

(12) **United States Patent**
Hodge

(10) **Patent No.:** **US 7,207,566 B2**
(45) **Date of Patent:** **Apr. 24, 2007**

(54) **METHOD AND APPARATUS FOR DETERMINING AND RETRIEVING POSITIONAL INFORMATION**

(51) **Int. Cl.**
F41J 5/00 (2006.01)
F41J 5/04 (2006.01)

(76) Inventor: **Bruce Hodge**, P.O. Box 428,
Greenfield, NY (US) 12833

(52) **U.S. Cl.** **273/371**
(58) **Field of Classification Search** None
See application file for complete search history.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 115 days.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,727,069 A 4/1973 Crittenden, Jr. et al.
5,516,113 A 5/1996 Hodge

(21) Appl. No.: **11/054,670**

Primary Examiner—Mark Sager

(22) Filed: **Feb. 9, 2005**

(74) *Attorney, Agent, or Firm*—Baker & McKenzie LLP

(65) **Prior Publication Data**

US 2006/0076736 A1 Apr. 13, 2006

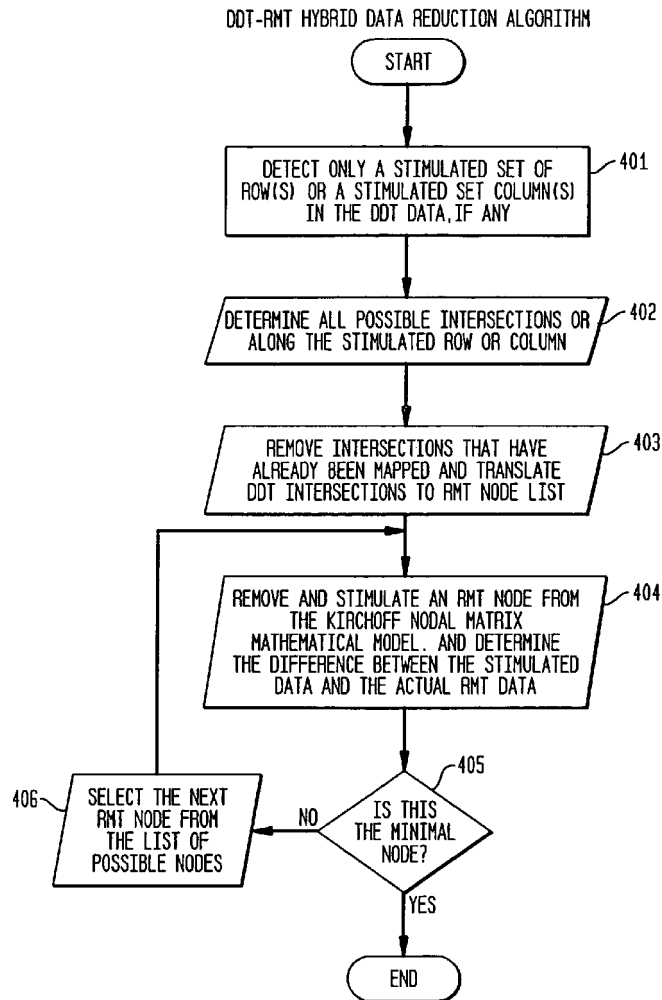
(57) **ABSTRACT**

Related U.S. Application Data

(60) Provisional application No. 60/543,342, filed on Feb. 10, 2004, provisional application No. 60/636,479, filed on Dec. 16, 2004.

A force-bearing object or non-penetrating projectile's contact location can be determined and mapped by a computer using methods of pressure, penetration, or stress sensitivity.

42 Claims, 18 Drawing Sheets



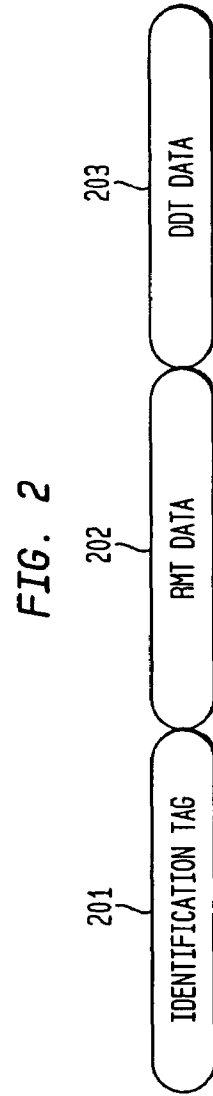
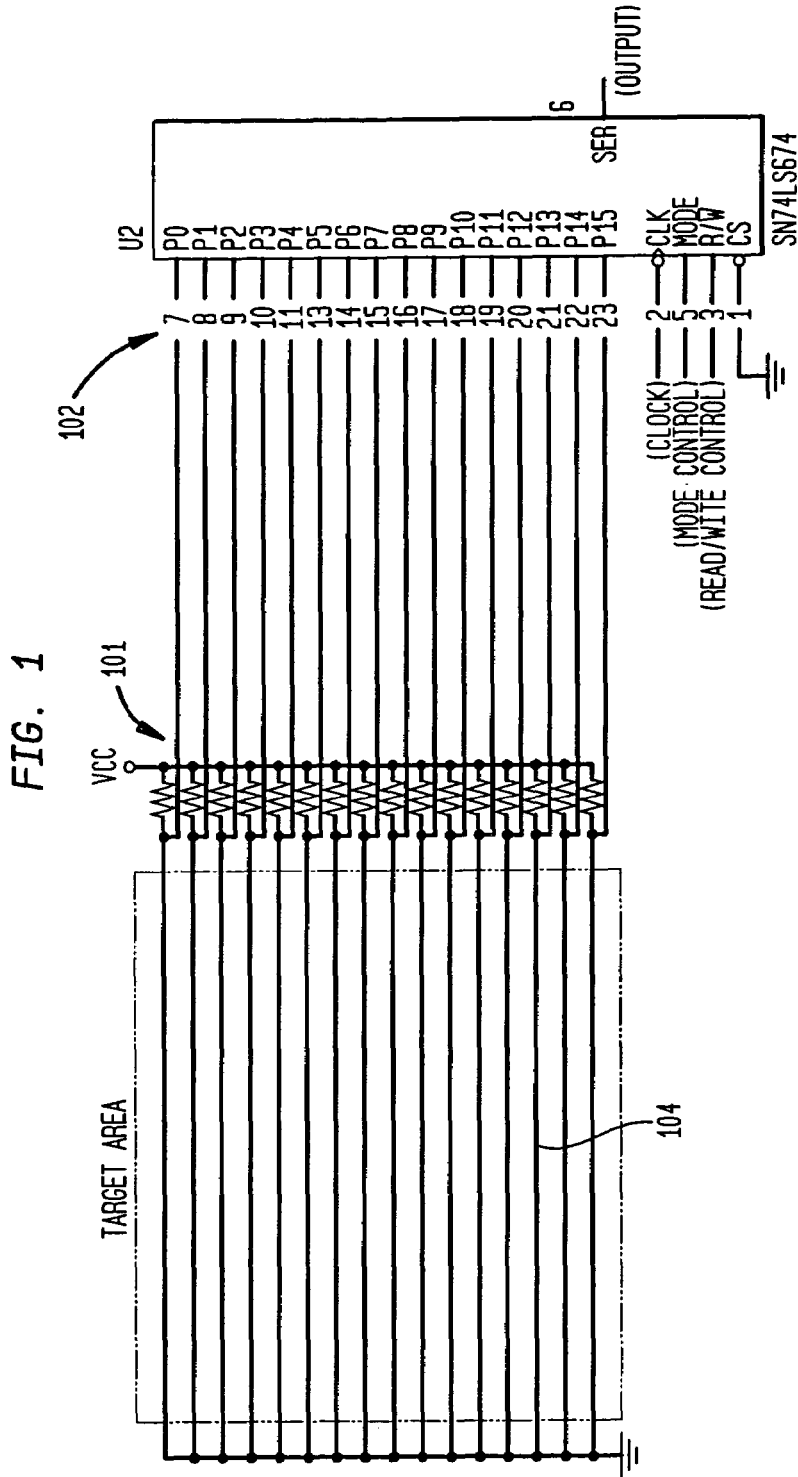


FIG. 3

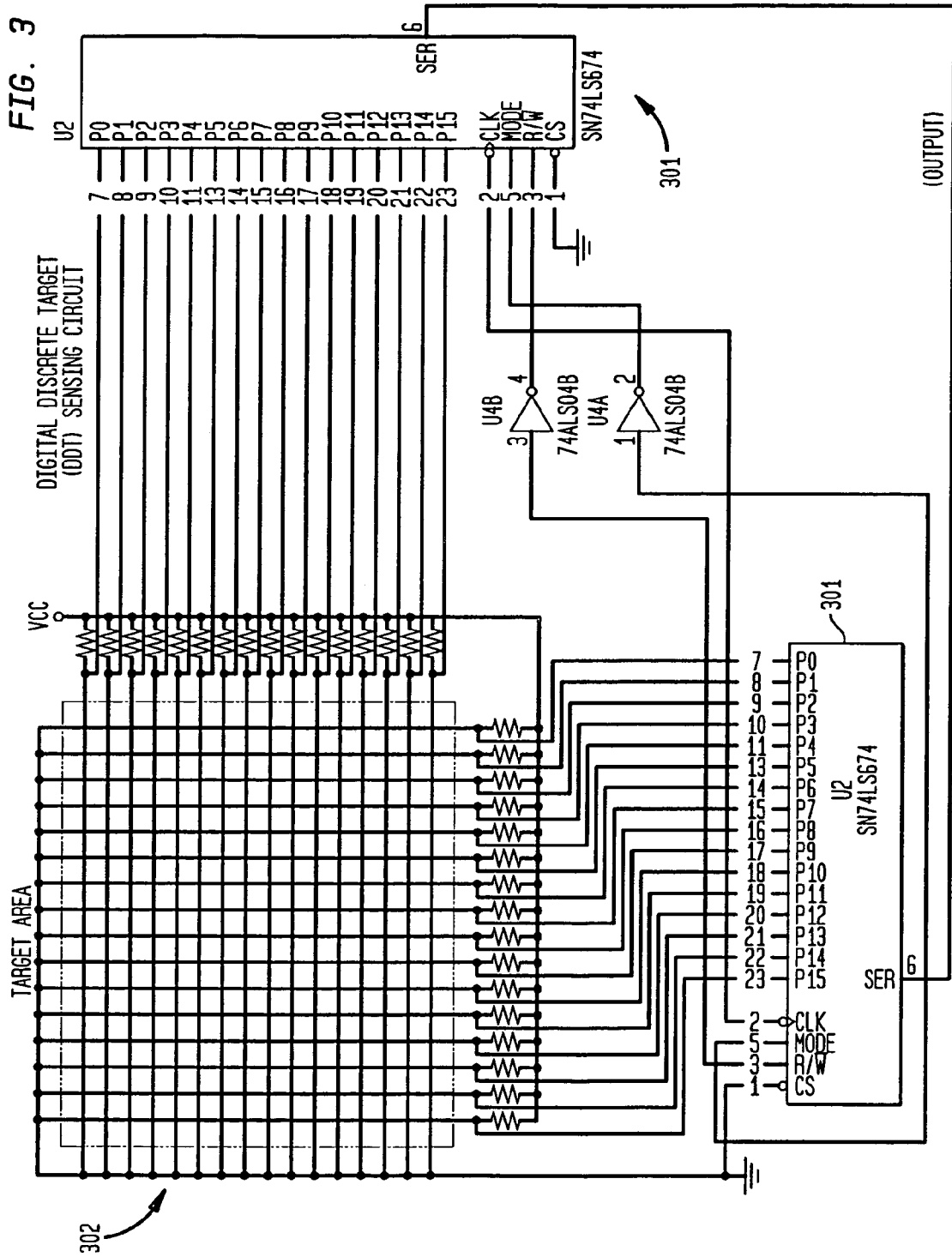


FIG. 4

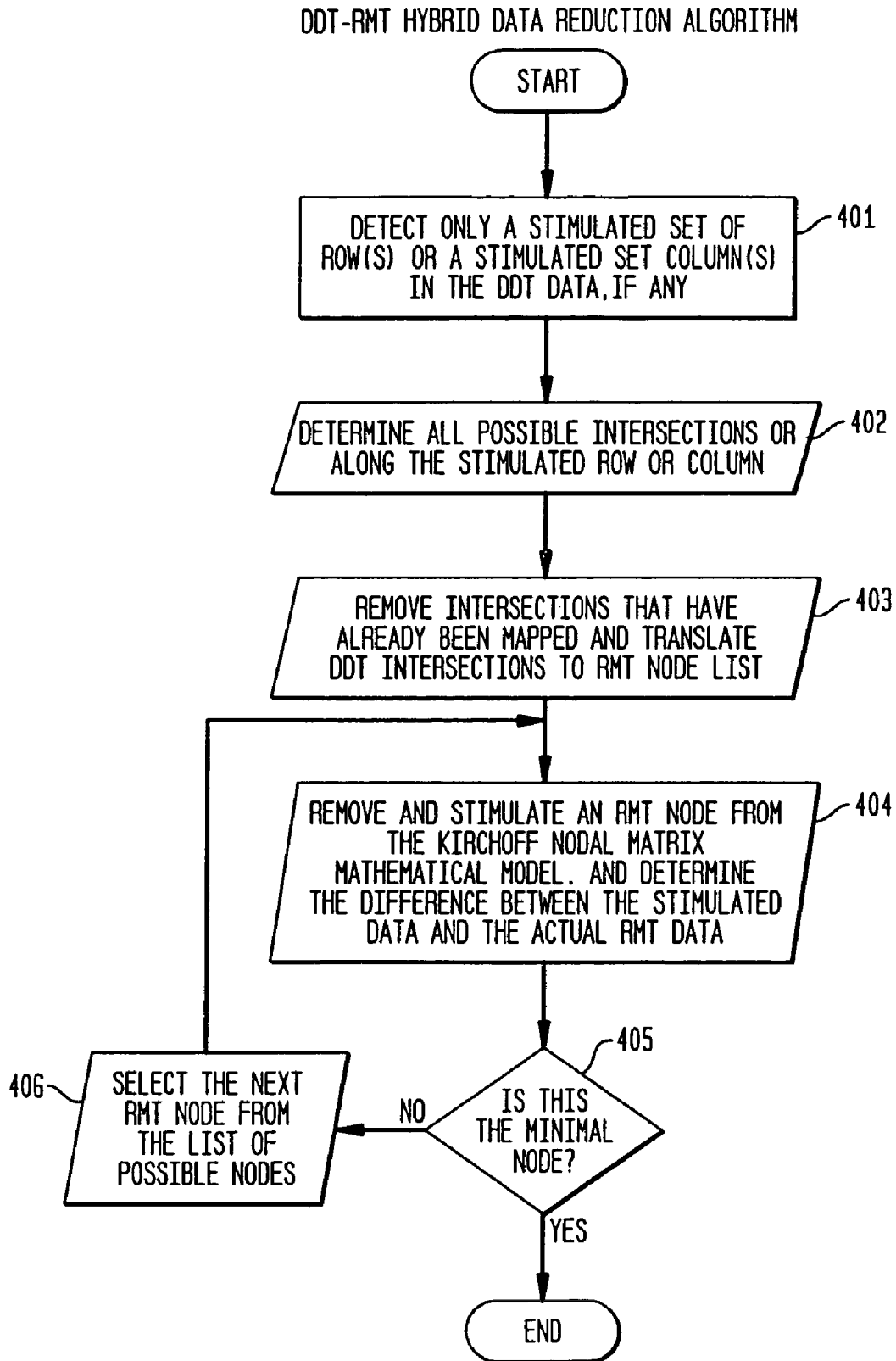


FIG. 5

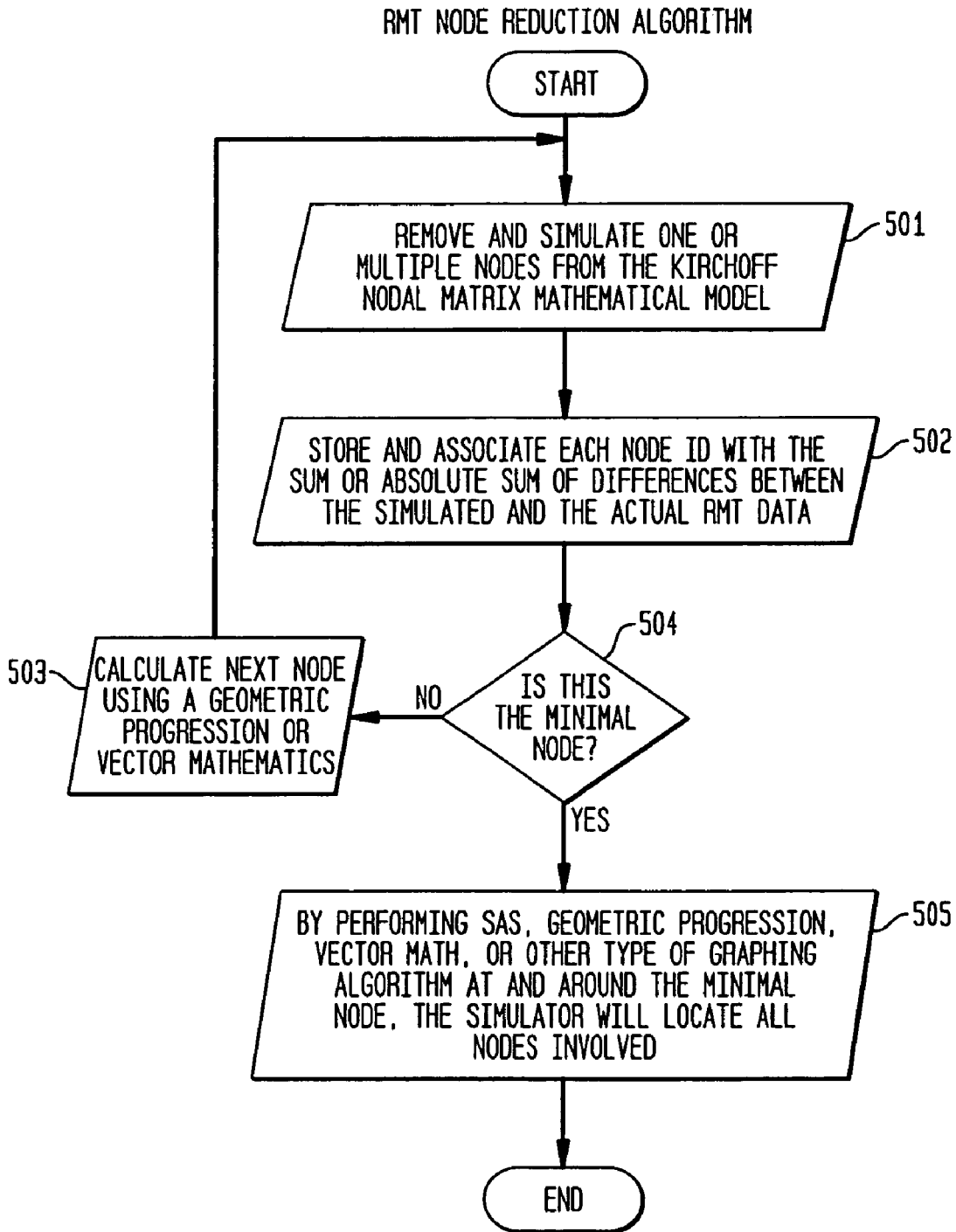


FIG. 6

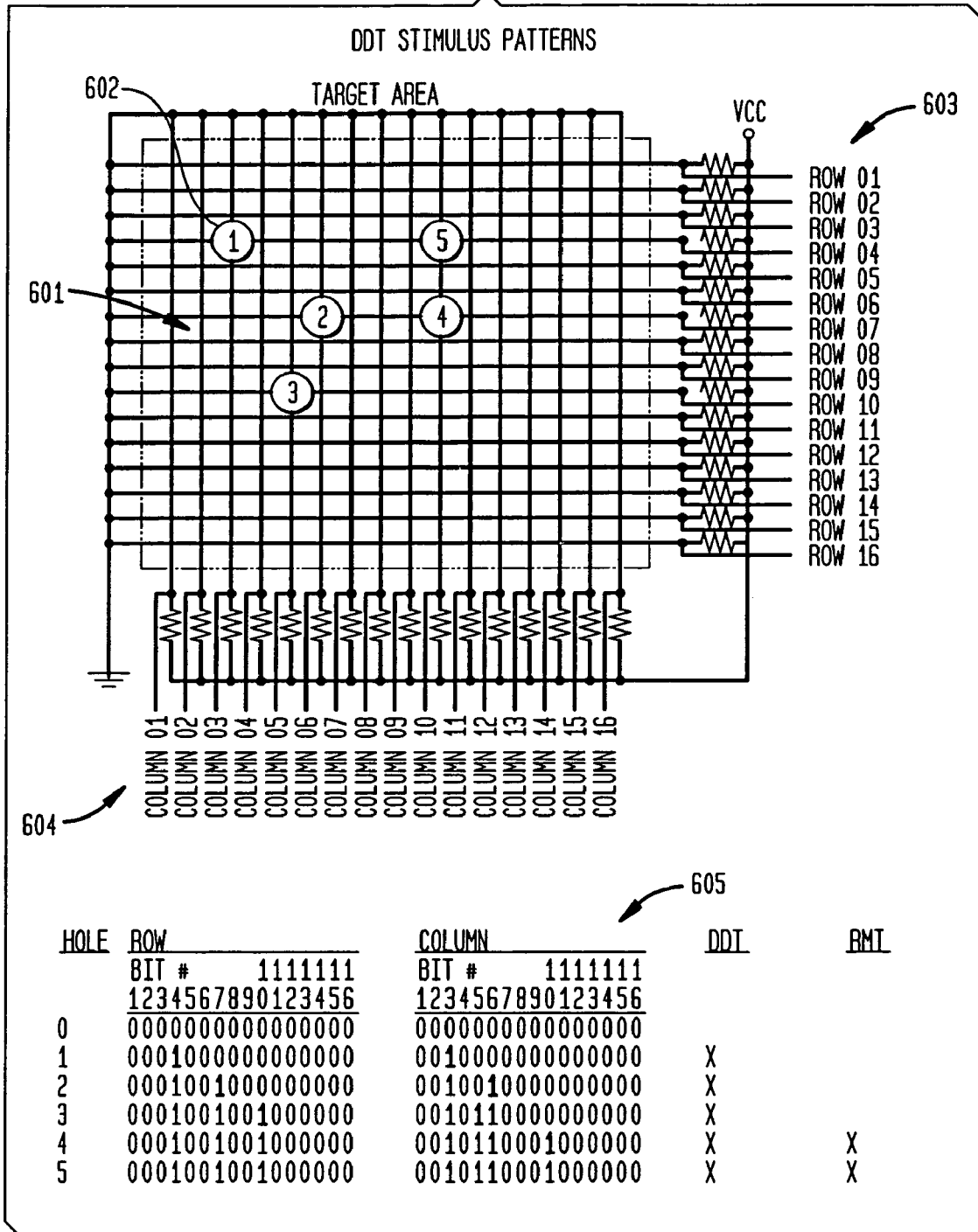


FIG. 7
TARGET SHIP WITH TOMAHAWK MISSILE

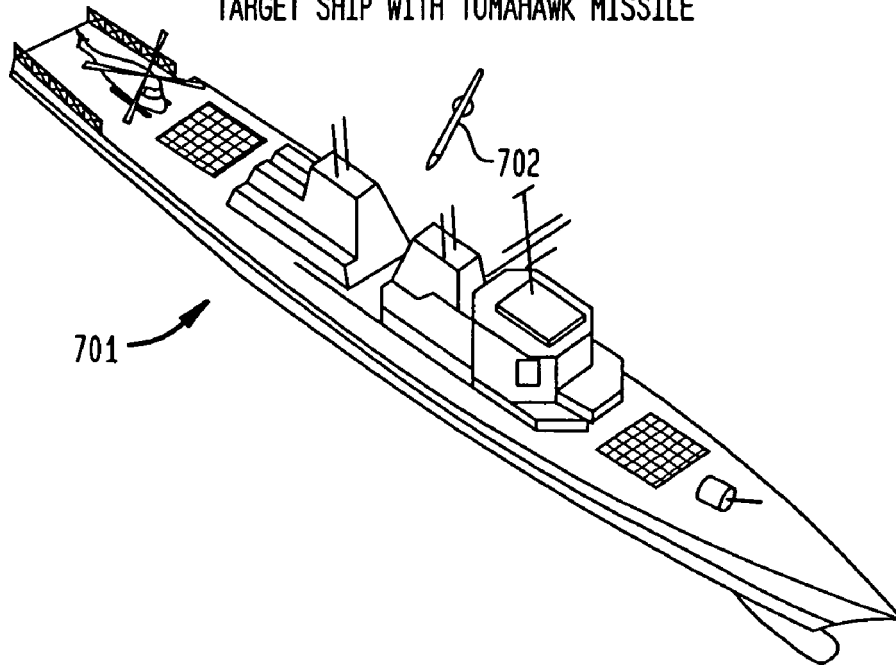


FIG. 8
BURLAP CLOTH TARGET SHEET

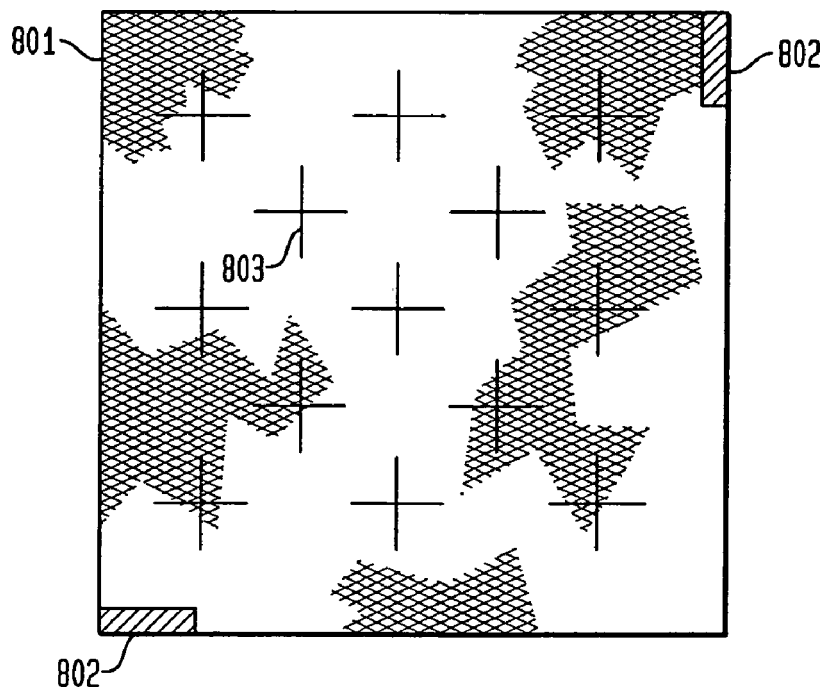


FIG. 9

TARGET SHIP 3D TRACKING SYSTEM

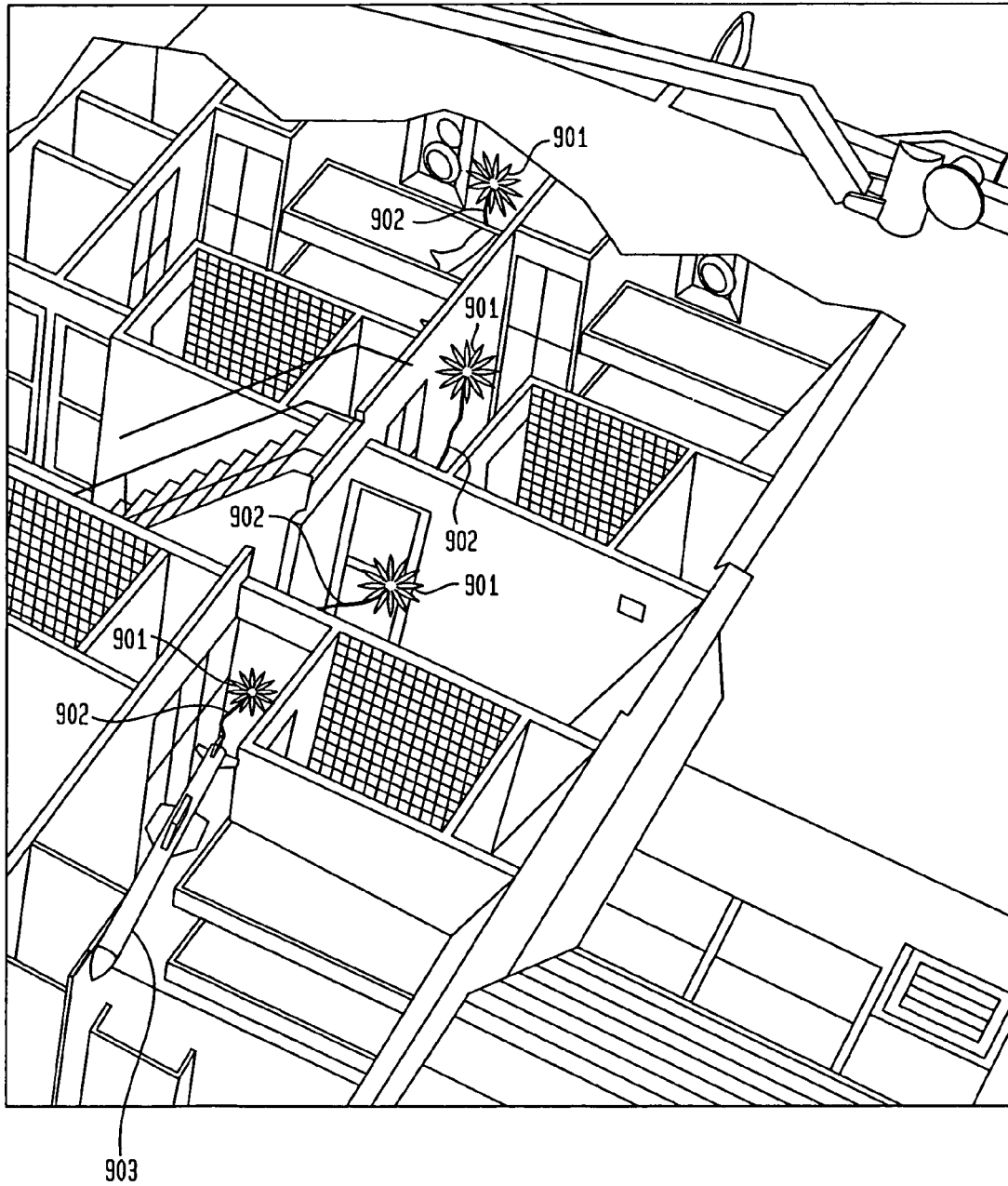


FIG. 10

EXPLODED DIAGRAM OF THERMAL IMAGE COMPOSITE LAYERS

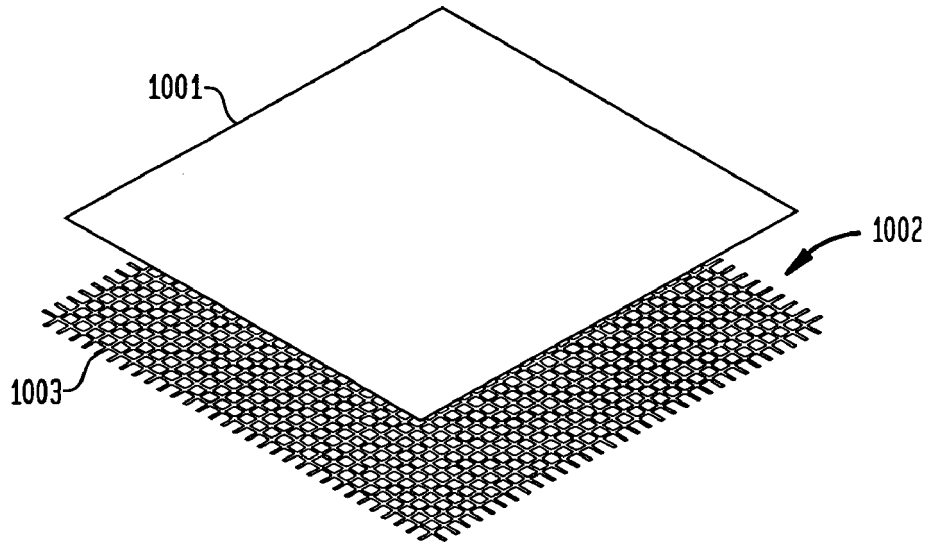


FIG. 11

EXPLODED DIAGRAM OF SENSE SHEET LAYERS

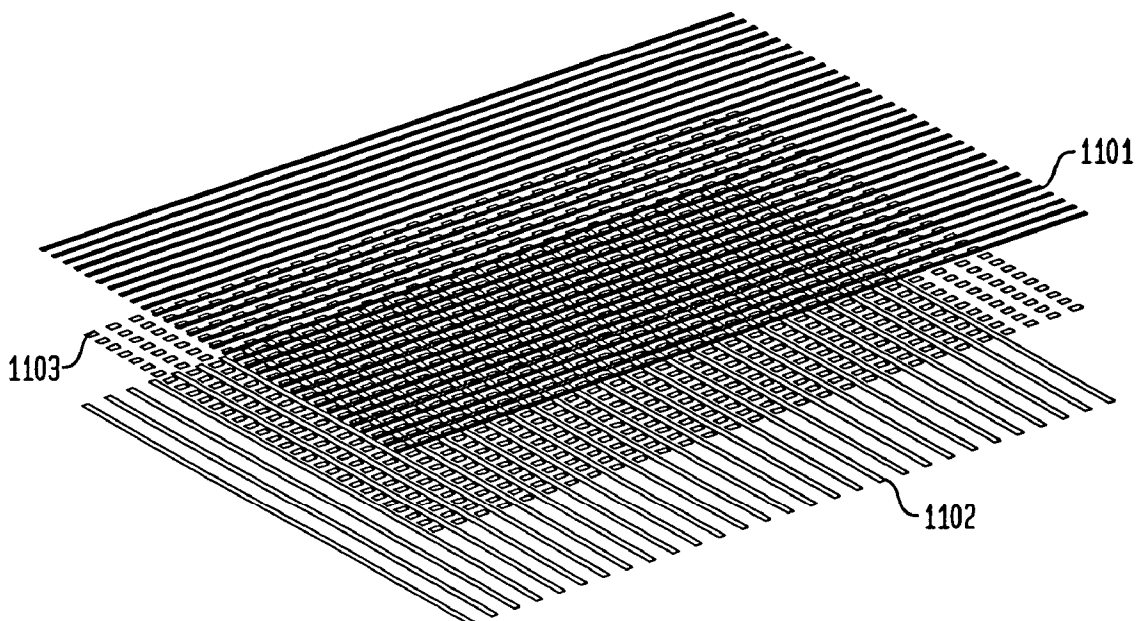


FIG. 12
PRESSURE SENSING CIRCUIT

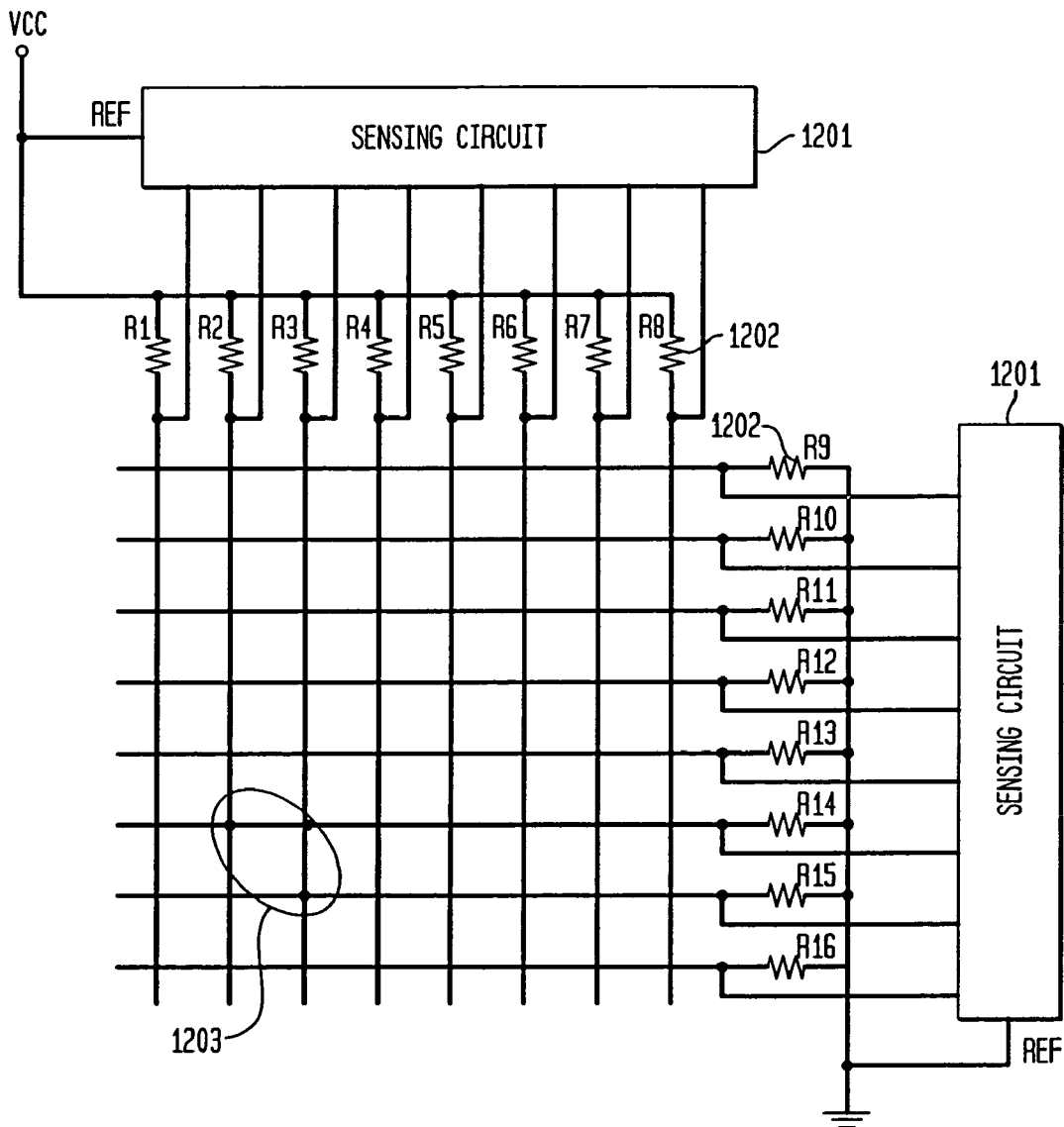


FIG. 13

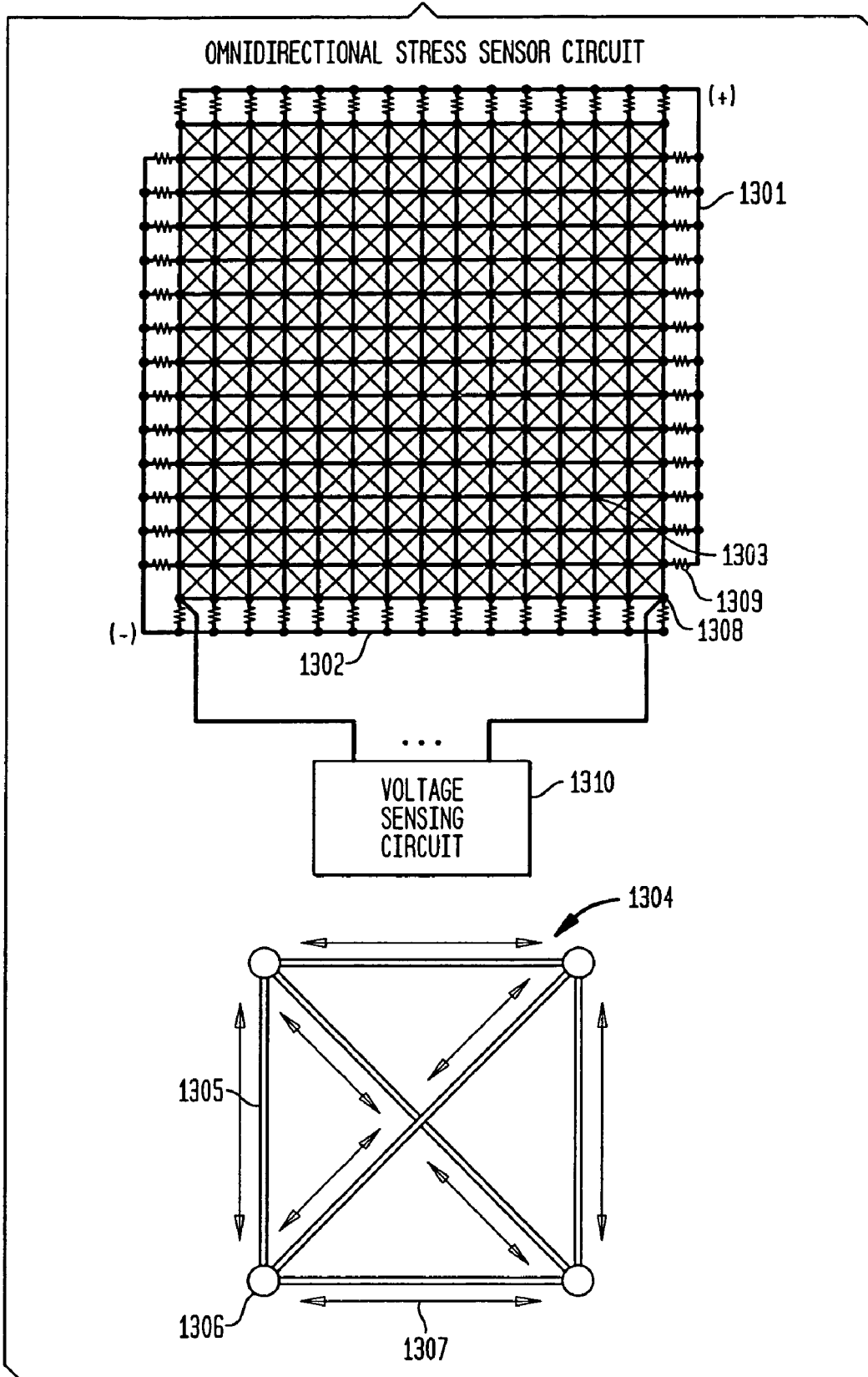


FIG. 14

SUCCESSIVE APPROXIMATION SIMULATION ALGORITHM

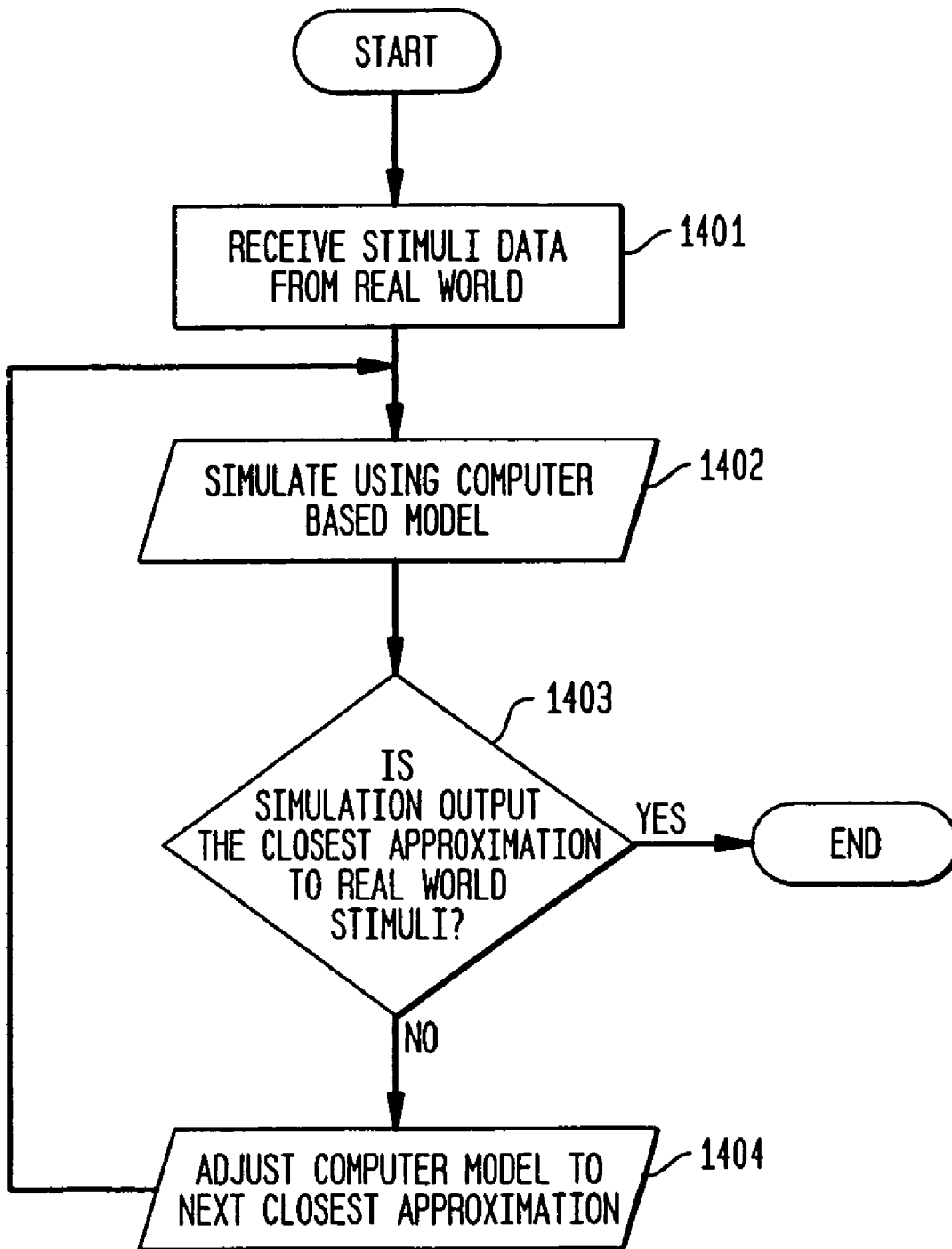


FIG. 15

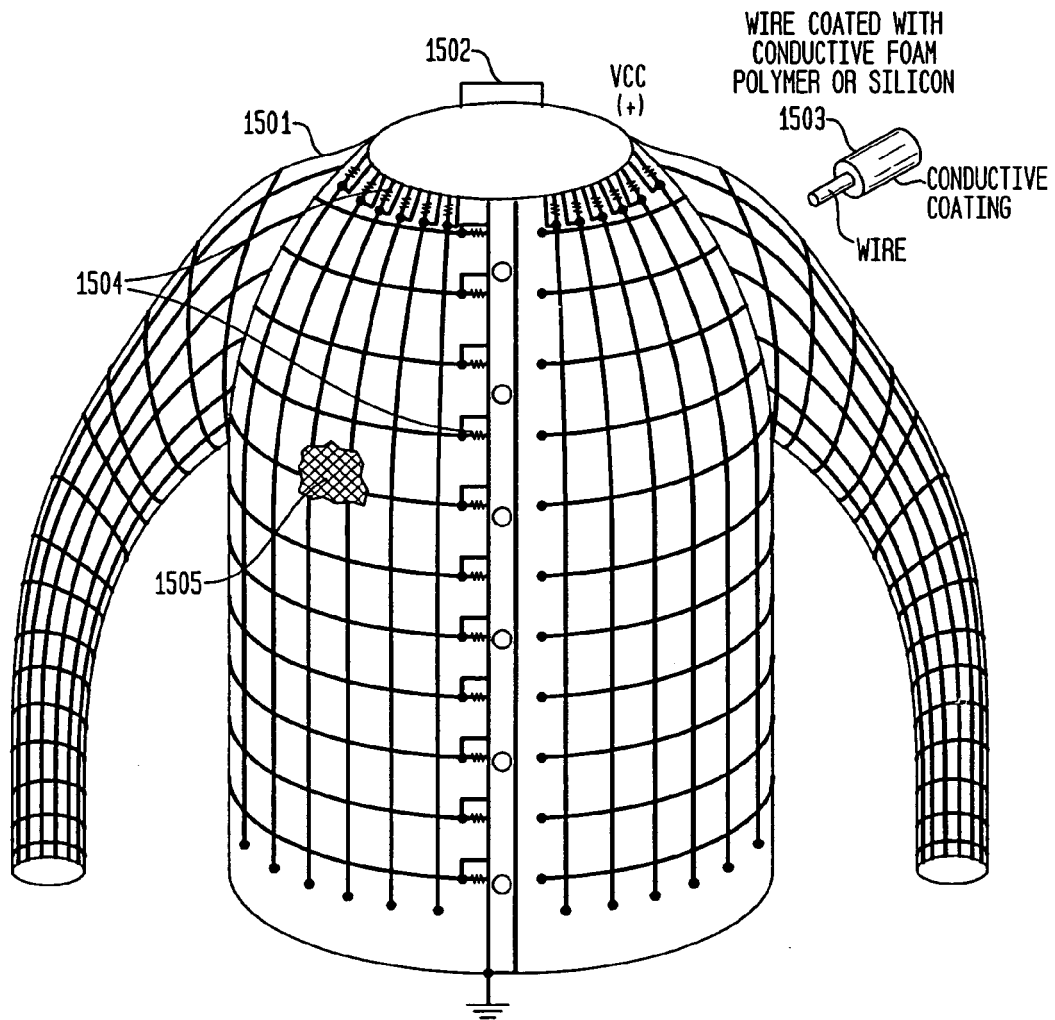


FIG. 16
SENSE SUIT TRACKING SYSTEM

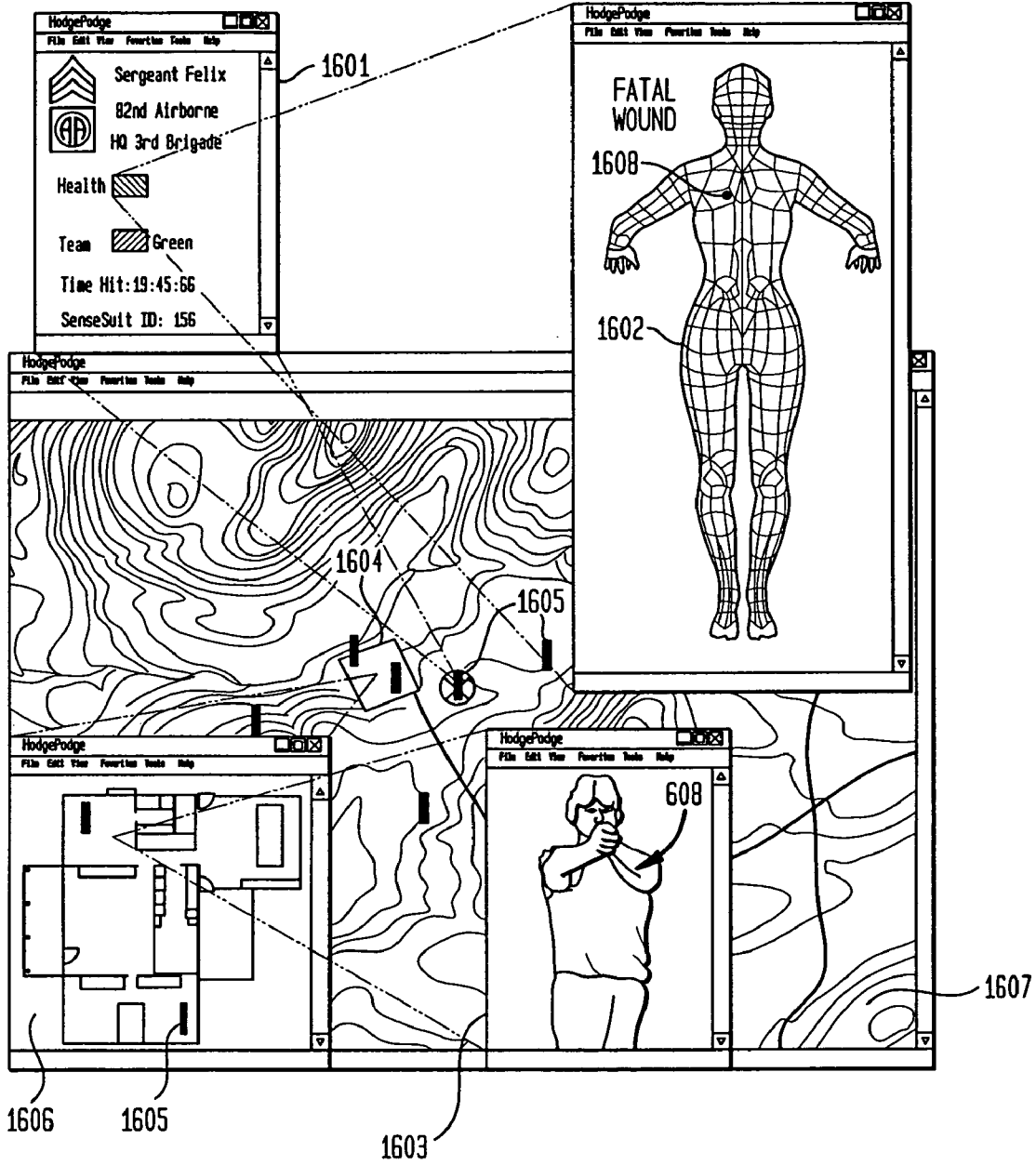


FIG. 17

LASER BASED TARGET SENSOR

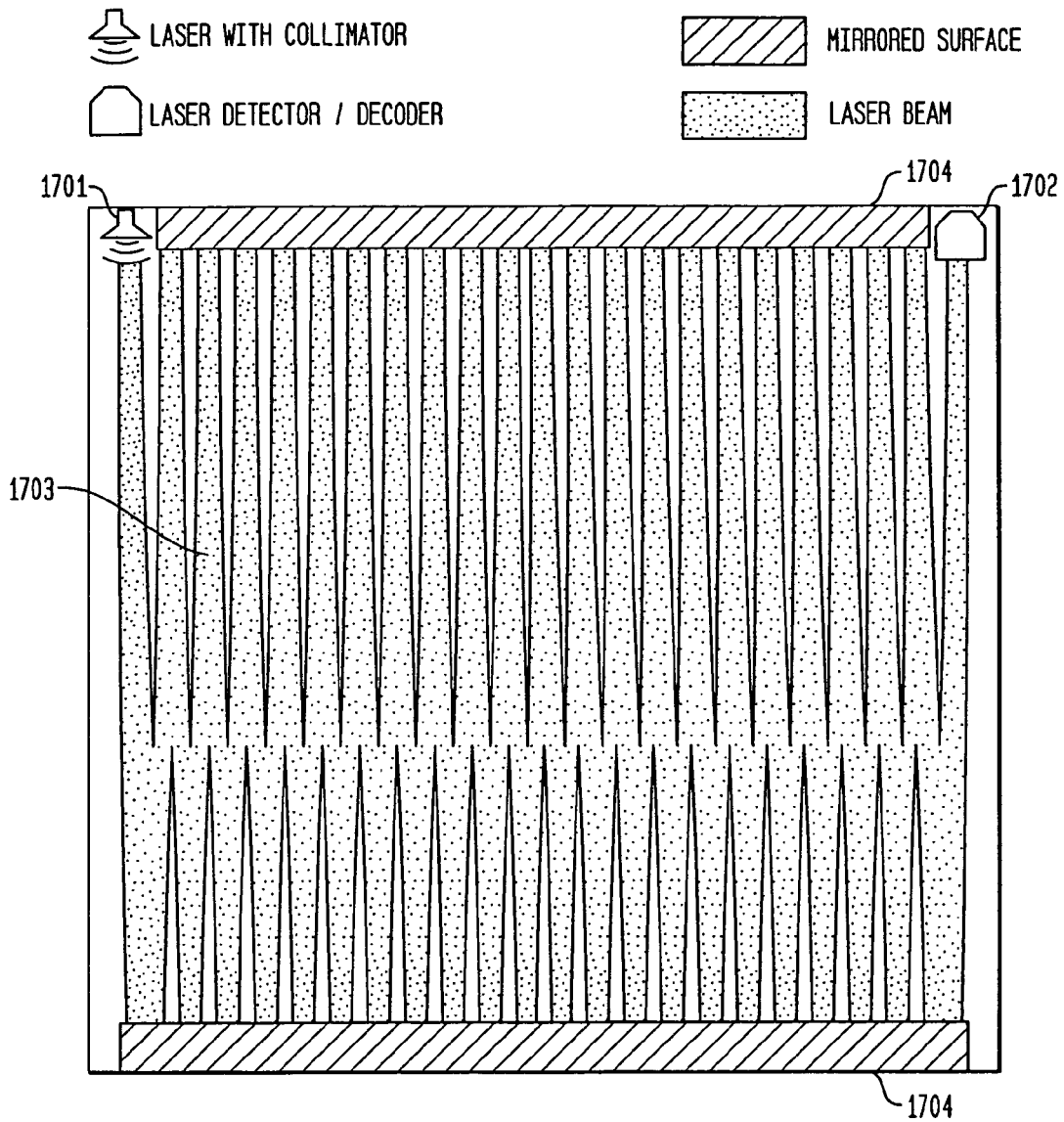


FIG. 18

LASER TARGET DETECTION BLOCK DIAGRAM

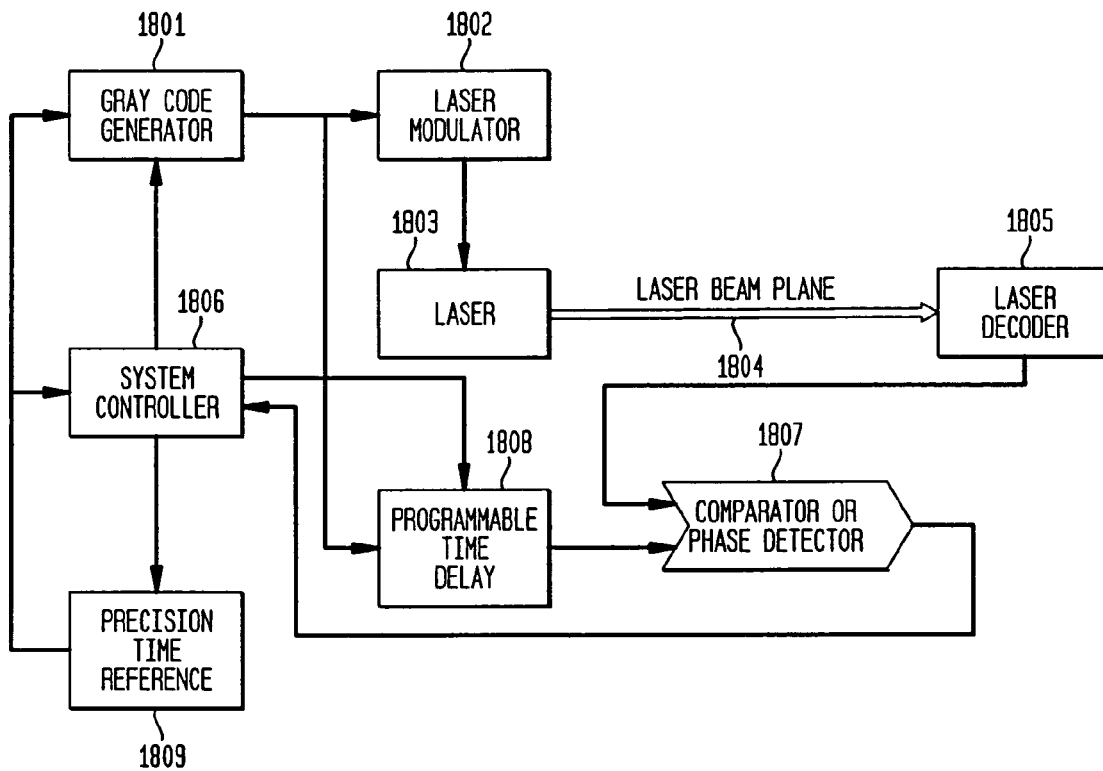
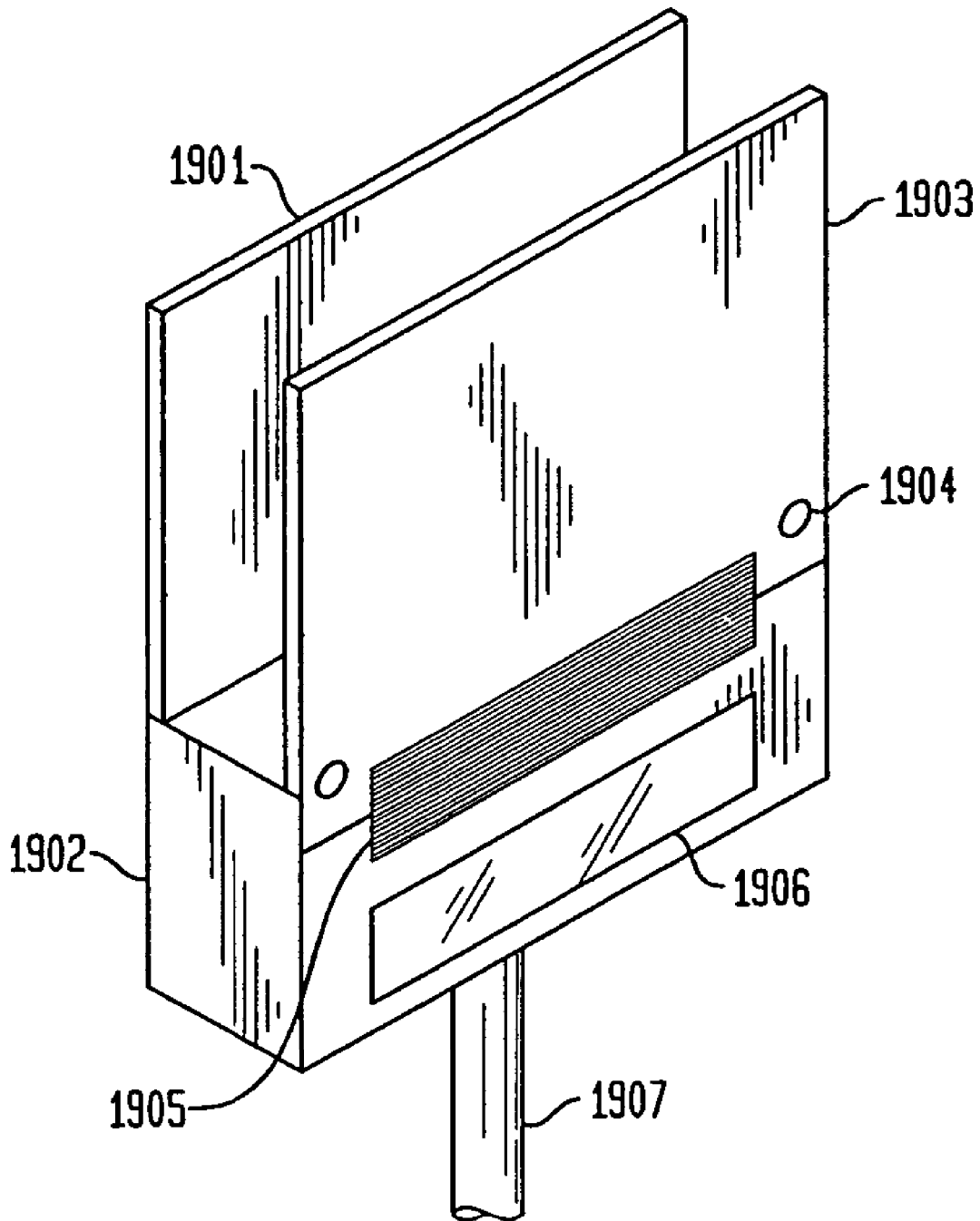


FIG. 19

REAL TIME SNIPER LOCATOR



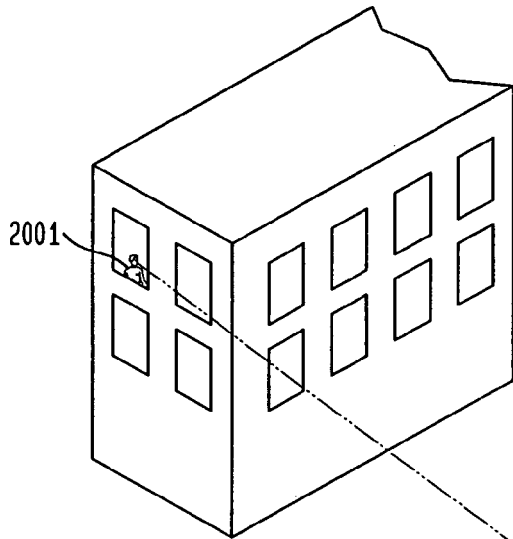


FIG. 20

RTSL IMPLEMENTATION SCENARIO

2002

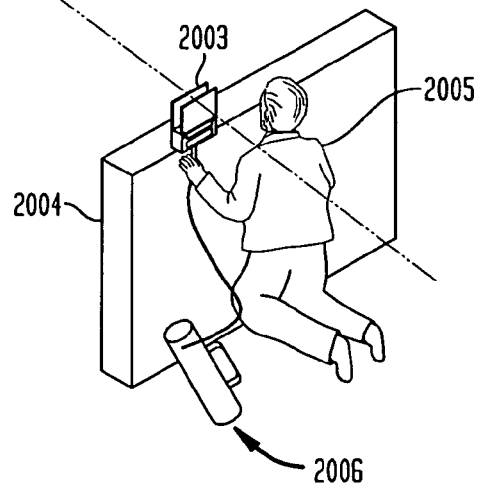
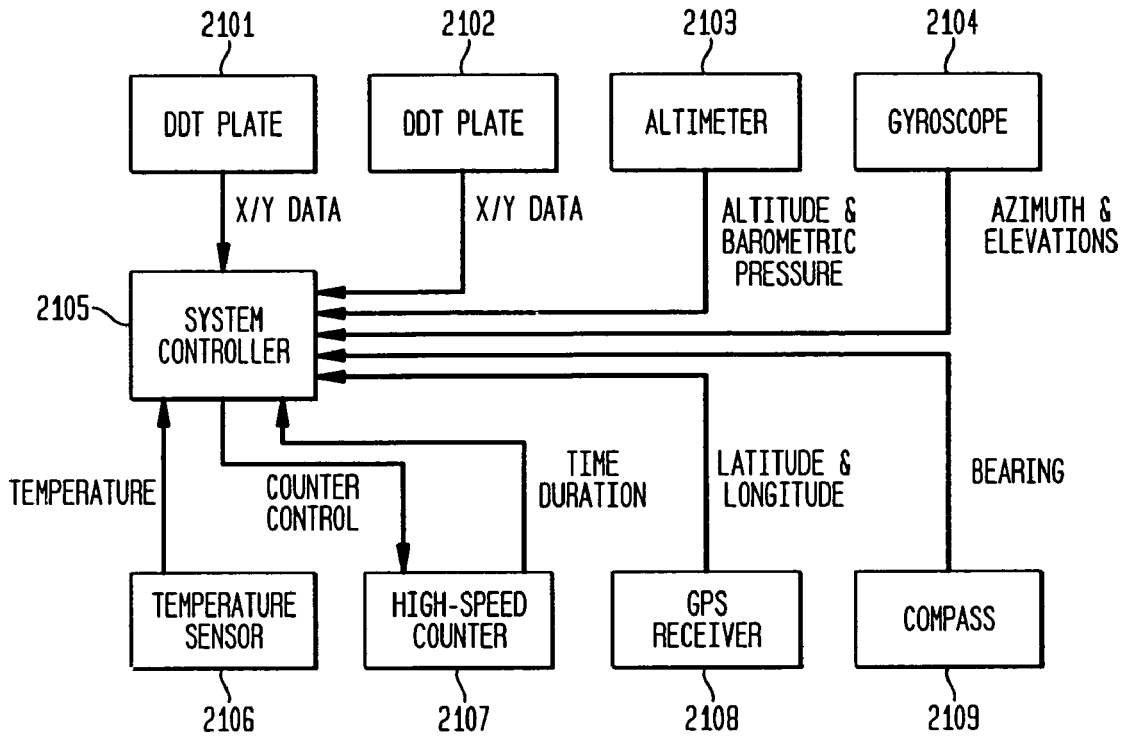


FIG. 21

RSTL INPUT COMPONENT BLOCK DIAGRAM



METHOD AND APPARATUS FOR DETERMINING AND RETRIEVING POSITIONAL INFORMATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 60/543,342 entitled Discrete Digital Target Design, filed on Feb. 10, 2004, the disclosure of which is incorporated herein by reference in its entirety. This application also claims the benefit of U.S. Provisional Patent Application No. 60/636,479 entitled Real-Time Sniper Locator, filed on Dec. 16, 2004, the disclosure of which is incorporated herein by reference in its entirety. This application is related to U.S. Pat. No. 5,516,113, the entire contents of which are incorporated herein by referenced.

COPYRIGHT NOTICE

A portion of the disclosure of this patent document contains material which is subject to copyright protection. The copyright owner has no objection to facsimile reproduction by anyone of the patent document or the patent disclosure, as it appears in the Patent & Trademark Office patent file or records, but otherwise reserves all copyright rights whatsoever.

TECHNICAL FIELD

The present application relates to methods and apparatus for detecting positional location(s) of pressure, stress, or penetration and, more specifically, to an apparatus and a computer-implemented approach for detecting and retrieving positional information from surface or spatial plane.

BACKGROUND

Conventional shooting ranges use paper targets and lethal bullets to determine a shooter's proficiency in a very static and non-realistic environment. The methods and apparatus in this application allow shooters to (1) use non-lethal rubber bullets to test a shooter's proficiency or (2) train shooters in more real-life scenarios.

Stress analysis requires multiple strain gauges to be placed on a surface under test in each unique direction of interest. Using methods and apparatus of this application, stress can be measured in all directions using a simple omnidirectional strain gauge.

Target ships currently use video cameras to record missile impact and trajectory path as the missile travels through the target ship. The method and apparatus of the present application allows for an inexpensive way to instrument an entire target ship with location sensors, so that a missile can be tracked and displayed in real-time as the missile is traveling through a target ship.

Everyday, our soldiers are being hit by sniper fire and are having a hard time locating a sniper's location. If a simple apparatus could be built that would allow our soldiers to quickly locate snipers, then soldiers' lives would be saved. This patent application originates from the need to save our soldiers' lives, by providing them with an easy-to-deploy sniper locator.

SUMMARY

A method and an apparatus for determining and retrieving positional information is disclosed. One embodiment of the apparatus comprises a surface having at least two sides. A plurality of horizontal lines are formed on one side of the surface, the plurality of horizontal lines being parallel to one another and formed at least of conductive material. The plurality of horizontal lines are connected across a potential and a first break detection device and further connected to a first detection circuit. A plurality of vertical lines are formed on an opposite side of the surface, the plurality of vertical lines being parallel to one another and formed of at least conductive material. The plurality of vertical lines are connected across a potential and a second break detection device, and further connected to a second detection circuit. A data transport medium is operative to at least transmit data in one or both of the first detection circuit and/or the second detection circuit.

A method for determining and retrieving positional information in one embodiment comprises forming a first plurality of conductive lines parallel to one another on one side of a surface. A second plurality of conductive lines parallel to one another are formed on the opposite side of the surface, the first plurality being perpendicular to the second plurality. The first plurality of conductive lines are connected to a first sensing circuit and the second plurality of conductive lines are connected to a second sensing circuit. Data detected in the first sensing circuit and the second sensing circuit is transmitted to a processor.

Further features, as well as the structure and operation of various embodiments, are described in detail below with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram depicting an approach for detecting breaks in conductive lines in one embodiment.

FIG. 2 is a diagram showing an embodiment of data encapsulation for a Digital Discrete Target (DDT)-Resistive Matrix Target (RMT) hybrid.

FIG. 3 is a circuit diagram depicting an approach for detecting breaks in both rows and columns of conductive lines of the DDT in one embodiment.

FIG. 4 is a flow diagram depicting the nodal reduction algorithm for the DDT-RMT hybrid in one embodiment.

FIG. 5 is a flow diagram depicting the Successive Approximation Simulation (SAS) reduction algorithm for minimal node(s) in one embodiment.

FIG. 6 is a circuit diagram of a DDT with nodes removed and their corresponding logic table in one embodiment.

FIG. 7 is a computer model depicting a target ship with a harpoon missile about to make contact in one embodiment.

FIG. 8 is a picture of a burlap cloth with break detection wires weaved through it in one embodiment.

FIG. 9 is a 3D computer model depicting a missile tracking system, displaying the trajectory path of a missile as it is penetrating a target ship in one embodiment.

FIG. 10 is an exploded diagram of a thermal signature generator showing the thermally conductive layer, the plastic substrate, and the resistive heating layer in one embodiment.

FIG. 11 is an exploded diagram of an embodiment showing the conductive ink traces with pressure sensitive conductors between them for pressure sensitive sense sheets in one embodiment.

FIG. 12 is a circuit diagram depicting an approach for a current sensing circuit used to locate sense wires of sense sheets, or sense suits in one embodiment.

FIG. 13 is a diagram depicting an omnidirectional strain gauge trace patterns in one embodiment.

FIG. 14 is a flow diagram depicting the Successive Approximation Simulation (SAS) algorithm in one embodiment.

FIG. 15 is a hand sketch showing an embodiment of the shirt component of a sense suit.

FIG. 16 is a screen shot showing an embodiment of a sense suit tracking apparatus.

FIG. 17 is a diagram showing the laser plane path of a laser location tracking apparatus in one embodiment.

FIG. 18 is a block diagram depicting a circuit to reduce the data return from a laser plane apparatus in one embodiment.

FIG. 19 is a hand sketch depicting a Real Time Sniper Locator (RTSL) in one embodiment.

FIG. 20 is a hand sketch depicting how the RTSL is implemented in one embodiment.

FIG. 21 is a block diagram of components used in a RTSL to determine the positional location of a sniper in one embodiment.

DETAILED DESCRIPTION

In one embodiment, the method and apparatus of determining and retrieving positional information may include a plurality of conductive lines formed on a single side of a plastic substrate, with a graphic colloidal suspension coating of conductive ink or conductive carbon nanotubes formed in one direction per side as shown in FIG. 1. The lines 104 formed on or bonded to the substrate may be purely conductive, for example, approximately zero ohms. When a projectile penetrates one of the conducting lines, it breaks the ground connection allowing the pull-up resistor 101 to bring the inputs for the lines penetrated from 0 volts to VCC or 5 volts 102. This penetration location detector locates which row(s) or X coordinate(s) were penetrated.

The row penetration detector shown in FIG. 1 may be rotated 90 degrees and placed on the other side of the substrate above, creating a matrix. This matrix or digital discrete target (DDT) can detect both row and column (X/Y) penetrations. The digital discrete target (DDT) is accurate for each unique pairs of rows and columns (X/Y) that are stimulated. Once a conductive line forming a row or column is broken, subsequent hits on that conductive line are non-detectable and other apparatus/methods are needed to accurately locate target penetration.

FIG. 3 shows the vertical and horizontal detection circuitry combined into a total X/Y penetration detection circuit. In one embodiment, the vertical lines are formed on the front of the target substrate with the sensing circuitry at the bottom, while the horizontal lines are formed on the back side of the substrate and have the sensing circuitry on the right. The sensing circuit on the right could be located at the bottom by routing the horizontal lines down the right side using colloidal suspension coating or conductive ink, thus keeping the detection circuitry out of harm's way. A person of ordinary skill in the art will appreciate that the actual locations of the sensing circuits may be altered as desired.

Other DDT sheets could be laminated at other than 90 degrees to add even more accuracy to the system. A 45 degree sheet may provide a diagonal indication of penetration, etc. Detection circuits such as a shift register 301 are connected to the horizontal and vertical lines 302, respectively. In one embodiment, both shift registers 301 may combine their data into a single stream and send it, for instance, via a data transport medium, to the remote or onboard computer for processing. For instance, the data from the shift registers may be in a digital word format comprising a plurality of bits. Each bit would represent X-Y position coordinate of the DDT. The data streaming out of both penetration location detectors of the DDT would be sent to a data transport medium. A data transport medium, for example, may be connected to the shift registers 301, and is, for example, any device or protocol used to transfer data from one entity to another. Some examples of the data transport medium include, but are not limited to, wireless transmitter, 802.11 protocol on category 5 cable, FSK encoded transmitter, a cellular transport system, etc.

If multiple DDTs are used in the same area, a unique identification tag can be embedded in the digital data stream to identify which DDT transmitted the data. The resolution of the target would be determined by the spacing of the grid formed by the conductive lines. The target could have an onboard computer that would hold the previous state of the digital data in memory and continuously compare it with the incoming digital data stream from the DDT. Then only send the X/Y coordinate of a projectile penetration when activity occurs on any of the lines causing a difference between what is stored in memory and what is streaming out of the DDT.

The DDT of the present application may be used in conjunction with other apparatuses. For instance, resistive matrix target (RMT) disclosed in U.S. Pat. No. 5,514,113 may be utilized with the DDT. If DDT was bonded or laminated to RMT to form a composite membrane target, DDT would provide a means to significantly reduce the number of permutations needed to isolate target penetration. Briefly, RMT is a resistive matrix target formed from colloidal suspension of resistive ink on one side of a substrate. The DDT would be bonded to the other side of the substrate insulating it from the RMT circuitry. In one embodiment of RMT, positional penetration information is determined by using Successive Approximation Simulations (SAS), a mathematical modeling technique. Each simulation processes a large number of simultaneous equations, so the less simulations to perform, the faster the data acquisition becomes.

By aligning the node locations in the RMT to the X/Y intersections of the DDT, the successive approximation simulation (SAS) algorithm can rapidly isolate the target penetration location. Knowing what nodes to simulate in the SAS algorithm is extremely useful, especially in handling simultaneous penetrations. It significantly limits the field of search or permutations generated. In one embodiment of the DDT, once a line has been broken, it will remain that way for the duration of the target's life. In one embodiment, the DDT-RMT hybrid data sent to the main or onboard computer could have horizontal and vertical data from the DDT 203 multiplexed with the RMT data 202 and tagged with a unique id 201 as shown in FIG. 2.

FIG. 6 shows a set of target penetration scenarios 602 on the DDT circuit diagram 601, along with the DDT digital logic table 605. Each column of bits in the logic table's Row field represents the output of each DDT Row 603. Each column of bits in the logic table's Column field represents the output of each DDT Column 604. A new target has all

bits set to zero because the conductive lines pull down each and every input, as shown in Hole (0) of the logic table 605. When the target is hit for the first time, its penetration location can be found directly without having to use the RMT data and SAS processing time as shown in Hole (1). The DDT X/Y location would tell exactly where that first hit occurred immediately. The DDT field in the logic table 605 has an X indicating that only the DDT data processing is required to locate the target penetration. After the first hit, there is a potential that an already previous line of the DDT that was broken was hit again at a different location. The DDT information is still useful because it significantly limits the amount of simulations required to reduce the data by restricting the area of search to only 'DDT possible' intersection locations. Hole (1) through Hole (3) each generate a unique pair of Row and Column stimulus and, therefore, only require DDT data processing to locate target penetration. When Hole (4) penetrates the DDT, only a Column (10) is stimulated because there is no change in any of the Row(s) state.

This, for example, is where the DDT-RMT hybrid is useful in locating Hole (4), as indicated by a 1 in only the Column 10 bit position and the X in both DDT and RMT fields of the logic table 605. The node id (identifier) of the RMT is calculated by counting nodes (intersections) from left to right, top to bottom. In FIG. 6, the laminated RMT layer is perfectly aligned with DDT matrix so an RMT node id can be calculated by $RMT_ID = (DDT_Row - 1) * 16 + (DDT_Column - 1)$. RMT nodes map directly to DDT intersections and can be referred to interchangeably. RMT nodes are referred to by a zero based unique id, whereas DDT intersections are referred to by 1 based (Row, Column) designators.

FIG. 4 shows a flowchart of the algorithm used to reduce the DDT-RMT data. The computer reducing the multiplexed data packets of the DDT-RMT shown in FIG. 2 would first detect only a change in the DDT's Column (10) data bit and not change in the DDT's Row data 401. Then, the computer would look at the bits set to 1 in the Row data (0001001001000000). A list of possible intersections 402 would be at Rows 4, 7, and 10. By combining the stimulated Column (10) with each 1 bit in the Row data intersections (Row 4, Column 10) or RMT node id 57, (Row 7, Column 10) or RMT node id 105, and (Row 10, Column 10) or RMT node id 153 are permutated. In this case, there are no intersections to remove 403 because a DDT column was stimulated and removed the ambiguity of the Column or Y axis. It is known that it is RMT node 57, 105 or 153. This also means that a method in one embodiment can locate the target penetration by performing only 3 simulations. The DDT intersections are, however, converted into RMT node ids for further processing. Next, the method in one embodiment removes an RMT node located at a DDT intersection from the mathematical model and simulates 404. The voltages coming back from the simulator's sense nodes are compared to the actual voltages returned from RMT sense nodes and a decision is made as to if this is the minimal node 405.

In one embodiment, that could entail storing all previous node ids, along with the sum or absolute sum of the delta differences in voltages between the simulated and actual RMT data. When the permutated list has been exhausted, the minimal node id would be looked up using a standard linear search algorithm. Another embodiment might set a minimum sum or absolute sum of delta voltages threshold value. Once that minimal threshold was crossed, the current node would be considered the minimal node. If the node is not the

minimal node, the next node is selected from the list of possible intersections 406 and control is passed back to the simulator for processing (as shown in FIG. 4). The minimal node id would be the node id of the actual target penetration in the RMT target. The penetration location would correlate to the same intersection of the laminated DDT target and, in the case of FIG. 6, Hole (4) would be RMT node id 105 or DDT (Row 7, Column 10).

Hole (5) does not stimulate the DDT because both Row and Column lines were previously broken and remain in the same state. The logic chart 605 shows that both Row and Column data remain static and an X in both the DDT and the RMT field indicating that DDT data, RMT data, and SAS processing are to be performed. The RMT data changes because of the shift in currents of the resistive matrix triggering the transmission of data packets.

FIG. 4 again shows processing of the data using the DDT-RMT hybrid target. Since there was no stimulated DDT Row or Column, all possible permutations are generated 402. In the case of FIG. 6, they are all possible permutations of Rows 4, 7, 10 and Columns 3, 5, 6, and 10. In X/Y pairs, they are (4,3), (4,5), (4,6), (4,10), (7,3), (7,5), (7,6), (7,10), (10,3), (10,5), (10,6), (10,10). From that list, X/Y pairs (4,3), (7,6), (10,5), (7,10) are removed 403 because they have already been mapped as being previously penetrated—leaving (X/Y) Pairs (4,5), (4,6), (4,10), (7,3), (7,5), (10,3), (10,6), (10,10) in the list of intersections to be processed or possible simulation to be performed. The intersections are converted into RMT node ids. A node from the list is removed from the mathematical model and simulated 404; then it is determined if it is a minimal node 405. If not the next node in the list is selected 406 to be removed from the mathematical model. The selection method to determine the next node from the list could be simply selecting the next node in the list or it could be calculated using geometric progression or vector based mathematics. Control is passed to the simulator as shown in FIG. 4 until the minimal node is located. In the case of FIG. 6, it would be DDT (Row 4, Column 10) or RMT node id 57. The minimal node location designates the location of penetration. This data would be used to position a dot on a computer screen mapped to the exact location where the penetration occurred on the remote target in real-time. This would be useful in determining scoring without have to use optical analysis or target retrieval/visual inspection techniques. It also allows one to store shot data for post-analysis, gun calibration, internet shooting competition, etc.

In another embodiment, node resistors may be successively removed from the normalized Kirchoff nodal matrix in a repetitive sweeping geometric progressive pattern. Once the closest approximation of the affected area of the actual target data is determined, the simulator would change nodes to a more finite graphing algorithm and pinpoint the actual resistors removed from the matrix (within close proximity to that pre-determined area) as described below.

FIG. 5 shows an embodiment of the algorithm used to reduce the time it would take to locate the penetration positional location of RMT data. This algorithm in one embodiment is a fundamental basis of nodal analysis between the simulator and the RMT data in the reduction and isolation of affected nodes. It is SAS at the node level. In one embodiment, a group of nodes forming a geometric pattern like a triangle are chosen to start the analysis. Each node in the nodal group are removed one at a time and simulated from the mathematical model 501. The sum of the absolute or real difference between the simulated sense node voltages and the RMT sense node voltages or delta differ-

ence are stored and associated with the node id being processed **502**. A determination is made as to whether the minimal delta difference node has been found at **504**. If not, the minimal node is located by repetitively simulating multiple nodes in a geometric progression or using vector math at **503** to predict the most likely candidate for the next simulation.

In one embodiment, determining the minimal node **504** could entail storing all previous node ids, along with the sum or absolute sum of the delta differences in voltages between the simulated and actual RMT data. When the permuted list has been exhausted, the minimal node id would be looked up using a standard linear search algorithm. Another embodiment might set a minimum sum or absolute sum of delta voltages threshold value. Once that minimal threshold was crossed, the current node would be considered the minimal node. Once the minimal delta difference node has been determined, a process which uses SAS, geometric progressions, vector math, or other type of graphing algorithms can locate all nodes involved **505**.

An example of a geometric progression would be to simulate 4 nodes in a square or 3 in a triangular pattern and locate the minimal node, then center on that node, reduce the geometric progression nodal spacing, and repeat the process again until the minimum delta difference node(s) are located. For example, using vector base math, the 3 points of the triangle delta differences would be used to create a vector map. Points chosen would have their sum of delta values stored, along with their position on the matrix. Points having a larger sum of voltage differences would be considered farther away from the actual point of penetration, while points with small sum of voltage differences would be considered closer to the point of penetration. Using 3 points on a plane with the sum of the voltages of each point as its magnitude, a resultant vector could be calculated using triangulation mathematics. The resultant vector origin would be the centroid of the next triangular nodal grouping or might even be the minimal node directly. By reducing the spacing between the nodes for each geometric progression, the method in one embodiment hones in on the exact location of penetration quickly.

Generally, the method in one embodiment locates the RMT penetration through a series of educated/calculated guesses using a mathematical model of the real-world resistive matrix target. Then, through a series of simulations and the help of standard vector or geometric progression mathematics, locate the penetration point in the simulator which is the closest approximation to the real-world. A good analogy is to make a volt meter by ramping a digital counter into a D/A converter, while taking the analog output of the D/A converter and feeding it into one side of a comparator. The other side of the comparator is tied to the signal from the real-world that is to be measured. When the comparator changes state, the counter is stopped and the counter data can be read directly. It will contain the digital value which, when converted to its analog value, represents the voltage from the real-world as specified in the D/A converter specs. For example. An 8 bit D/A with a 0-5 volt range has a least significant bit weight of 0.0196 volts. So if the counter stops at count of 128 then the real-world stimuli is $128 * 0.0196$ or 2.51 volts.

In another embodiment, LU decomposition or Chebyshev approximation may be used for solving the resistive matrix nodal equations, instead of using Gauss-Jordan method (as shown in U.S. Pat. No. 5,516,113). Any simultaneous equation solving function that can efficiently process a tri-diagonal banded symmetrical matrix will work. Also,

instead of using nodal analysis, one may use mesh analysis to solve the resistive matrix equations. Since the matrix is composed of a finite set of linear equations, using standard linear algebra mathematics should be able to solve it. In one embodiment, the grid could be broken into smaller quadrants, thereby reducing the amount of area needed for simulation.

Another embodiment of determining and retrieving positional information uses burlap bag cloth **801** with small wires weaved into them **803**, creating a pliable target sheet (as show in FIG. **8**). Each target sheet has a similar circuit (shown in FIG. **3**) attached with a data acquisition circuit and wireless transmitter using a unique frequency and/or having a unique identification tag inserted into the data stream **802**. By spraying adhesive glue to a target ship's bulkheads, ceilings, and flooring and adhering target sheets to each surface, a collection of target planes can be formed by the target sheets. Each target sheet, in one embodiment, has a unique location within the ship and has a unique identification tag associated with it. Only one side of each bulkhead, ceiling, or floor needs to be instrumented with a target sheet. Each target sheet may represent a surface of the ship and each vertical and horizontal wire intersection of the target sheet represents a positional location within that surface. The resolution of accuracy would depend on the distance between the rows and columns of wires **803** embedded in the target sheet. Once in place, an exact computer model of the target ship may be rendered using the planes formed by the target sheets and identified by each unique id. After being instrumented with target sheets, a remote data collection boat may be placed within reception range of the target ship **701** and testing can begin.

FIG. **7** shows a scenario where a target ship has been instrumented with target sheets and a harpoon missile is about to penetrate the target ship. When the harpoon missile **702** impacts the target ship, its entry point and penetration path would be displayed on a transparent 3D computer simulated model of the target ship in real-time. Each target sheet would have a battery powered transmitter(s) that would send its X/Y penetration information only if it was penetrated, thereby reducing the amount of data that needs to be recorded and redundant transmitters **802** could be used to increase fault tolerance. In another embodiment, the data from each target sheet could be routed through the target ship by a series of redundant cables and brought to a pair of transmitters on the top of the ship for transmission. Each data packet sent from each target would be tagged with that target sheet's id and a transport medium such as 802.11 protocol running on category 5 cable could be used to bring the data to the transmitters. The damage assessment could be done in real-time as the missile is traveling through the ship. Each surface would display activity as it is happening.

FIG. **9** shows an embodiment of the tracking system used to monitor the activity of the missile **903** as it is penetrating the ship. Each surface area, instrumented with a target sheet that is penetrated by the missile, is mapped by the computer and the centroid of its X/Y penetration point **901** is calculated in real-time, then plotted and displayed on the tracking system 3D ship model. This is done by measuring the time it takes the missile to penetrate one surface to the next and combining the time duration with the penetration locations within each surface. Using vector math, the magnitude, velocity, and direction of the missile's trajectory path **902** can be determined and plotted on a 3D computer model. All the data from the missile test can be stored and used to feed simulation models during post-analysis.

Surface-to-air missiles (SAM) and other types of missiles, like air-to-air missiles, are used on flying target tow bodies or drones to assess the accuracy of the missile. A target tow body is a flying target vehicle that is towed behind an airplane by cable. Currently, it is a hit or miss scenario when testing missiles. A flying target tow body or drone used for testing of missiles could use the same technology (as shown in FIG. 3) to detect and assess a near-miss penetration. In this embodiment, an adhesive may be used to adhere the thin plastic membrane of DDT or RMT to the target vehicle and route sense wires into the vehicle to the data acquisition system. All the data would be sent to a ground station using PCM-encoded data or other standard telemetry techniques. When a missile detonates close to the vehicle and is hit by fragments, the fragment penetration location(s) would be detected and relayed down to the ground station for real-time analysis.

In one embodiment, the targets could be bonded or laminated with a sheet of thermally-conductive membrane/substrate to form a composite target. One that detects penetration while radiating a thermal image for night fire training. This substrate would be electrically insulated on the side that is laminated to the DDT or RMT and have a resistive colloidal suspension coating or resistive ink with thermally conductive additives in a matrix pattern. The matrix is heated up by placing a large potential across the matrix similar to the potential shown in FIG. 13. When current flows through the resistive ink, the temperature would increase in the ink lines combined with the thermally-conductive additives would assist in distributing the heat evenly. This may be used to generate an evenly distributed thermal signature or image for night fire training and could be applied to all kinds of targets. The DDT or RMT target sheet would indicate the target penetration, while the thermal layer maintains a consistent thermal image.

In another embodiment, the method and apparatus may include coating one side of the thin plastic substrate 1002 with a thermally conductive colloidal suspension coating 1001 and the other side with a graphic colloidal suspension coating of resistive ink in a matrix pattern 1003. The thin plastic substrate 1002, for example, is a sheet of plastic. It works as follows in one embodiment: the resistive matrix 1003 is heated up by placing a large potential across the resistive matrix 1003 in a similar manner to the potential shown in FIG. 13 designated, for example, by the (+) and (-) signs indicating polarity. The current flowing through the resistive matrix causes it to heat up. That heat is transferred through the plastic substrate and onto the top thermally conductive coating where it is evenly distributed by the thermally conductive coating. This thermal signature layer when bonded to a DDT or RMT would be used to generate a consistent thermal image. Programmable constant current sources and/or thermal couple feedback may ensure that the thermal image maintains proper temperature relevant to its current ambient temperature.

Another embodiment of determining and retrieving positional information comprises two separate sheets of plastic substrate, each having a graphic colloidal suspension coating of conductive ink lines formed in one direction on one side. FIG. 11 shows taking one of the sheets, flipping it over and rotating 90 degrees 1101 so that the conductive lines are facing each other and are perpendicular to each other 1102. Then, a discrete pressure sensitive switch type material of conductive foam rubber, bubble switch membrane, or carbon impregnated rubber/silicon may be placed at each intersection 1103 and laminated together. This would form a pressure sensitive sheet or sense sheet target that could be

used to detect an impact at any intersection(s). When pressure is applied at any intersection(s), the resistance between the X (Row) and Y (Column) would go from open circuit to a short circuit. In the carbon impregnated rubber, the carbon molecules would go into compression causing the carbon molecules to come in contact with adjacent carbon molecules causing the resistance to decrease with pressure. A thin membrane device like a bubble switch could also be used. When the membrane is put under pressure, it changes state from an open circuit to a closed circuit. The medium of this invention is shown by way of example and is not limited to those examples.

A circuit shown in FIG. 12 may be used to detect those currents and retrieve the X/Y positional information. When pressure is applied 1203, the sense resistors 1202 located at the affected X/Y position(s) start drawing current, causing a change in voltage across the sense resistors. The current sensor circuits 1201 detect that change and transmit the data to a data acquisition circuit for processing and transmission. Current sensing circuit may be, but is not limited to, current sense amplifiers, op amps, high-side current monitors, latches, or shift registers.

The Sense Sheet Technology (SST) described in the present application may be applied to targets to detect an impact from a paintball, rubber T-ball, or Simunition® rubber bullet, golf club faces to determine ball impact point, golf courses to detect ball impact and roll path, touch screens to locate finger impact, dentist office to measure and digitally mark tooth high spots, manufacturing where more than one material comes in contact with another to assist in alignment or proper bonding pressures, shoes to measure load bearing pressure points, and sports equipment for impact location such as batting cages, tennis courts, etc.

In another embodiment, stress directional information is possible. Stress analysis in every direction on virtually any surface may be accomplished by replacing the resistive ink of RMT with a compound that changes resistance with stress (like a strain gauge). Current strain gauge technologies allow stress to be measured in only one direction. By adhering a stress sensitive or strain gauge to a surface, stress can be measured in direction of interest. If more than one direction of stress measurement is desired, then multiple strain gauges have to be used and oriented in the desired direction of stress.

In one embodiment, omnidirectional stress measurement may be done by using molecular nanotechnology or similar molecular manufacturing technologies to produce a crystalline or piezoelectric crystalline colloidal suspension coating as a base for this new application of RMT. Instead of using the grid shown on U.S. Pat. No. 5,516,113, the present application may use multiple omnidirectional stress cells whose triangular patterns are shown in FIG. 13. A single omnidirectional stress cell would contain one square with the X pattern inside 1304, for example, forming a lattice matrix. Each line of stress sensitive ink 1305 (for example, crystalline colloidal suspension coating and/or piezoelectric nano-tubes) changes resistance proportional to the amount of stress being applied to it along its line of direction. The voltages measured at the end nodes 1306 would vary proportionally to the change in the resistance, directly correlated to the amount of stress being applied to the cell. Lines of stress 1307 either put the crystalline resistive ink into compression causing the resistance to decrease or expansion causing the resistance to increase.

FIG. 13 is an example of a lattice matrix of multiple omnidirectional stress cells 1303. This crystalline stress sensitive ink may be bonded to a thin plastic substrate with

an adhesive backing and applied to virtually any surface that needs stress analysis. It works, for example, by applying a positive voltage **1301** to two adjacent sides and a negative voltage **1302** the other two adjacent sides as shown on FIG. **13**. The voltage at each sense node **1308** contains a voltage that is proportional to the current through each sense resistor **1309** and, for example, in one embodiment can be digitized with a high speed A/D converter or voltage sensing circuit **1310**, then transmitted, for example, wirelessly to a remote computer for analysis. The sensing circuit **1310** may be connected to all sense nodes surrounding the lattice matrix. The data may be reduced using RMT "Successive Approximation Simulation" (SAS) method. This method and apparatus may be useful in measuring stress in airplanes, cars, boats, trains, and anywhere omnidirectional stress measurements are needed.

The algorithm described in U.S. Pat. No. 5,516,113, entitled "Computer Target Analysis Flow Chart," is known as "Successive Approximation Simulation" (SAS). A real world stimulus **1401** is compared to a computer simulation **1402** in successive steps, each step involving a change in the simulation model **1404** and a re-simulation to determine if the simulation output is the closest approximation **1403** of the real-world stimuli. When the delta differences between the real-world stimuli and the simulation output are at a minimum, the simulation has modeled the real-world stimuli to the best of its ability. SAS can be used to solve very complex problems in the real-world (beyond targets). For example, in the biomedical field, SAS may be used to correctly isolate genes in an enzyme by simulating with different DNA chains until the simulation results most closely match that of the enzyme under study. More exactly, one could measure the enzyme PH factor and use that as the stimulus for the computer model. Then, by modifying the proteins or amino acids in the DNA chain of the computer enzyme model and monitoring the PH level of the model, SAS could determine the closest approximation of the enzyme. Basically, the closest approximation configuration of amino acids in the computer model would determine the actual sequence of amino acids in the real-world enzyme. One could also use SAS to simulate the stress sensor data that came back from a space shuttle wing when hit by debris and get a close approximation as to what real damage has occurred. One could use the stress analysis implementation shown in FIG. **13** and described above to possibly prevent a potentially catastrophic failure due to excessive stress in a critical structure.

Another embodiment of a method and apparatus to determine and retrieve positional information comprises creating a suit made out of pressure-sensitive material that would conduct current when put under pressure, for example, from a paintball, rubber T-balls, or Simunition® rubber bullet ammunition impact. FIG. **15** shows that by weaving pressure sensitive conductive fibers **1503** into the shirt **1501** and pants of paint ball participants and attaching a wireless transceiver with a GPS receiver **1502**, one may create a suit that could be used to monitor players' activities during a simulated warfare scenario. The impact location **1505** can be determined from the current drawn in sense resistors **1504**. One embodiment of the conductive fiber that can be used in the shirt/pants may be a thin wire coated with conductive foam, carbon impregnated rubber/silicon, or a conductive polymer called a sense wire **1503**. The conductive coating's resistance would dramatically decrease with pressure. The lines traveling vertically would have a positive voltage applied and sense resistors on one end. The horizontal wires would be grounded with sense resistors at one end.

Another embodiment can have cloth spun out of conductive polymer such that resistance decreases with pressure, with conductive ink printed vertically on the outside and horizontally on the inside. When a paint ball hits the participant, the vertical wires would short out against the horizontal wires because the resistance of the cloth approximates near zero resistance when under pressure. This causes the sense resistor voltages to increase in both the horizontal and vertical wires due to increase in current flow. These voltages translate into X/Y coordinates and can be sent to the main computer via the wireless transceiver for processing. Another embodiment may simply use one layer of sense sheet or SST, for example, shown in FIG. **11**, bonded to the cloth. Each transmitter, for example, using 802.11 wireless protocol or similar protocol, generates a unique identifier along with real-time GPS coordinates and hit location information. The unique identifier is associated with the person or player wearing it in the remote computer's database, so that the player's identification information can be retrieved during a training exercise.

In this embodiment, a remote computer can analyze the hit location information in real-time and determine the level of simulated injury (kill/non-kill). The computer can then send an automated response to the transceiver of the player illuminating his/her hit status LEDs, embedded in the lapel of their shirt, will notify each player as to whether he/she can continue to participate or needs to 'play dead'.

FIG. **16** shows the sense suit tracking system topographical map **1607** which displays the movement and health of each player **1605** involved in a simulated urban assault scenario. Each player's team color is associated with his/her icon. Players that have an X superimposed over them are considered to be 'dead'. As the players move, their movements and any bullet impact locations **1608** are being recorded by a remote computer that is receiving the wireless data from each player's sense suit transmitter. The wireless data contains a unique id, the transmitters GPS latitude and longitude, and any (X/Y) hit location(s). While the urban assault scenario is engaged, the trainer could click on a player and get his/her information **1601** that is associated with the sense suite identification number. If that player had been tagged as hit, the trainer could click on the player's health icon and see a 3D computer model of the player's body showing all impact area(s) **1602**. The trainer could also click on a shoot house **1604** and the shoot house floor plan **1606** would pop up showing all players and targets located inside. The trainer could then click on the targets **1603** within the shoot house and assess players' shooting patterns for each target hit.

When shooters hit targets and/or other players, the impact information could be stored with the shooters' recorded data on a remote computer for real-time scoring and selective playback. The scoring would be determined by line of fire trajectory path. Each player would have their kill score associated with their suit id which is also bonded to their personal identification information. In the case of police departments, after the scenario has been replayed for each shooter's edification, the recorded data could be sterilized by removing user's identification information. That way, the recorded scenario could still be used for training purposes and not leave any liability for any of the players involved. In this embodiment, the equipment used to track the sense suits is not limited to, but includes, 802.11 access points. The system can be portable and, therefore, the entire system could be easily deployed in a variety of simulated real-world situations and locations.

In another embodiment, the sense suit technology could be used to track the activity of soldiers in a live-fire situation. The sense suit's identification, GPS, and hit location data would be encrypted (using standard encryption techniques) and the pressure-sensitive hit material may be replaced with DDT or RMT technology. The tracking system allows for real-time coordination of forces in a live-fire scenario. Medics could be dispensed when a soldier was hit and his/her exact location would be known to expedite extraction from the battle field. In another embodiment, the transmission of data from each suit could be controlled by the tracking system's controller. The sense suit would remain dormant and would not transmit location/hit information unless requested by the system controller or possibly only when the suit has been penetrated. The sense suit could save soldiers' lives and help, for example, the military become more effective in coordinating overall operations.

FIG. 17 shows an embodiment of determining and retrieving positional information that uses one or more lasers 1701, mirrors 1704, and laser detectors 1702 to locate any projectile passing through the laser beam plane 1703. The beam may be modulated with an ultra high frequency stream of digital data. When the projectile passes through the laser plane, it will disturb the beam and, therefore, the data stream. That disturbance in the data stream can be detected using a comparator and the projectile's X/Y position can be calculated using a high resolution real-time clock. The diagram in FIG. 18 shows an embodiment of how a detection circuit works. The system controller 1806 signals both the gray code generator 1801 or digital counter and the precision time reference 1809 to start simultaneously. The time reference ensures that the gray code generator stays in synch. The gray code generator would feed the laser modulator 1802 and encode the digital data into a modulated laser beam by the laser 1803. With the beam tilted slightly (less than 5 degrees) the beam would bounce off of the mirrored surfaces creating a laser plane 1804 (as shown in FIG. 17-1703) until it reaches the laser detector 1805. The original gray code signal would pass through a time delay circuit 1808 to synchronize with the data stream coming out of the laser detector. Both the time delayed gray code and the laser detector decoded gray code would be passed to the comparator circuit or phase detection circuit 1807 for comparison. If there is a difference between the two data streams, the controller is notified and uses the time reference, along with the gray code count or the phase interference pattern, to determine where the beam was distributed in the space/time continuum. The controller then converts that information to X/Y coordinates and returns the coordinates back to the main computer for processing.

Another embodiment of the present application uses semi-reflective mirrored surface and places a discrete laser detector at each location where the beam bounces off of the semi-reflective mirrored surface. Similar to what we discussed in FIG. 3 with the plurality of conductive lines, each laser plane has beams bouncing back and forth along a single plane line. To create an X/Y laser plane, two laser planes—one with the detectors along a horizontal plane and another along the vertical plane—are located right next to each other. The detectors would act as discrete row and column detectors, similar to what is achieved with the conductive lines in FIG. 3. Once a projectile breaks a beam in each plane, its X/Y location is detected immediately by the first stimulated X/Y laser detector closest to the laser source. Example applications of these embodiments are shooting ranges, indoor golf ranges, batting cages, other sporting equipment, and manufacturing.

If two or more of these X/Y laser planes are placed a short distance from each other, a three-dimensional vector of the projectile could be derived from comparing the X/Y penetration points through each X/Y laser plane. The magnitude of the vector could be calculated by tracking the time it takes the projectile to traverse through the space between each X/Y laser plane.

In another embodiment, an apparatus and method are used to return the position of a sniper's location and may include a simple, hand-held acquisition system called a Real-Time Sniper Locator (RTSL). In one embodiment, the RTSL contains a DDT planar sheet or plate on each side 1901–1903 of the hand-held unit shown in FIG. 19. These disposable sensor plates, in one embodiment, use DDT technology to locate the penetration point and have a sensing circuit shown in FIG. 3. The apparatus and method in this embodiment may be used to acquire the 3D direction vector and distance range of the sniper. The RTSL electronics compartment 1902 may contain the electronics necessary to properly locate the sniper. In this embodiment, it may include a gyroscope, a compass, a GPS tracking device, an altimeter, a temperature sensor, a high-speed counter, and communication devices to control both the display 1906 and transmit the sniper location data to a rocket propelled side arm weapon as shown in FIG. 20, 2006. When a bullet penetrates the first plate 1901, its X/Y penetration location is recorded and a high-speed counter is started. When that same bullet penetrates the second plate 1903, its X/Y penetration location is recorded and the time clock is stopped and recorded.

FIG. 21 shows a RTSL block diagram and the data returned to the system controller 2105 for analysis in one embodiment. The 3D direction vector is calculated from the entry 2101 (X/Y) and exit (X/Y) points 2102 of the DDT plates. The system controller calculates the 3D vector's magnitude by using bullet velocity calculations derived from the time duration data sent by the High-Speed Counter 2107, the altitude and barometric pressure reading from the Altimeter 2103, and the temperature reading from the temperature sensor 2106.

The calculated velocity is compared to a lookup table of known muzzle velocities and the distance of magnitude of the 3D vector is derived. Next, the 3D vector information, along with the azimuth and elevation data from the gyroscope 2104, latitude/longitude data from the GPS receiver 2108, and bearing data from the compass 2109, are used to properly orientate the 3D vector on Earth. The resultant 3D vector will exactly pinpoint the location of the sniper. In this embodiment, the RTSL also has guide posts 1904 to properly align the plates with the pickup contacts located under the spring-loaded clamp 1905. The handle 1907 is used to properly orientate the plates in reference to the sniper as shown in FIG. 20, 2001 and to supply an access point for cabling in the programmable rocket propelled side arm weapon 2006.

Another embodiment could use wireless medium to communicate with such devices or the soldier 2005 could simply read the coordinates of the display 1906 and call in the location to exterior support units. The soldier would stay out of harm's way behind a protective structure 2004 and hold the RTSL, with a silhouette painted on the face of the plate closest to the sniper up over the protective structure, and wait for the sniper to hit it as shown in FIG. 2, 203. Once hit by the sniper bullet 2002, the system would, for example, instantly provide the coordinates as to where the sniper is located and appropriate action could be immediately taken.

15

In another embodiment, more than one of these systems may be used for a single sniper and gain added accuracy in determining the sniper's location using triangulation technology, for example, by allowing each RTSL to share data with other RTSLs in the nearby vicinity. This data could be also uploaded to command centers for possible air strikes and the like.

In another embodiment, a servo-controlled infrared laser could be housed on the side of the unit, outside of the electronic compartment, and used to illuminate the sniper for a smart bomb or smart rocket hit. Once the RTSL was hit and the sniper's location determined, the soldier could turn the unit on its side, allowing only the laser to be exposed, and thereby minimizing the chance of the sniper fire taking out the electronics housed inside the electronic compartment. By making the servo-controlled laser a plug in module, a replacement could easily be done in the field to minimize down-time. A fixed laser could be used and the display panel could guide the soldier, based on the resultant 3D vector, where the shot originated from and while he holds the RTSL, locked on the sniper coordinates, another soldier could fire a laser guided missile at the illuminated target.

In another embodiment, if the sniper's location is accurate enough using RTSL technology, RTSL could be mounted right on a soldier's gun and he or she could dynamically reposition his or her sight as they move their gun, pinpointing the sniper in real-time for return fire. This dynamic system would literally move the cross hairs on the gun, guiding the shooter to the intended target. Using wireless technology, a sharp shooter gun sight may be controlled remotely by allowing the decoy using RTSL to locate the sniper and a remote shooter to return fire.

The system and method of the present disclosure may be implemented and run on a general-purpose computer. The embodiments described above are illustrative examples and it should not be construed that the present application is limited to these particular embodiments. Thus, various changes and modifications may be affected by one skilled in the art, without departing from the spirit or scope of the invention as defined in the appended claims.

I claim:

1. An apparatus for determining and retrieving positional information, comprising:

a surface having at least two sides;

a plurality of horizontal lines formed on one side of the surface, the plurality of horizontal lines being parallel to one another and formed at least of conductive material, the plurality of horizontal lines being connected across a potential and a first break detection device, the plurality of horizontal lines further connected to a first detection circuit;

a plurality of vertical lines formed on an opposite side of the surface, the plurality of vertical lines being parallel to one another and formed of at least conductive material, the plurality of vertical lines being connected across a potential and a second break detection device, the plurality of vertical lines further connected to a second detection circuit; and

a data transport medium operative to at least transmit data in one or both of the first detection circuit and the second detection circuit.

2. The apparatus of claim 1, wherein one or both of the plurality of horizontal lines and the plurality of vertical lines formed of conductive ink.

16

3. The apparatus of claim 1, wherein one or both of the plurality of horizontal lines and the plurality of vertical lines include graphic colloidal suspension coating.

4. The apparatus of claim 1, further including:

a processor operable to extract position coordinates from the data received from the data transport medium.

5. The apparatus of claim 1, wherein the surface is attached to a target ship or a target used to test surface to air missile or both.

6. The apparatus of claim 1, wherein the surface is made of burlap material.

7. The apparatus of claim 1, wherein the surface is a clothing.

8. The apparatus of claim 1, wherein the surface is a substrate, a shirt, a plastic sheet, or material that insulates two polarities of the plurality of horizontal lines and the plurality of vertical lines from each other, or combinations thereof.

9. The apparatus of claim 1, wherein one or both of the first break detection device and the second break detection device includes a pull-up register, or a circuit sensing device, or combinations thereof.

10. The apparatus of claim 1, wherein one or both of the first detection circuit and the second detection circuit includes a shift register, a latch, or a multiplexer, or combinations thereof.

11. The apparatus of claim 1, wherein one or both of the plurality of horizontal lines and the plurality of vertical lines are purely conductive lines of silver.

12. The apparatus of claim 1, wherein the data transport medium includes a wireless transceiver, 802.11 protocol on category 5 cable, FSK encoding, or a cellular transport system, or combinations thereof.

13. The apparatus of claim 1, wherein the data includes one or more digital words comprising a plurality of bits, the plurality of bits representing x-y position coordinates.

14. The apparatus of claim 1, wherein the apparatus is bonded to a resistive matrix target.

15. The apparatus of claim 14, wherein one surface of the resistive matrix target is coated with a thermally conductive colloidal suspension coating.

16. The apparatus of claim 1, wherein the first detection circuit and the second detection circuit are the same one circuit.

17. A thermal imaging generator, comprising:

a sheet of material coated on one side with thermally conductive colloidal suspension coating; and
a resistive suspension colloidal suspension coating formed in a matrix pattern on another side of the sheet.

18. The thermal imaging generator of claim 17, wherein the sheet of material is bonded to a resistive matrix target.

19. The thermal imaging generator of claim 17, wherein the sheet of material is bonded to the apparatus of claim 1.

20. An apparatus for determining and retrieving positional information, comprising:

a first sheet having at least a first plurality of conductive parallel lines, the first plurality of conductive parallel lines being connected to a first sensing circuit;

a second sheet having at least a second plurality of conductive parallel lines, the second plurality of conductive parallel lines connected to a second sensing circuit, the second sheet placed on the first sheet such that the second plurality of conductive parallel lines meet perpendicularly to the first plurality of conductive parallel lines;

a plurality of pressure sensitive switch type material placed between the first sheet and the second sheet at

17

least where the first plurality of conductive parallel lines intersect the second plurality of conductive parallel lines,

the first sensing circuit and the second sensing circuit detecting change in current in one or both of the first plurality of conductive parallel lines and the second plurality of conductive parallel lines as a result of pressure being applied to the first sheet or the second sheet or both; and

a data transport medium operative to at least transmit data in the first sensing circuit or the second sensing circuit or both.

21. The apparatus of claim 20, further including: a processor operative to at least receive the data from the data transport medium and translate the data to a position coordinate.

22. The apparatus of claim 20, wherein the data transport medium include a wireless transceiver, 802.11 protocol on category 5 cable, FSK encoding, or a cellular transport system, or combinations thereof.

23. The apparatus of claim 20, wherein one or both of the first sensing circuit and the second sensing circuit includes a shift register, a latch, or a multiplexer, or combinations thereof.

24. The apparatus of claim 20, wherein the apparatus is attached to a golf club face, golf course surface, a touch screen, a material that marks tooth high spots, shoe, or sports equipment, or combinations thereof.

25. The apparatus of claim 20, wherein the apparatus is used to detect pressure on material.

26. A method of determining and retrieving positional information, comprising:

- forming a first plurality of conductive lines parallel to one another on one side of a surface;
- forming a second plurality of conductive lines parallel to one another on opposite side of the surface, the first plurality being perpendicular to the second plurality;
- connecting the first plurality of conductive lines to a first sensing circuit;
- connecting the second plurality of conductive lines to a second sensing circuit; and
- transmitting data detected in the first sensing circuit and the second sensing circuit.

27. The method of claim 26, further including: extracting position coordinate from the data.

28. An apparatus for determining and retrieving positional information, comprising:

- a plurality of horizontal conductive lines representing row positions;
- a plurality of vertical conductive lines representing column positions, the plurality of vertical lines being insulated from the plurality of horizontal lines;
- a first sensing circuit connected to the plurality of horizontal lines for receiving change in status of one or more of the plurality of horizontal conductive lines;
- a second sensing circuit connected to the plurality of vertical lines for receiving change in status of one or more of the plurality of vertical conductive lines; and
- a transport medium operative to at least transmit status of the plurality of horizontal conductive lines and the plurality of vertical conductive lines.

29. The apparatus of claim 28, further including: a GPS receiver connected to the data transport medium.

30. The apparatus of claim 29, wherein the data transport medium is further operable to transfer latitude and longitude information of the apparatus.

18

31. The apparatus of claim 29, wherein latitude and longitude information are used to track one or more movements of one or more entities utilizing the apparatus.

32. The apparatus of claim 28, wherein the data transport medium includes an identifier that uniquely identifies the data transport medium.

33. The apparatus of claim 28, wherein the data transport medium is further operable to receive status information about the apparatus.

34. The apparatus of claim 28, wherein the data is encrypted.

35. The apparatus of claim 28, wherein the apparatus is formed into clothing.

36. The apparatus of claim 28, wherein the plurality of horizontal conductive lines and the plurality of vertical conductive lines are weaved into a burlap material.

37. An apparatus for determining and retrieving positional information, comprising:

- a crystalline structure whose resistance changes with stress, the crystalline structure formed into a lattice matrix;
- a sense resistor connected to the crystalline structure, the sense resistor for at least detecting a change in current of the crystalline structure resulting from a stress applied to the crystalline structure;
- a sense node connected to the sense resistor, the sense node for at least converting the change in current to voltage, the voltage being directly proportionally to change in the stress; and
- a transport medium operable to receive data associated with the voltage from the sense node and transmit the data.

38. An apparatus determining and retrieving positional information, comprising:

- a laser;
- a generator operatively connected to the laser, the generator operative to at least generate one or more digital patterns;
- at least two spaced apart mirrors adjacent to the laser, the mirrors reflecting a laser beam generated in the laser superimposed with the one or more digital patterns into a space between the mirrors, the space forming a laser beam plane;
- a laser detector for receiving the reflected laser beam;
- a programmable time delay operatively connected to the generator to synchronize a signal from the generator with the laser beam received in the laser detector;
- a comparator operative to receive data from the laser detector and the signal from the programmable time delay, the comparator further operative to detect a disturbance in the laser beam plane by detecting a difference in the signal from the programmable time delay and the data from the laser detector; and
- a time reference operative to determine time of the disturbance using the difference and determine a position in the laser beam plane using at least the time.

39. A method of determining and retrieving positional information, comprising:

- generating a matrix-array model of an array of electrical elements by a computer processor;
- detecting a stimulated row or column or both in the matrix-array model;
- determining a plurality of possible intersections along the stimulated row or column or both;
- removing one or more of the plurality of possible intersections that have already been mapped;

19

translating remaining intersections to RMT node identifiers;
 predicting which of the RMT node identifiers have a status change;
 modifying the matrix-array model based on the predicting step;
 running simulations based on the modified matrix-array;
 comparing the results of the running simulations step with an actual sensed information of said array; and
 repeating the steps of modifying, running simulations, and comparing one or more times until the results match the actual sensed information of said array.

40. The method of claim 39, wherein the predicting includes:
 predicting which of the RMT node identifiers have a status change using a linear search, geometric progression, or vector mathematics, or combinations thereof to predict next one or more RMT nodes to remove from the matrix array model.

41. An apparatus for determining and retrieving positional information, comprising:
 at least two sheets spaced and facing one another, each of the at least two sheets having a surface having at least two sides;
 a plurality of horizontal lines formed on one side of the surface, the plurality of horizontal lines being parallel to one another and formed at least of conductive material, the plurality of horizontal lines being connected across a potential and a first break detection

20

device, the plurality of horizontal lines further connected to a first detection circuit;
 a plurality of vertical lines formed on an opposite side of the surface, the plurality of vertical lines being parallel to one another and formed of at least conductive material, the plurality of vertical lines being connected across a potential and a second break detection device, the plurality of vertical lines further connected to a second detection circuit; and
 a controller operable to detect penetration times of the two sheets and compute three dimensional direction vector from entry point in one of the two sheets and exit point in another of the two sheets, the controller further operable to determine velocity of a source of the penetration from the three dimensional direction vector and determine direction and distance of the source, the controller further operable to receive positional attitude information and combine the positional attitude information with the three dimensional direction vector to locate the source.

42. An apparatus for determining and retrieving positional information, comprising:
 a resistive matrix target including at least a matrix of conductive lines formed at least from resistive colloidal suspension coating including at least thermally conductive additive.

* * * * *