that the invention is not limited in thereto and that many modifications and/or additions are possible within the scope of the amended claims. In particular, the invention is not limited to the imaging of circuit breaking events in circuit breakers, but is of application to imaging events in general. The invention is of particular application to the imaging of high speed events which are sampled at a low resolution. Also, although in the present embodiment the imaging of the event is performed by software, it is apparent that one or more of the logical operations performed during the construction of the image can be implemented by means of special purpose hardware logic.

Claims

1. An imaging system for two dimensional imaging of an event, the imaging system comprising a array of sensors (PD) for sampling event parameters at an array of event locations (25), each sensor (PD) being responsive to an event parameter at a respective event location, the system further comprising memory means (20) for recording sampled event parameters, and first means (S1) responsive to the recorded event parameter values for identifying a collection of groups of event locations, each event location within the thus identified groups having an event parameter value exceeding a predetermined event parameter threshold value, characterised by the provision of
 - a) second means (S2) for identifying, for each group of event locations (25), event locations at the boundary of an area encompassing the group, and
 - b) third means (S3) responsive to the identified boundary event locations to plot, for each group, at a distance from points indicative of the centres of the identified event locations lying on the edge of the area, a line around the area of the identified locations representing a contour dividing the identified event locations with an associated event parameter value exceeding the threshold value from event locations with an associated event parameter value smaller than the threshold value.
2. A system as claimed in Claim 1 wherein the third means (S3) plots contour lines (C1 to C5) at a distance from the event location (25) which reduces

for groups representative of higher threshold values to provide nesting of contours.

3. A system as claimed in any one of the preceding claims comprising display means for displaying image(s) of the event including the contour lines (C1 to C5) for respective event parameter threshold values. 5
4. A system as claimed in Claim 3 comprising means for area-filling between contour lines with respective colours and/or textures. 10
5. A system as claimed in Claim 3 or Claim 4 comprising means for superimposing the contour lines on a representation of the environment, including the event locations, in which the event takes place. 15
6. A system as claimed in any one of the preceding claims wherein the event parameter is a luminance value and wherein each sensor comprises a photosensitive element (PD) and a polymer optical fibre (12) for guiding light from an event location to the photosensitive element. 20
7. A system as claimed in Claim 6 comprising a positioning block (13) defining an array of holes (11) with each hole aligned, in use, with a respective event location, and with each polymer optical fibre (12) located in a respective hole, the polymer optical fibres forming a friction fit within the holes so that the position of the optical fibres is slidably adjustable along the holes (11). 25
8. A system as claimed in Claim 6 or Claim 7 wherein the photosensitive element comprises a photodiode (PD) operated in a reverse bias configuration whereby a current through the photodiode proportional to the light intensity generates a voltage across a load resistor (Rb). 30
9. A system as claimed in any one of Claims 6, 7 or 8 wherein each sensor (PD) comprises an amplifier (A) for amplifying the sensed luminance signal and wherein the system comprises multiplexer means (16) for multiplexing the signals from a plurality of sensors, flash analogue to digital converter means (A/D) connected to the multiplexer means for converting successive signals from the multiplexer means into digital values, successive digital values output from the analogue to digital converter means being written to respective locations in the memory means (20). 35
10. A system as claimed in Claim 9 wherein the multiplexer means, the analogue to digital converter means and write operations for the memory means are controlled by a common system clock (32) with 40

one event parameter sample value being stored in the memory means (20) per clock cycle.

11. A system as claimed in any one of the preceding claims for an event for which the event parameter values change with time, wherein event parameter values for the plurality of event locations are sampled at successive event timings, a set of event parameter samples being recorded for each event timing. 45
12. A system as claimed in any one of the preceding claims wherein the event is the motion of an electric arc in an electric component, the array of event locations (25) being an array of positions in an arcing chamber. 50
13. A system as claimed in Claim 12 wherein the electric component is a miniature circuit breaker (10).
14. A system as claimed in Claim 12 or Claim 13 wherein the electric component is provided with a transparent window (15) for viewing the motion of the electric arc.
15. A method of two-dimensional imaging of an event comprising sampling event parameters at an array of event locations (25) using an array of sensors (PD) each sensor being associated with a respective event location, recording a set of sampled event parameter values associated with each event timing in real time in memory means and subsequently imaging the set of recorded event parameter values, the method comprising the steps of
 - a) identifying a group of event locations (25) at which the event parameter sample value exceeds a predetermined threshold value;
 - b) identifying event locations at the boundary of an area encompassing the group;
 - c) responding to the identified boundary event locations to plot, at a distance from points indicative of the centres of the identified event locations lying on the edge of the area, a line (C1 to C5) around the area of identified event locations, the line representing a contour dividing the identified event locations with an associated event parameter value exceeding the threshold value from event locations with an associated event parameter value smaller than the threshold value; and
 - d) increasing the predetermined threshold and repeating steps (a), (b) and (c) for the increased threshold until a predetermined plurality of contour lines for respective event parameter threshold values have been generated.
16. A method as claimed in Claim 15 wherein, in step 55

(c), a contour line is plotted at a distance from the event location which reduces for groups representative of higher threshold values to provide nesting of contours.

17. A method as claimed in any one of Claims 15 or 16 comprising the step of area-filling between contour lines with respective colours and/or textures. 5
18. A method as claimed in Claim 17 comprising displaying a representation of the environment, including the event locations, in which the event takes place and superimposing the contour lines on the representation. 10
19. A method as claimed in any one of Claims 15 to 18 wherein the event parameter is a luminance value and wherein each sensor comprises a photosensitive element (PD) and a polymer optical fibre (12) for guiding light from an event location (25) to the photosensitive element: the method comprising the steps of locating a positioning block (13) which defines an array of holes (11) such that each hole is aligned with a respective event location, slidably locating each polymer optical fibre (12) along a re- 20
spective hole to give a desired response to a desired area surrounding the event location. 25
20. A method as claimed in Claim 19 comprising amplifying each sensed luminance signal, multiplexing signals from a plurality of sensors to a flash analogue to digital converter for converting successive signals into digital values, and writing successive digital values output from the analogue to digital converter means to respective locations in the memory means. 30
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21. A method as claimed in Claim 20 comprising controlling the multiplexer means (16), the analogue to digital converter means (A/D) and write operations for the memory means (20) by a common system clock (32) such that one event parameter sample is recorded in the memory means per clock cycle. 40
22. A method as claimed in any one of Claims 15 to 21 wherein the event is the motion of an electric arc in an electric component. 45
23. A method as claimed in Claim 22 wherein the electric component is a miniature circuit breaker (10). 50
24. A method as claimed in Claim 22 or Claim 23 comprising the step of providing the electric component with a transparent window (15) for viewing the motion of the electric arc. 55

Patentansprüche

1. Abbildungssystem für die zwei-dimensionale Abbildung eines Ereignisses, mit einer Anordnung aus Sensoren (PD) zum Abtasten von Ereignisparametern bei einer Anordnung von Ereignispositionen (25), wobei jeder Sensor (PD) bei einer bestimmten Ereignispositionen auf einen Ereignisparameter anspricht, und mit einer Speichervorrichtung (20) zum Aufzeichnen abgetasteter Ereignisparameter und einer ersten Vorrichtung (S1), welche auf die aufgezeichneten Ereignisparameterwerte anspricht, um eine Sammlung aus Gruppen aus Ereignispositionen zu identifizieren, wobei jede Ereignisposition innerhalb der so identifizierten Gruppen einen Ereignisparameterwert hat, der einen vorgegebenen Ereignisparameter-Schwellwert überschreitet, 5
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gekennzeichnet durch

- a) eine zweite Vorrichtung (S2) zum Identifizieren von Ereignispositionen für jede Gruppe aus Ereignispositionen (25) bei der Grenze eines Bereiches, der diese Gruppe umschließt, und 20
- b) eine dritte Vorrichtung (S3), welche auf die identifizierten Grenz-Ereignispositionen anspricht, um für jede Gruppe mit einem Abstand zu den Punkten, welche die Zentren der identifizierten Ereignispositionen angeben, die auf dem Rand des Bereiches liegen, eine Linie um den Bereich der identifizierten Positionen zu zeichnen, die einen Umriß darstellt, der die identifizierten Ereignispositionen mit einem zugeordneten Ereignisparameterwert, der den Schwellwert überschreitet, von Ereignispositionen mit einem zugeordneten Ereignisparameterwert, der kleiner ist als der Schwellwert, trennt. 25
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2. System nach Anspruch 1, bei dem die dritte Vorrichtung (S3) Umrißlinien (C1 bis C5) mit einem Abstand zu der Ereignisposition (25) zeichnet, welche sich für Gruppen verringert, die höheren Schwellwerten entsprechen, um eine Schachtelung der Umrisse vorzusehen. 40
3. System nach einem der vorangehenden Ansprüche, mit einer Anzeigevorrichtung zum Anzeigen eines Bildes (mehrere Bilder) des Ereignisses mit den Umrißlinien (C1 bis C5) für entsprechende Ereignisparameter-Schwellwerte. 45
4. System nach Anspruch 3, mit einer Vorrichtung zum Ausfüllen eines Bereiches zwischen den Umrißlinien mit entsprechenden Farben und/oder Strukturen. 50
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5. System nach Anspruch 3 oder 4 mit einer Vorrich-

tung zum Überlagern der Umrißlinien auf eine Darstellung der Umgebung, welche die Ereignispositionen, bei dem das Ereignis stattfindet, enthält.

6. System nach einem der vorangehenden Ansprüche, bei dem der Ereignisparameter ein Luminanzwert ist, und bei dem der Sensor ein Photoelement (PD) und eine Polymer-Lichtfaser (12) zum Leiten des Lichtes von einer Ereignisposition zu dem Photoelement aufweist. 5
7. System nach Anspruch 6, mit einem Positionierblock (13), der eine Anordnung aus Löchern (11) definiert, wobei jedes Loch in Gebrauch zu einer entsprechenden Ereignisposition ausgerichtet ist und jeweils ein Polymer-Lichtfaser (12) in einem zugehörigen Loch liegt, wobei die Polymer-Lichtfasern reibschlüssig in den Löchern sitzen, so daß die Positionen der Lichtfasern verschiebbar entlang der Löcher (11) einstellbar ist. 10
8. System nach Anspruch 6 oder 7, bei dem das Photoelement eine Photodiode (PD) aufweist, die in Sperrichtung vorgespannt arbeitet, wobei ein Strom durch die Photodiode, der proportional zur Lichtintensität ist, eine Spannung über einem Lastwiderstand (Rb) erzeugt. 15
9. System nach einen der Ansprüche 6, 7 oder 8, bei dem jeder Sensor (PD) einen Verstärker (A) zum Verstärken des erfaßten Luminanzsignals aufweist, und wobei das System ein Multiplexvorrichtung (16) zum Multiplexen der Signale von mehreren Sensoren und einer Hochgeschwindigkeits-Analog-Digital-Wandler-Vorrichtung (A/D) aufweist, die mit der Multiplexvorrichtung verbunden ist, um aufeinanderfolgende Signale von der Multiplexvorrichtung in digitale Werte umzuwandeln, wobei die von der Analog-Digital-Wandler-Vorrichtung ausgegebenen aufeinanderfolgenden digitalen Werte in entsprechende Positionen in der Speichervorrichtung (20) geschrieben werden. 20
10. System nach Anspruch 9, bei dem die Multiplexvorrichtung, die Analog-Digital-Wandler-Vorrichtung und Schreiboperationen der Speichervorrichtung von einem gemeinsamen Systemtakt (32) gesteuert werden, wobei ein Ereignisparameter-Abtastwert pro Taktzyklus in der Speichervorrichtung (20) gespeichert wird. 25
11. System nach einen der vorhergehenden Ansprüche für ein Ereignis, bei dem sich die Ereignisparameterwerte mit der Zeit ändern, wobei Ereignisparameterwerte für die mehreren Ereignispositionen bei aufeinanderfolgenden Ereigniszeitpunkten abgetastet werden und eine Gruppe aus Ereignisparameter-Abtastwerten für jeden Ereigniszeitpunkt aufge- 30

zeichnet wird.

12. System nach einen der vorhergehenden Ansprüche, bei dem das Ereignis die Bewegung eines elektrischen Bogens in einer elektrischen Komponente ist, und die Anordnung der Ereignispositionen (25) eine Anordnung aus Positionen in einer Lichtbogenkammer ist. 35
13. System nach Anspruch 12, bei dem die elektrische Komponente ein Miniatur-Schaltungsunterbrecher (10) ist. 40
14. System nach Anspruch 12 oder 13, bei dem die elektrische Komponente ein durchsichtiges Fenster (15) zum Beobachten des Bewegung des elektrischen Bogens aufweist. 45
15. Verfahren zum zwei-dimensionalen Abbilden eines Ereignisses, bei dem Ereignisparameter bei einer Anordnung aus Ereignispositionen (25) mit einer Anordnung aus Sensoren (PD) abgetastet werden, wobei jeder Sensor einer entsprechenden Ereignisposition zugeordnet ist, eine Gruppe aus abgetasteten Ereignisparameterwerten, die zu jedem Ereigniszeitraum gehören, in einer Speichervorrichtung in Echtzeit aufgezeichnet werden und die Gruppe aus aufgezeichneten Ereignisparameterwerten nachfolgend abgebildet wird, mit folgenden Verfahrensschritten: 50
 - a) Identifizieren einer Gruppe aus Ereignispositionen (25), bei denen der Ereignisparameter-Abtastwert einen vorgegebenen Schwellwert überschreitet;
 - b) Identifizieren von Ereignispositionen an der Grenze eines Bereiches, welcher die Gruppe umschließt;
 - c) Reagieren auf die identifizierten Grenzereignispositionen durch Zeichnen einer Linie (C1 bis C5) um den Bereich der identifizierten Ereignispositionen mit einem Abstand zu den Punkten, welche die Zentren der identifizierten Ereignispositionen, welche auf dem Rand des Bereiches liegen, angeben, wobei die Linie einen Umriß darstellt, der die identifizierten Ereignispositionen mit einem zugeordneten Ereignisparameterwert, der den Schwellwert überschreitet, von Ereignispositionen mit einem zugeordneten Ereignisparameterwert, der kleiner ist als der Schwellwert, trennt; und
 - d) Erhöhen des vorgegebenen Schwellwertes und Wiederholen der Schritte (a), (b) und (c) für den erhöhten Schwellwert, bis eine vorgegebene Mehrzahl von Umrißlinien für entsprechende Ereignisparameter-Schwellwert erzeugt worden ist. 55

16. Verfahren nach Anspruch 15, bei dem im Schritt (c) eine Umrißlinie mit einem Abstand von der Ereignisposition gezeichnet wird, der sich für Gruppen, die höheren Schwellwerten entsprechen, vermindert, um eine Schachtelung der Umrisse vorzusehen. 5
17. Verfahren nach einem der Ansprüche 15 oder 16, bei dem ein Bereich zwischen den Umrißlinien mit entsprechenden Farben und/oder Strukturen gefüllt wird. 10
18. Verfahren nach Anspruch 17, bei dem eine Darstellung der Umgebung, welche die Ereignisposition enthält und in der das Ereignis stattfindet, angezeigt wird, und die Umrißlinien der Darstellung überlagert werden. 15
19. Verfahren nach einem der Ansprüche 15 bis 18, bei dem der Ereignisparameter ein Luminanzwert ist und bei dem jeder Sensor ein Photoelement (PD) und eine Polymer-Lichtfaser (12) zum Leiten des Lichtes von einer Ereignisposition (25) zu dem Photoelement aufweist, mit den weiteren Verfahrensschritten: Lokalisieren eines Positionierblocks (13), der eine Anordnung aus Löchern (11) eingrenzt, so daß jedes Loch zu einer entsprechenden Ereignisposition ausgerichtet ist, und verschiebbares Einbringen jeder Polymer-Lichtfaser (12) in ein entsprechendes Loch, um eine gewünschte Reaktion auf einen gewünschten Bereich, der die Ereignisposition umgibt, zu erzeugen. 20 25 30
20. Verfahren nach Anspruch 19, bei dem jedes erfaßtes Luminanzsignal verstärkt wird, Signale von mehreren Sensoren im Multiplexverfahren an einen Hochgeschwindigkeits-Analog-Digital-Wandler weitergegeben werden, um aufeinander erfolgende Signale in digitale Werte umzuwandeln, und die von dem Analog-Digital-Wandler ausgehenden aufeinanderfolgende digitalen Werte in entsprechende Positionen in der Speichervorrichtung geschrieben werden. 35 40
21. Verfahren nach Anspruch 20, bei dem die Multiplexvorrichtung (16), der Analog-Digital-Wandler (A/D) und der Schreibbetrieb der Speichervorrichtung (20) von einem gemeinsamen Systemtakt (32) gesteuert werden, so daß ein Ereignisparameter-Abtastwert pro Taktzyklus in der Speichervorrichtung aufgezeichnet wird. 45 50
22. Verfahren nach einem der Ansprüche 15 bis 21, bei dem das Ereignis die Bewegung eines elektrischen Bogens in einer elektrischen Komponente ist. 55
23. Verfahren nach Anspruch 22, bei dem die elektrische Komponente ein Miniatur-Schaltkreisunter-

brecher (10) ist.

24. Verfahren nach Anspruch 22 oder 23, bei dem die elektrische Komponente mit einem transparenten Fenster (15) versehen wird, um die Bewegung des elektrischen Bogens zu beobachten.

Revendications

1. Système d'imagerie pour la mise en image bidimensionnelle d'un événement, ledit système d'imagerie comprenant un réseau de détecteurs (PD) pour l'échantillonnage des paramètres d'un événement à un réseau de positions de l'événement (25), chaque détecteur (PD) étant sensible à un paramètre de l'événement au niveau d'une position respective de l'événement, le système comprenant en outre des moyens de mémorisation (20) pour enregistrer les paramètres échantillonnés de l'événement et des premiers moyens (S1) sensibles aux valeurs des paramètres de l'événement enregistré, pour identifier une collection de groupes de positions de l'événement, chaque position de l'événement à l'intérieur des groupes ainsi identifiés ayant une valeur de paramètre de l'événement dépassant une valeur de paramètre de l'événement dépassant une valeur de seuil prédéterminée des paramètres de l'événement, caractérisé par la fourniture de

a) des second moyens (S2) pour l'identification, pour chaque groupe de positions de l'événement (25), de positions de l'événement à la frontière d'une zone entourant le groupe, et

b) des troisième moyens (S3) sensibles aux positions identifiées de l'événement de la frontière à tracer, pour chaque groupe, à une distance des points indicatifs des centres des positions identifiées de l'événement se trouvant au bord de la zone, une ligne autour de la zone des positions identifiées représentant un contour séparant les positions identifiées de l'événement avec une valeur de paramètre de l'événement associée dépassant la valeur de seuil de celles des positions de l'événement avec une valeur de paramètre de l'événement associée inférieure à la valeur de seuil.

2. Système tel que revendiqué dans la revendication 1, dans lequel les troisième moyens (S3) tracent des lignes de contour (C1 à C5) à une distance de la position de l'événement (25) qui se réduit pour des groupes représentatifs de valeurs supérieures au seuil pour fournir une imbrication des contours.
3. Système tel que revendiqué dans l'une quelconque des revendications précédentes, comportant des moyens d'affichage pour visualiser l'(les)image(s)

de l'événement incluant les lignes de contour (C1 à C5) pour des valeurs de seuil respectives des paramètres de l'événement.

4. Système tel que revendiqué dans la revendication 3, comportant des moyens de remplissage de zone entre des lignes de contour avec des couleurs et/ou des textures respectives. 5
5. Système tel que revendiqué dans la revendication 3 ou la revendication 4, comportant des moyens pour la superposition des lignes de contour sur une représentation de l'environnement, incluant les positions de l'événement, dans lequel l'événement se passe. 10
6. Système tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel le paramètre de l'événement est une valeur de luminance et dans lequel chaque détecteur comporte un élément photosensible (PD) et une fibre optique polymère (12) pour le guidage de la lumière depuis une position de l'événement jusqu'à l'élément photosensible. 20
7. Système tel que revendiqué dans la revendication 6, comportant un bloc de positionnement (13) définissant un réseau de trous (11) avec chaque trou aligné, en fonctionnement, avec une position respective de l'événement, et avec chaque fibre optique polymère (12) disposée dans un trou respectif, les fibres optiques polymères formant un arrangement à friction à l'intérieur des trous, de telle sorte que la position des fibres optiques soit ajustable par glissement le long des trous (11). 25 30 35
8. Système tel que revendiqué dans la revendication 6 ou la revendication 7, dans lequel l'élément photosensible comporte une photodiode (PD) actionnée en configuration de polarisation inverse par laquelle un courant traversant la photodiode proportionnellement à l'intensité lumineuse engendre une tension aux bornes d'une résistance de charge (Rb). 40
9. Système tel que revendiqué dans l'une quelconque des revendications 6, 7 ou 8, dans lequel chaque détecteur (PD) comporte un amplificateur (A) pour l'amplification du signal de luminance détecté et dans lequel le système comporte des moyens de multiplexage (16) pour multiplexer les signaux en provenance d'une pluralité de détecteurs, des moyens de conversion analogique/numérique d'éclairs (A/D) reliés aux moyens de multiplexage pour la conversion de signaux successifs en provenance des moyens de multiplexage en valeurs numériques, des valeurs numériques successives délivrées en sortie des moyens de conversion analogique/numérique étant écrites en des positions respectives dans les moyens de mémorisation (20). 45 50 55

gique/numérique étant écrites en des positions respectives dans les moyens de mémorisation (20).

10. Système tel que revendiqué dans la revendication 9, dans lequel les moyens de multiplexage, les moyens de conversion analogique/numérique et les opérations d'écriture pour les moyens de mémorisation sont commandés par un système commun d'horloge (32) avec une valeur d'échantillon du paramètre de l'événement qui est emmagasinée dans les moyens de mémorisation (20) par cycle de l'horloge.
11. Système tel que revendiqué dans l'une quelconque des revendications précédentes, pour un événement pour lequel les valeurs du paramètre de l'événement changent avec le temps, dans lequel les valeurs du paramètre de l'événement pour la pluralité des positions de l'événement sont échantillonnées à des instants successifs de l'événement, un ensemble d'échantillons du paramètre de l'événement étant enregistré pour chaque instant de l'événement.
12. Système tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel l'événement est le déplacement d'un arc électrique dans un composant électrique, le réseau de positions de l'événement (25) étant un réseau de positions dans une chambre à arc.
13. Système tel que revendiqué dans la revendication 12, dans lequel le composant électrique est un coupe-circuit miniature (10).
14. Système tel que revendiqué dans la revendication 12 ou la revendication 13, dans lequel le composant électrique est pourvu d'une fenêtre transparente (15) pour la visée du déplacement de l'arc électrique.
15. Procédé de mise en image bidimensionnelle d'un événement comprenant l'échantillonnage de paramètres de l'événement à un réseau de positions de l'événement (25) utilisant un réseau de détecteurs (PD), chaque détecteur étant associé à une position respective de l'événement, l'enregistrement d'un ensemble de valeurs échantillonnées de paramètres de l'événement associé à chaque instant de l'événement en temps réel dans des moyens de mémorisation et ultérieurement la mise en image de l'ensemble des valeurs de paramètres de l'événement enregistrées, ladite méthode comprenant les étapes de
 - a) identification d'un groupe de positions de l'événement (25) pour lequel la valeur d'échantillonnage de paramètres de l'événement dé-

- passe une valeur de seuil prédéterminée ;
 b) identification des positions de l'événement au niveau de la frontière d'une zone entourant le groupe ;
 c) réaction à l'encontre des positions identifiées de l'événement de frontière pour tracer, à une distance des points indicatifs des centres des positions identifiées de l'événement se trouvant sur le bord de la zone, une ligne (C1 à C5) autour de la zone des positions identifiées de l'événement, ladite ligne représentant un contour séparant les positions identifiées de l'événement avec une valeur de paramètre de l'événement associée dépassant la valeur de seuil de celles des positions de l'événement avec une valeur de paramètre de l'événement associée inférieure à la valeur de seuil ; et
 d) accroissement du seuil prédéterminé et répétition des étapes (a), (b) et (c) pour le seuil augmenté jusqu'à ce qu'une pluralité prédéterminée de lignes de contour pour les valeurs de seuil de paramètre de l'événement respectives ait été engendrée.
- 16.** Procédé tel que revendiqué dans la revendication 15, dans lequel, dans l'étape (c), une ligné de contour est tracée à une distance de la position de l'événement qui décroît pour des groupes représentatifs de valeurs supérieures au seuil pour fournir l'imbrication des contours.
- 17.** Procédé tel que revendiqué dans les revendications 15 ou 16, comportant l'étape de remplissage de zone entre des lignes de contour avec des couleurs et/ou des textures respectives.
- 18.** Procédé tel que revendiqué dans la revendication 17, comportant l'affichage d'une représentation de l'environnement, incluant les positions de l'événement, dans lequel l'événement se passe et la superposition des lignes de contour sur la représentation.
- 19.** Procédé tel que revendiqué dans l'une quelconque des revendications 15 à 18, dans lequel le paramètre de l'événement est une valeur de luminance et dans lequel chaque détecteur comporte un élément photosensible (PD) et une fibre optique polymère (12) pour le guidage de la lumière depuis une position de l'événement (15) jusqu'à l'élément photosensible : ledit procédé comprenant les étapes de localisation d'un bloc de positionnement (13) qui définit un réseau de trous (11) tel que chaque trou soit aligné avec une position de l'événement respective, localisant par glissement chaque fibre optique polymère (12) le long d'un trou respectif pour donner une réponse voulue à une zone voulue entourant la position de l'événement.
- 20.** Procédé tel que revendiqué dans la revendication 19, comportant l'amplification de chaque signal de luminance détecté, le multiplexage des signaux à partir d'une pluralité de détecteurs jusqu'à un convertisseur analogique/numérique d'éclairs en vue de la conversion des signaux successifs en valeurs numériques, et l'écriture des valeurs numériques successives délivrées depuis les moyens de conversion analogique/numérique jusqu'aux positions respectives dans les moyens de mémorisation.
- 21.** Procédé tel que revendiqué dans la revendication 20, comportant la commande des moyens de multiplexage (16), des moyens de conversion analogique/numérique (A/D) et des opérations d'écriture pour les moyens de mémorisation (20) par un système commun d'horloge (32) tel qu'un échantillon de paramètre de l'événement soit emmagasiné dans les moyens de mémorisation par cycle de l'horloge.
- 22.** Procédé tel que revendiqué dans l'une quelconque des revendications 15 à 21, dans lequel l'événement est le déplacement d'un arc électrique dans un composant électrique.
- 23.** Procédé tel que revendiqué dans la revendication 22, dans lequel le composant électrique est un coupe-circuit miniature (10).
- 24.** Procédé tel que revendiqué dans la revendication 22 ou la revendication 23, comportant l'étape consistant à pourvoir le composant électrique d'une fenêtre transparente (15) pour la visée du déplacement de l'arc électrique.

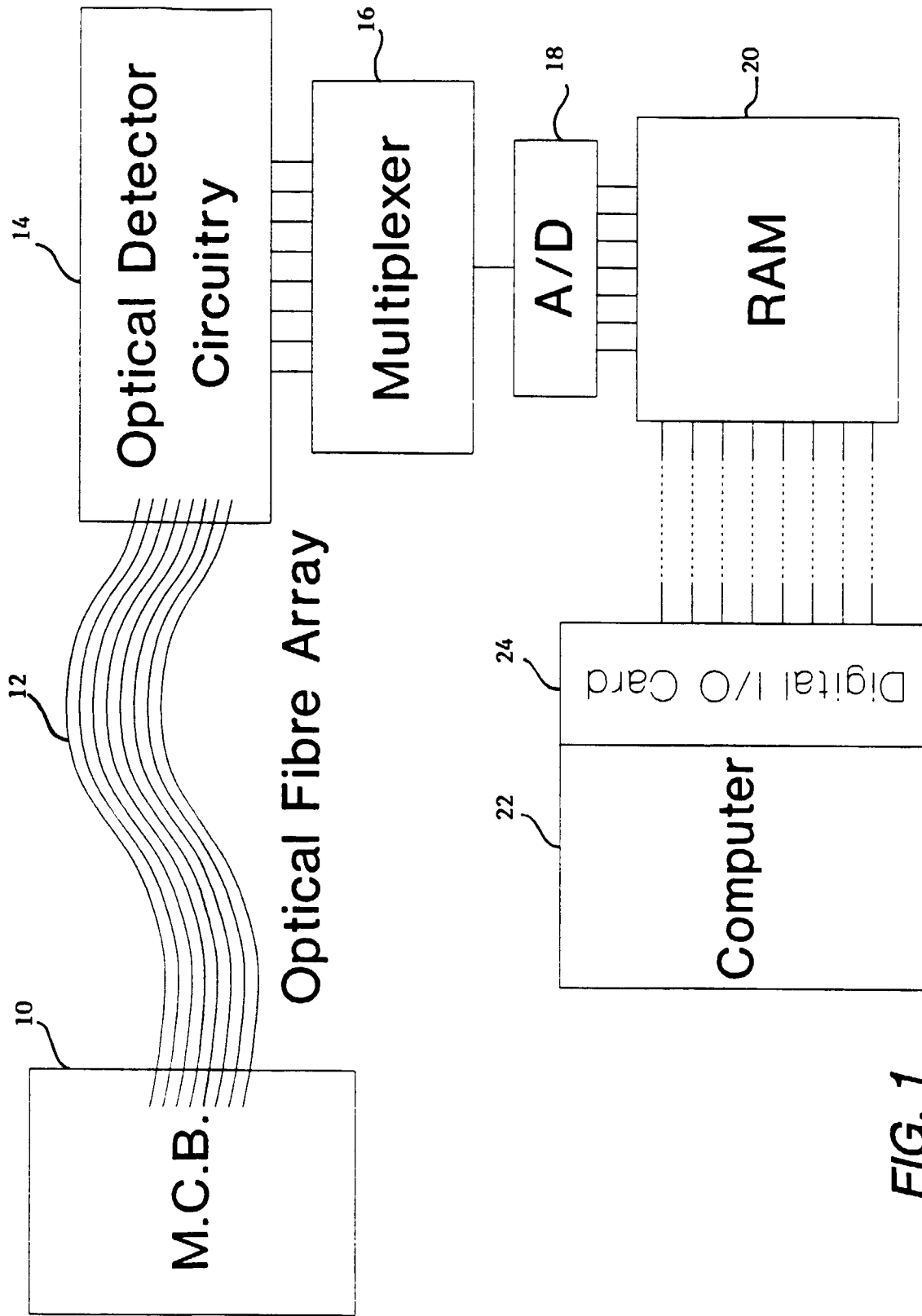
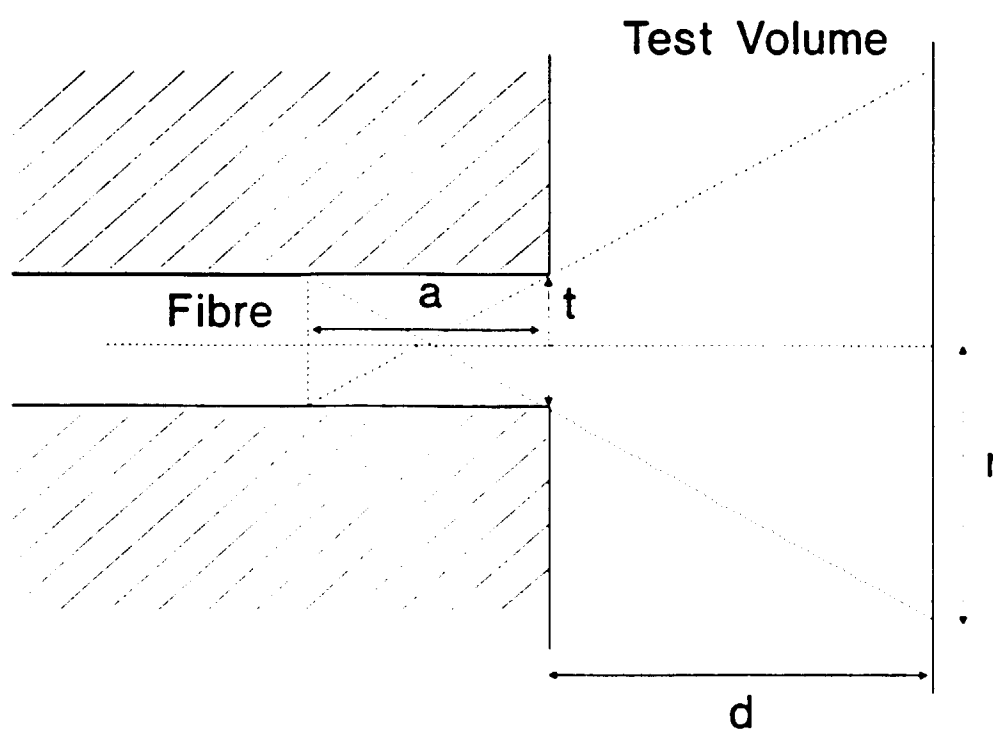
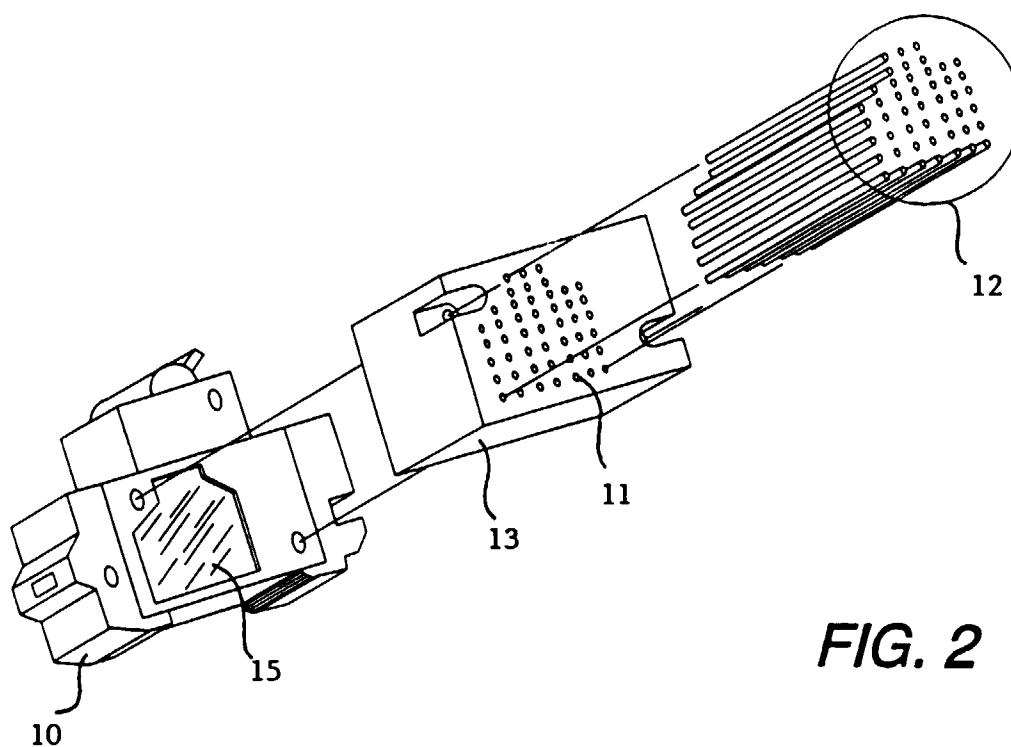


FIG. 1



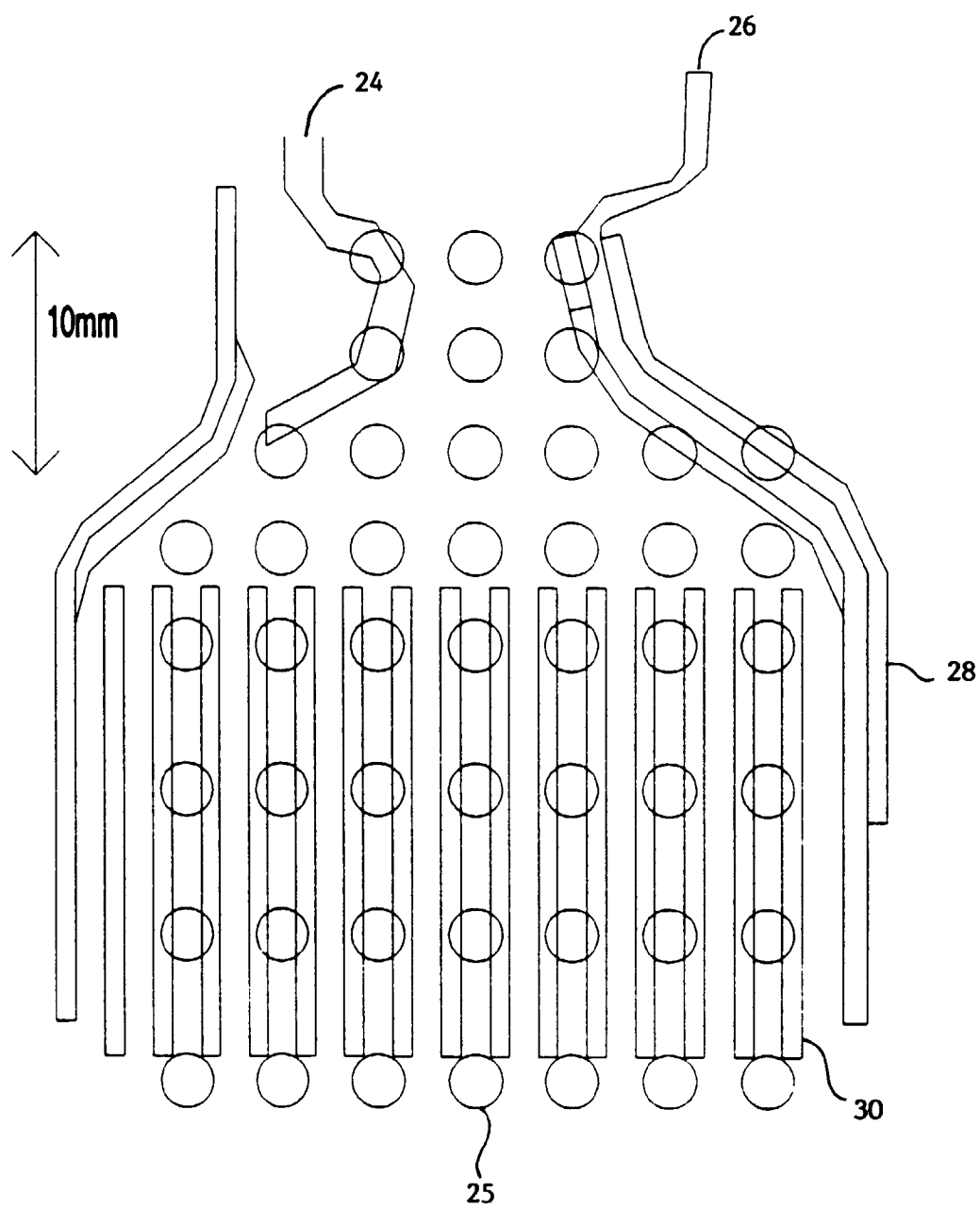


FIG. 4

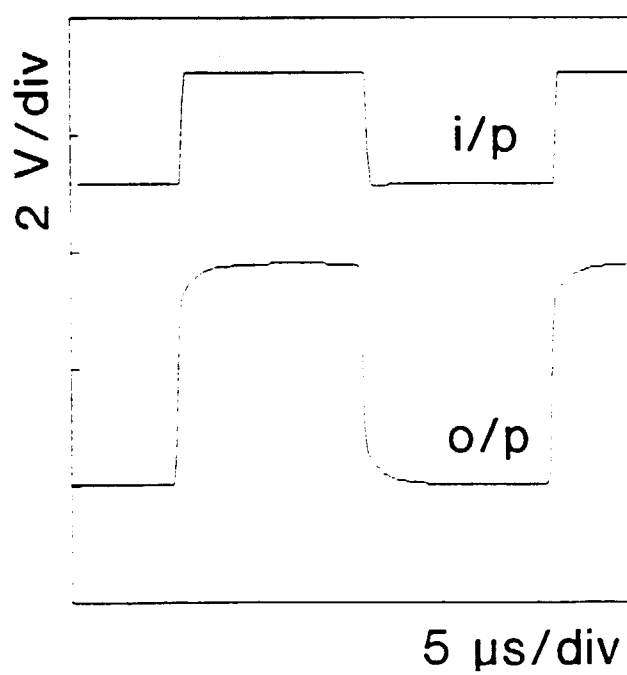
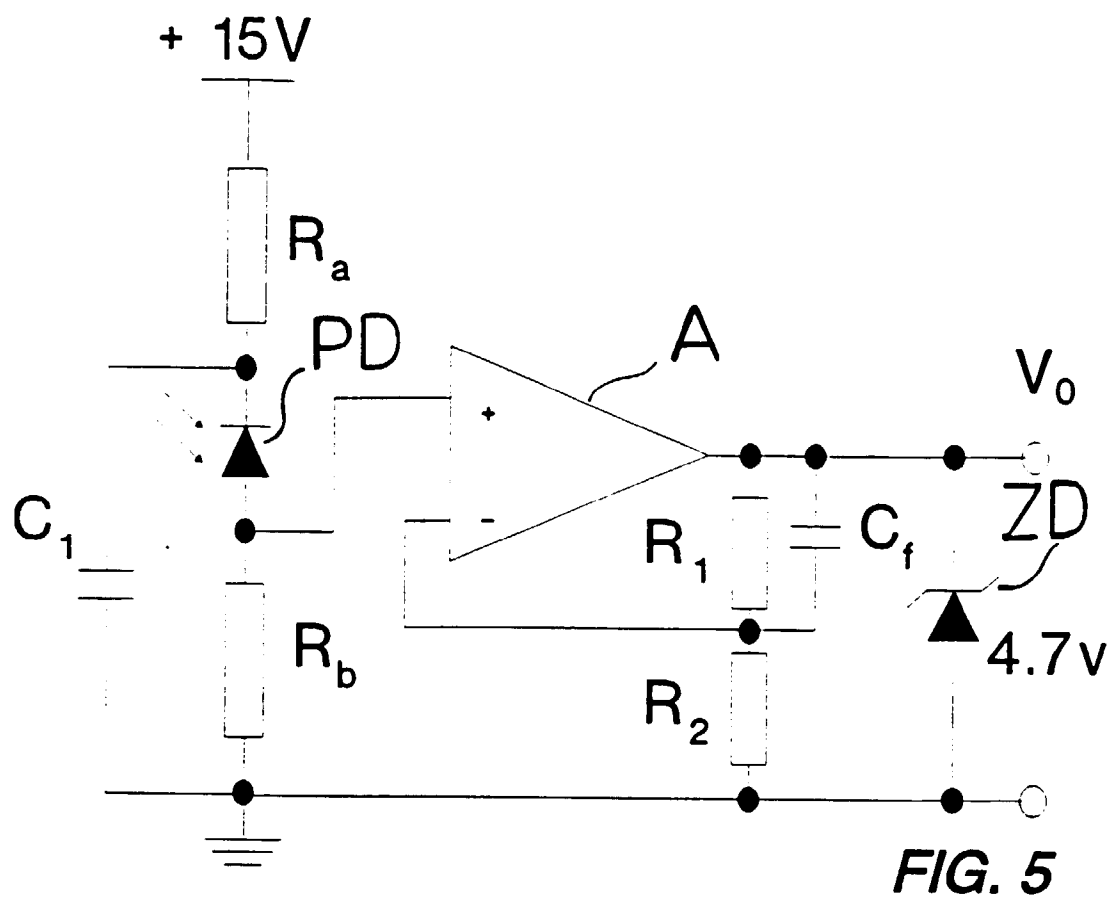


FIG. 6

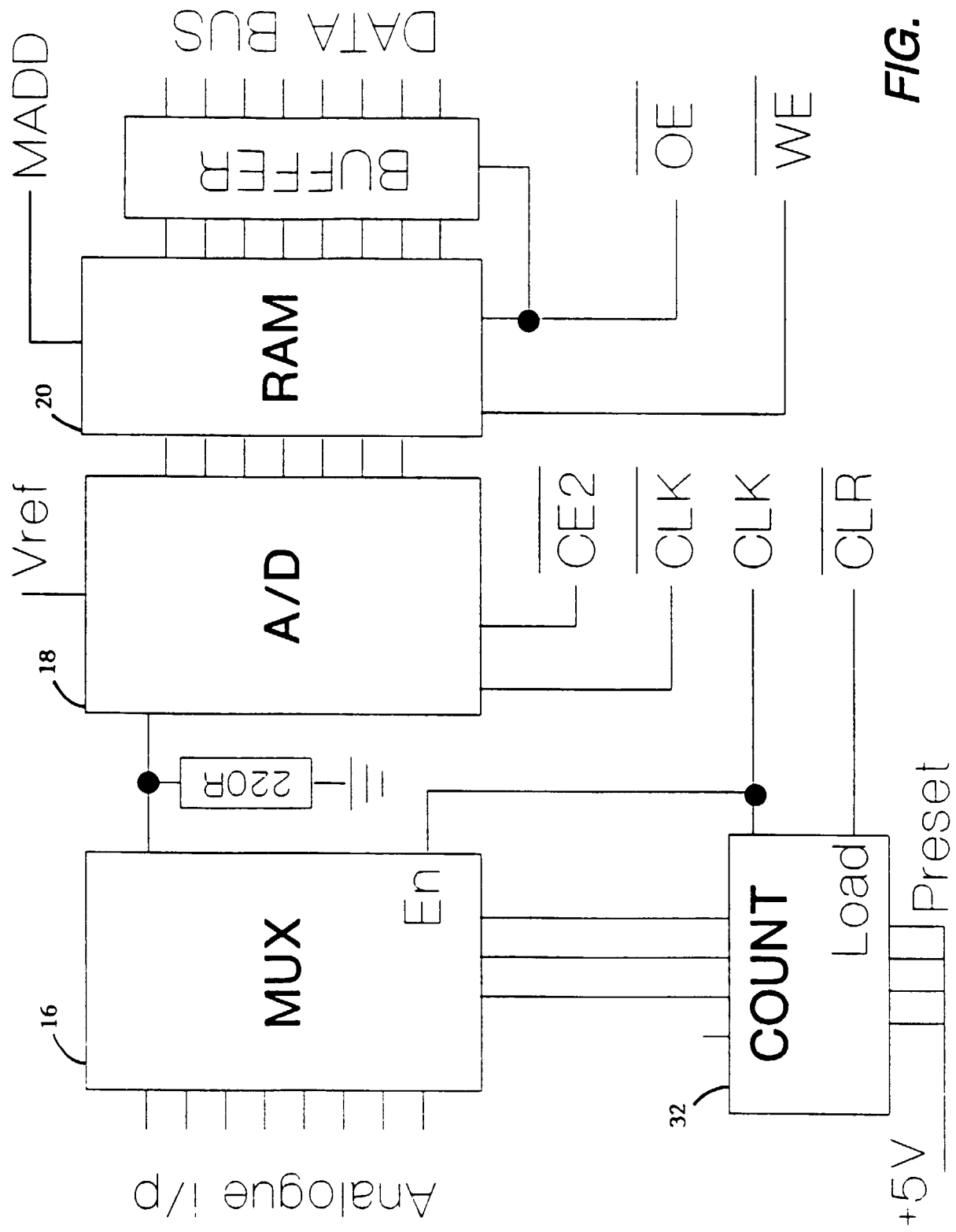
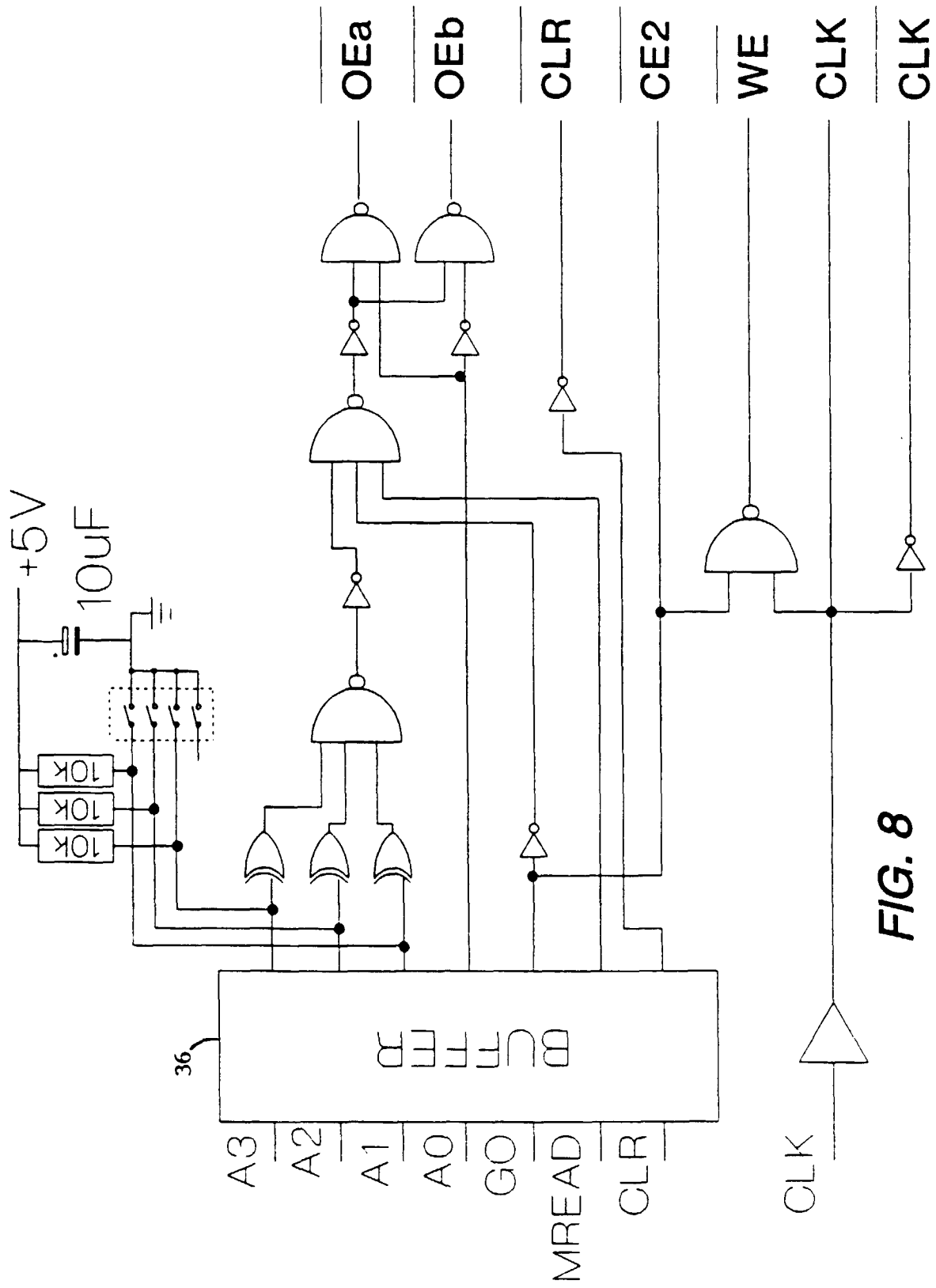


FIG. 7



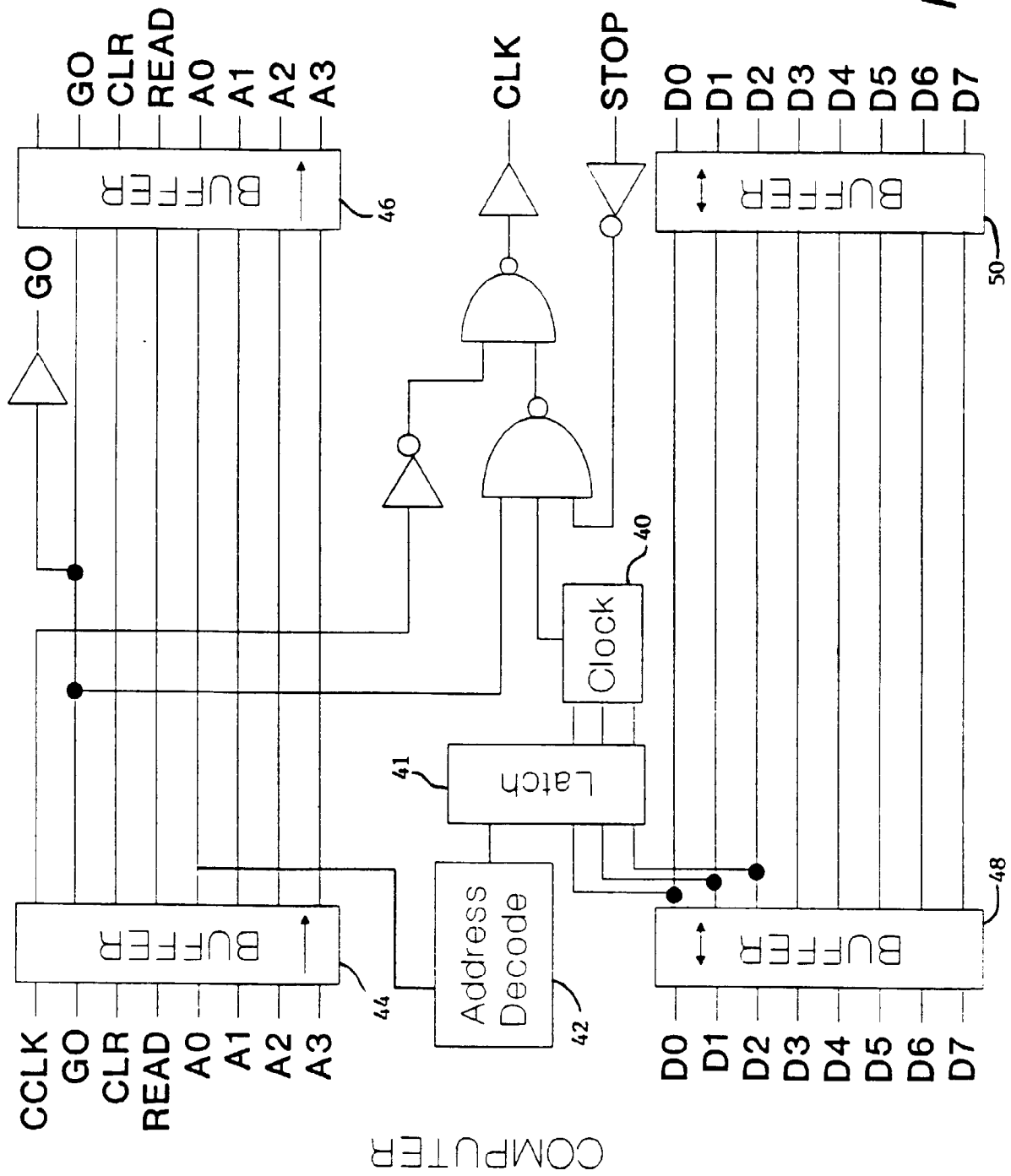
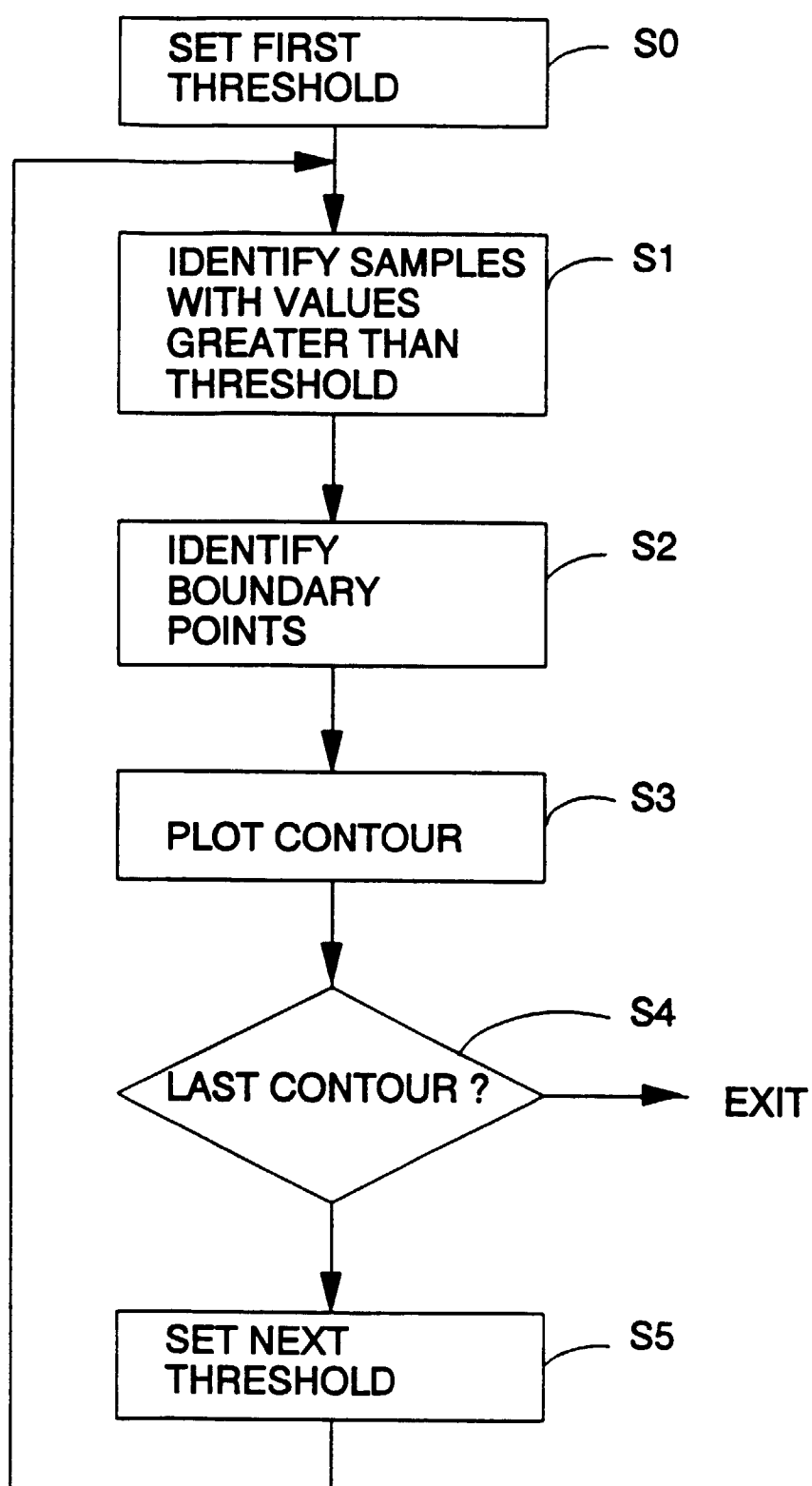
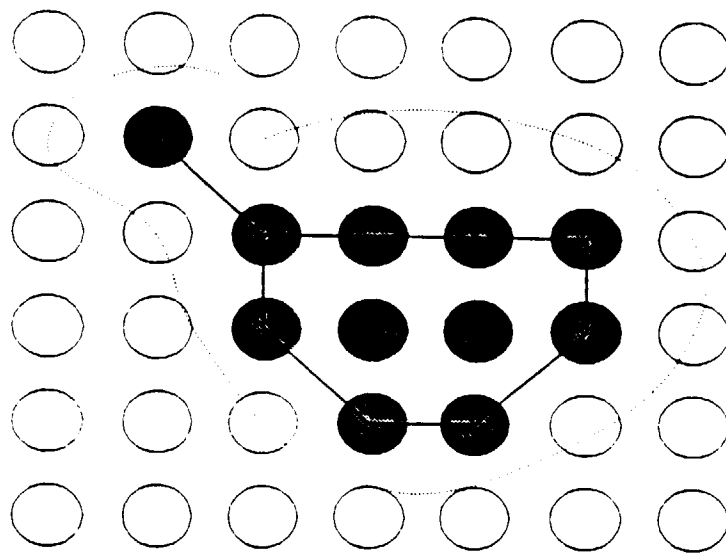


FIG. 9

*FIG. 10*



— Line joining boundary points

..... Contour line

FIG. 11

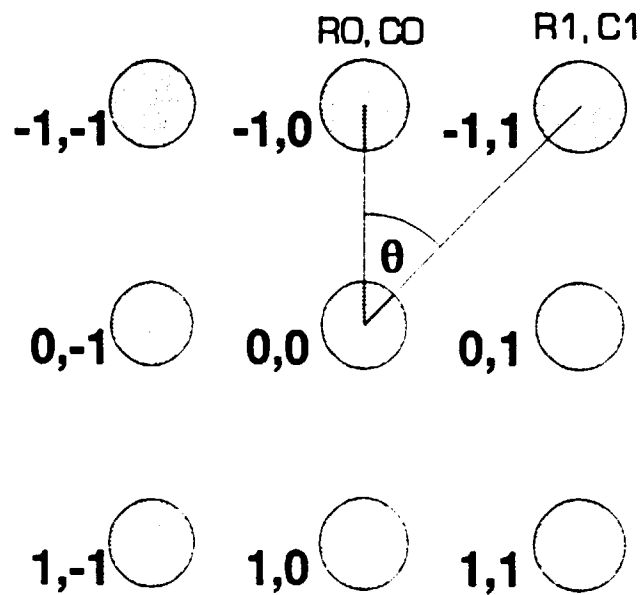


FIG. 12

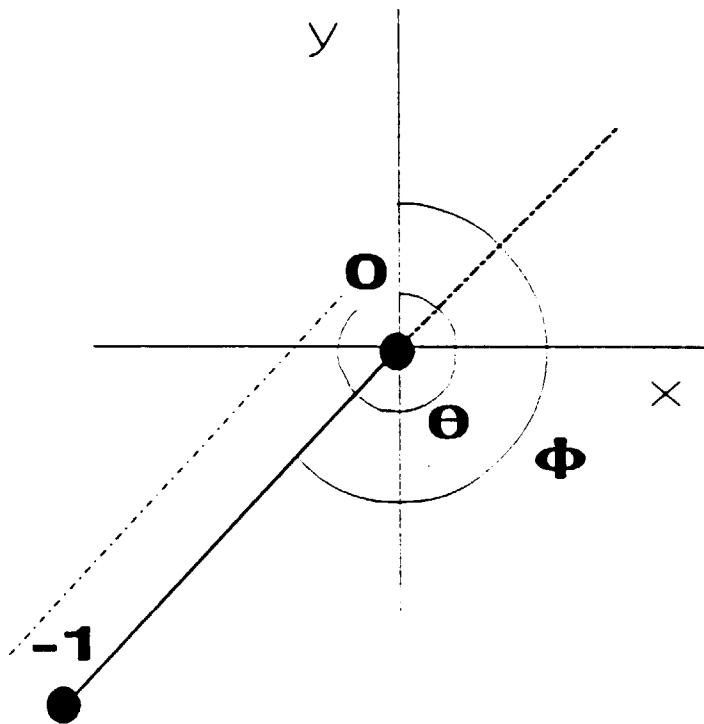
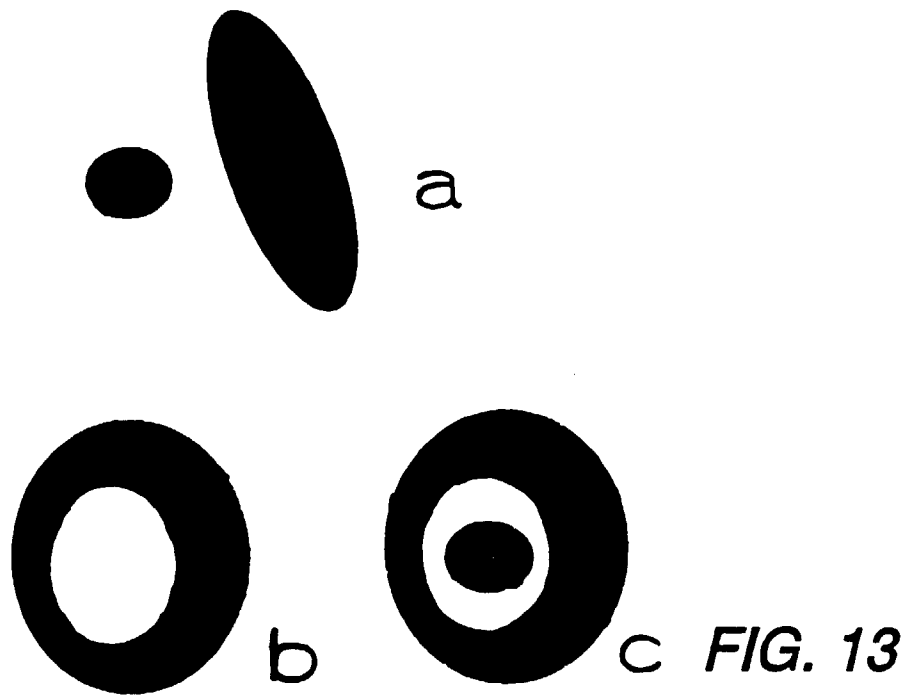


FIG. 14

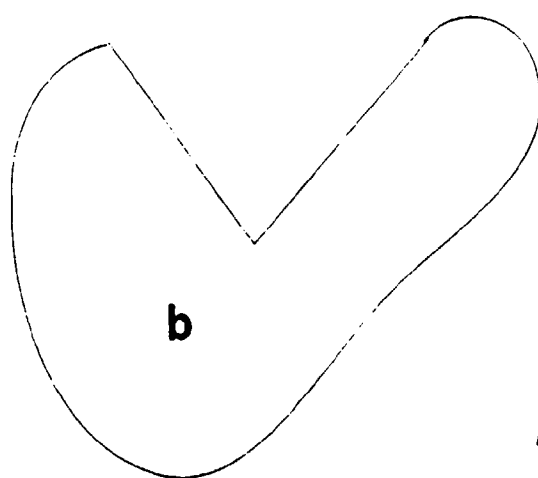
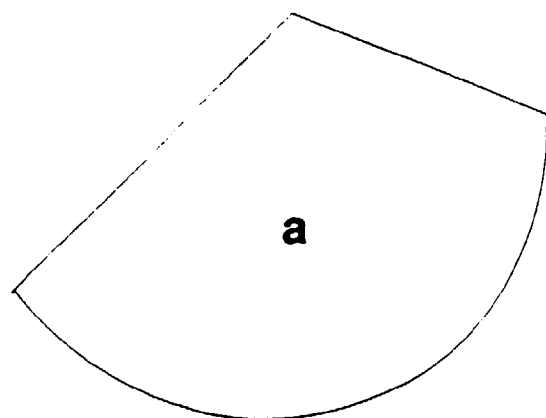


FIG. 15

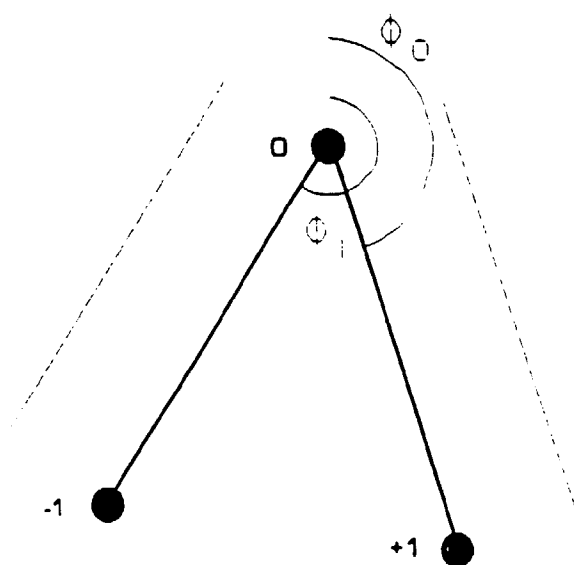


FIG. 16

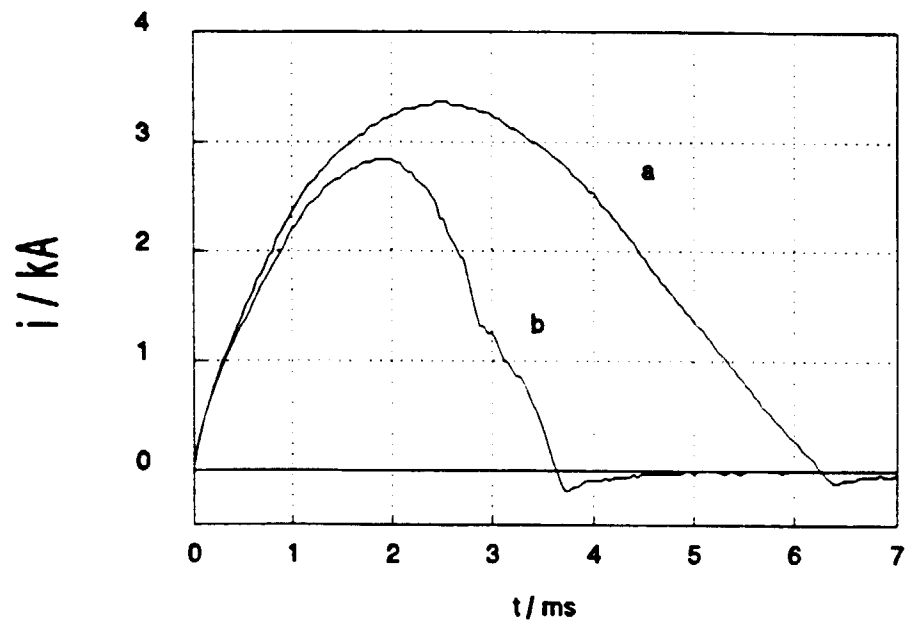


FIG. 17

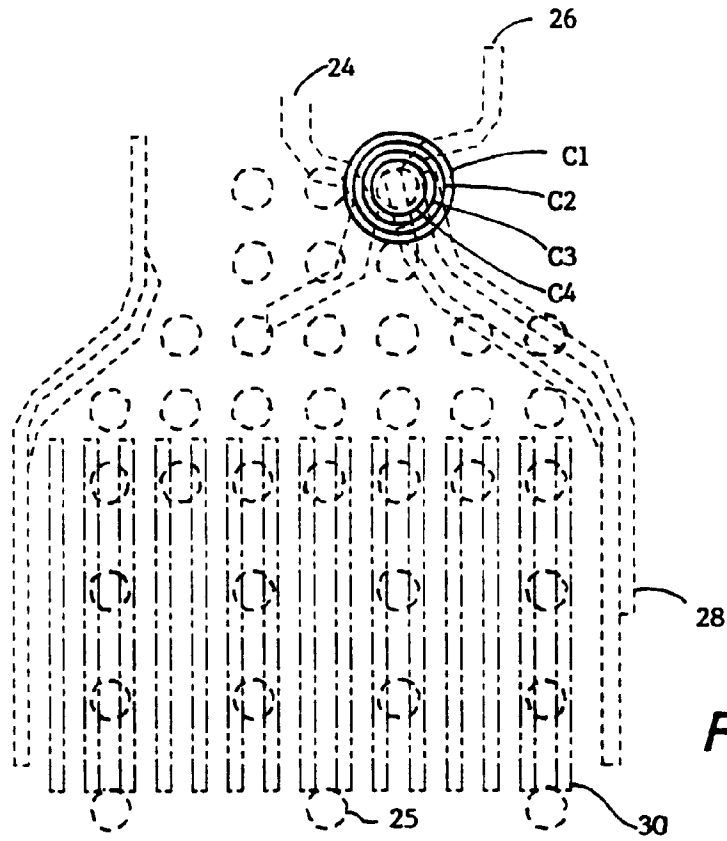


FIG. 18A

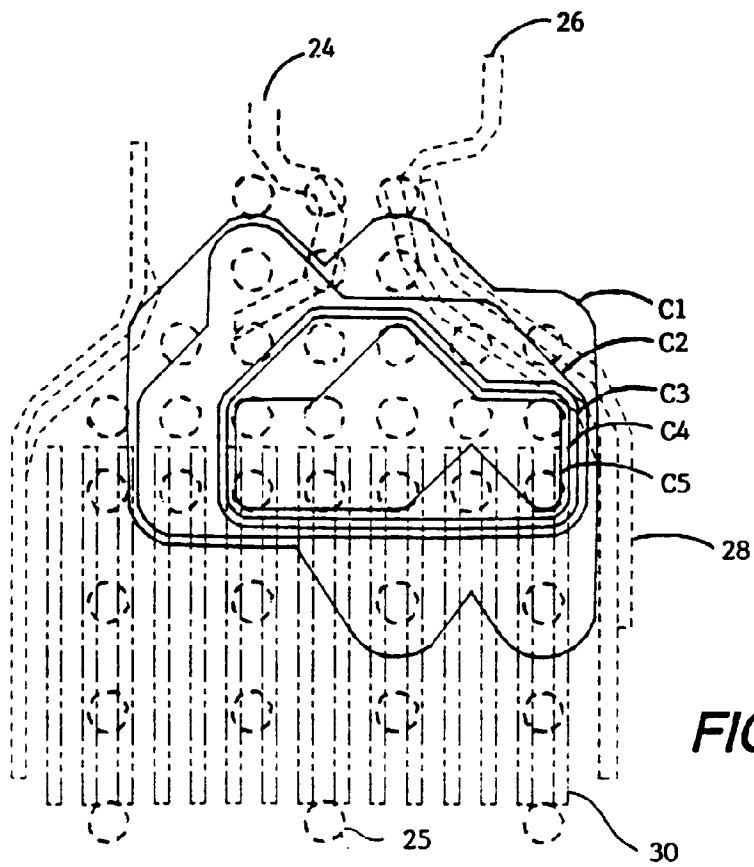


FIG. 18B