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(54) **INTERROGATION OF AN OBJECT FOR DIMENSIONAL AND TOPOGRAPHICAL INFORMATION**

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(52) **U.S. Cl.** **342/22**; 342/179
(58) **Field of Search** 342/22, 179; 367/8

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,713,156	A	1/1973	Pothier	343/17
4,635,367	A	1/1987	Vigede	33/15
4,705,401	A	11/1987	Addleman et al.	356/376
4,737,032	A	4/1988	Addleman et al.	356/376
4,916,634	A	4/1990	Collins et al.	364/513
5,060,393	A	10/1991	Silverman et al.	33/512
5,073,782	A	12/1991	Huguenin et al.	342/179
5,081,456	A	1/1992	Michiguchi et al.	342/22
5,170,170	A	* 12/1992	Soumekh	342/179
5,227,797	A	7/1993	Murphy	342/22
5,227,800	A	7/1993	Huguenin et al.	342/179
5,414,803	A	5/1995	Malzbender	395/127
5,455,590	A	10/1995	Collins et al.	342/179
5,557,283	A	9/1996	Sheen et al.	342/179
5,680,528	A	10/1997	Korszun	395/135
5,740,800	A	4/1998	Hendrickson et al.	128/630
5,747,822	A	5/1998	Sinclair et al.	250/559.19
5,796,363	A	8/1998	Mast	342/22
5,833,599	A	11/1998	Schrier et al.	600/300
5,835,054	A	11/1998	Warhus et al.	342/22
5,859,609	A	1/1999	Sheen et al.	342/179
5,864,640	A	1/1999	Miramonti et al.	382/312
5,870,220	A	2/1999	Migdal et al.	359/216
5,956,525	A	9/1999	Minsky	396/3
6,144,388	A	11/2000	Bornstein	345/435

OTHER PUBLICATIONS

David Sheen, Douglas McMakin, and Thomas E. Hall, "Combined illumination cylindrical millimeter–wave imaging technique for conceald weapon detection", SPIE Proceedings Publication (Apr. 26, 2000).
Clive Cookson, "Body scanners to shape our shopping", London (Dated at least as early as Dec. 1, 2000).
SAE International, print–out of website at URL www.sae-.org/technicalcommittees (Feb. 2000).
Andrea Ahles, "The Caesar Project", print–out of website at URL thunder.temple.edu/~mridenou/pe204/BodyAnthro-Caesar.html, Philadelphia Inquirer (Feb. 11, 1999).

(List continued on next page.)

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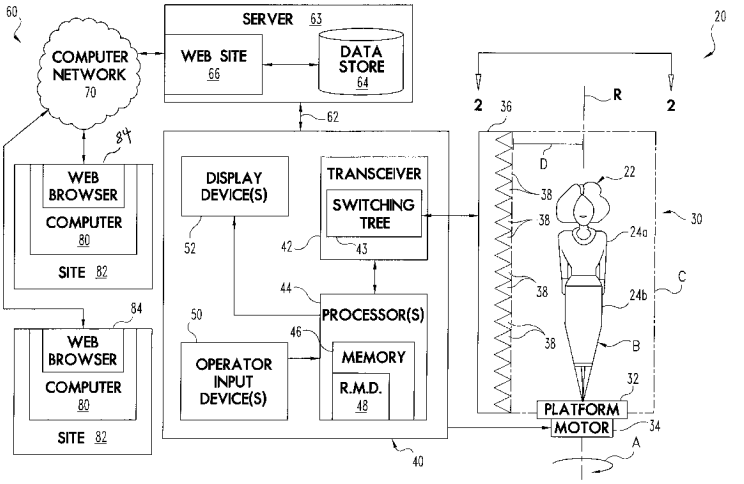
(57) **ABSTRACT**

Disclosed are systems, methods, devices, and apparatus to interrogate a clothed individual with electromagnetic radiation to determine one or more body measurements at least partially covered by the individual's clothing. The invention further includes techniques to interrogate an object with electromagnetic radiation in the millimeter and/or microwave range to provide a volumetric representation of the object. This representation can be used to display images and/or determine dimensional information concerning the object.

48 Claims, 9 Drawing Sheets



OTHER PUBLICATIONS

Cyberware, "The World's First Whole Body Scanners Bring True Human Forms to Computer Graphics", print–out of website at URL www.cyberware.com/pressReleases/firstW-B.html, Monterey, CA (May 11, 1995).

Cyberware, "Cyberware Whole Body Scanning", print–out of website at URL www.cyberware.com/products/Whole-Body.html. (1999).

Cyberware, "Cyberware Extracts Tailor Measurements from 3D Scan Data", print–out of website at URL www.cyber-ware.com/pressReleases/arn.html, Monterey, CA (Aug. 1, 1997).

Cyberware, "Body Measurement/Garment Fitting Soft-ware", print–out of website at URL www.cyberware.com/pressRelease/digisize_PR1.html, Monterey, CA (Aug. 9, 1999).

Cyberware, "Laser Sizes Up Your Body, Fits Your Cloth-ing", print–out of website at URL www.cyberware.com/pressRelease/digisize_PR2.html, Monterey, CA (Aug. 9, 1999).

* cited by examiner

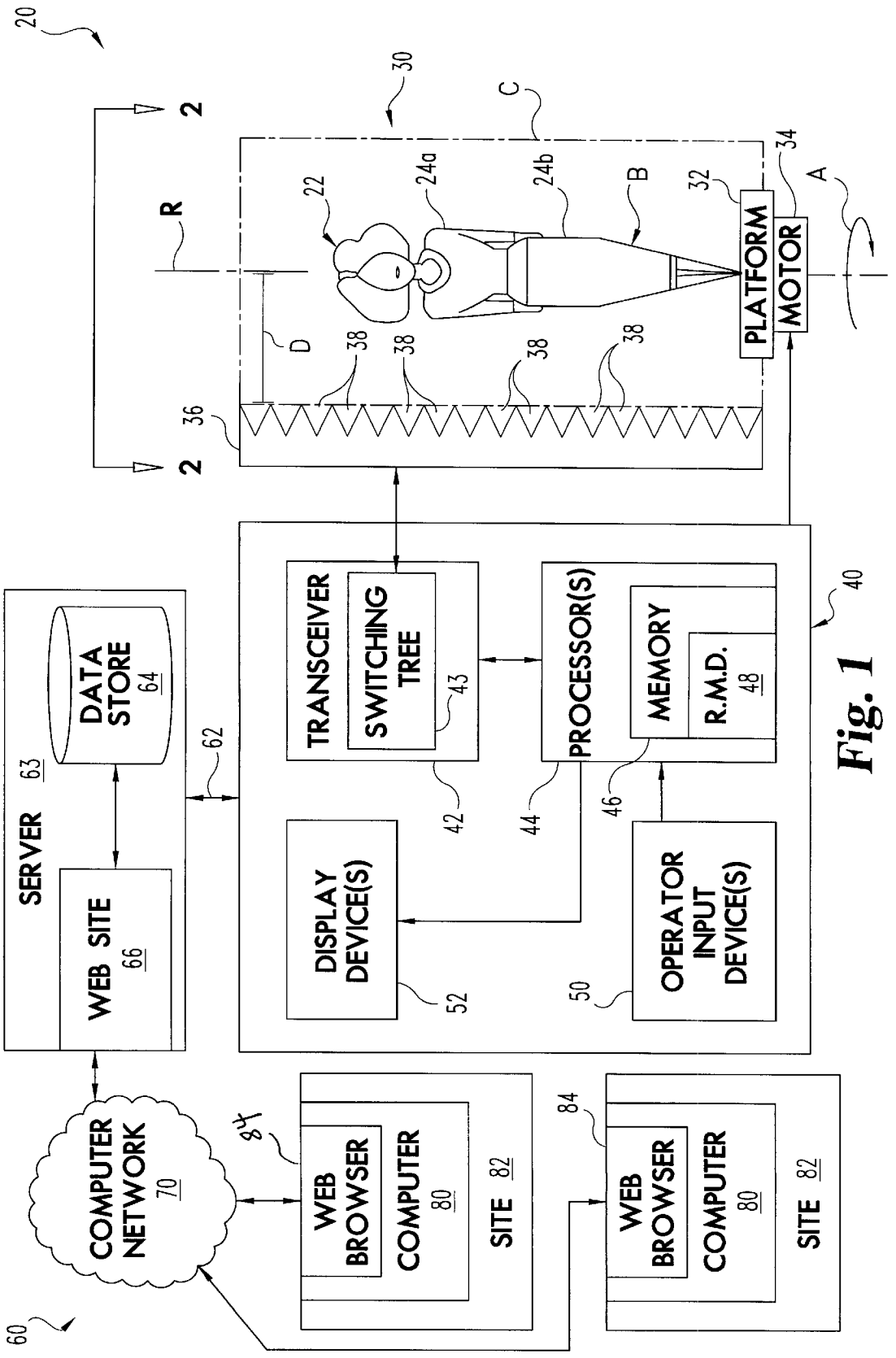

20
30
C
2
2
R
22
24a
24b
B
32
34
A
PLATFORM
MOTOR
D
38
38
38
38
36
TRANSCEIVER
SWITCHING TREE
43
PROCESSOR(S)
MEMORY
R.M.D.
48
40
DATA STORE
64
SERVER
63
62
WEB SITE
66
DISPLAY DEVICE(S)
52
42
44
46
OPERATOR INPUT DEVICE(S)
50
COMPUTER NETWORK
70
60
84
WEB BROWSER
COMPUTER
80
SITE
82

Fig. 1

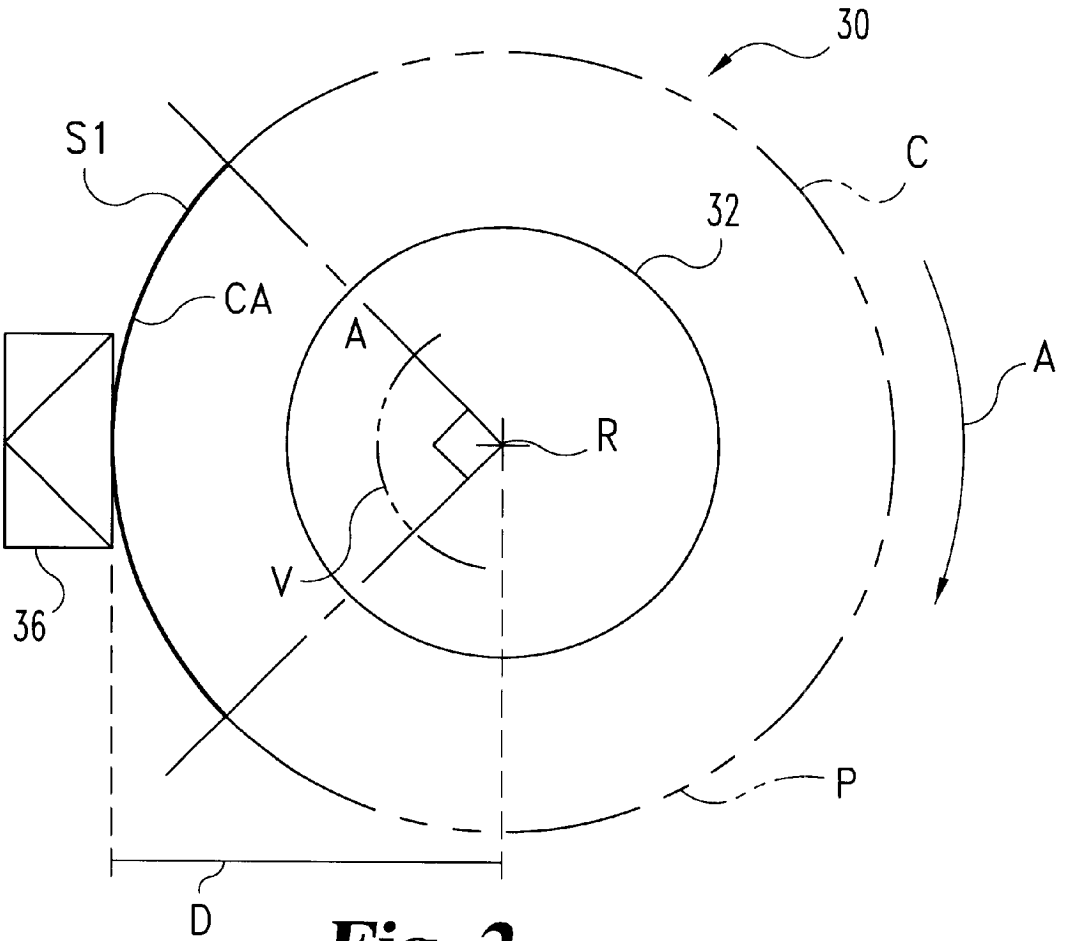


Fig. 2

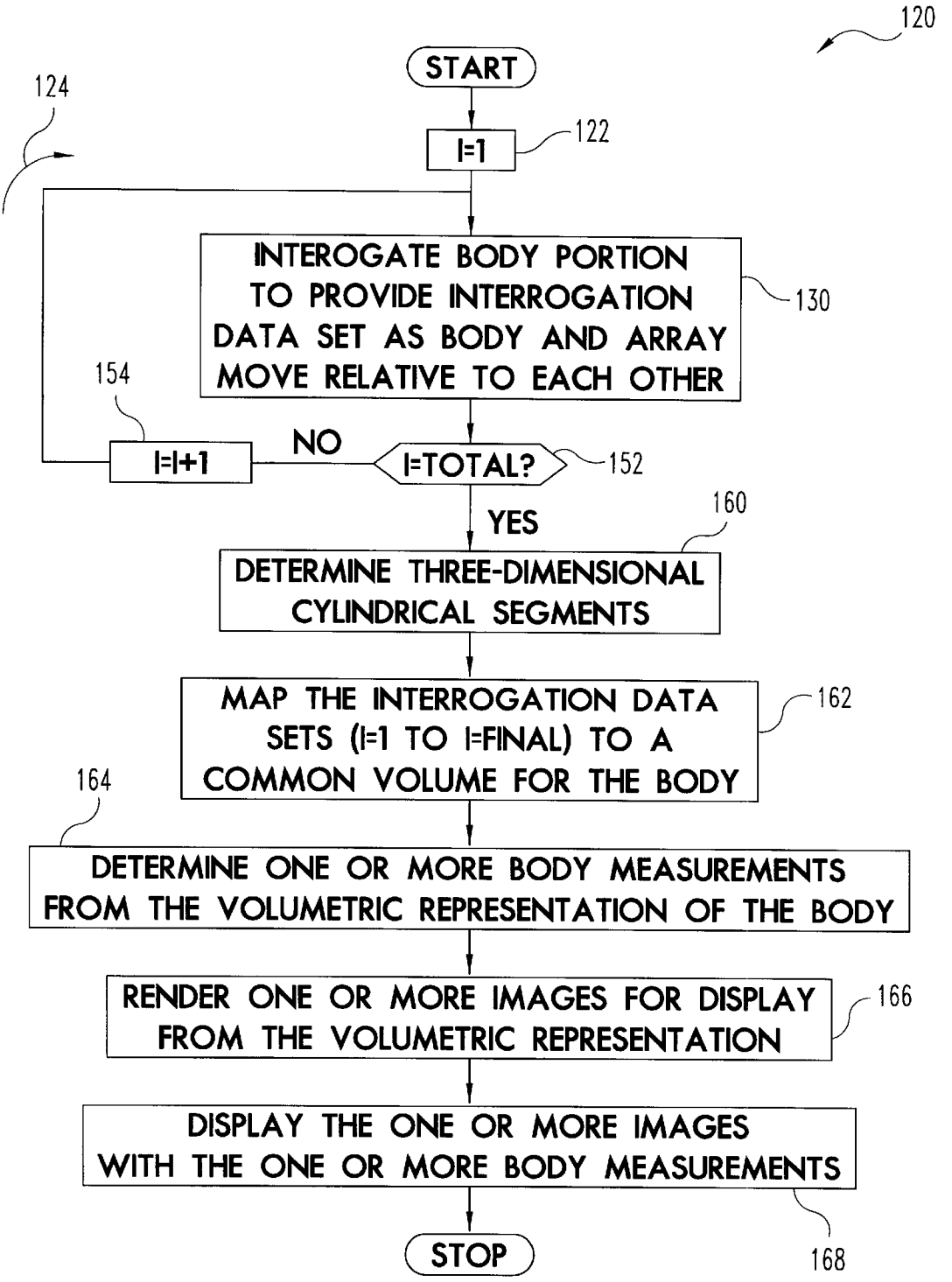

120
START
124
I=1
122
INTEROGATE BODY PORTION TO PROVIDE INTERROGATION DATA SET AS BODY AND ARRAY MOVE RELATIVE TO EACH OTHER
130
154
I=I+1
NO
I=TOTAL?
152
YES
160
DETERMINE THREE-DIMENSIONAL CYLINDRICAL SEGMENTS
MAP THE INTERROGATION DATA SETS (I=1 TO I=FINAL) TO A COMMON VOLUME FOR THE BODY
162
164
DETERMINE ONE OR MORE BODY MEASUREMENTS FROM THE VOLUMETRIC REPRESENTATION OF THE BODY
RENDER ONE OR MORE IMAGES FOR DISPLAY FROM THE VOLUMETRIC REPRESENTATION
166
DISPLAY THE ONE OR MORE IMAGES WITH THE ONE OR MORE BODY MEASUREMENTS
STOP
168

Fig. 3

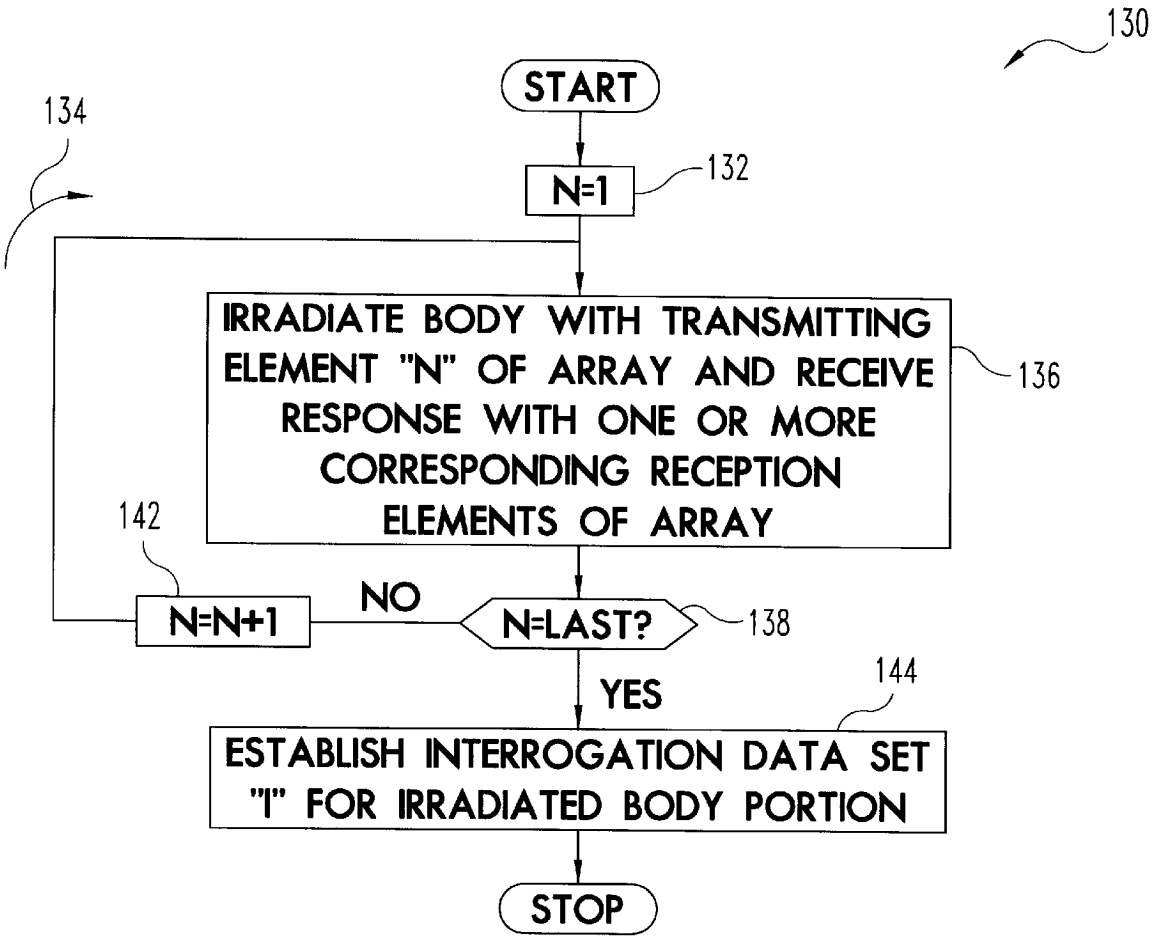

130
START
134
N=1
132
IRRADIATE BODY WITH TRANSMITTING ELEMENT "N" OF ARRAY AND RECEIVE RESPONSE WITH ONE OR MORE CORRESPONDING RECEPTION ELEMENTS OF ARRAY
136
142
N=N+1
NO
N=LAST?
138
YES
144
ESTABLISH INTERROGATION DATA SET "I" FOR IRRADIATED BODY PORTION
STOP

Fig. 4

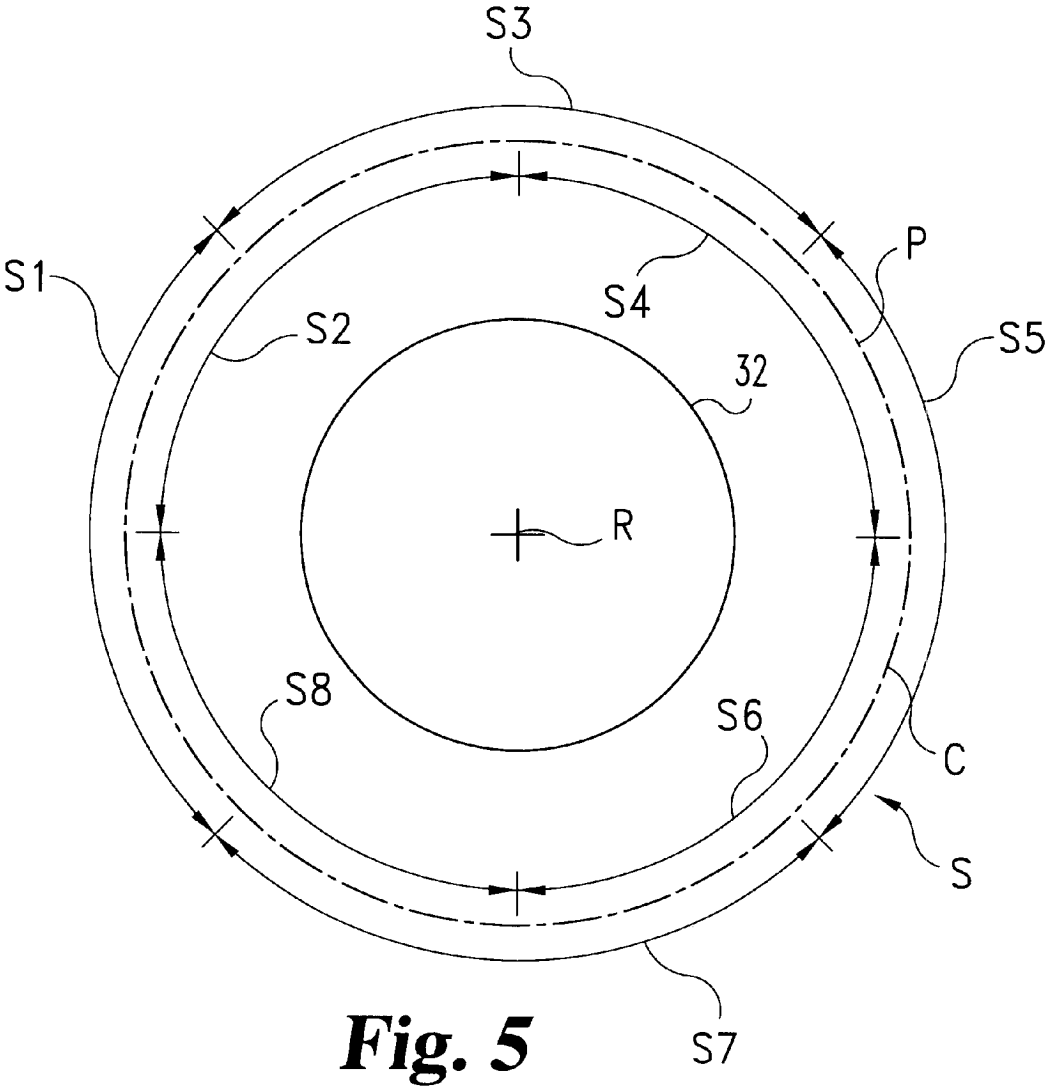


Fig. 5

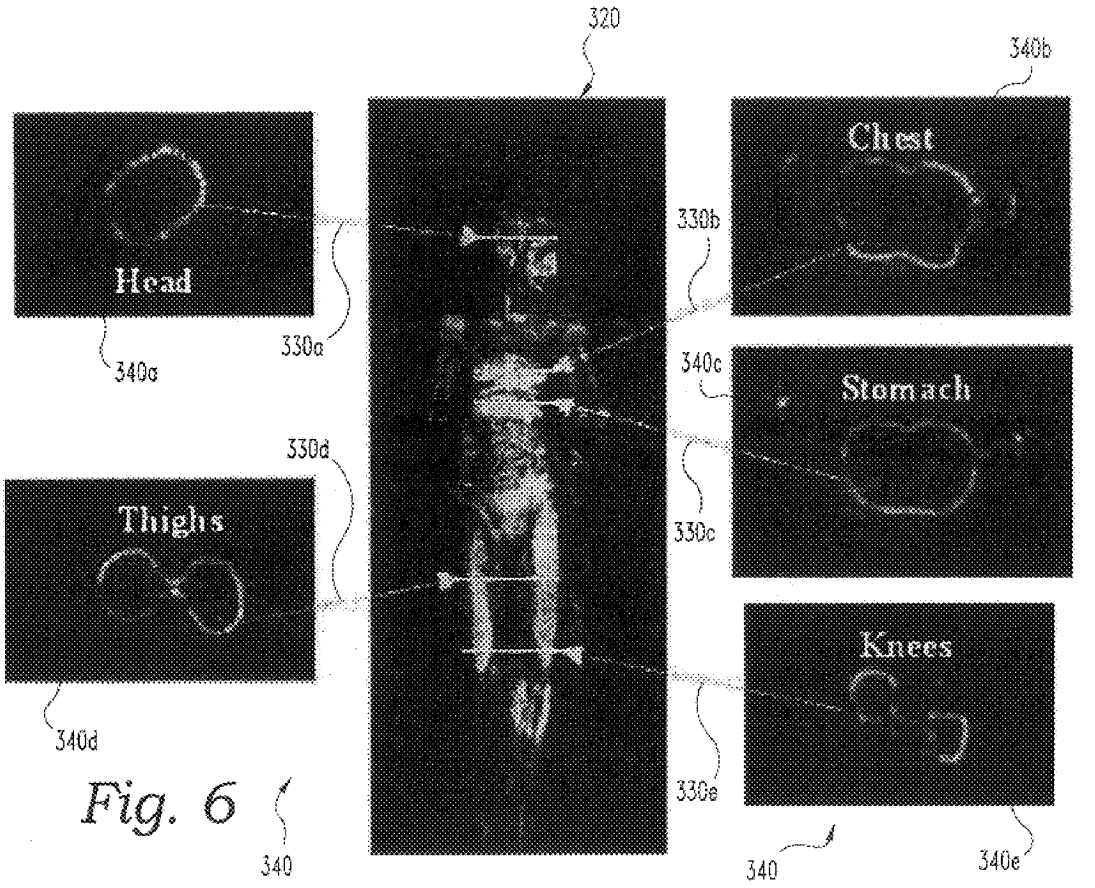

320
340b
Chest
330b
Head
330a
340a
340c
Stomach
330d
Thighs
330c
340d
Knees
330e
340
340
340e

Fig. 6

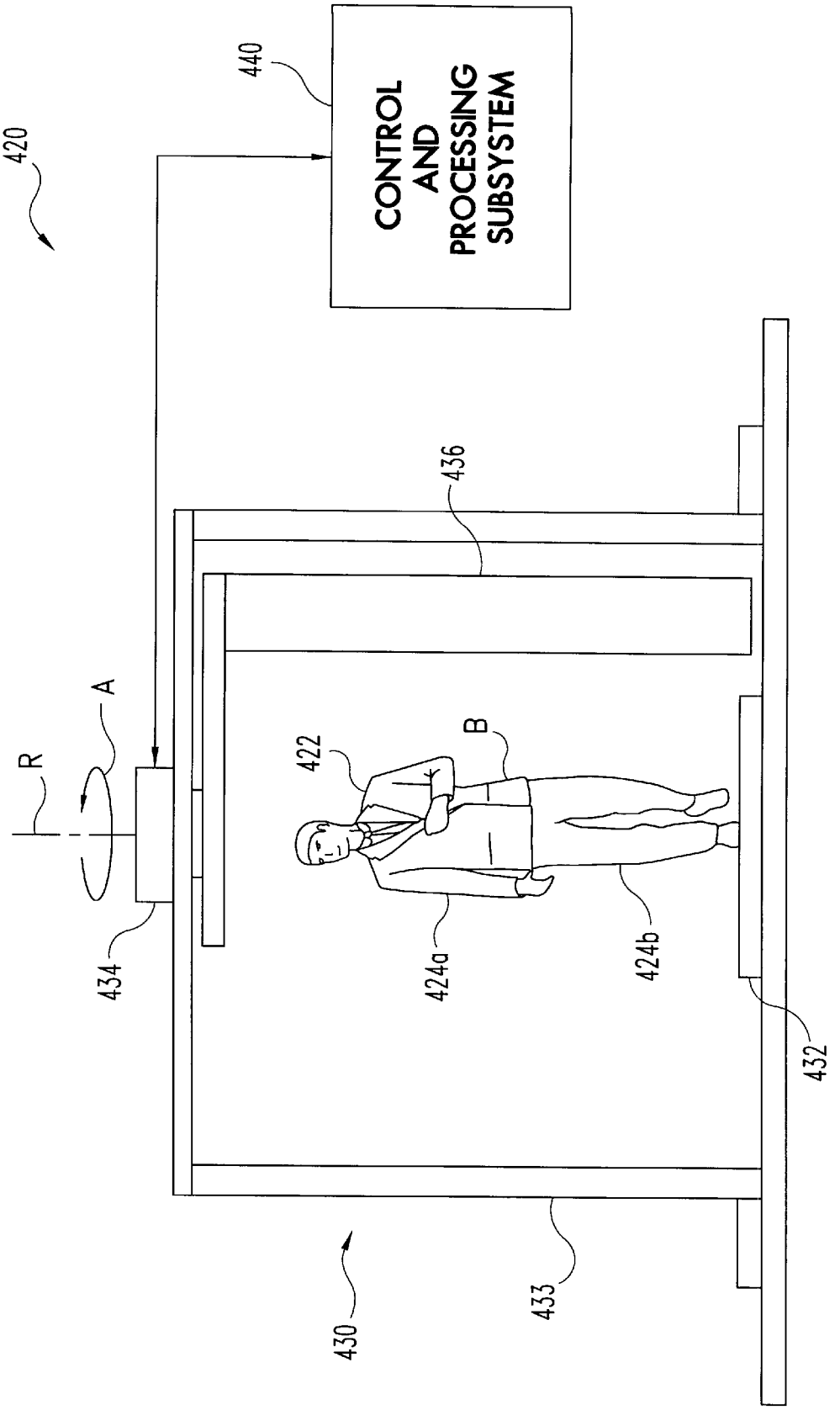

420
440
CONTROL AND PROCESSING SUBSYSTEM
436
R
A
B
422
434
424a
424b
432
433
430

Fig. 7

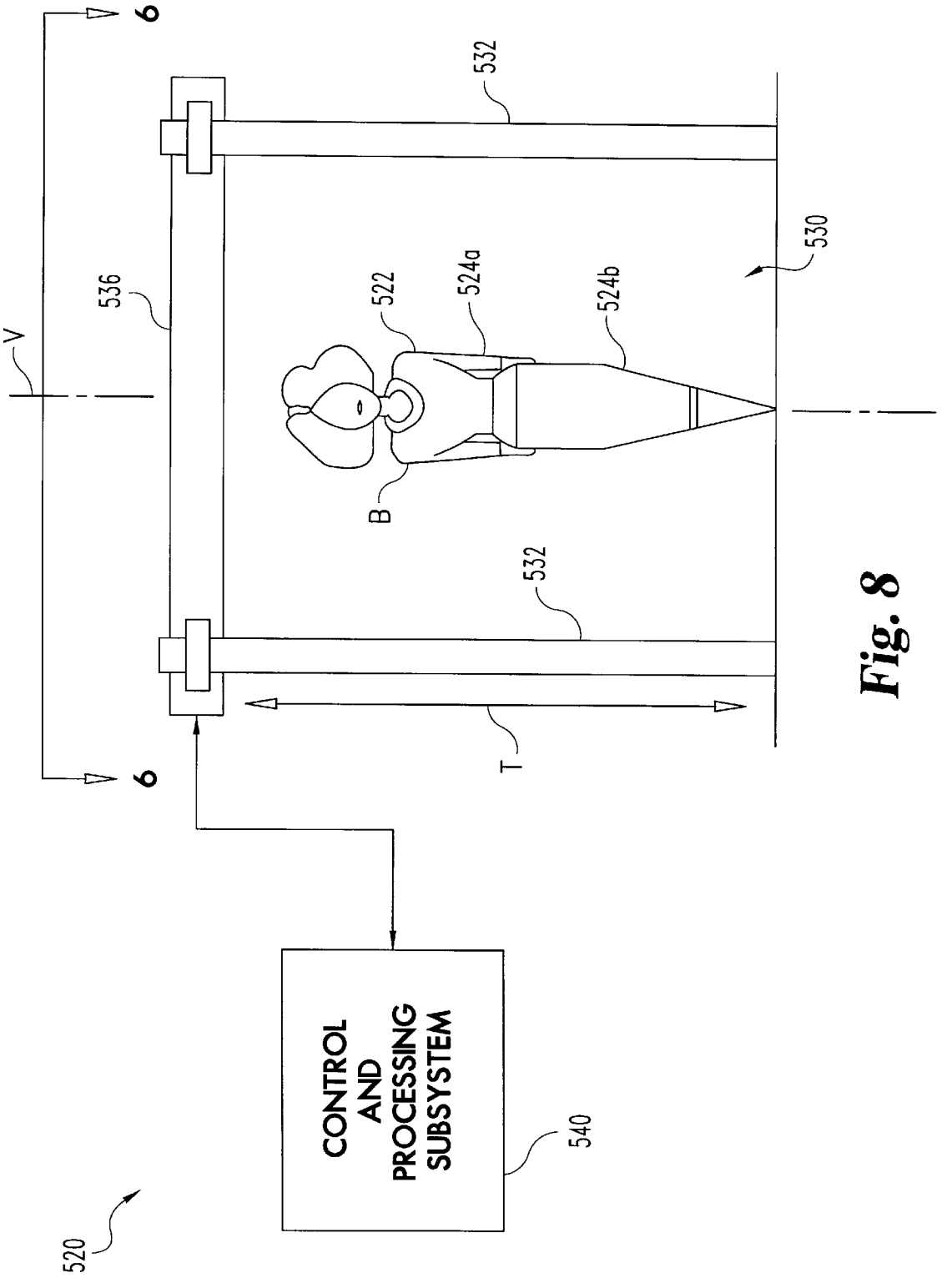

6
6
532
530
536
522
524a
524b
V
B
532
T
CONTROL AND PROCESSING SUBSYSTEM
540
520

Fig. 8

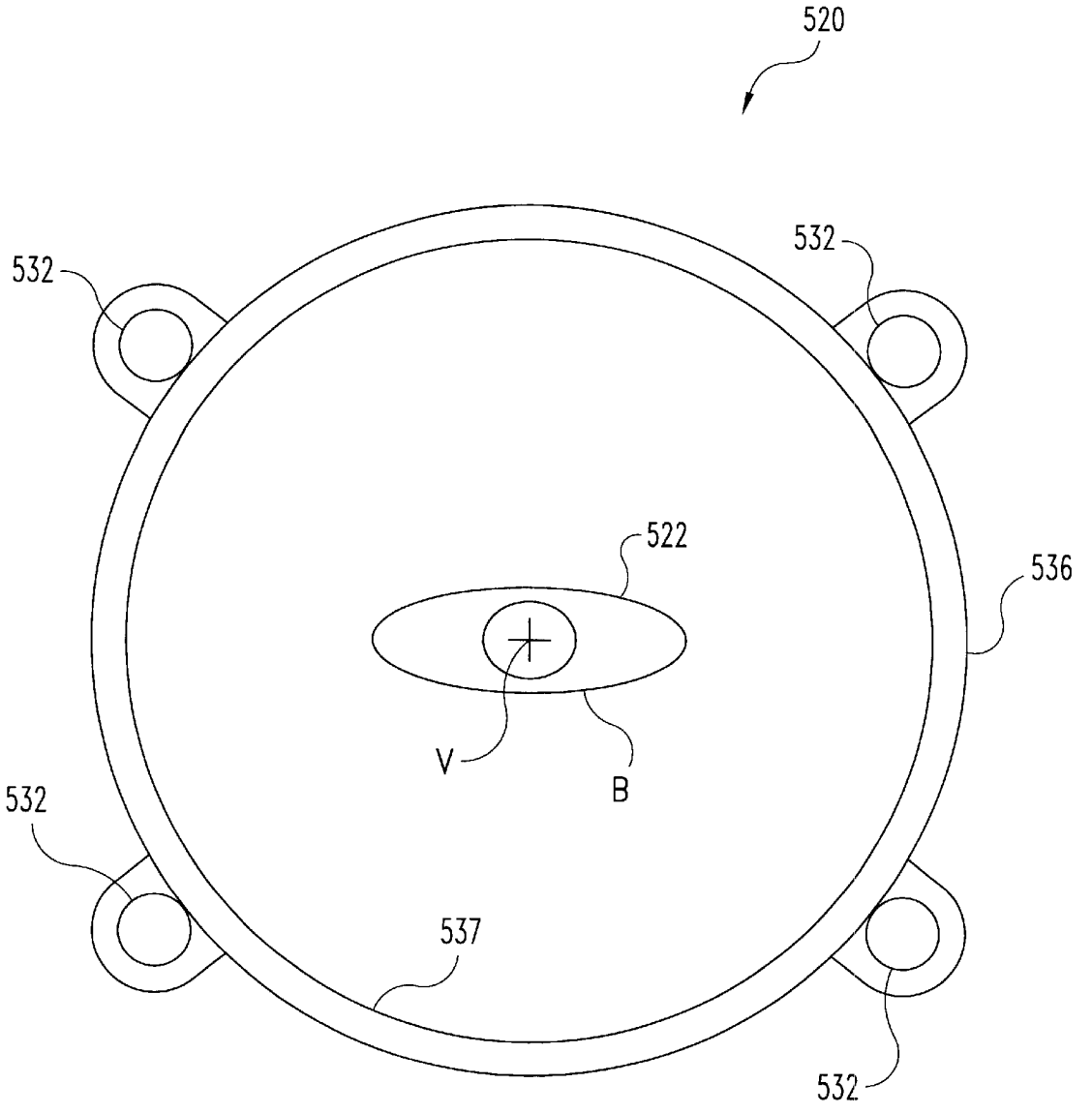


Fig. 9

INTERROGATION OF AN OBJECT FOR DIMENSIONAL AND TOPOGRAPHICAL INFORMATION

GOVERNMENT RIGHTS

This invention was made with Government support under Contract Number DE-AC0676RLO1830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

BACKGROUND

The present invention relates to interrogation of an object with electromagnetic radiation, and more particularly, but not exclusively relates to determining dimensional and topographical information about a person's body.

Schemes from the common tape measure to visible light laser scanning have been employed to obtain measurements of a person's body. Unfortunately, these schemes often require a significant degree of mechanical intervention or preparation, such as the placement of a measuring device or marker on the person and/or removal of the person's clothing. Moreover, it is typically desirable to nonintrusively interrogate an object for dimensional information with less object handling, reduced interrogation time, and/or greater resolution relative to existing schemes. Another goal that is sometimes related to object mensuration is the desire to determine the topography of an object's surface. Thus, there is a demand for further contributions in this area of technology, including new ways to obtain dimensional and/or topographical information.

SUMMARY OF INVENTION

One embodiment of the present invention is a unique technique to obtain one or more body measurements of a person. Other embodiments include unique systems, devices, methods, and apparatus to determine dimensional, topographical, and/or image information about an object. Still other embodiments include unique ways to utilize such information.

In a further embodiment of the present invention, electromagnetic radiation interrogates an object to determine dimensional information about the object. This interrogation can include determining a measurement of one or more features at least partially covered by a substance that is penetrated by the electromagnetic radiation. In one form, the electromagnetic radiation is of a nonionizing type that can penetrate the clothing of a person to determine one or more body measurements corresponding to a skin surface that is at least partially covered by the clothing. In another form, the invention may be applied to determine dimensional information concerning a body surface that is not covered by clothing or the like.

Still another embodiment includes irradiating a body at least partially covered with clothing and detecting electromagnetic radiation returned from a surface of the body through the clothing in response to this irradiation. A measurement of the body is determined from the electromagnetic radiation that corresponds to this surface. The body can be of a person with the surface corresponding to the person's skin. In one preferred form of this embodiment, the electromagnetic radiation includes at least one frequency in a frequency range of about 200 Megahertz (MHz) to about 1 Terahertz (THz). In a more preferred form, the electromagnetic radiation is in a frequency range of about 1 Gigahertz (GHz) to about 300 GHz. In a most preferred form, the electromagnetic radiation is in a frequency range of about 5 GHz to about 110 GHz.

Yet a further embodiment of the present invention is directed to irradiation of an object to obtain data corresponding to a number of different images of the object. A topographical representation is determined from the data. This representation can be used to generate a desired output, such as one or more images of the object. In one preferred form, the electromagnetic radiation is in a frequency range of about 200 Megahertz (MHz) to about 1 Terahertz (THz). In a more preferred form, the electromagnetic radiation is in a frequency range of about 1 GHz to about 300 GHz. In a most preferred form, the electromagnetic radiation is in a range of about 5 GHz to about 110 GHz.

For another embodiment, a system includes an array to interrogate a person with electromagnetic radiation. One or more processors are included that respond to signals from the array to determine a body measurement of the person. The body measurement corresponds to a skin surface of the person that is at least partially covered by clothing during interrogation with the array. In one preferred form, the electromagnetic radiation includes one or more wavelengths in the range from about 300 micrometers (μm) to about 1.5 meters (m). In a more preferred form, the electromagnetic radiation includes one or more wavelengths in the range from about 2 millimeters (mm) to about 1 centimeter (cm).

Still another embodiment includes a device carrying one or more signals that comprise logic to operate one or more processors. This logic is operable to process a number of data sets each corresponding to a different portion of a body interrogated with electromagnetic radiation. The logic is further operable to provide a volumetric and/or topographical representation of the body from the data sets and determine one or more body measurements from such representation(s).

In yet another embodiment, a system includes at least one array to interrogate an object with electromagnetic radiation at one or more frequencies in a range of about 200 MHz to about 1 THz. Also included are one or more processors responsive to this array that are operable to: establish a number of data sets each representative of a three-dimensional image of a different one of a number of portions of the object; map the data sets to a volumetric representation of the object, the volumetric representation corresponding to a volume of the object defined by each of the portions of the object; and process the volumetric representation to provide an output. The system can further include a display device responsive to this output.

Another embodiment includes irradiating an object and detecting electromagnetic radiation reflected by the object in response to this irradiation. This electromagnetic radiation is in a frequency range of about 200 MHz to about 1 THz. Data determined from the electromagnetic radiation detection is used to generate a volumetric or topographical representation of the object. This representation can define at least one circumference of the object from which a circumferential measurement of the object can be determined.

Among other embodiments of the present invention is: providing a sensing array and one or more processors coupled to the array; interrogating an object with electromagnetic radiation from the array; generating data representative of the object from this interrogation with the one or more processors; and transmitting the data over a computer network to a remote site. The electromagnetic radiation has a frequency in a range of about 200 MHz to about 1 THz.

Further embodiments include a system, method, device, and/or apparatus to determine dimensional and/or imaging information about an object with electromagnetic radiation. In one preferred form, the electromagnetic radiation is selected from a frequency range of about 200 Magahertz (MHz) to about 1 Teraheertz (THz). In a more preferred form, the electromagnetic radiation is in a frequency range of about 1 GHz to about 300 GHz. In a most preferred form, the electromagnetic radiation is in a range of about 5 GHz to about 110 GHz.

Accordingly, one object of the present invention is to provide a unique technique to obtain information through interrogation with electromagnetic radiation.

Another object is to provide a unique system, method, device, or apparatus to determine dimensional, topographical, image, and/or volumetric information about an object.

Other objects, embodiments, forms, features, advantages, aspects and benefits of the present invention shall become apparent from the detailed description and drawings included herein.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a partial, diagrammatic view of an interrogation system.

FIG. **2** is a partial, top view of the FIG. **1** system along the view line **2**—**2** shown in FIG. **1**.

FIGS. **3** and **4** are flow charts illustrating one procedure for operating the system of FIG. **1**.

FIG. **5** is a schematic, top view of the system of FIG. **1** illustrating a number of overlapping arc segments.

FIG. **6** is a computer-generated image provided in accordance with the procedure of FIGS. **3** and **4**.

FIG. **7** is a partial, diagrammatic view of another interrogation system.

FIG. **8** is a partial, diagrammatic view of yet another interrogation system.

FIG. **9** is a partial, top view of the system of FIG. **8**.

DETAILED DESCRIPTION

While the present invention may be embodied in many different forms, for the purpose of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

One nonlimiting form of the present invention includes an interrogation technique to obtain topographic data about a surface of an object that can be hidden by one or more layers, such as clothing, or exposed. The interrogation is performed with a scanner that emits electromagnetic radiation in frequency range including the millimeter and/or microwave wavelength bands. The data can be used to form a three-dimensional topographical representation of the surface, determine object dimensions, and/or render one or more images of the object. When applied to a clothed individual, the scanner is capable of discriminating between layers of clothing and identifying skin impressions (indentations) left by tight fitting clothing (e.g., socks, belts, undergarment bands and straps). This data can be of interest for apparel designers. Likewise, the scanner can be used to measure one or more features of an individual's body to fit clothing or select body-fitted equipment. Additionally or alternatively, the scanner can interrogate inanimate and animate objects residing on a person's body (even if covered by clothing), in clothing itself, and in baggage. These features can be desirable for certain security applications.

FIG. **1** illustrates system **20** of one embodiment of the present invention. In operation, system **20** determines dimensional and/or topographical information about an animate or inanimate object by illuminating it with electromagnetic radiation in the 200 Megahertz (MHz) to 1 THz frequency range and detecting the reflected radiation. The corresponding wavelength range includes the millimeter and microwave bands. Certain natural and synthetic fibers are often semi-transparent to such frequencies/wavelengths, permitting the detection and/or imaging of surfaces positioned beneath such materials. When the subject of interrogation is a clothed individual, dimensional information about portions of a person's body covered by clothing or garments can typically be obtained with system **20**, as well as those portions that are not covered by clothing or garments.

As illustrated in FIG. **1**, body B is in the form of a person **22** presented for interrogation by system **20**. Person **22** is portrayed in a typical manner, being at least partially covered by garments or clothing designated by reference numerals **24***a* and **24***b*. Person **22** is positioned in scanning/illumination booth **30** of system **20**. Booth **30** includes platform **32** connected to motor **34**. Platform **32** is arranged to support person **22** or such other object desired to be examined with system **20**. Motor **34** is arranged to selectively rotate about rotational axis R while person **22** is positioned thereon. For the orientation shown, axis R is approximately vertical, and person **22** is in a generally central position relative to axis R and platform **32**.

Booth **30** further includes a multiple element-sensing array **36**. Referring additionally to the partial top view of FIG. **2**, the relationship of platform **32** to array **36** is further illustrated. Axis R is generally perpendicular to the view plane of FIG. **2** and is represented by crosshairs. As motor **34** causes platform **32** to rotate about axis R, array **36** circumscribes a generally circular pathway P about axis R. Circular pathway P corresponds to an imaginary cylinder C with radius D. Radius D is the distance from axis R to array **36**. In one preferred form, radius D is about 0.5 to about 2 meters. In a more preferred form, radius D is about **0.5** meters to 1.5 meters—corresponding to about a 1 meter to 3 meter diameter. Arrow A shown in FIGS. **1** and **2** represents the selective rotation of platform **32** about axis R.

Sensing array **36** includes a number of linearly arranged elements **38** only a few of which are schematically illustrated and specifically designed by reference numerals to preserve clarity. Elements **38** each operate to transmit or receive electromagnetic radiation within a selected bandwidth. Sensing array **36** is coupled to control and processing subsystem **40**. Subsystem **40** includes transceiver **42** with switching tree **43** coupled to elements **38** of array **36**. In one form, the position of array **36** relative to platform **32** is determined with one or more positional encoders (not shown) that are coupled to subsystem **40**. In other forms, one or more different position tracking devices and/or techniques can be used.

Under the control of transceiver **42**, individual elements **38** can be selectively activated with switching tree **43**. Each

element **38** is dedicated to transmission or reception. Elements **38** are arranged in two generally vertical columns arranged in a generally back-to-back relationship with one another. Elements **38** comprising one of the columns are dedicated to transmission and elements **38** comprising the other of the columns are dedicated to reception. The number of elements **38** in each column is in a range of about 200 to about 600 elements and spans a vertical distance of about 2 to 2.5 meters along axis R; however, in other embodiments, a different vertical span and/or number of elements can be utilized. Transceiver **42** can control switching tree **43** to irradiate body B with only one element **38** of the transmitting column at a time and simultaneously receive with one or more elements **38** of the receiving column. Transceiver **42** includes logic to direct successive activation of each element **38** of the transmitting column and the corresponding one or more elements **38** of the receiving column to provide a scan of a portion of body B along a vertical direction with array **36**. The corresponding "down range" or "time-of-flight" information can be used to provide positional data about a corresponding portion of body B under interrogation (such as person **22**). Further information about such arrangements is provided in commonly owned U.S. Pat. No. 5,859,609, which is hereby incorporated by reference.

In a preferred embodiment, transceiver **42** and elements **38** of array **36** are of a form suitable to transmit and/or receive electromagnetic radiation selected from the range of about one Gigahertz to about one Terahertz (about 1 GHz to about 1 THz), which corresponds to a free space electromagnetic radiation wavelength range of about 0.3 meter (m) to about 300 micrometers (μm). In another preferred embodiment, an impulse transceiver arrangement is utilized that generates frequencies in a range of about 200 MHz to about 15 GHz depending on the impulse width, which corresponds to a free space electromagnetic radiation wavelength range of about 1.5 m to about 0.02 m. In a more preferred embodiment, the frequency range is about 1 GHz to about 300 GHz with a corresponding free space wavelength range of about 0.3 meter to about 1 millimeter (mm). In a most preferred embodiment, the frequency range is about 5 GHz to about 110 GHz with a corresponding free space wavelength range of about 0.06 m to about 2.7 mm.

The transmission pathway for a given element **38** of the transmitting column can be selected to be about the same length as the transmission pathway for the corresponding element(s) **38** of the receiving column to simplify calibration. Nonetheless, in other embodiments, the transmission/reception arrangement can differ. For example, in one alternative embodiment, one or more elements **38** are used for both transmission and reception. In another alternative embodiment, a mixture of both approaches is utilized. Typically, the signals received from array **36** are down-shifted in frequency and converted into a processible format through the application of standard techniques. In one form, transceiver **42** is of a bi-static heterodyne Frequency Modulated Continuous Wave (FM/(CW) type like that described in U.S. Pat. No. 5,859,609 (incorporated by reference herein). Commonly owned U.S. Pat. No. 5,557,283 and 5,455,590, each of which are incorporated by reference herein, provide several nonlimiting examples of other transceiver arrangements. In still other embodiments, a mixture of different transceiver/sensing element configurations with overlapping or nonoverlapping frequency ranges can be utilized that may include one or more of the impulse type, monostatic homodyne type, bi-static heterodyne type, and/or such other type as would occur to those skilled in the art.

Transceiver **42** provides the data corresponding to the array signals to one or more processors **44** of subsystem **40**. Processor(s) **44** can be comprised of one or more components of any type suitable to process the data received from transceiver **42**, including digital circuitry, analog circuitry, or a combination of both. Processor(s) **44** can be of a programmable type; a dedicated, hardwired state machine; or a combination of these. For a multiple processor form; distributed, pipelined, and/or parallel processing can be utilized as appropriate. In one arrangement, an integrated circuit form of a programmable digital signal processor is utilized that is capable of at least 1 Gigaflop operation.

Memory **46** is included in processor(s) **44**. Memory **46** can be of a solid-state variety, electromagnetic variety, optical variety, or a combination of these forms. Furthermore, memory **46** and can be volatile, nonvolatile, or a mixture of these types. Memory **46** can be at least partially integrated with processor(s) **44**. Removable processor-readable Memory Device (R.M.D.) **48** is also included with processor(s) **44**. R.M.D. **48** can be a floppy disc, cartridge, or tape form of removable electromagnetic recording media; an optical CD or DVD disc; an electrically reprogrammable solid-state type of nonvolatile memory, and/or such different variety as would occur to those skilled in the art. In still other embodiments, R.M.D. **48** is absent.

Subsystem **40** is coupled to motor **34** to selectively control the rotation of platform **32** with processor(s) **44** and/or transceiver **42**. Subsystem **40** includes one or more operator input devices **50** and one or more display devices **52**. Operator input device(s) **50** can include a keyboard, mouse or other pointing device, a voice recognition input subsystem, and/or a different system as would occur to those skilled in the art. Operator display device(s) **52** can be of a Cathode Ray Tube (CRT) type, Liquid Crystal Display (LCD) type, plasma type, Organic Light Emitting Diode (OLED) type, or such different type as would occur to those skilled in the art. In one form, at least a standard keyboard and mouse are included in input devices(s) **50**, and at least one high-resolution color graphic display is included in display devices **52**.

System **20** further includes communication subsystem **60** coupled to subsystem **40** by communication link **62**. Subsystem **60** includes network server **63** coupled to computer network **70**. Computer network **70** includes the internet. Communication link **62** can be provided in the form of one or more dedicated communication channels for subsystem **40**, a Local Area Network (LAN), and/or a Wide Area Network (WAN), such as the internet. In other words, server **63** can be remotely located relative to subsystem **40** with computer network **70** providing link **62**. Indeed, in one embodiment, server **63** is coupled to a number of remotely located subsystems **40** with corresponding booths **30**. In still other embodiments, more than one server **63** can be coupled to a common booth **30** and subsystem **40** arrangement.

Server **63** is operable to communicate via the world wide web over network **70**. Server **63** includes a data store **64** to collect data provided from subsystem **40** and is arranged to provide a web site **66** comprising one or more web pages of information. Computer network **70** communicatively couples a number of sites **80** together. Each site **80** includes a computer **82** arranged to communicatively interface with computer network **70** through web browser **84**. Each computer **82** includes one or more operator input device(s) **50** and one or more operator output device(s) **52** as previously described for subsystem **40**, that are not shown to preserve clarity. Device(s) **50** and **52** at each site **80** selectively provide an operator input and output (I/O) capability via web browser **84**. Computer **82** can be in the form of a personal computer, computer workstation, another computer

server, Personal Digital Assistant (PDA), and/or a different configuration as would occur to those skilled in the art. While only two user sites **80** are illustrated to preserve clarity, it should be understood that more or fewer can be coupled to computer network **70**.

Collectively, server **63**, computer network **70**, and sites **80** provide an arrangement to remotely access and/or control subsystem **40** or booth **30**. The interconnection of these components can be hardwired, wireless, or a combination of both. In other embodiments, an interconnection technique other than the internet could be alternatively or additionally utilized with the connection interfaces of server **63** and/or sites **80** adapted accordingly. For example, sites **80** and server **63** could be coupled by a LAN, dedicated cabling, and the like. In one alternative embodiment, server **63** is an integral part of subsystem **40**. For still other embodiments, server **63**, network **70** and sites **80** are absent. Indeed, removable memory device **48** can be used to alternatively or additionally transfer data between subsystem **40** and other computing/processing devices.

Referring additionally to FIG. **3**, one mode of operating system **20** is illustrated as procedure **120**. Procedure **120** is performed to provide a three-dimensional topographical representation of Body B with system **20**. Various body measurements can be determined from this representation with system **20**. Procedure **120** begins with initialization operation **122** that sets interrogation index "I" to one (I=1). From operation **122**, procedure **120** enters interrogation loop **124** beginning with interrogation subroutine **130**. Interrogation subroutine **130** interrogates a portion of body B within a field of view of array **36** as body B rotates on platform **32**. Index I is an integer index to the number of different interrogation subroutines **130** performed as part of procedure **120**.

Referring to FIG. **4**, interrogation subroutine **130** is further illustrated. Subroutine **130** begins with initialization operation **132** in which transmission index N is set to one (N=1). From operation **132**, element sequencing loop **134** is entered, beginning with transmission/reception operation **136**. Index N is an integer index to the number of transmission/reception operations **136** performed during subroutine **130**.

In operation **136**, a portion of the body in the field of view of a transmitting element number "N" of array **36** is irradiated with electromagnetic radiation and one or more corresponding reception elements collect the reflected electromagnetic radiation in response to the transmission. The transmitting and reception elements are selected by logic of transceiver **42** with switching tree **43** as previously described. From operation **136**, subroutine **130** proceeds to conditional **138**, which tests whether transmitting element number "N" is the last element needed to transmit (N=LAST?); where LAST is the total number of the transmitting elements to be activated by transceiver **42**. In one form, for each execution of subroutine **130**, transmitting element "N" sweeps through a selected frequency range twice, and the corresponding backscatter information for each of the two sweeps is received with a different reception element. The transmitting elements can be staggered relative to the reception elements such that transmitting element N aligns with a point between the two reception elements along a common axis of the array. U.S. Pat. No. 5,557,283 (incorporated by reference) describes an example of this arrangement of transmitting and reception elements. In other forms, a different technique can be utilized involving more or fewer sweeps, different types of sweeps, and/or different transmitting/reception orientations and numbers. If the test of conditional **138** is negative (N<LAST), then increment operation **142** is performed, incrementing N by one (N=N+1). Loop **134** returns from operation **142** to transmission/reception operation **136** for execution with the transmitting/receiving subset of elements **38** corresponding to the new, incremented value of N from operation **142**. In this manner, elements **38** are activated in a vertical path along array **36** with transceiver **42** to provide data along a contiguous region of body B.

The resolution of interrogation information obtained with transceiver **42** can be enhanced by linearly sweeping through a selected ultrawide frequency range during each operation **136**. In one preferred form, transceiver **42** sweeps through a range of at least 10 GHz for each execution of operation **136**. This sweep can occur, for example, over a range of about 10 GHz to about 20 GHz. In a more preferred form, transceiver **42** and elements **38** are arranged for a sweep range of 16 GHz. This sweep can occur, for example, over a range of about 24 GHz to about 40 GHz. In one most preferred form, the ultrawide sweep range is selected such that the range resolution is generally the same as the lateral resolution. For these forms, elements **38** are selected to be of a type with a frequency response suitable for the selected sweep range, including, but not limited to the taper slot or end-fire antenna type. In another form, the transmitter can sweep through a given frequency range (such as **10** GHz to **20** GHz) in a pseudo-random order—sometimes known as frequency hopping.

Loop **134** is repeated LAST number of times, sequencing through the desired transmitting/receiving elements **38** of array **36** under the control of transceiver **42**. When the test of conditional **138** is true, the affirmative branch proceeds to data operation **144**. Data resulting from the execution of operation **136** is provided by transceiver **42** to processor(s) **44**. In data operation **144**, an interrogation data set is established for the information gathered through the repeated execution of operation **136** from N=1 through N=LAST. This data set corresponds to the current value of integer index I and the body portion illuminated during these executions. Initially, the interrogation data set can be accumulated and organized by transceiver **42**, processor(s) **44** or both; and then stored in memory **46** for further processing by processor(s) **44** as described in connection with the remainder of procedure **120**. From operation **144**, subroutine **130** returns to the next stage of procedure **120**.

Referring back to FIG. **3**, procedure **120** continues with conditional **152** that tests whether the final value of index I has been reached (I=TOTAL?); where TOTAL is the total number of desired executions of loop **124** (and subroutine **130**) for process **120**. If the test of conditional **152** is negative (I<TOTAL), process **120** proceeds to increment operation **154** to increment index I by one (I=I+1). Loop **124** then returns to subroutine **130** for the next execution until I is incremented to be equal to TOTAL.

With the execution of loop **124** TOTAL number of times, TOTAL number of interrogation data sets are stored in memory **46**. When the performance of subroutine **130** is relatively fast compared to the rotational speed of platform **32**, each of the interrogation data sets corresponds to a general vertical portion of body B. In one such example, the following parameters apply:

(a) platform rotational speed of 20 seconds per revolution;

(b) 600 executions of loop **134** for each execution of subroutine **130**; and

(c) execution time of subroutine **130** of no more than 12 milliseconds.

For the indicated rotational speed in (a), the platform rotates through less than one quarter (¼) of a degree in the time it takes to execute subroutine **130**. Accordingly, each execution of subroutine **130** and the corresponding interrogation data set generally approximates a vertical body portion. In other examples for which the rotational speed is relatively fast compared to subroutine **130** execution, a body portion corresponding to a helical or spiral path along the body results that can also be processed in accordance with the teachings of the present invention by taking into account his more complex spatial relationship.

When the test of conditional **152** is true, procedure **120** continues with cylindrical segmentation operation **160**. In operation **160**, the interrogation data sets are processed with processor(s) **44** to generate a number of cylindrical image data sets that each correspond to an arc segment of cylinder C. Referring to FIG. **2**, arc segment Si subtends a viewing angle V of about 90 degrees with respect to body B. Arc segment S**1** defines a cylindrical aperture CA that extends along axis R. The image data set corresponding to arc segment SI represents the three-dimensional surface of body B that is reflective with respect to the selected electromagnetic radiation, as if viewed through cylindrical aperture CA. In one convenient form, the image data set is defined in terms of cylindrical coordinates, although any three-dimensional coordinate system can be used. Each image data set is determined from the interrogation data gathered for the corresponding arc segment by processor(s) **44**. Reference is made to commonly owned U.S. Pat. No. 5,859,609 (incorporated herein by reference) for further description about the determination of cylindrical image data.

During operation **160**, cylindrical image data sets are determined for a number of arc segments about axis R that collectively circumscribe body B. In FIG. **5**, eight overlapping arc segments S**1**, S**2**, S**3**, S**4**, S**5**, S**6**, S**7**, and S**8** (collectively segments S) are illustrated with respect the generally circular pathway P and corresponding cylinder C. Segments S**1**, S**3**, S**5**, and S**7** are schematically represented by double-headed arrows slightly to the outside of path P and segments S**2**, S**4**, S**6** and S**8** are schematically represented by double-headed arrows slightly inside path P to preserve clarity. In FIG. **5**, segments S each correspond to a viewing angle of about **90** degrees, and each one overlaps two others by about 45 degrees. It should be understood that each different segment S corresponds to a representation of a different portion of body B. In other embodiments, the viewing angle can differ and/or may be nonuniform from one arc segment S to the next. Alternatively or additionally, overlap may be intermittent or absent.

Procedure **120** continues with mapping operation **162**. In operation **162**, the image data obtained for the circumscribing arc segments S are mapped by processor(s) **44** to a common surface for body B, which is turn defines a common volume of body B. Operation **162** can include reconciling a data point for one of the arc segments S for a given location that differs by a threshold amount from the data point of the same location for another of the arc segments S. In one embodiment, an averaging technique is used and intermediate data points are interpolated. In another embodiment, a weighting function is utilized that progressively reduces the contribution of a data point as the distance of that data point from the midpoint of the corresponding arc segment S increases. The cylindrical data sets are preferably combined incoherently (after computing the magnitude) to reduce undesirable phase interference in the images. Operation **162** provides a volumetric representation of body B bounded by its surface(s) about axis R that are reflective with respect to the electromagnetic radiation used for the interrogations of subroutine **130**. This representation includes topographic information about such surface(s).

From operation **162**, one or more measurements of body B are determined with processor(s) **44** in operation **164**. For this determination, a reference unit corresponding to the desired measurement can be provided on platform **32**, a background panel, or by a different means as would occur to those skilled in the art. This reference is used to quantify the desired measurement in terms of desired units.

In one application, body measurements correspond to those desired to size clothing for person **22**. For this application, the interrogating electromagnetic radiation is selected to be generally transparent to and/or penetrate clothing **24***a*, **24***b* to provide lineal body measurements that correspond to the skin surface of person **22**—including skin surfaces beneath clothing **24**a and **24**b. The selection of electromagnetic radiation frequency and/or frequency sweep range is made to provide the desired resolution of the body measurements.

Commonly, body measurements to fit clothing include circumferences of the neck, chest, waist, and/or hip region. Other lineal or distance measurements can include inseam, sleeve, and/or torso lengths. Still further measurements include head, breast, thighs, palm and/or foot girth for the purposes of fitting hats, brassieres, pants, gloves and/or footwear, respectively. Besides clothing, measurements of an individual can be used in other applications, such as ergonomic product design, prosthetics, and the representation/prediction of a change in appearance that might occur with weight loss or gain, cosmetic surgery, and the like.

In still other applications, measurements may be made of inanimate objects for many other purposes, including, but not limited to: analysis of the contents of an object having an outer layer that is penetrated by the selected electromagnetic radiation, determining one or more dimensions of an object to make or select object packaging, assessing shipping costs based on object dimensions, and the like. The measurement/quantification of individuals and/or inanimate objects using the teachings of the present invention can be of a surface area and/or volume as an alternative or addition to lineal measurements.

Procedure **120** proceeds from operation **164** to operation **166**. In operation **166**, one or more images are determined with processor(s) **44** from the volumetric/topographical representation of body B determined in operation **162**. Operation **166** renders one or more two-dimensional images from the data representing the volume of body B by performing a two-dimensional parallel ray projection from a desired viewing angle. Along each parallel ray, the intensity is attenuated in proportion to the data it encounters in the representation. After attenuation, the maximum voxel intensity is selected to represent an image pixel intensity for the corresponding ray. The attenuation factor is adjusted so that the back surface of the representation does not contribute to the rendering. The two-dimensional rendering can be displayed using device(s) **52** as appropriate.

In one embodiment, a number of two-dimensional images from different viewing angles are rendered from the volumetric/topographical representation. These images can be presented in a selected sequence to provide an animation of body B. In one form, a sequence of about **32** to about **64** generally evenly spaced views about axis R are used to generate a rotating animation of body B about axis R.

From operation **166**, procedure **120** continues with operation **168**. In operation **168**, one or more measurement

indicators are also displayed that overlay one or more body images. In one embodiment, the displayed image of a person can be adjusted to hide/conceal body features to which a privacy objection might be made. Alternatively, the rendering can include a schematic body image similar to a mannequin in appearance.

Alternatively or additionally, the volumetric/topographical representation of body B can be displayed as a number of sectional images. FIG. **6** presents computer-generated images determined from an experiment that was performed using an arrangement to simulate system **20**. Image **320** corresponds to a front viewing angle of a clothed person; where the person's clothing is generally transparent to the interrogating electromagnetic radiation. For image **320**, indicator lines **330***a*, **330***b*, **330***c*, **330***d*, and **330***e* correspond to various sectional views **340** that are more specifically designated head sectional view **340***a*, chest sectional view **340***b*, stomach sectional view **340***c*, thigh sectional view **340***d*, and knee sectional view **340***e*; respectively. Image **320** and sectional views **340** were determined from a volumetric/topographical representation obtained in accordance with procedure **120** using an ultrawide sweep range of 24 GHz to 40 GHz for each activation of an array element. Eight arc segments S were processed for this experiment in an arrangement like that represented in FIG. **5**. It should be appreciated that this topographic representation defines a number of different circumferences of the depicted body, such as those represented by sectional views **340**.

In still other embodiments, display of body images may be absent. Alternatively or additionally, the information gathered with subsystem **40** is sent via computer network **64** to one or more remote sites **80**. Sites **80** can perform some or all of the data processing represented by operations **160**, **162**, **164**, **166**, and/or **168** in lieu of processor(s) **44**. In one process, a clothed individual is nonintrusively scanned by booth **30** and the measurement(s), image(s), animation, and/or topographical information of the individual's body is sent via server **63** and network **64** to a designated computer **82**. From this computer **82**, the measurement information can be sent via network **64** to one or more e-commerce clothing suppliers or other clothing business to electronically order or manufacture clothing of the desired size and style. Alternatively or additionally, the topographical information can be used to automatically generate by computer or otherwise custom two-dimensional (2-D) patterns for apparel manufacture.

For procedure **120**, transceiver **42** and processor(s) **44** include logic to perform the various operations described. This logic can be in the form of software programming instructions, firmware, and/or of a hardwired form, just to name a few. Furthermore such logic can be in the form of one or more signals carried by, on, or with memory **46**, R.M.D. **48**, and/or one or more parts of computer network **70**. In one example, logic signals to perform one or more operations is transmitted to or from processor(s) **44** via network **70**. Alternatively or additionally, programming for processor(s) **44** is transported or disseminated through R.M.D. **48** and/or one or more other storage devices.

FIG. **7** illustrates interrogation system **420** of another embodiment of the present invention. System **420** illuminates body B with selected electromagnetic radiation in the manner described in connection with system **20**. For system **420**, body B is in the form of person **422** wearing clothing articles **424***a* and **424***b*. As in previously described embodiments, system **420** can be used to interrogate inanimate objects as well.

System **420** includes scanning booth **430** coupled to control and processing subsystem **440**. Scanning booth **430** includes stationary platform **432** arranged to support body B and frame **433** to support motor **434** coupled to array **436**. In contrast to the platform rotation of booth **30**, scanning booth **430** selectively rotates array **436** about rotational axis R and platform **432** during interrogation. For this arrangement, array **436** follows a generally circular pathway to provide a corresponding imaginary cylinder about platform **432**. In one form suitable for scanning a person in the standing position, the radius of this cylinder is about 1 meter. Array **436** is otherwise configured the same as array **36**.

In system **420**, subsystem **440** is configured the same as subsystem **40** of system **420** and is likewise arranged to perform procedure **120**. However, during the performance of procedure **120**, the operation of subsystem **440** accounts for the movement of array **436** relative to platform **432** instead of the movement of platform **32** relative to array **36**. System **420** can include one or more encoders (not shown) operatively coupled to subsystem **440** and/or other devices/techniques to track the position of array **436** relative to platform **432**. System **420** can further include a communication subsystem (not shown) the same as subsystem **60** to remotely communicate with subsystem **440**. Like previously described embodiments, system **420** is used to determine measurement, topographical, image, animation, and/or three-dimensional volume information about body B.

FIG. **8** illustrates electromagnetic radiation interrogation system **520** of yet another embodiment of the present invention. System **520** illuminates body B with selected electromagnetic radiation of the type previously described. For system **520**, body B is in the form of person **522** wearing garments/clothing designated by reference numerals **524***a* and **524***b*. As in previously described embodiments, system **520** can be used to interrogate animate or inanimate objects.

System **520** includes scanning booth **530** coupled to control and processing subsystem **540**. Scanning booth **530** includes frame **533** arranged to receive body B and support array **536**. In contrast to the linear arrays **36** and **436** of previously described systems **20** and **420**, array **532** is arranged as a ring or hoop generally centered with respect to centerline vertical axis V. A number of electromagnetic radiation transmitting/receiving elements are arranged in a generally circular pathway along the ring. These elements operate to interrogate body B with electromagnetic radiation including one or more wavelengths in the millimeter, microwave, and/or adjacent wavelength bands. Array **536** is arranged for translational movement along axis V to scan body B as represented by arrow T. One or more motors or other prime mover(s) (not shown) are utilized to selectively move array **536** along axis V.

Referring further to the partial top view of FIG. **9**, array **536** is sized with opening **537** to receive body B therethrough as array **536** moves up and down along axis V. In FIG. **9**, axis V is generally perpendicular to the view plane and is represented by crosshairs. With the vertical motion of array **536**, an imaginary cylinder is defined about body B in accordance with the circular path defined by the array ring; however, neither body B nor array **536** is rotated relative to the other, instead translational movement of array **536** is used to scan body B vertically.

Subsystem **540** is configured the same as subsystems **40** and **440** and is operable to perform procedure **120**, except that processing of subsystem **540** is adapted to account for the vertical movement of array **436** instead of rotational movement. System **520** can further include a communication subsystem (not shown) the same as subsystem **60** to

remotely communicate with subsystem **440**. Like previously described embodiments, system **520** is used to determine measurement, image, animation, topographical, and/or three-dimensional volume information about body B.

Compared to array **36**, a larger number of transmitting/receiving elements is typically needed for array **536** to have a comparable resolution to previously described embodiments. In one comparison, between 500 and 2000 transmitting/receiving elements would be desired for array **536** versus 200 to 600 for array **36** for comparable resolution, depending on the frequency band selected. However, under appropriate conditions, scanning booth **530** can perform a scan substantially faster than booth **30**. In one nonlimiting example, the scan time for booth **30** is in a range of about 10 to 20 seconds versus about 2 to 5 seconds for scanning booth **530**.

In a further embodiment of the present invention, the body undergoing interrogation and the array both move. In one such example, array elements are arranged in an arc segment that can move vertically while the body rotates. In another example, both the array and body rotate. The processing of interrogation data can be adjusted for these different motion patterns using techniques known to those skilled in the art.

In another embodiment, the interrogation and corresponding topographic representation do not correspond to the full circumference of the body undergoing interrogation. Instead, the segment of interest can be less than 360 degrees. For such embodiments, the topographic representation can still be determined by combining data corresponding to two or more different cylindrical arc segment apertures. In a clothing sizing application, the inseam, sleeve, and/or torso length measurements can be made using less than a full 360 degree volumetric representation. Alternative or additionally, less than the full height, width, and/or length of the body may be scanned in alternative embodiments. For such alternatives, the array size and/or scanning pattern can be correspondingly adjusted. In other applications, views and/or dimensions of interest can also be based on data that accounts for less than all the surfaces of the object under investigation.

In still other embodiments, a topographic representation provided in accordance with the present invention can be utilized for different purposes in addition or as an alternative to mensuration. In one example, the topographic representation can be used to detect concealed items. For one form of this application, the scanning booth platform can be comprised of a material, such as an organic thermoplastic or thermoset polymer, that permits the interrogation in or beneath the soles of shoes where weapons can sometimes be hidden. In another example, a three-dimensional likeness is generated from the topographic representation to perform further analysis relating to the corresponding person or object.

In one further embodiment, a topographical representation is obtained in accordance with procedure **120** and/or system **20**, **420**, or **520** to identify an individual. One form of this embodiment includes a technique to control access to a restricted area, comprising: scanning an individual attempting to gain access to the restricted area; determining a topographical representation of the individual from the scan; comparing one or more aspects of this representation, such as one or more relative body dimensions, to data stored for those permitted access to the restricted area; and allowing access to the restricted area by the individual if there is a match within a desired degree of error. The determination of a match can be used to activate a portal, gate, or other access control device. In one variation of this embodiment, one or more other biometrics (such as a fingerprint, palm print, retina image, vocal pattern, etc.) of the individual are compared in addition to the topographical representation related data as part of the determination of whether to allow access. The body dimension(s) used for identification can be changed for each access to reduce the likelihood that the access control measures will be circumvented. Such embodiments can be provided as a method, apparatus, system, and/or device.

In still a further embodiment, topographical representation information can be used for profiling. One nonlimiting example includes: scanning an individual to obtain topographical information; comparing this information to a database of topographical information for known terrorists or other undesirable parties; and taking further action to screen access of the individual to a sensitive area if the comparison indicates an unacceptable degree of similarity. This action can be taken irrespective of whether a concealed object, such as a weapon, is indicated by the scan. Various forms of this embodiment include methods, systems, apparatus and/or devices.

Another embodiment directed to an identification technique includes: scanning passengers of a commercial transportation vehicle, such as a commercial aircraft, for identifying topographical information; and in the event the vehicle is later involved in an accident resulting in injury or death, identifying one or more passenger bodies or body parts using the information. If a seating arrangement is known for the vehicle, the information for each passenger can be correlated to this arrangement to assist with identification. The scanning can be performed with the nonintrusive interrogation methods of the present invention as part of the vehicle boarding process. Such embodiments can be provided in the form of a method, apparatus, system, and/or device.

For yet a further embodiment, scanned topographical information regarding an individual is stored in a portable storage device, such as a "smart card." This device can be used for identification purposes and/or to customize equipment to the individual. One nonlimiting example directed to customization includes establishing an interface between the device and a vehicle and automatically adjusting a vehicle seat or other vehicle equipment to the individual's body dimensions and/or shape based on the information. This embodiment can be in the form of a method, apparatus, system, and/or device.

Still other embodiments of the present invention use procedure **120** and/or one or more of systems **20**, **420**, or **520** to provide at least one topographical representation for use in a virtual space or computer-defined domain. One such embodiment includes: scanning an individual to generate a corresponding topographical representation; generating a three-dimensional visualization of the individual with a computer based on the representation; and incorporating the visualization into a sequence of computer-generated images to provide a likeness of the individual. This likeness can be animated in a manner consistent with the images. The sequence of images can be provided in the context of a game, a virtual reality process, and/or a movie, to name just a few examples. Such embodiments can be provided in the form of method, apparatus, system, and/or device.

Another embodiment directed to a computer domain/virtual space application, includes: interrogating a number of objects to obtain a corresponding number of topographical representations and determining one or more relationships between the objects by analysis of the representations with a computer. One form of this embodiment includes:

scanning several pieces of wreckage resulting from a vehicle accident, such as an aircraft accident, to provide a corresponding number of topographical representations; and arranging the representations relative to one another with a computer to analyze the accident. This form can include orienting the pieces in different spatial relationships relative to one another in a computer domain to at least partially reconstruct the vehicle; removing apparent deformities of one or more of the pieces in a computer domain to assist with reconstruction; visualizing one or more of the pieces with a computer; generating a record in a computer of the time and place of discovery of each of the pieces; and/or detecting metal fragments or other radar reflective material at least partially embedded in a radar transparent/translucent material. This embedded material can be indicative of an explosion. Such embodiments can be provided as a method, apparatus, system, and/or device. Yet other embodiments are directed to other applications as would occur to those skilled in the art.

In a further embodiment of the present invention, a topographic representation of an object is determined from electromagnetic radiation interrogation that combines two or more cylindrical segment data sets. This unique technique can provide topographical data defining one or more circumferences of an object about an axis with high resolution. In contrast, conventional cylindrical imaging schemes do not combine cylindrical segment data—instead being rather limited to the utilization of a much larger number of uncombined images to provide an animated presentation.

All publications and patent applications cited in this specification are herein incorporated by reference as if each individual publication or patent application were specifically and individually indicated to be incorporated by reference. Further, any theory, mechanism of operation, proof, or finding stated herein is meant to further enhance understanding of the present invention, and is not intended to limit the present invention in any way to such theory, mechanism of operation, proof, or finding. While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only selected embodiments have been shown and described and that all equivalents, changes, and modifications that come within the spirit of the inventions as defined herein or by the following claims are desired to be protected.

What is claimed is:

1. A method, comprising:

irradiating a body at least partially covered with clothing;

detecting electromagnetic radiation reflected from a surface of the body through the clothing in response to said irradiating; and

determining a measurement of the body corresponding to the surface from the electromagnetic radiation.

2. The method of claim **1**, wherein the electromagnetic radiation is selected from a frequency range of about 200 MHz to about 1 THz.

3. The method of claim **1**, wherein said irradiating and said detecting are performed for each of a number of different portions of the body to provide a number of data sets each corresponding to a different view of the body, and said determining includes providing a volumetric representation of the different portions of the body from the data sets.

4. The method of claim **3**, further comprising displaying an image of the body determined from the volumetric representation.

5. The method of claim **3**, wherein the measurement is a circumference of the body determined from the volumetric representation.

6. The method of claim **1**, wherein the body is of a person and the surface corresponds to skin of the person, and further comprising rendering a sectional image of the person at least partially bounded by the skin.

7. A method, comprising:

interrogating a person with electromagnetic radiation having at least one frequency in a range of about 200 MHz to about 1 THz; and

determining a measurement along a skin surface of the person from said interrogating.

8. The method of claim **7**, wherein at least a portion of the skin surface is beneath clothing during said interrogating.

9. The method of claim **7**, further comprising performing said interrogating with a sensing array and rotating at least one of the array and the person relative to an axis to irradiate different portions of the person during said interrogating.

10. The method of claim **9**, wherein the measurement corresponds to a circumference of the person about the axis.

11. The method of claim **7**, wherein said interrogating includes changing frequency of the electromagnetic radiation over a range of at least about 10 GHz.

12. A method, comprising:

interrogating an object with electromagnetic radiation including one or more frequencies in a range of about 200 MHz to about 1 THz for each of a number of different views of the object;

determining a number of data sets each representative of a cylindrical image of the object for a respective one of the different views; and

combining the data sets to generate a topographical representation of the object corresponding to the different views.

13. The method of claim **12**, further comprising rendering a two-dimensional image of the object from the topographical representation.

14. The method of claim **12**, wherein the topographical representation defines at least one circumference of the object.

15. The method of claim **12**, wherein said object is a clothed person and the image includes a skin surface of the person positioned beneath clothing during said irradiating and said detecting.

16. The method of claim **12**, further comprising determining one or more measurements of the object from the topographical representation.

17. The method of claim **12**, further comprising rendering a number of two-dimensional images from the topographical representation and displaying the images to provide a rotating animation of the object.

18. The method of claim **12**, further comprising determining sectional image data from the topographical representation.

19. A system, comprising:

an array to interrogate a person with electromagnetic radiation in a frequency range of about 200 MHz to about 1 THz; and

one or more processors responsive to said array to determine a body measurement of the person, the body measurement corresponding to a skin surface of the person at least partially covered by clothing during interrogation with said array.

20. The system of claim **19**, further comprising a display device responsive to said one or more processors to provide at least one image corresponding to the person.

21. The system of claim **19**, further comprising a platform proximate to said array to support the person and a motor to rotate at least one of said array and said platform about an axis.

22. The system of claim 19, further comprising a computer network coupled to said one or more processors and a remote computer, said one or more processors being operable to transmit data corresponding to the body measurement to said remote computer over said computer network.

23. The system of claim 19, wherein said one or more processors are further operable to determine a volumetric representation of the person from a number of data sets, said data sets each corresponding to a different view of the person.

24. A device carrying one or more signals, the one or more signals comprising: logic to operate one or more processors, said logic being operable to process data corresponding to a number of different portions of a body interrogated with electromagnetic radiation in a frequency range of about 200 MHz to about 1 THz, said logic being further operable to provide a topographical representation of the body from the data and determine one or more body measurements from the topographical representation.

25. The device of claim 24, wherein the device is in the form of a removable, processor-readable memory and said logic is in the form of a number of instructions for the one or more processors stored in said memory.

26. The device of claim 24, wherein the device includes one or more parts of a computer network and said logic is encoded in the one or more signals for transmission over said computer network.

27. The device of claim 24, wherein said data includes a number of different sets each corresponding to a different arc segment of a cylinder.

28. The device of claim 24, wherein at least one of the one or more body measurements corresponds to a body circumference determined from the topographical representation with said logic.

29. The device of claim 24, wherein said logic is further operable to define sectional image data from the topographical representation to provide a sectional image of the body.

30. A method, comprising:

irradiating an object;

detecting electromagnetic radiation reflected by the object in response to said irradiating, the electromagnetic radiation being in a frequency range of about 200 MHz to about 1 THz; and

determining a circumferential measurement of the object from the electromagnetic radiation.

31. The method of claim 30, wherein said irradiating is performed with a sensing array and further comprising rotating at least one of the object and the array.

32. The method of claim 30, wherein said determining includes establishing a volumetric representation of the object from data corresponding to a number of different images of the object.

33. The method of claim 30, wherein the object is a clothed person and the circumferential measurement is along a skin surface of the person at least partially covered by clothing during said irradiating.

34. The method of claim 30, further comprising providing a visualization of the object with an indicator corresponding to the circumferential measurement.

35. A system, comprising:

at least one array to interrogate an object with electromagnetic radiation at one or more frequencies in a range of about 200 MHz to about 1 THz;

one or more processors responsive to said array, said one or more processors being operable to: establish a number of data sets each representative of a three-dimensional image of a different one of a number of portions of the object; map the data sets to a topographical representation of the object, the topographical representation corresponding to a surface of the object defined by each of the portions of the object; and process the topographical representation to provide an output; and

a device responsive to said output.

36. The system of claim 35, wherein said output represents to one or more measurements of the object.

37. The system of claim 35, wherein the object is a clothed person and the output includes an image of a skin surface of the person positioned beneath clothing during said interrogating.

38. The system of claim 35, wherein the data sets each correspond to a different arc segment of a cylinder about the object.

39. The system of claim 35, wherein the output includes a number of two-dimensional images rendered from the representation by said one or more processors.

40. A method, comprising:

providing a sensing array and one or more processors coupled to the array;

interrogating an object with electromagnetic radiation from the array, a frequency of the electromagnetic radiation being in a range of about 200 MHz to about 1 THz;

generating data representative of the object from said interrogating with the one or more processors, the data corresponding to one or more lineal measurements of the object; and

transmitting the data over a computer network to a remote site.

41. The method of claim 40, wherein the object is a person at least partially covered by clothing and the data includes one or more lineal body measurements about the person.

42. The method of claim 40, wherein the data corresponds to a topographical representation of at least a portion of the object.

43. The method of claim 42, wherein the computer network includes the internet and said transmitting includes sending the data with a network server coupled to the one or more processors and the computer network.

44. The method of claim 43, wherein the frequency is in a range of about 5 GHz to about 110 GHz, and further comprising changing the frequency by at least 10 GHz during said interrogating.

45. The method of claim 40, further comprising sending information representative of at least one of the one or more measurements from a computer at the remote site to a different site coupled to the computer network.

46. The method of claim 45, wherein the object is a clothed person, the one or more measurements correspond to body measurements to size clothing, and the different site corresponds to a clothing business.

47. The method of claim 40, wherein the data corresponds to a circumference of at least a portion of the object.

48. The method of claim 40, further comprising manufacturing a two-dimensional clothing pattern based on the data.

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