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(54) SYSTEM AND METHOD FOR SIMULATED DOSIMETRY USING A REAL TIME LOCATING SYSTEM

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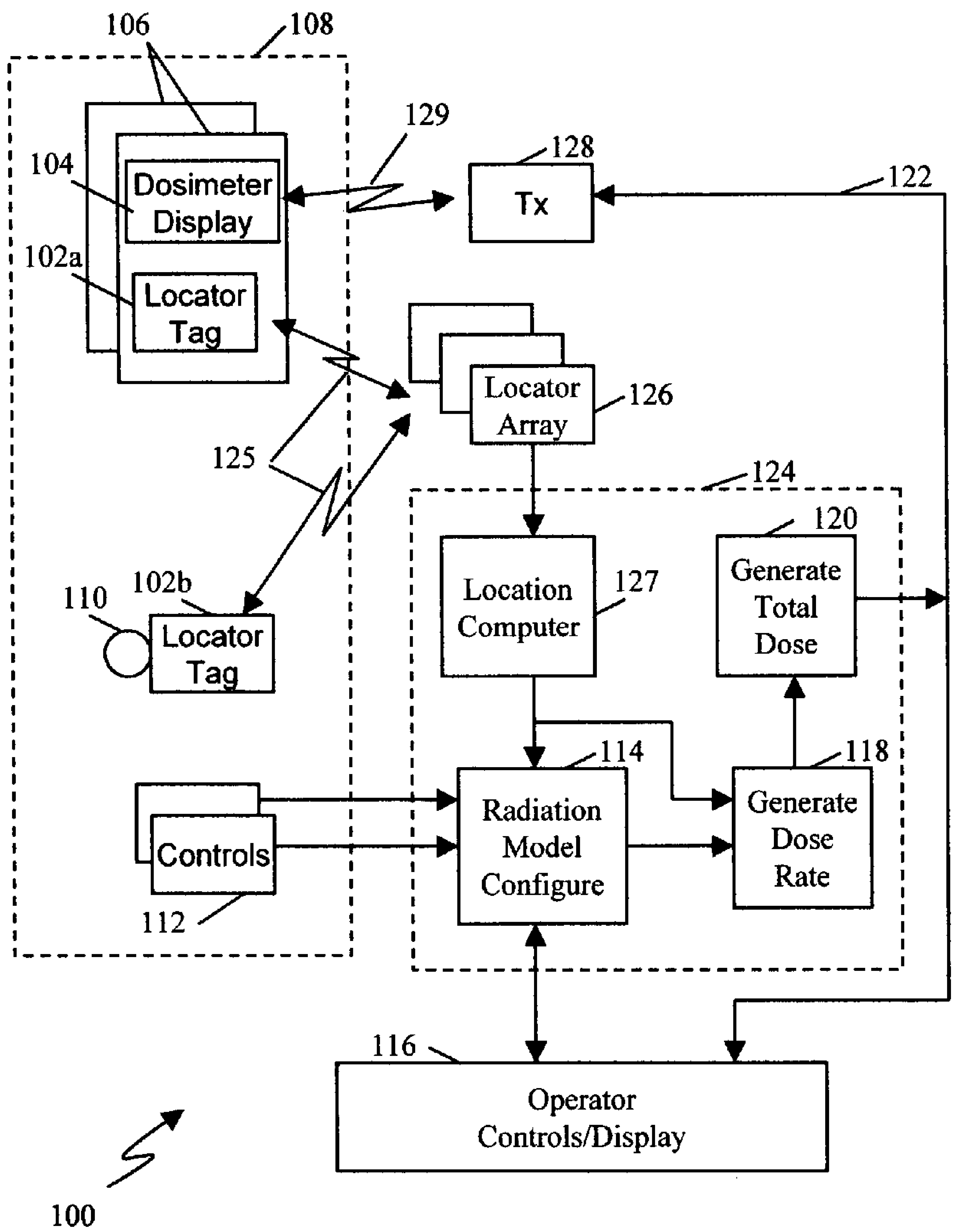
(57) **ABSTRACT**

A system for providing a simulated total dose exposure measurement during a nuclear facility training exercise by locating participants using a real time location system, modeling incremental exposure as a function of location and summing incremental exposure to produce a total dose for each of the participants. Total dose may be displayed via a wireless link to a simulated dosimeter worn by each participant. Radiation sources may also have location tags and the exposure model may be modified in real time according to the tracked location of the radiation source. In one embodiment, the locating technology comprises near field locating technology based on comparing near field signal characteristics. Alternative locating technologies may be used.



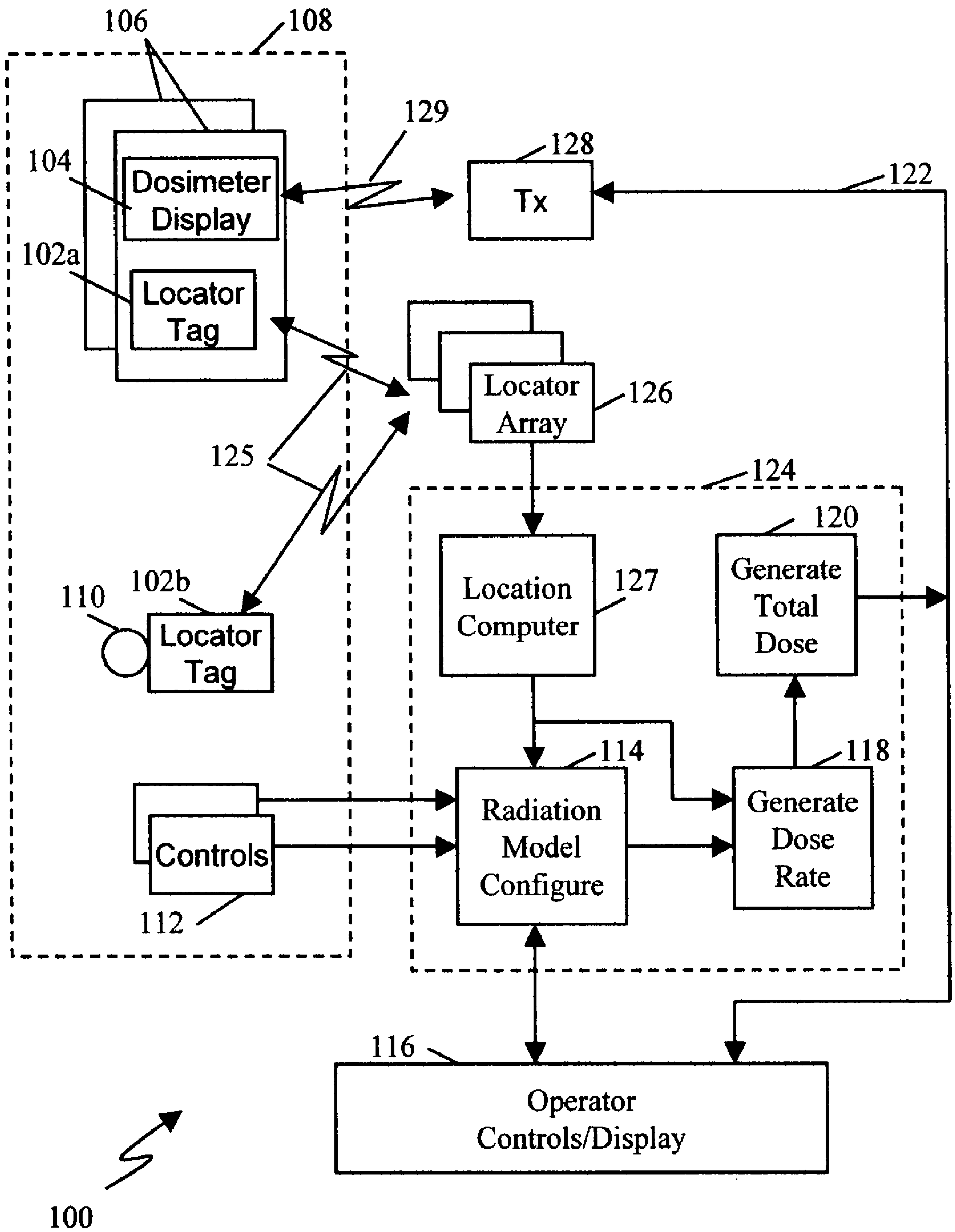

106
108
129
128
122
104
Dosimeter Display
Tx
102a
Locator Tag
Locator Array
126
125
124
120
110
102b
Location Computer
127
Generate Total Dose
Locator Tag
114
118
Radiation Model Configure
Generate Dose Rate
Controls
112
116
Operator Controls/Display
100

Fig. 1

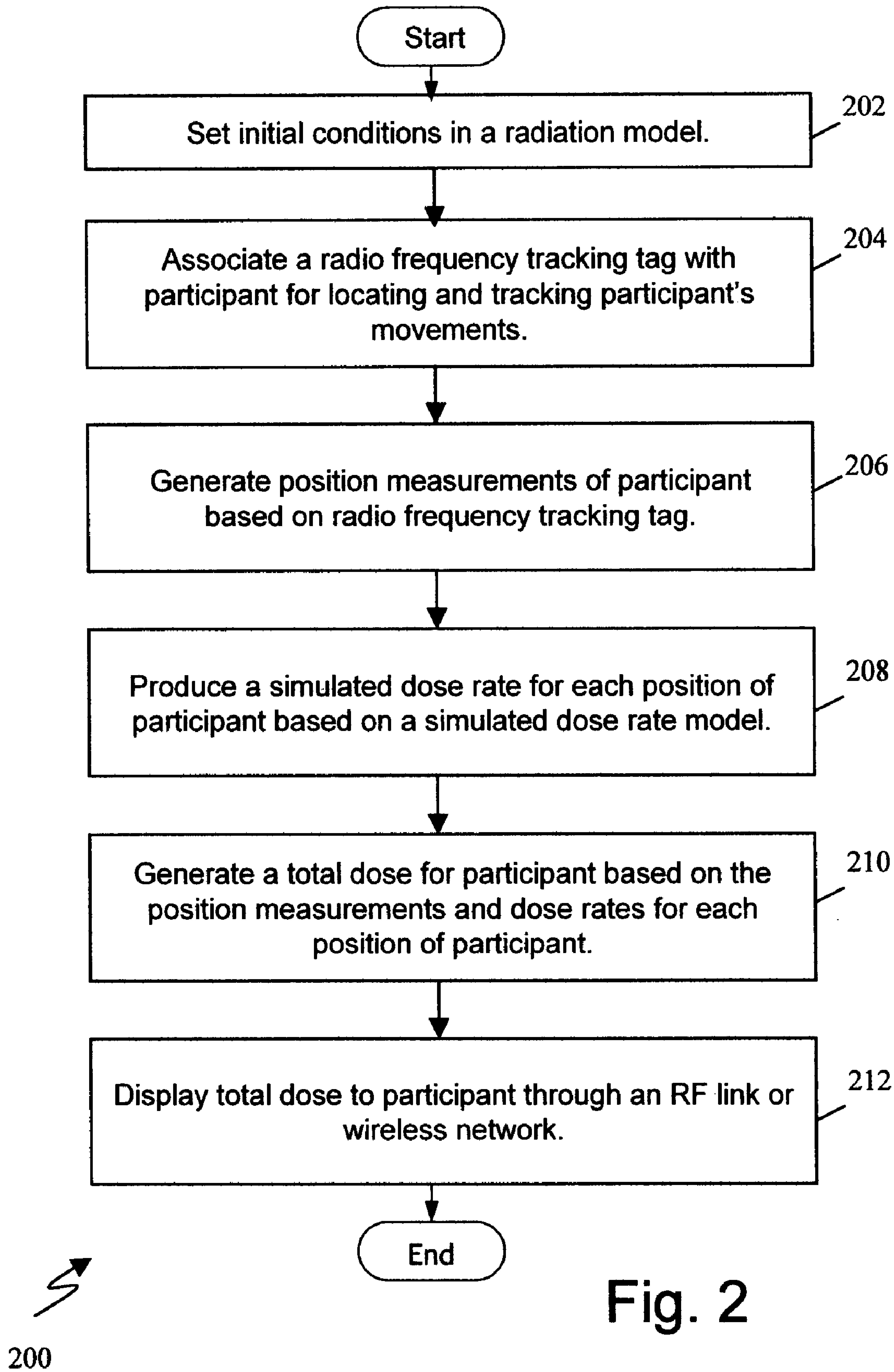

Start
Set initial conditions in a radiation model.
202
Associate a radio frequency tracking tag with participant for locating and tracking participant's movements.
204
Generate position measurements of participant based on radio frequency tracking tag.
206
Produce a simulated dose rate for each position of participant based on a simulated dose rate model.
208
Generate a total dose for participant based on the position measurements and dose rates for each position of participant.
210
Display total dose to participant through an RF link or wireless network.
212
End
200

Fig. 2

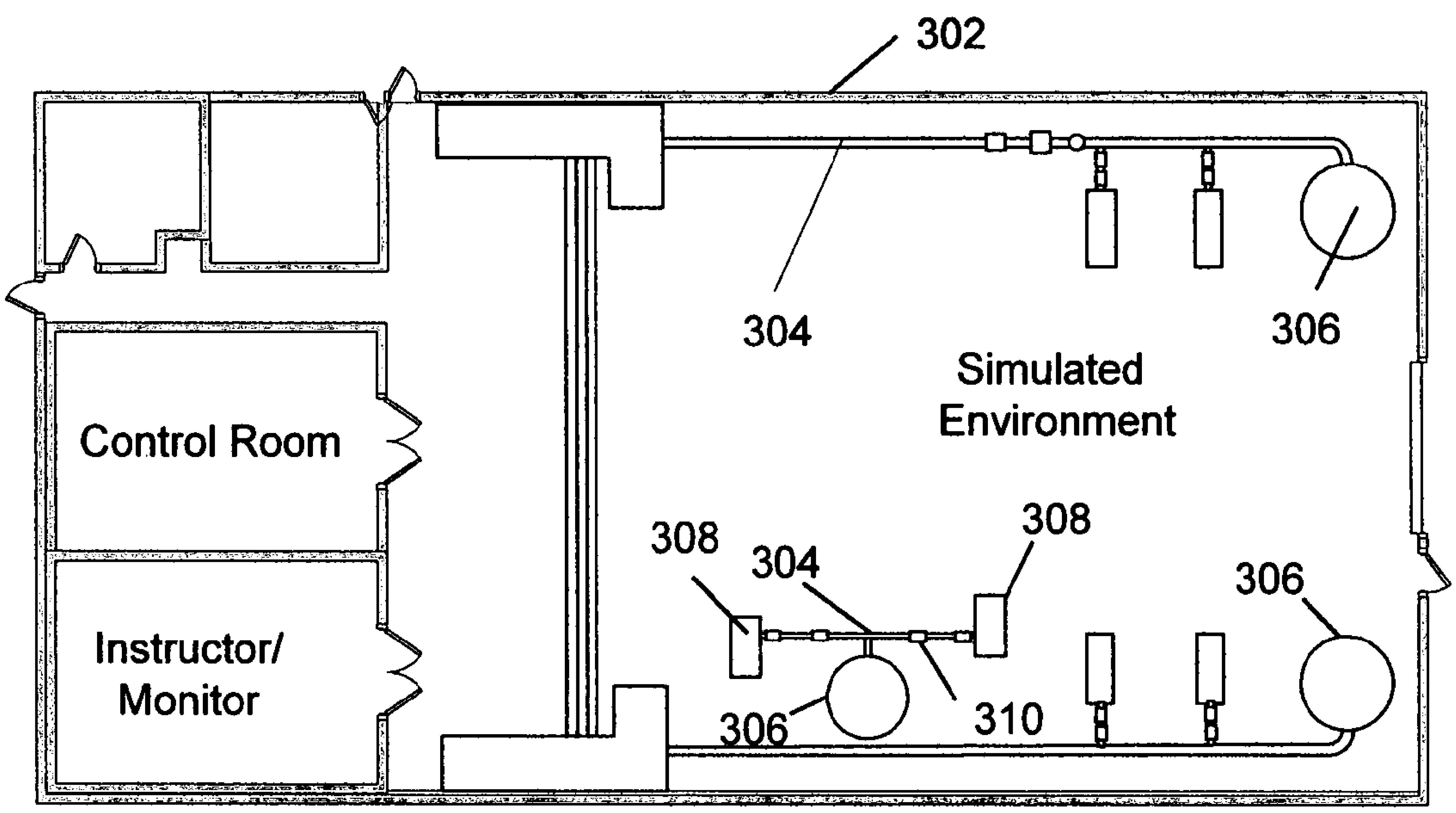

302
304
306
Simulated
Environment
Control Room
Instructor/
Monitor
308
304
308
306
306
310

Fig. 3

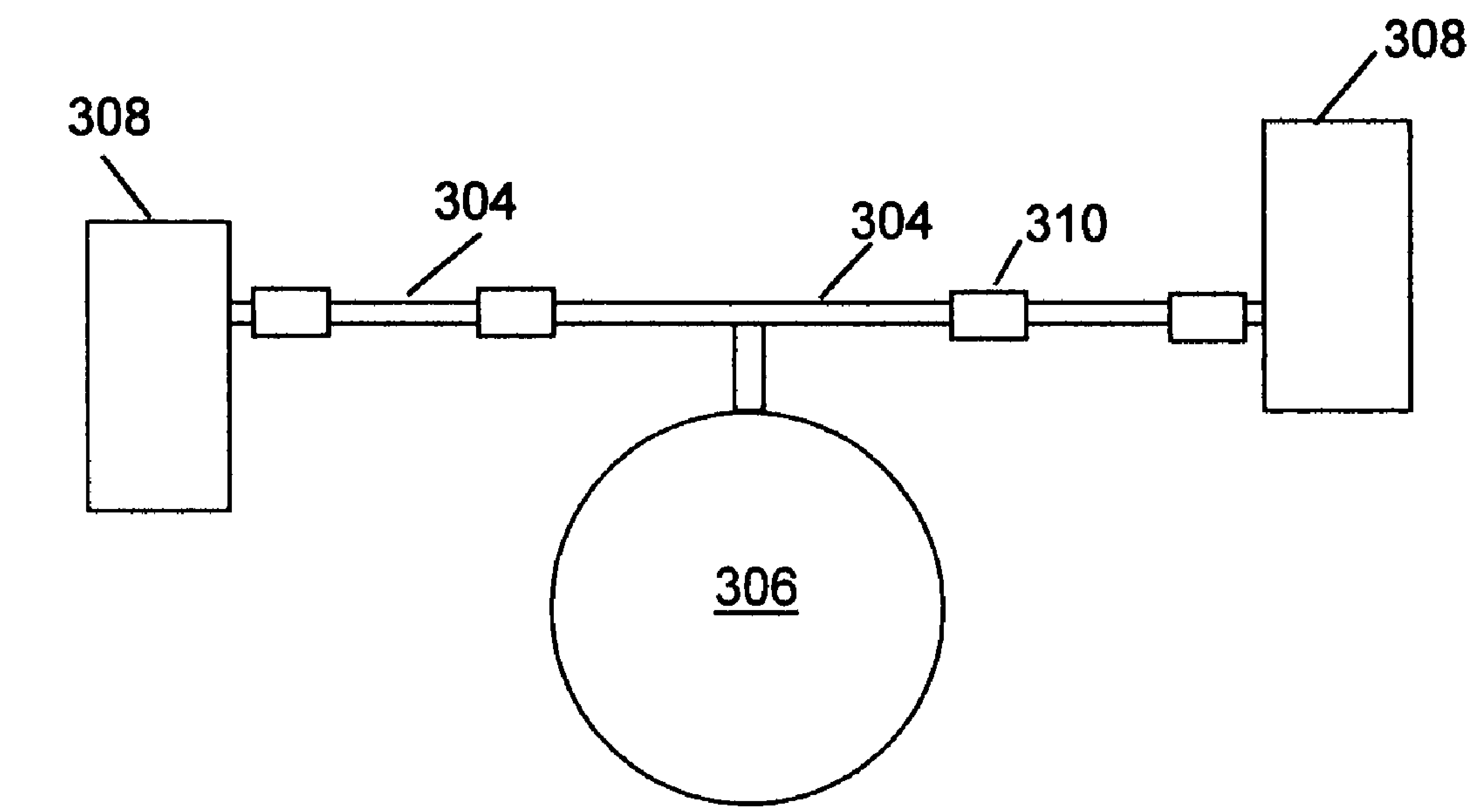


Fig. 4

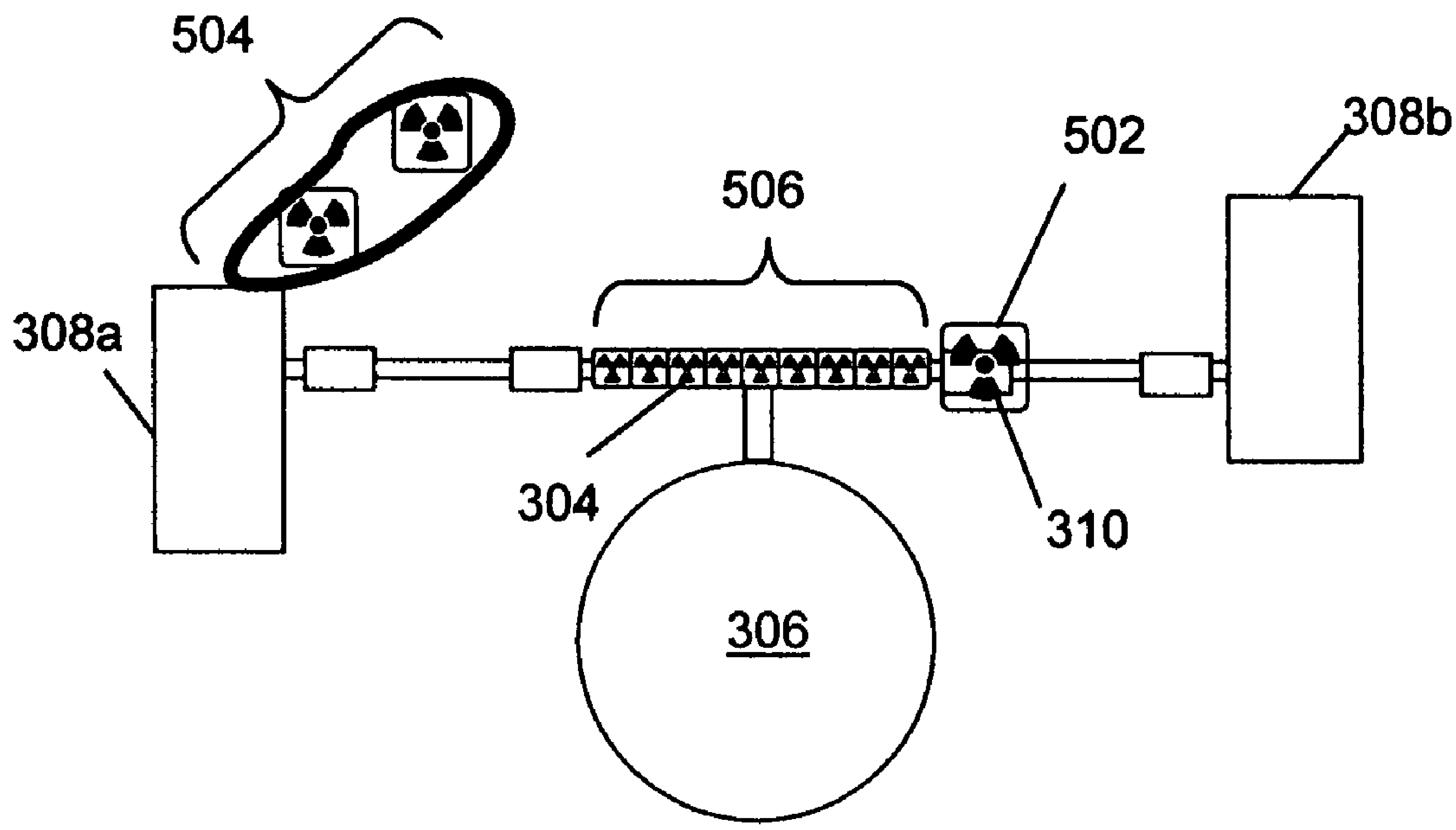


Fig. 5

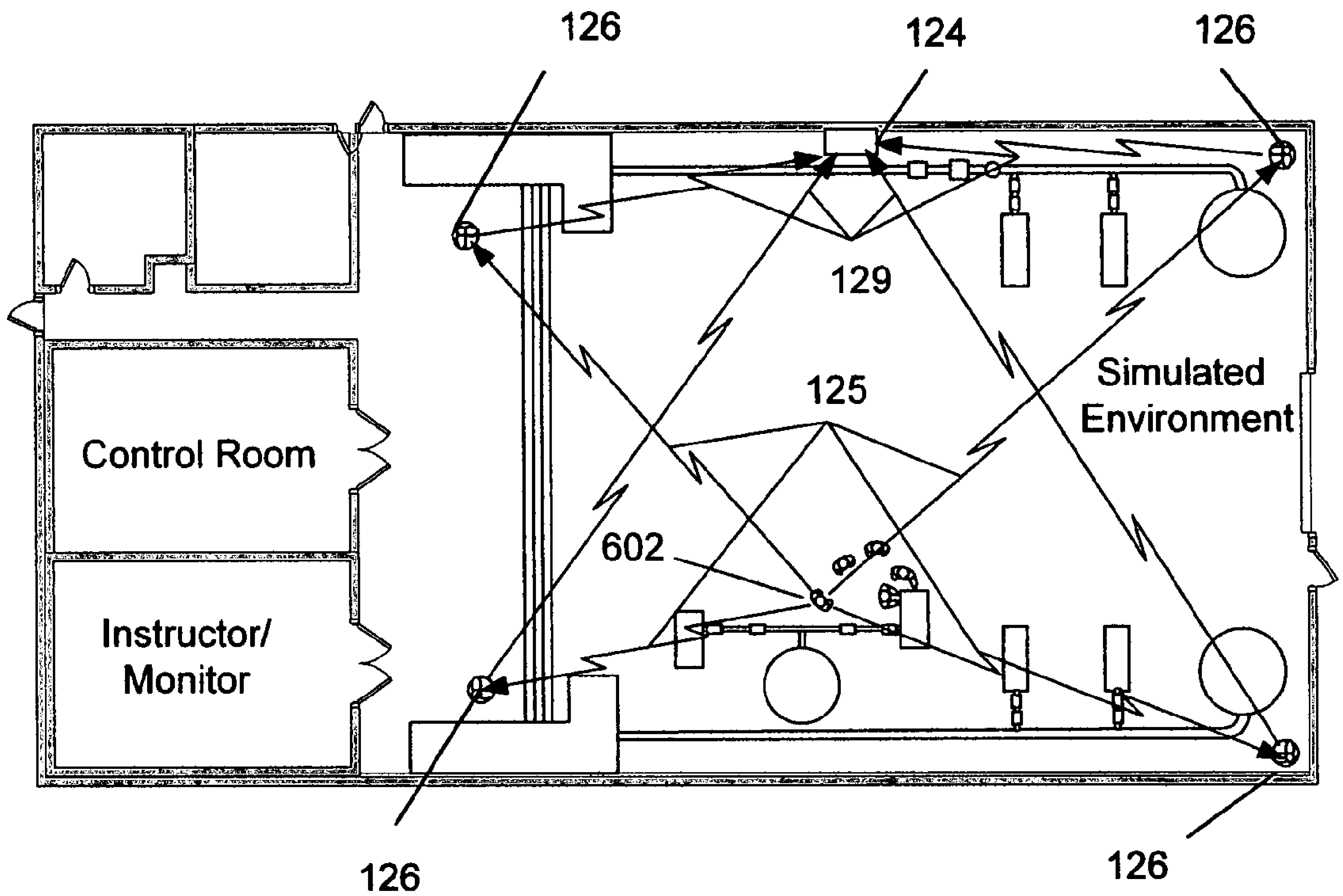

126
124
126
129
125
Simulated Environment
Control Room
Instructor/ Monitor
602
126
126

Fig. 6

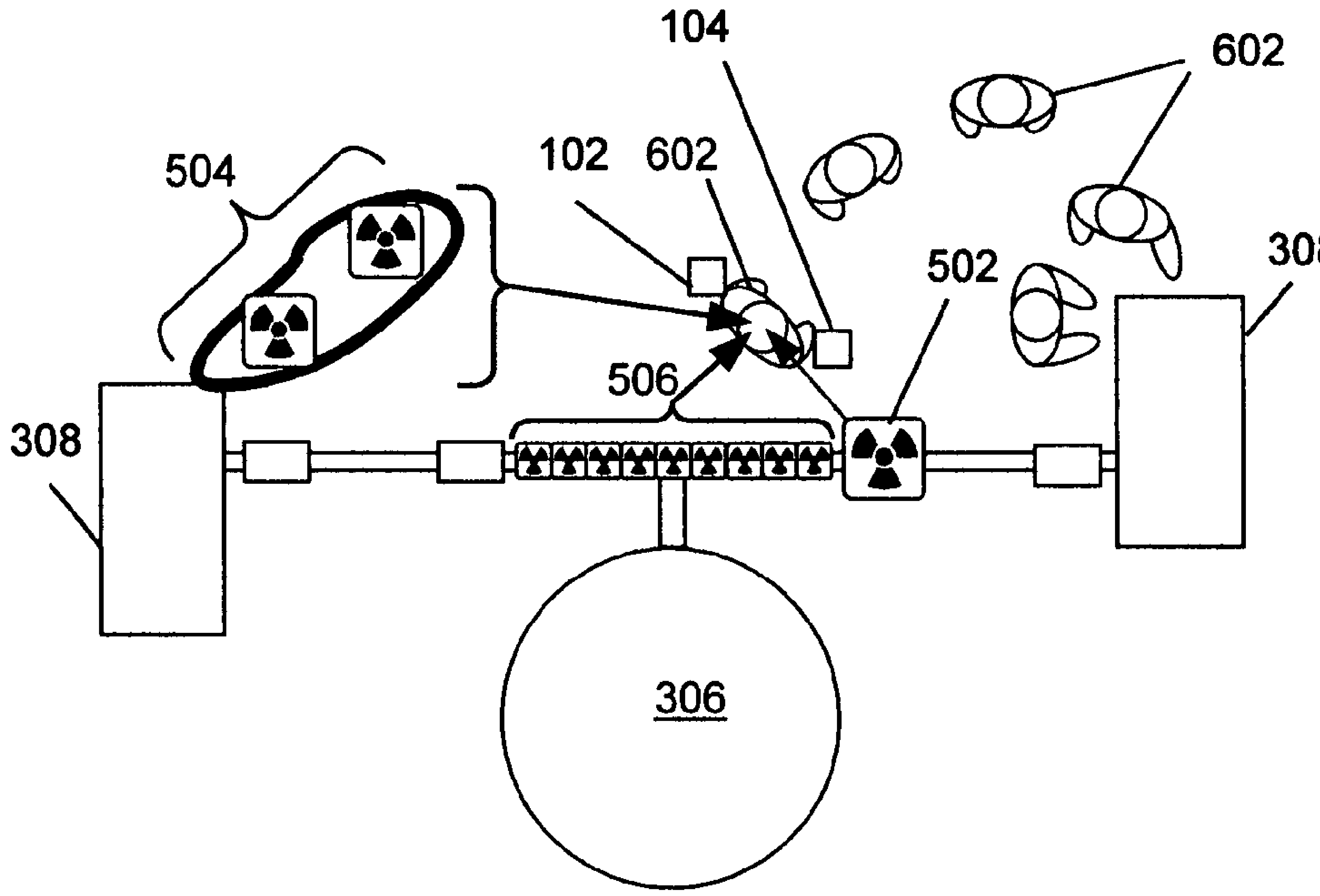
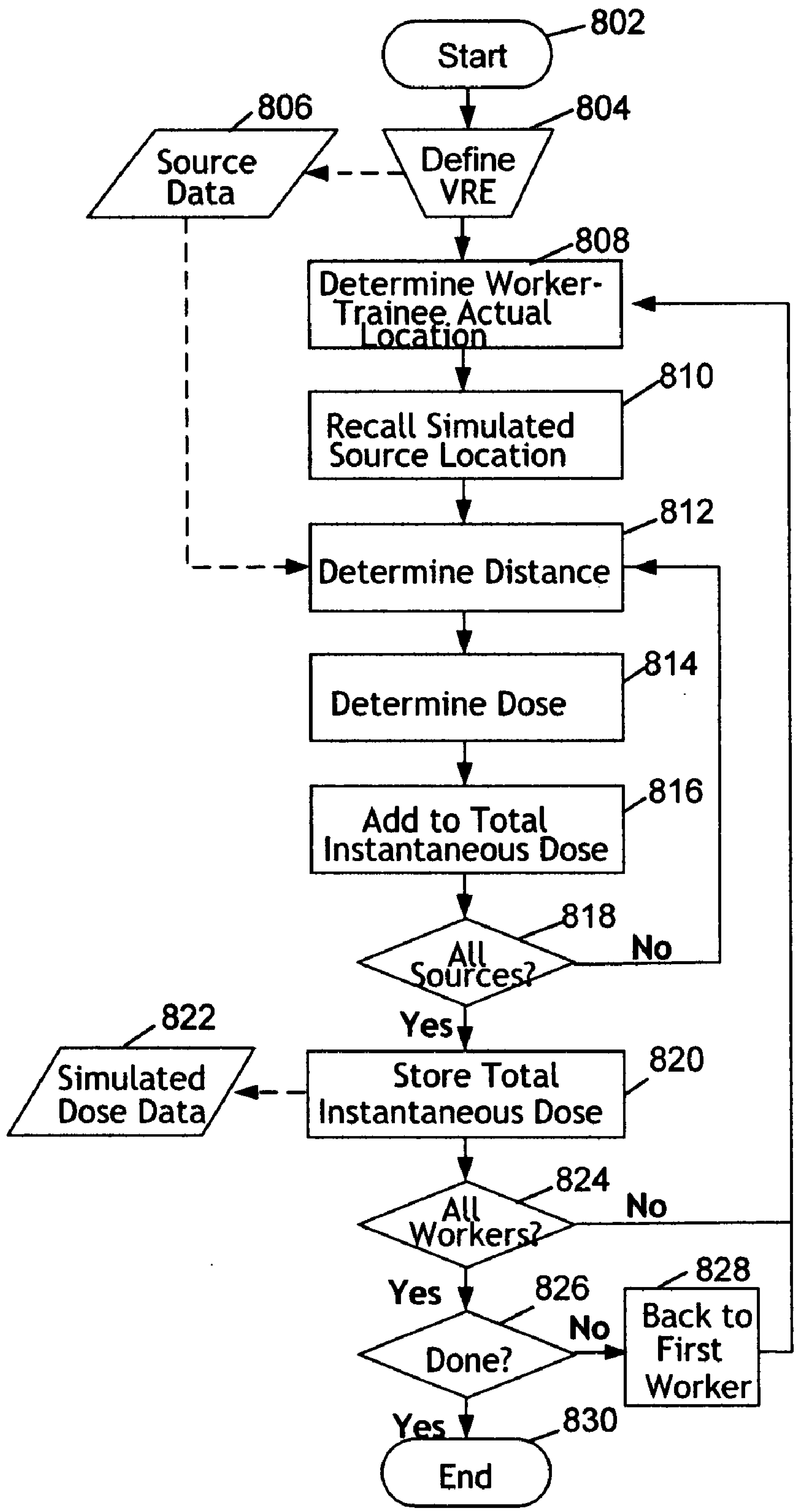

104
602
504
102
602
502
308
506
308
306

Fig. 7



Start
802
Define VRE
804
Source Data
806
Determine Worker-Trainee Actual Location
808
Recall Simulated Source Location
810
Determine Distance
812
Determine Dose
814
Add to Total Instantaneous Dose
816
All Sources?
818
No
Yes
Store Total Instantaneous Dose
820
Simulated Dose Data
822
All Workers?
824
No
Yes
Done?
826
No
Back to First Worker
828
Yes
End
830

Fig. 8

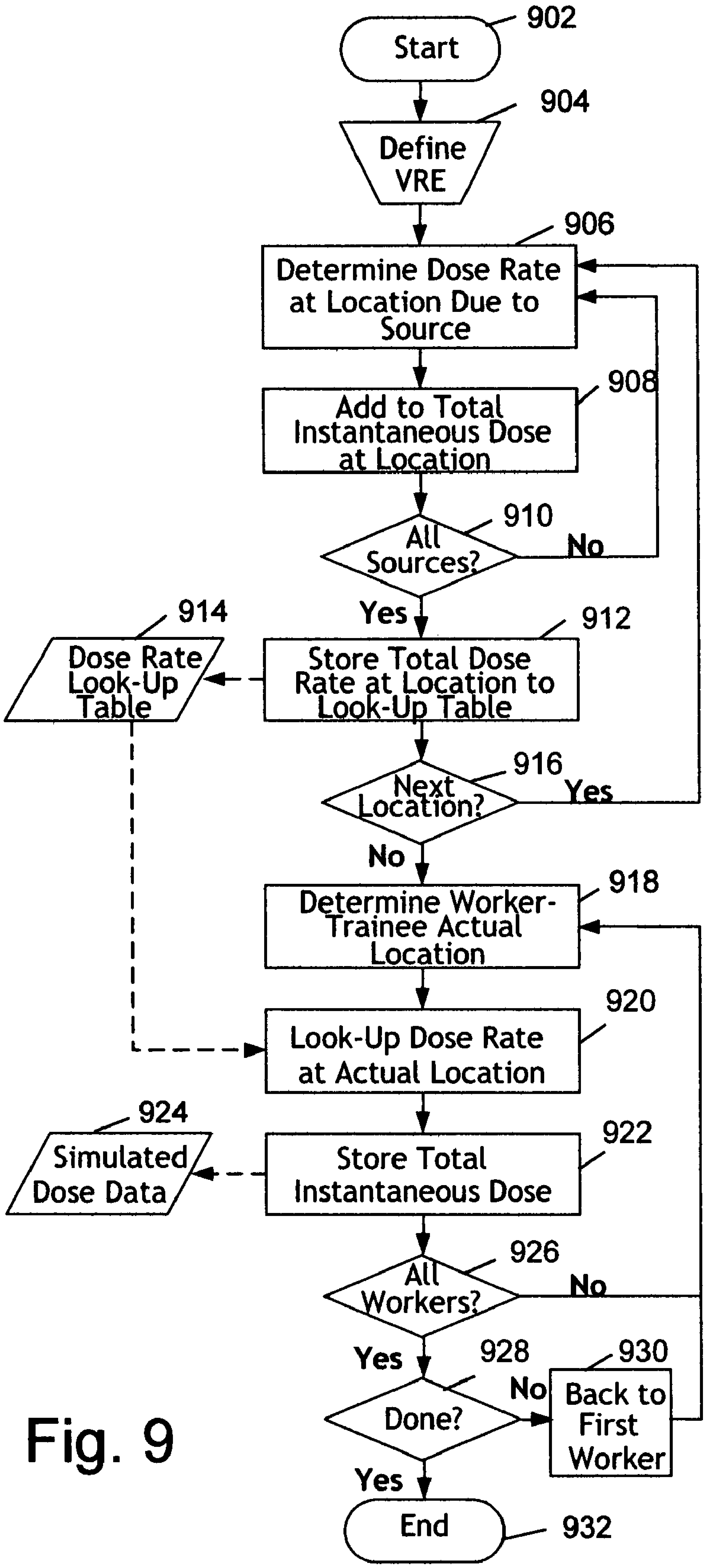

902
Start
904
Define VRE
906
Determine Dose Rate at Location Due to Source
908
Add to Total Instantaneous Dose at Location
910
All Sources?
No
Yes
914
Dose Rate Look-Up Table
912
Store Total Dose Rate at Location to Look-Up Table
916
Next Location?
Yes
No
918
Determine Worker-Trainee Actual Location
920
Look-Up Dose Rate at Actual Location
924
Simulated Dose Data
922
Store Total Instantaneous Dose
926
All Workers?
No
Yes
928
930
No
Done?
Back to First Worker
Yes
End
932

Fig. 9

SYSTEM AND METHOD FOR SIMULATED DOSIMETRY USING A REAL TIME LOCATING SYSTEM

RELATED APPLICATIONS

[0001] This application claims the benefit under 35 USC 119(e) of provisional application Ser. No. 60/841,598, titled: "System and Method of Simulated Dosimetry Using a Real Time Locating System," filed Aug. 31, 2006, by Schantz, which is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention pertains generally to the field of real time simulation based training systems, more particularly to training systems for workers in nuclear or other hazardous environments.

[0004] 2. Background of the Invention

[0005] Radiation exposure of workers in the nuclear industry poses a significant safety and health hazard to the workers, and imposes significant costs to the utilities that employ them. Training is essential to help workers avoid unnecessary exposure to radiation hazards and minimize total dosage.

[0006] Existing training techniques involve equipping workers with simulated dosimeters during training exercises. A trainer supervising the exercise may remotely control the readouts on these simulated dosimeters.

[0007] This approach leaves much to be desired. Since the simulated dosimetry is left to the subjective judgment of a trainer, the simulated dose is subject to considerable variation. Further, in complicated simulated radiation environments, it may be difficult for a trainer to accurately estimate the simulated dose. Similarly, in a complex exercise involving multiple workers, an individual trainer may not be capable of realistically modifying several dosimetry readings.

[0008] Thus, there is a need for a system and method of simulated dosimetry in which simulated dosimetry can be acquired automatically, without the direct intervention or input of a trainer.

BRIEF DESCRIPTION OF THE INVENTION

[0009] Briefly, the present invention pertains to a system for providing a simulated total dose exposure measurement during a nuclear facility training exercise by locating participants using a real time location system, modeling incremental exposure as a function of location and summing incremental exposure to produce a total dose for each of the participants. Total dose may be displayed via a wireless link to a simulated dosimeter worn by each participant. Radiation sources may also have location tags, and the exposure model may be modified in real time according to the tracked location of the radiation source.

[0010] In one embodiment, the locating technology comprises near field locating technology based on comparing near field signal characteristics. Alternative locating technologies may be used.

[0011] These and further benefits and features of the present invention are herein described in detail with reference to exemplary embodiments in accordance with the invention.

BRIEF DESCRIPTION OF THE FIGURES

[0012] The present invention is described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number identifies the drawing in which the reference number first appears.

[0013] FIG. **1** illustrates an exemplary simulated dosimetry system in accordance with the present invention.

[0014] FIG. **2** illustrates an exemplary simulated dosimetry process in accordance with the present invention.

[0015] FIG. **3** illustrates an exemplary flow loop training facility.

[0016] FIG. **4** shows a flow section of the flow facility of FIG. **3**, which may be displayed to a trainer in a virtual radiation environment (VRE) display.

[0017] FIG. **5** shows the flow section of FIG. **4** with radiation sources placed in the VRE.

[0018] FIG. **6** illustrates the training facility of FIG. **3** with a system for simulated dosimetry installed in accordance with the present invention.

[0019] FIG. **7** shows a flow section of FIG. **6** with the VRE setup of FIG. **5** and including trainees **602**, one of which is wearing a locating tag and a simulated dosimeter display.

[0020] FIG. **8** illustrates a method for simulated dosimetry for multiple trainees using real time calculation of radiation for each point.

[0021] FIG. **9** illustrates a method for simulated dosimetry for multiple trainees using pre-calculated radiation for each point retrieved from a lookup table.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The present invention offers a solution to the problem of providing accurate simulated dosimetry to nuclear facility training programs by using a real-time-location-systems (RTLS) in combination with a radiation exposure model. The RTLS may employ near-field electromagnetic ranging (NFER) technology, ultrawideband (UWB), time difference of arrival (TDOA), time-of-flight (ToF) or any other RTLS technology known by practitioners of the RF arts.

[0023] FIG. **1** illustrates an exemplary simulated dosimetry system **100** in accordance with the present invention. Referring to FIG. **1**, a training facility **108** may include any number of different types of hardware as are necessary to provide the necessary training. Included in the training may be exercises directed to handling fault conditions including leaks or spills of radioactive materials. Such fault conditions may be modeled by computer **124** as set up by a trainer/operator. Multiple functions are shown performed by computer **124**; however, the functional partitions and number of computers is for convenience of illustration and may be implemented many different ways according to the preference of the implementer. Each participant (also referred to as a worker/trainee) may wear a simulated dosimeter **106** comprising a locator tag **102***a*, for reporting the trainee's position, and a display **104**, for displaying computed simulated total dose. The locator tag **102***a* and display **104** may be housed in the same package **106** or may be separate, as desired. The locator tag **102***a* communicates with an array of locator receivers **126** for determining the location of the tag **102***a*. Receiver output signals are processed by a location computer **127** to determine the location coordinates of each trainee. Location tags **102***b* may also be placed on items, such as radiation sources **110** within the environment **108**. Location coordinates for such items **110** as well as control inputs **112** which may be operated by the trainees may be used to vary the radiation dose rate model **114** for the environment **108**. The dose rate model may also be configured by a system operator through operator inputs **116**. Trainee location coordinates together with the current real time radiation model **114** output are used to generate a dose rate **118** for the trainee at the measured location at the given time. Dose rate values are summed **120** over the time of the training exercise to provide a total dose value **120**. The total dose value **122** may be displayed to the operator **116** and may be delivered to the trainee via a wireless link or network **128**. Thus, the trainee may wear a simulated dosimeter device **104** similar in appearance to an actual radiation dosimeter that provides a display during simulation training showing simulated exposure to radiation based on the trainee's actual proximity and path through the simulated environment **108**. The system further allows for the real time varying of the environment by the trainees and trainer as the training event unfolds. Real time, within this disclosure, refers to measurements or other events that occur and are acted upon during the original progress of the training event.

[0024] FIG. **2** illustrates an exemplary simulated dosimetry process **200** in accordance with the present invention. Referring to FIG. **2**, the process **200** starts by setting initial conditions in the radiation model **202** and associating a locating tag/dosimeter with each participant **204**. The training event starts, and during the event, participants are tracked and coordinates for the participants are mapped **206**. At each mapped point, the received dose rate from the radiation model is used to determine an incremental dose for the associated time interval at the mapped point of the participant **208**. Dose increments are accumulated for each participant **210**. As the training event progresses, continuous updates of total dose may be displayed to each participant via an RF link or network to a simulated dosimeter display worn by each participant **212**.

[0025] The process **200** may be further understood by considering an exemplary training process at an exemplary flow-loop training facility.

[0026] FIG. **3** illustrates an exemplary flow loop training facility. Referring to FIG. **3**, the flow-loop training facility **302** contains a variety of pumps **308**, pipes **304**, valves **310**, tanks **306**, and other mechanical equipment similar to those used in actual nuclear facilities. Although the present invention is described in terms of a flow-loop raining facility, the teachings of the present invention apply to any industrial, operational, simulation, or other environment in which one might chose to operate a simulated dosimetry system.

[0027] FIG. **4** shows a flow section of the flow facility of FIG. **3** which may be displayed to a trainer in a virtual radiation environment (VRE) display. FIG. **3** shows various pumps **308**, pipes **304**, valves **310**, and a tank **306**.

[0028] FIG. **5** shows the flow section of FIG. **4** with radiation sources placed in the VRE. Referring to FIG. **5**, a point source **502** is shown at the valve **310**. A line source **506** is shown at pipe **304**, and a volume source **504** is shown near pump **308***a*.

System for Simulated Dosimetry Using RTLS

[0029] FIG. **6** illustrates the training facility of FIG. **3** with a system for simulated dosimetry installed in accordance with the present invention. Referring to FIG. **6**, four locator receivers **126** are placed at the corners of the area or in other suitable locations to measure the position of a locating tag **102** on a trainee **602**. Positioning signals **125** from the exemplary locating tag **102** are shown being received by all four receivers **126**. Position information from the receivers **126** is sent to a computer **124** for processing via communication signals **129**, which may be a wireless network. Alternatively, a wired network may be used.

[0030] FIG. **7** shows a flow section of FIG. **6** with the VRE setup of FIG. **5** and including trainees **602**, one of which is wearing a locating tag **102** and a simulated dosimeter display **104**.

[0031] Before each exercise, a trainer sets up one or more virtual radiation environment (VRE) configurations by defining simulated point, line, area, volume, and other sources of radiation throughout the training facility (see FIG. **5**). The trainer inputs the location, intensity, and geometry of the radiation sources. In a preferred embodiment, a software application records the simulated sources defined by a trainer and calculates the radiation exposure (or dose rate) for the VRE at a suitable resolution for each location throughout the training facility.

[0032] The trainer may create multiple VRE's to capture time varying radiation characteristics. For instance during a training exercise, a trainer may switch to an alternate VRE to model changing plant characteristics, like opening or closing of valves, turning on or off pumps, variations of flow, or other operations that might impact radiation characteristics.

[0033] A worker-trainee **602** undergoes training in the training facility. The worker-trainee **602** carries a locator tag **102** that enables a real-time locating system (RTLS) **126** and **127** to determine the worker-trainee's location. A variety of RTLS technologies are known in the RF arts by which one may accomplish this localization. In a preferred embodiment, the tag **102** radiates localizing signals **125** that are picked up by a plurality of locator-receivers **126**. The plurality of locator-receivers **126** then send data signals **129** to a computer **127** (part of **124**). The data signals **129** may be wireless data signals (e.g. 802.11b, 802.11g, &c.), hardwired Ethernet data signals, or any other convenient form of data signaling. The computer **127** receives the data signals **129** and determines the location of the worker-trainee **602** (see FIG. **6**). The computer **124** updates the location of the worker-trainee **602** on a time scale appropriate to create a suitable simulation of the worker-trainee's radiation exposure.

[0034] The computer **124** uses the actual location of the worker-trainee **602** and the locations of the plurality of simulated radiation sources **502**, **504**, **506**, to calculate an instantaneous simulated dose rate based on the distance between the simulated source and the actual location of the worker-trainee (see FIG. **7**).

[0035] The computer **124** monitors and records the instantaneous simulated dose rate. The instantaneous simulated dose rate may be integrated over time to determine a cumulative simulated dose. The computer **124** may also send signals to a simulated dosimeter **104** to cause the simulated dosimeter **104** to display a simulated dose rate and a cumulative simulated dose. The simulated dosimeter **104** may flash, alarm, or otherwise convey information to a worker-trainee **602** in analogous fashion to the alerts of a real dosimeter in a real environment. In a preferred embodiment, a simulated dosimeter may be a PDA or other device with a software application to enable the PDA to provide simulated dose and simulated dose rate and otherwise behave as a simulated dosimeter **104**.

Method for Simulated Dosimetry Using RTLS

[0036] FIG. **8** illustrates a method for simulated dosimetry for multiple trainees using real time calculation of radiation for each point. Referring to FIG. **8**, the method, referred to as a first method, begins at a start block **802**. The first method continues with a training supervisor, health physicist, or other appropriate individual defining the VRE **804**. The definition of a VRE includes defining appropriate point, line, area, or other sources of radiation. The definition must include location and source strength. Distributed sources like line or area sources must further include the geometry of the source distribution and the variation of source strength or concentration along, across or throughout the simulated source. The VRE may also be defined so as to vary according to any appropriate health physics model including, for instance, the variation or distribution of airborne radiation sources in a plume, or radiation sources dissolved in a liquid spill. The VRE may evolve in time, may vary in accord with activities in a training exercise or may change in accord with simulated changes in plant operations or other factors. The VRE is captured, encompassed, and stored in particular source data.

[0037] The first method continues by determining a location of a worker-trainee **808**. In preferred embodiments, this step may be accomplished through use of an RTLS. The first method recalls the source data for the first source **810**. Then the first method determines the distance between the simulated radiation source and the actual location of the worker-trainee **812**. In the case of a point simulated radiation source, this is the distance between the simulated point source and the actual location of the worker-trainee. In the case of a line source, this may be the effective distance integrating along the line (accounting for any variation in source distribution along the line source). In the case of an area source, this may be the effective distance integrating across the area (accounting for any variation in source distribution across the source area).

[0038] The first method continues by determining the dose due to this source **814**. If the source in question is a point source, then dose (D) follows from point source strength (P) and distance (a) according to the formula:

$$D = \frac{P}{d^2} \tag{1}$$

If the source in question is a line source, then dose follows from line source strength (L in source strength per unit length) according to the formula:

$$D = \int_{e1}^{e2} \frac{L(l)}{d(l)^2}\, dl \tag{2}$$

Note that both the line source strength and the distance d between the source point and the worker-trainee location depend upon the location (l) along the line. The line integral is evaluated from one end of the line (e**1**) to the other (e**2**).

[0039] If the source in question is an area source, then dose follows from area source density (a in source strength per unit area) according to the formula:

$$D = \iint_A \frac{\sigma(x, y)}{d^2(x, y)}\, dx\, dy \tag{3}$$

Note that both the area source density and the distance between the source point and the worker-trainee location depend upon the location (x, y) within the area. The area integral is evaluated for all locations within the area A.

[0040] If the source in question is a volume source, then dose follows from volume source density (ρ in source strength per unit volume) according to the formula:

$$D = \iiint_V \frac{\rho(x, y, z)}{d^2(x, y, z)}\, dx\, dy\, dz \tag{4}$$

Note that both the volume source density and the distance between the source point and the worker-trainee location depend upon the location (x, y, z) within the volume. The volume integral is evaluated for all locations within the volume V.

[0041] The first method continues with the instantaneous dose for the first source being added to the total instantaneous dose for the first worker-trainee **816**. Total instantaneous dose is initially set to zero until the contribution of the first source is determined.

[0042] The first method continues with a decision block **818**. If all sources have not been accounted for, the first method continues by determining distance to the next source. Thus the first method loops through and accounts for dose contributions due to all simulated sources in the VRE. If all sources have been accounted for, then the first method continues by storing **820** the total simulated instantaneous dose for the first worker-trainee in a simulated dose data database **822**. In alternate embodiments, the first method may send the total simulated instantaneous dose to a simulated dosimeter or may add the total simulated instantaneous dose to a total simulated cumulative dose. In still further alternate embodiments the first method may send the total simulated cumulative dose to a simulated dosimeter.

[0043] The first method continues with a decision block **824**. If all worker-trainees have not been accounted for, the first method continues by finding the actual location of the next worker-trainee. Thus the first method loops through and determines the instantaneous simulated dose for every worker-trainee in the training exercise.

[0044] If all worker-trainees have been accounted for, then the first method continues with a decision block **826**. If the exercise is over, then the first method terminates in an end block **830**.

[0045] If the exercise is not over, then the first method continues back by determining the actual location of the first worker-trainee **828**.

[0046] FIG. **9** illustrates a method for simulated dosimetry for multiple trainees using pre-calculated radiation for each point retrieved from a lookup table. Referring to FIG. **9**, the lookup table method, referred to as a second method, begins at a start block **902**. The second method continues with a training supervisor, health physicist, or other appropriate individual defining a VRE **904** as in the first method. In the second method, the VRE is used to create a dose rate look-up table for each location of interest within the training environment **906-916**.

[0047] Once the VRE is defined, the second method continues by determining the instantaneous dose rate at a first location due to a first source **906**. The second method continues by adding the instantaneous dose rate due to a source to the total instantaneous dose rate at a location **908**. The second method continues with a decision block **910**. If all sources have not yet been accounted for, then the second method continues by looping back to consider the contribution of the next source. Thus, the second method loops over all sources to determine the total instantaneous does rate due to all sources at a particular location. If all sources have been accounted for, then the second method continues by storing **912** the total dose rate at a particular location to a dose rate look-up table **914**.

[0048] The second method continues with a decision block **916**. If all locations have not yet been considered, then the second method continues by evaluating the dose rate due to the first source at the next location. If all locations have been accounted for, then the dose rate look-up table is completed, and the second method is ready to begin simulated dosimetry.

[0049] The second method continues by determining worker-trainee actual location **918**. Then, the second method continues by using the dose rate look-up table to look-up the dose rate at the worker-trainee's actual location **920**. Depending on the resolution of the dose rate look-up table, the second method may select the dose rate at the location closest to the worker-trainee's actual location or the second method may interpolate between a few of the closest locations in the dose rate look-up table.

[0050] The second method continues by storing **922** the total simulated instantaneous dose for the first worker-trainee in a simulated dose data database **924**. In addition or in alternate embodiments, the second method may send the total simulated instantaneous dose to a simulated dosimeter or may add the total simulated instantaneous dose to a total simulated cumulative dose. In still further alternate embodiments the second method may send the total simulated cumulative dose to a simulated dosimeter.

[0051] The second method continues with a decision block **926**. If all worker-trainees have not been accounted for, the second method continues by determining actual location of the next worker-trainee. Thus the second method loops through and determines the instantaneous simulated dose for every worker-trainee in the training exercise.

[0052] If all worker-trainees have been accounted for, then the second method continues with a decision block **928**. If the exercise is over, then the second method terminates in an end block **932**. If the exercise is not over, then the second method continues back by determining the actual location of the first worker-trainee **930**.

[0053] Both the first method and the second method may be augmented by providing real-time feedback to worker-trainees and to a training supervisor. Both the first method and the second method may be further augmented by integrating real-time simulated dose data with video or other telemetry captured during the exercise.

Near-Field Location System

[0054] In a preferred embodiment, the active location tag and locating receiver of the present invention are based on transmitting and receiving near field signals. Location by near field signals is fully described in the US patents and patent applications incorporated by reference below. In summary, near field signals are signals received within a near field of the transmitter. The near field is best within ⅙ wavelength, but the effects may be utilized out to one wavelength or so. Near field signals show unique amplitude and phase changes with distance from the transmitter. In particular E field and H field antennas couple in different ways to the signal with different amplitude decay profiles and different signal phase changes with distance. These amplitude and phase profiles may be used to measure distance. In particular, by comparing E field and H field phase or E field and H field amplitude, distance may be determined by referring to the theoretical predictions for the measured property as a function of distance. Alternatively, the signal properties may be pre-measured for a particular site to account for site specific disturbances and the range measurement compared with previously measured data. An E field antenna is typically a whip antenna and may be on the order of a meter in length for a 1 MHz signal. An H field antenna is typically a coil and may include a ferrite core. The H field antenna may be on the order of a few centimeters in length, width, and height. Thus, it can be advantageous to utilize magnetic antennas for mobile units because of the compact size and to use both E field and H field antennas for the fixed units because of the size of the whip antenna. In some situations however, the reverse may be desired. Numerous variations are disclosed in the applications incorporated by reference below.

[0055] In particular, an often preferred configuration utilizes a magnetic antenna (H field antenna) for the mobile beacon transmitter (active location tag) and a vertically polarized E field antenna with two orthogonally oriented H field antennas for each of the fixed receiver locations. The two H field antennas have the null axes in the horizontal plane. An exemplary signal set from this arrangement includes:

[0056] E, Electric field strength from the E field antenna

[0057] H**1**, magnetic field strength from the first H field antenna

[0058] H**2**, magnetic field strength from the second H field antenna

[0059] EH**1**, phase angle between E and H**1** signals

[0060] EH**2**, phase angle between E and H**2** signals

[0061] Thus, multiple determinations of range may be made from this configuration by making different comparisons between E field and H field amplitude and phase. Typically, a weighted average of available determinations is used based on the strongest or most reliable signals from the set.

[0062] To find a position within an area, as needed for the exemplary warehouse example, typically multiple receivers are positioned to allow triangulation based on multiple range measurements, i.e., to each location receiver from the active location tag. If height is desired, additional receivers may be deployed to improve the height resolution. The receivers may be connected to a central computer for combining the measurements from all receivers to determine location. The connection may be by wired or wireless network or other methods as desired.

[0063] In a further alternative embodiment, the area may be pre-measured to account for specific local propagation disturbances and to reduce errors from equipment variations. A calibration set of measurements is made by placing an active location tag at known locations and measuring the signals and phases at all receivers. A finer grid, or set of grids, of locations may be generated from extrapolation and interpolation from the measured locations. In operation, an unknown location is determined by transmitting from the unknown location and comparing the set of measured data from all receivers with the stored calibration data to find a location having the best match. Best match may be determined by summing absolute value of the differences between each respective signal from each receiver, the best match being the lowest sum. In the sum, amplitudes and phases may be scaled to have similar effect on the sum. Weak signals may be ignored. Other criteria may be applied to weight each element. Other matching criteria such as sum of squared differences or other error criteria may be used. In one embodiment, a location is determined as the centroid of a region having an error value above a predetermined threshold. In further embodiments, motion constraints, such as walls and motion dynamics including momentum are used to improve position.

[0064] Further details on near field positioning systems can be found in:

[0065] U.S. patent application Ser. No. 11/272,533 titled: "Near field location system and method," filed Nov. 10, 2005 by Schantz et al., now published as Publication US20060132352, Jun. 22, 2006,

[0066] U.S. patent application Ser. No. 11/215,699 titled: "Low frequency asset tag tracking system and method," filed Aug. 30, 2005 by Schantz et al., now published as Publication US20060192709, Aug. 31, 2006,

[0067] U.S. patent application Ser. No. 11/473,595 titled: "Space efficient magnetic antenna system," filed Jun. 23, 2006 by Schantz et al., now published as Publication US20060244673, Nov. 2, 2006,

[0068] U.S. patent application Ser. No. 11/890,350 titled: "Asset Localization, Identification, and Movement System and Method," filed Aug. 6, 2007 by Beucher et al.,

[0069] U.S. patent application Ser. No. 10/958,165 titled: "Near field electromagnetic positioning system and method," filed Oct. 4, 2004 by Schantz et al., now published as Publication US20050046608, Mar. 3, 2005,

[0070] U.S. Pat. No. 6,963,301: "System and Method for near field electromagnetic ranging," issued Nov. 8, 2005 to Schantz et al., and

[0071] U.S. patent application Ser. No. 11/500,660, titled "Electromagnetic location display system and method," filed Aug. 8, 2006 by Langford et al, now published as Publication US20060267833, Nov. 30, 2006.

[0072] All of the above listed US Patent, Patent Applications and publications are hereby incorporated herein by reference in their entirety.

CONCLUSION

[0073] The present invention has been described above with the aid of functional building blocks illustrating the performance of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed. Any such alternate boundaries are thus within the scope and spirit of the claimed invention. One skilled in the art will recognize that these functional building blocks can be implemented by discrete components, application specific integrated circuits, processors executing appropriate software and the like or any combination thereof.

[0074] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. A system for determining a simulated radiation dose for a participant comprising:
- a real time location system, said real time location system comprising:
  - a first locator tag to be worn by said participant, and
  - a locator system for determining a plurality of positions for said first locator tag during a training period;
- a radiation field model for determining a dose rate for a position within a training area during said training period; and
- a computer, said computer determining a dose rate for each position of said plurality of positions of said first locator tag based on said radiation field model, said computer calculating a total received dose for said participant based on said dose rate for each position of said plurality of positions of said first locator tag during said training period.

2. The system of claim **1**, wherein the real time location system comprises a near field location system.

3. The system of claim **2**, wherein said first locator tag comprises a transmitter tag.

4. The system of claim **1**, further including:
- a dosimeter worn by said participant, said dosimeter displaying said total received dose for said participant.

5. The system of claim **1**, further including an input from a trainer to modify said radiation field model during said training period.

6. The system of claim **1**, further including an input from said participant to modify said radiation field model during said training period.

7. The system of claim **1**, further including a second locator tag, said second locator tag associated with an item in said training area, wherein said radiation field model is modified by location information from said second locator tag.

8. The system of claim **7**, wherein the item is a radiation source.

9. The system of claim **1**, wherein the radiation model comprises a pre-calculated lookup table of dose rate values for a plurality of locations within said training area.

10. A method for determining a simulated radiation dose for a participant comprising:
- associating a radio frequency locating tag with said participant for locating said participant's movements within a training facility;
- generating a plurality of position measurements of said participant based on said radio frequency locating tag;

producing a simulated dose rate for each position of said plurality of position measurements for said participant based on a simulated dose rate model; and

generating a total dose for said participant based on said plurality of position measurements and said simulated dose rate for each position of said plurality of position measurements for said participant.

11. The method of claim **10**, further including the step of:

displaying said total dose for viewing by said participant by a simulated dosimetry display to be worn by said participant.

12. The method of claim **10**, further including the step of:

modifying the simulated dose rate model in real time based on an input from a trainer.

13. The method of claim **10**, further including the step of:

modifying the simulated dose rate model in real time based on an input from said participant.

14. The method of claim **10**, further including the step of:

modifying the simulated dose rate model in real time based on a position measurement of an item within said training facility.

15. The method of claim **10**, wherein the simulated dose rate model includes a pre-calculated lookup table of dose rate values for a plurality of positions within said training facility.

16. The method of claim **10**, wherein the radio frequency locating tag comprises a near field locating tag.

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