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(54) **MULTIPLE TRACE PORTAL DETECTION SYSTEMS**

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G01N 1/14 (2006.01)

(52) **U.S. Cl.** **73/28.01; 73/863.21; 73/863.33; 73/864.33**

(58) **Field of Classification Search** 73/28.01, 73/863.21, 863.33, 864.33
See application file for complete search history.

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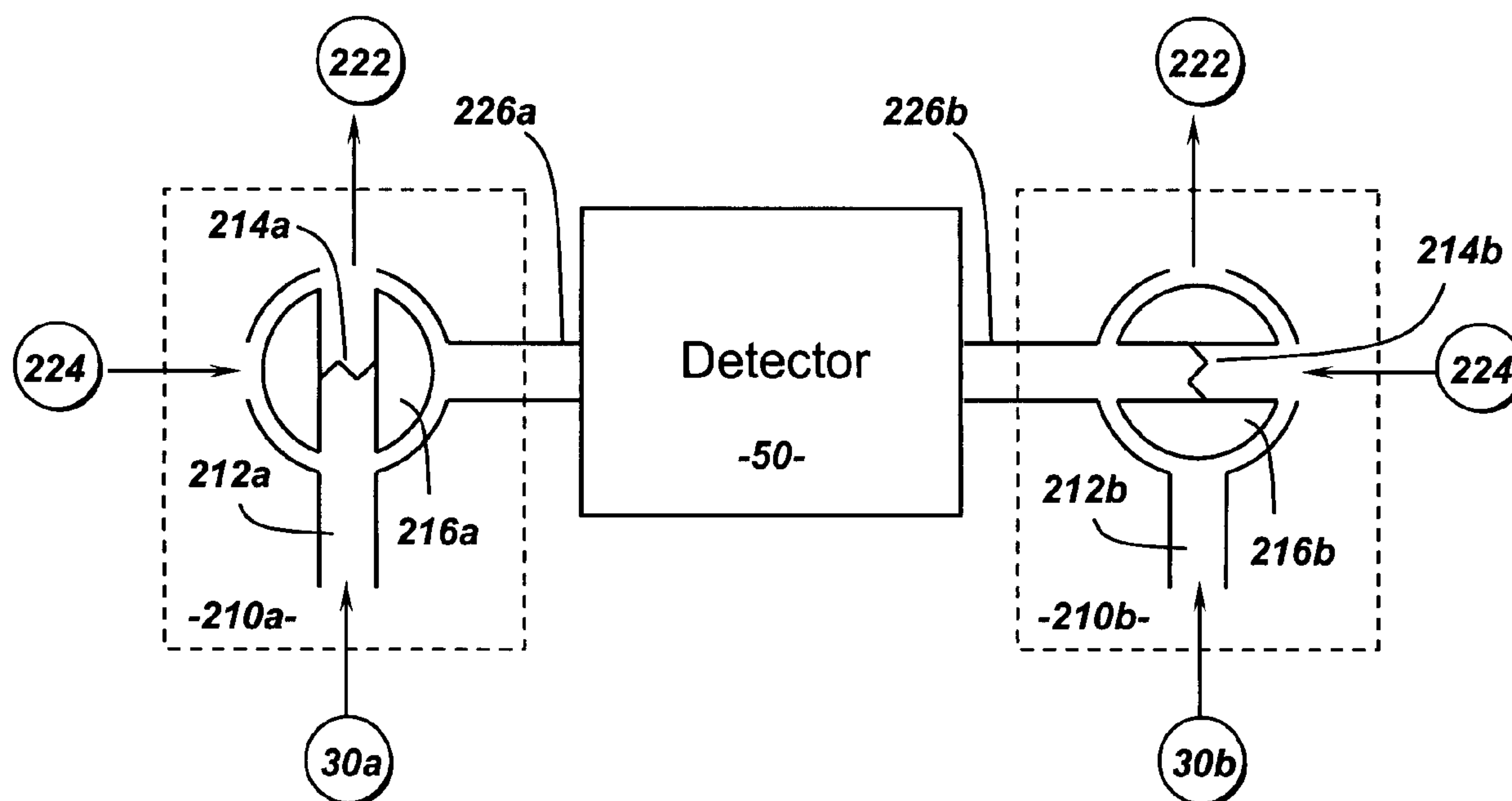
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(57) **ABSTRACT**

A detector system that can analyze multiple samples with a single detector. The detector may contain a portal with a first opening and a second opening. A first sample is obtained from the first opening and a second sample is obtained from the second opening. The openings are coupled to a single detector that can analyze both samples.

13 Claims, 8 Drawing Sheets



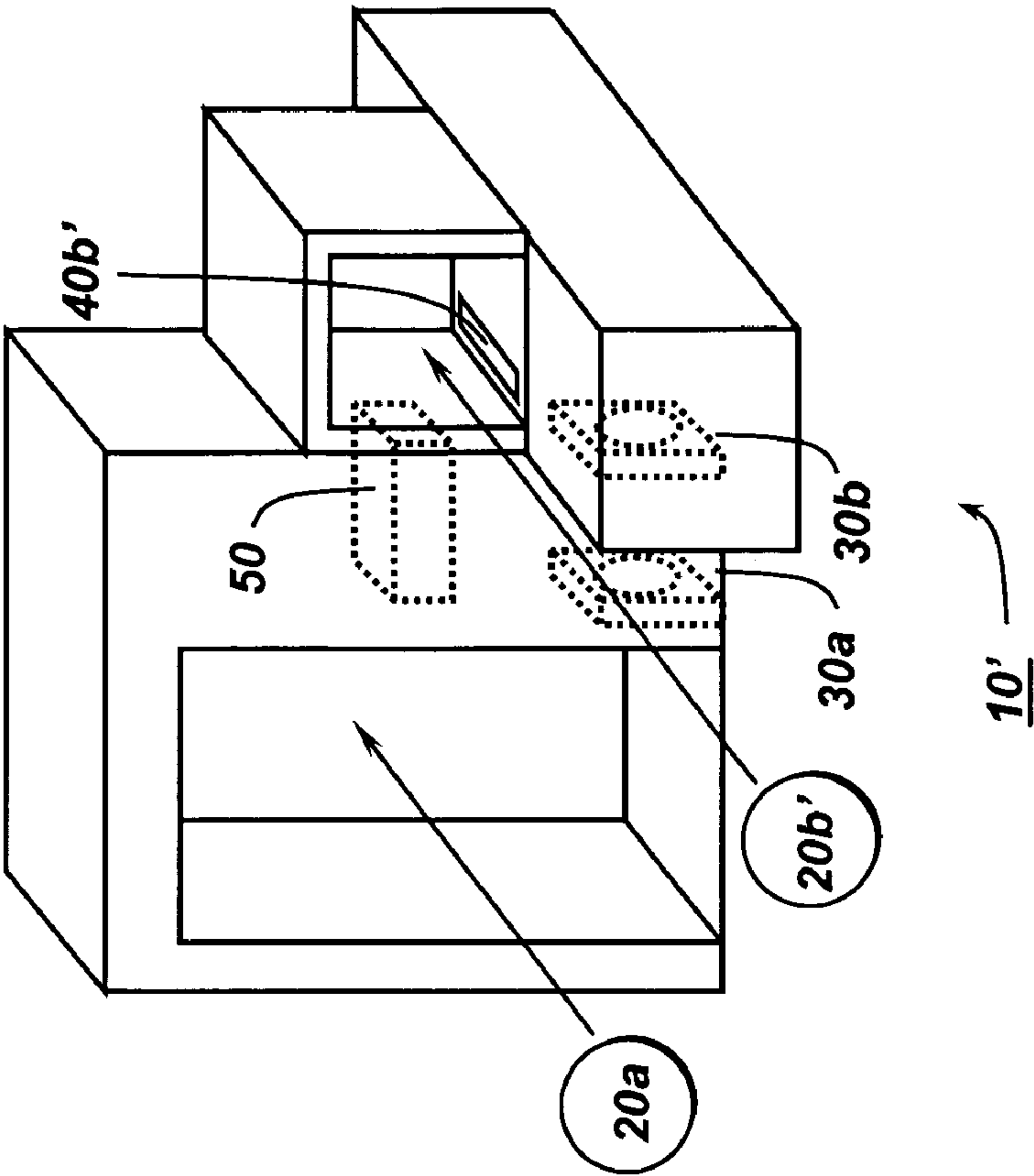


FIG. 1

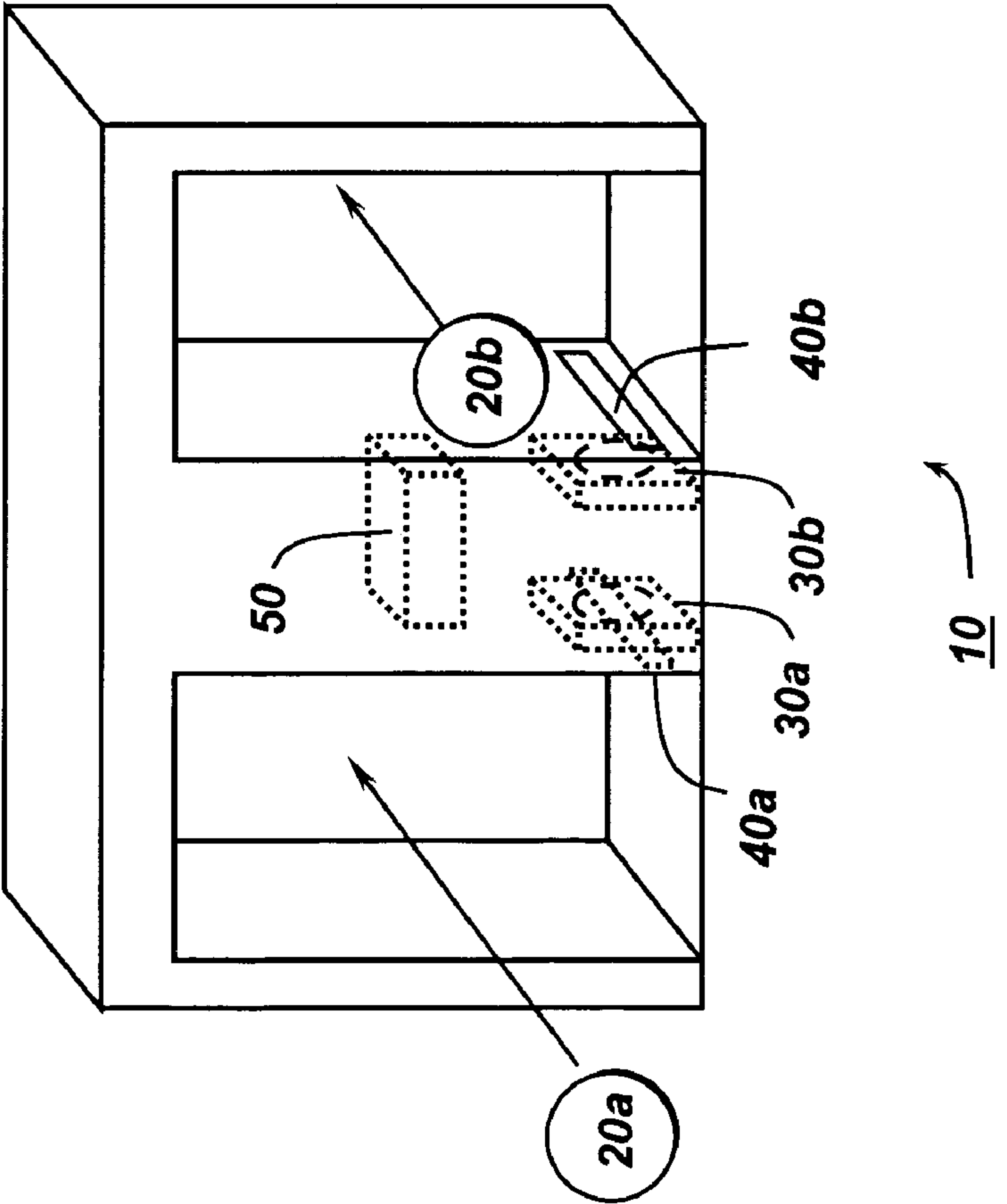


FIG. 2

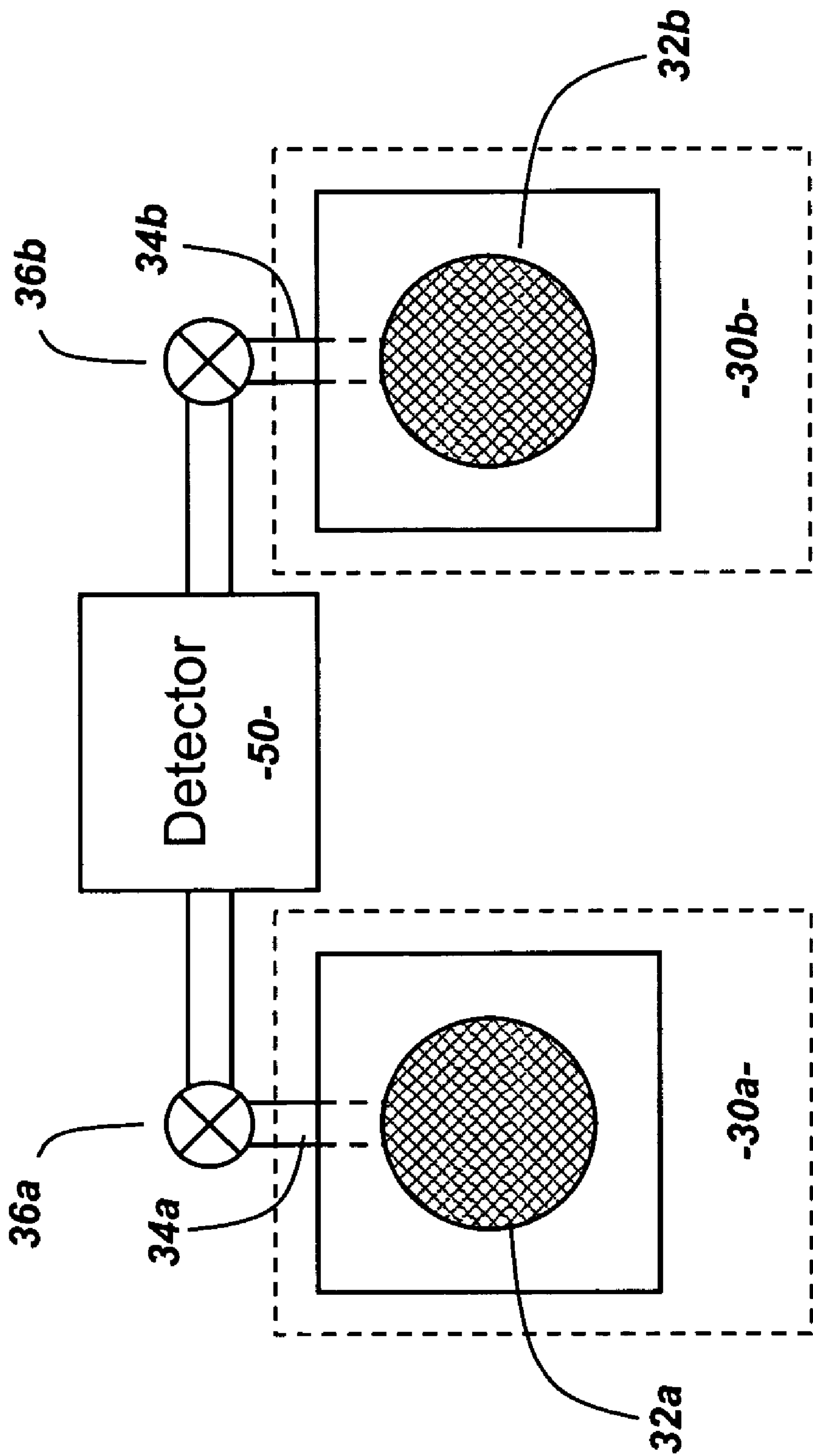


FIG. 3

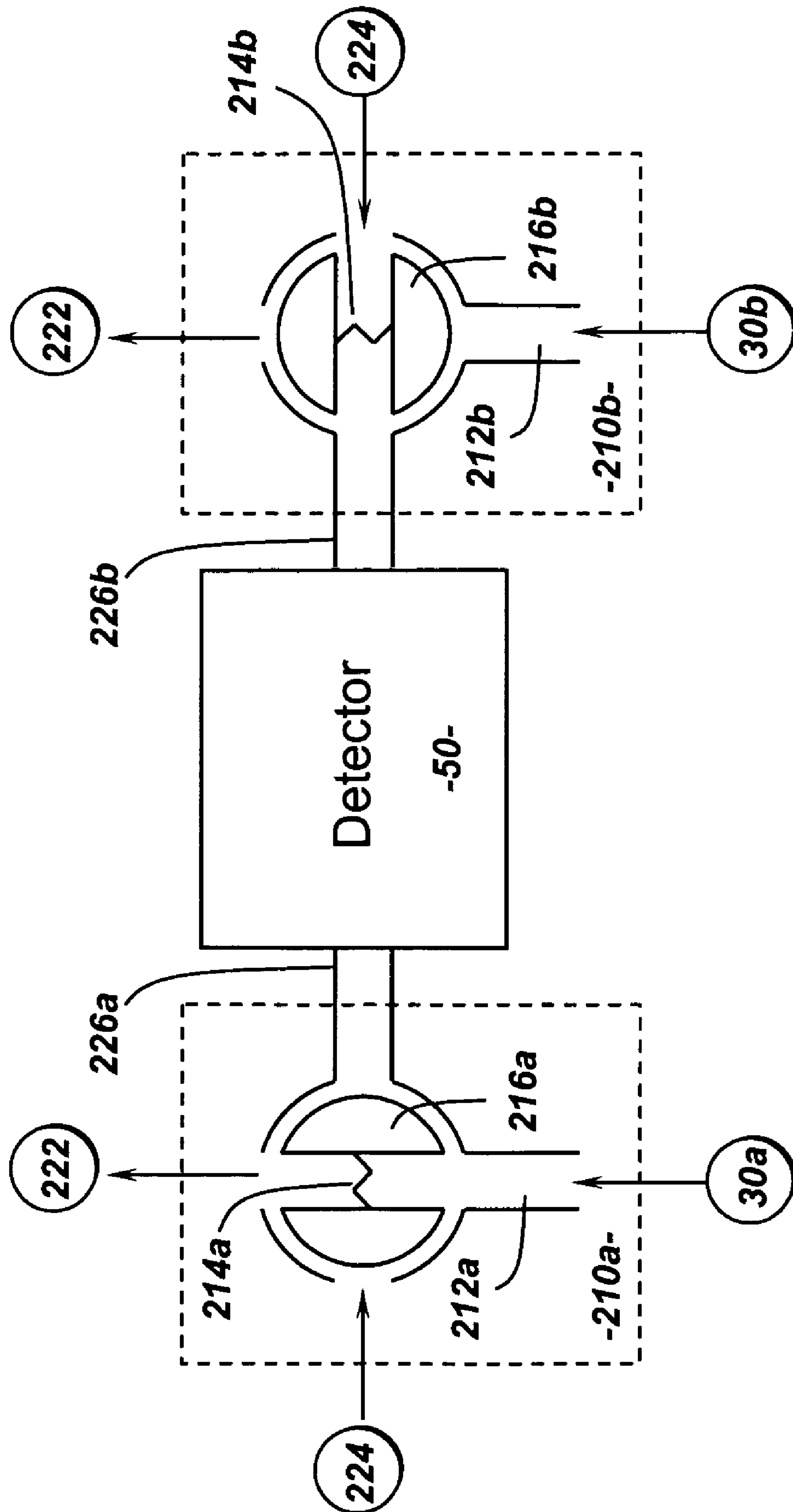


FIG. 4

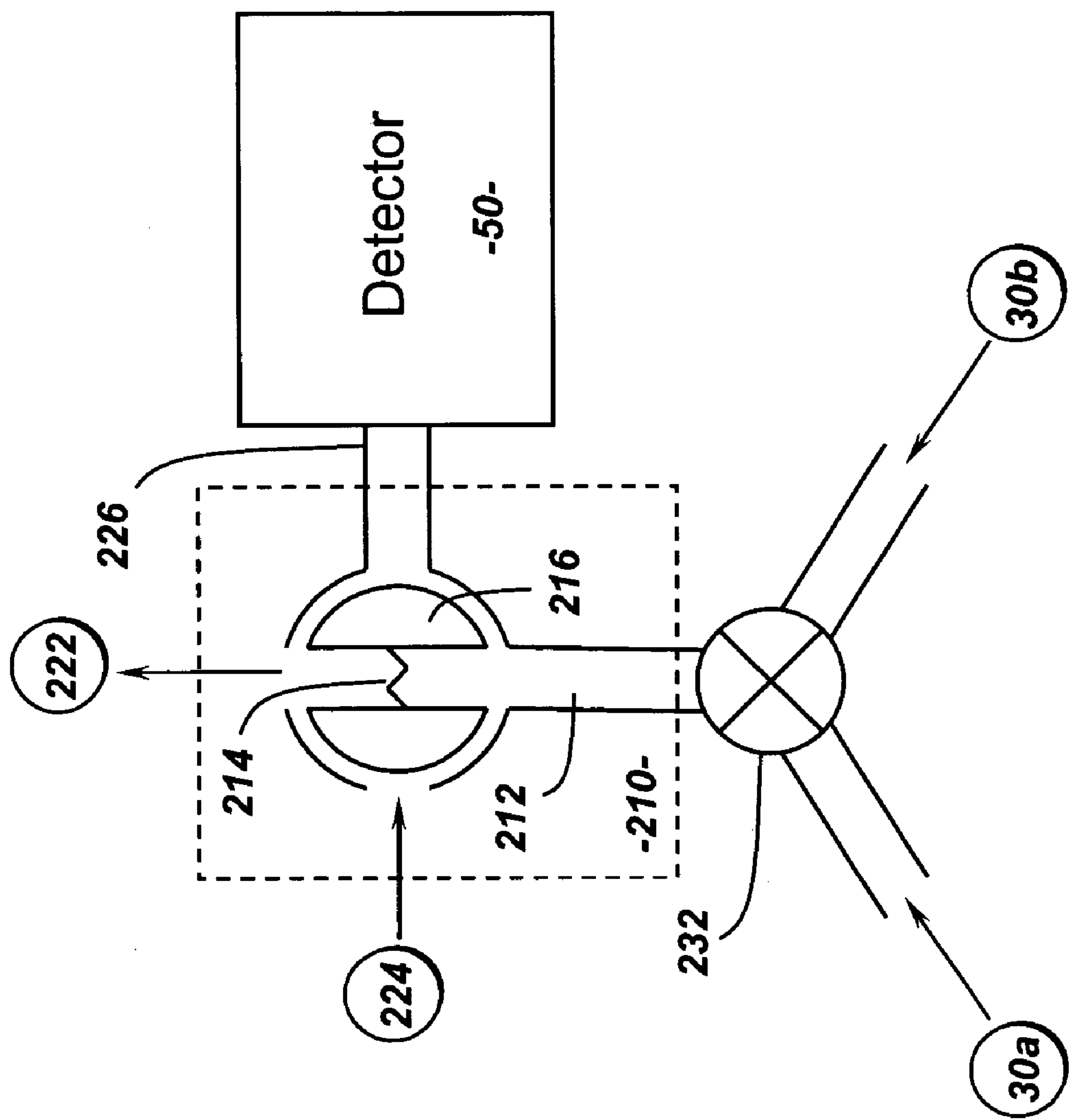


FIG. 5

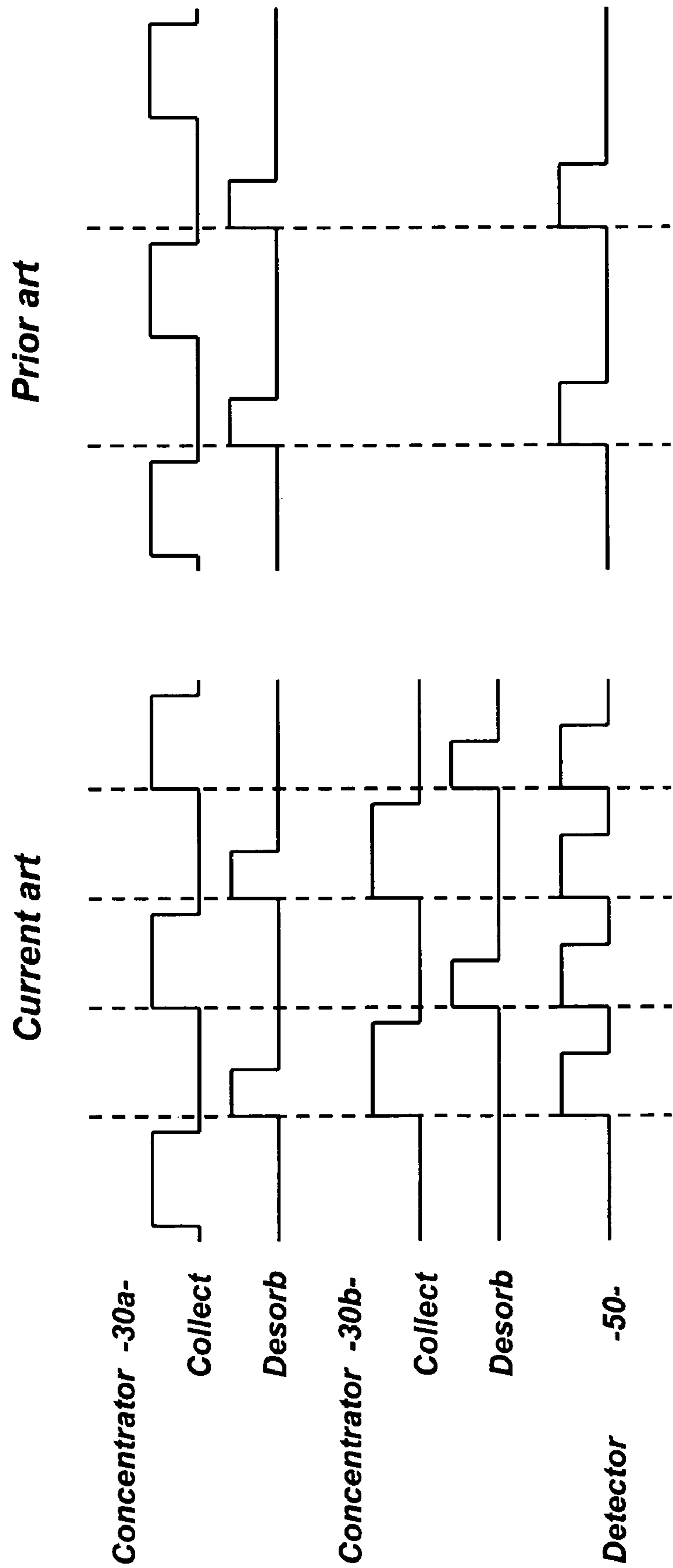


FIG. 6

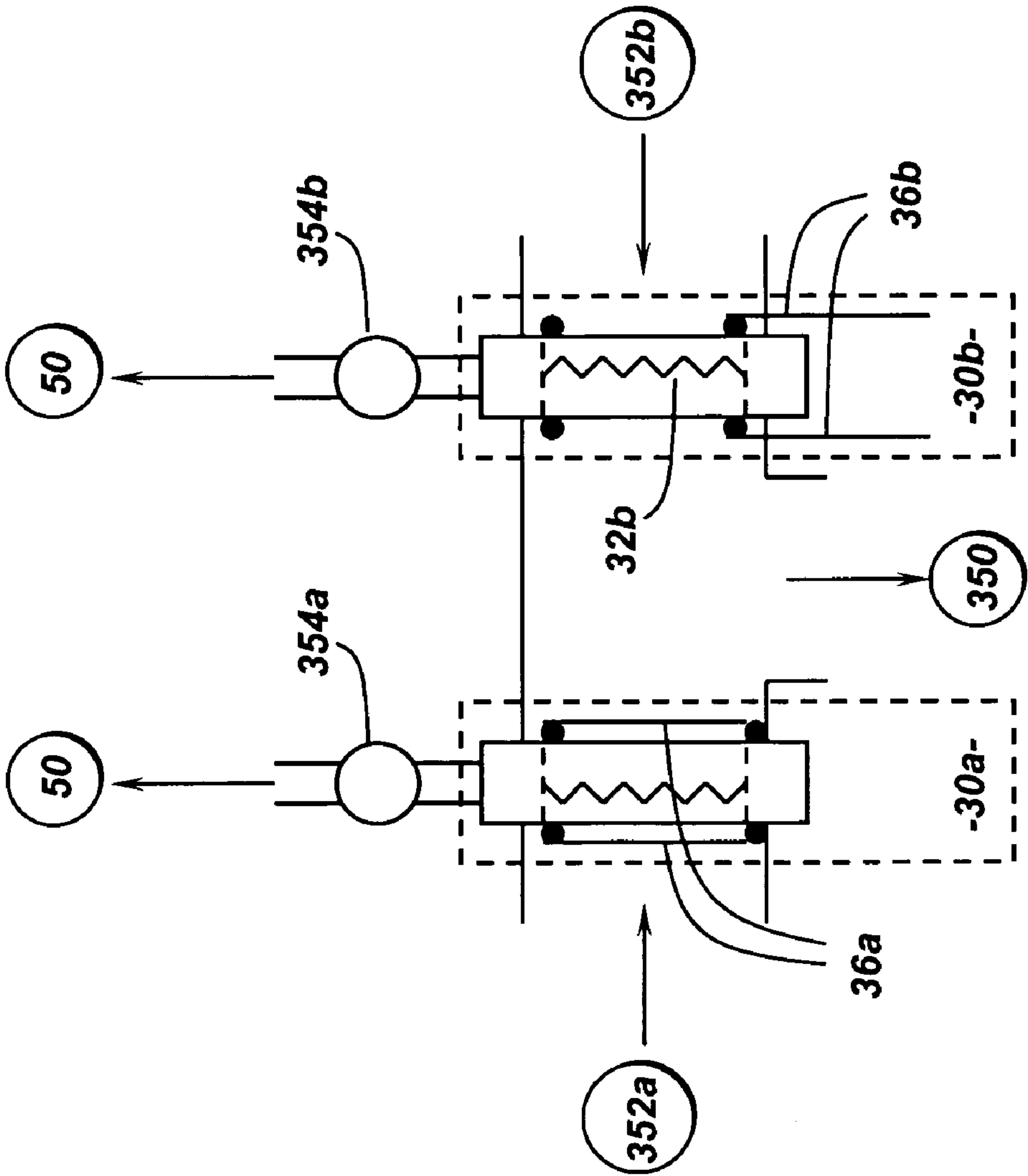


FIG. 7

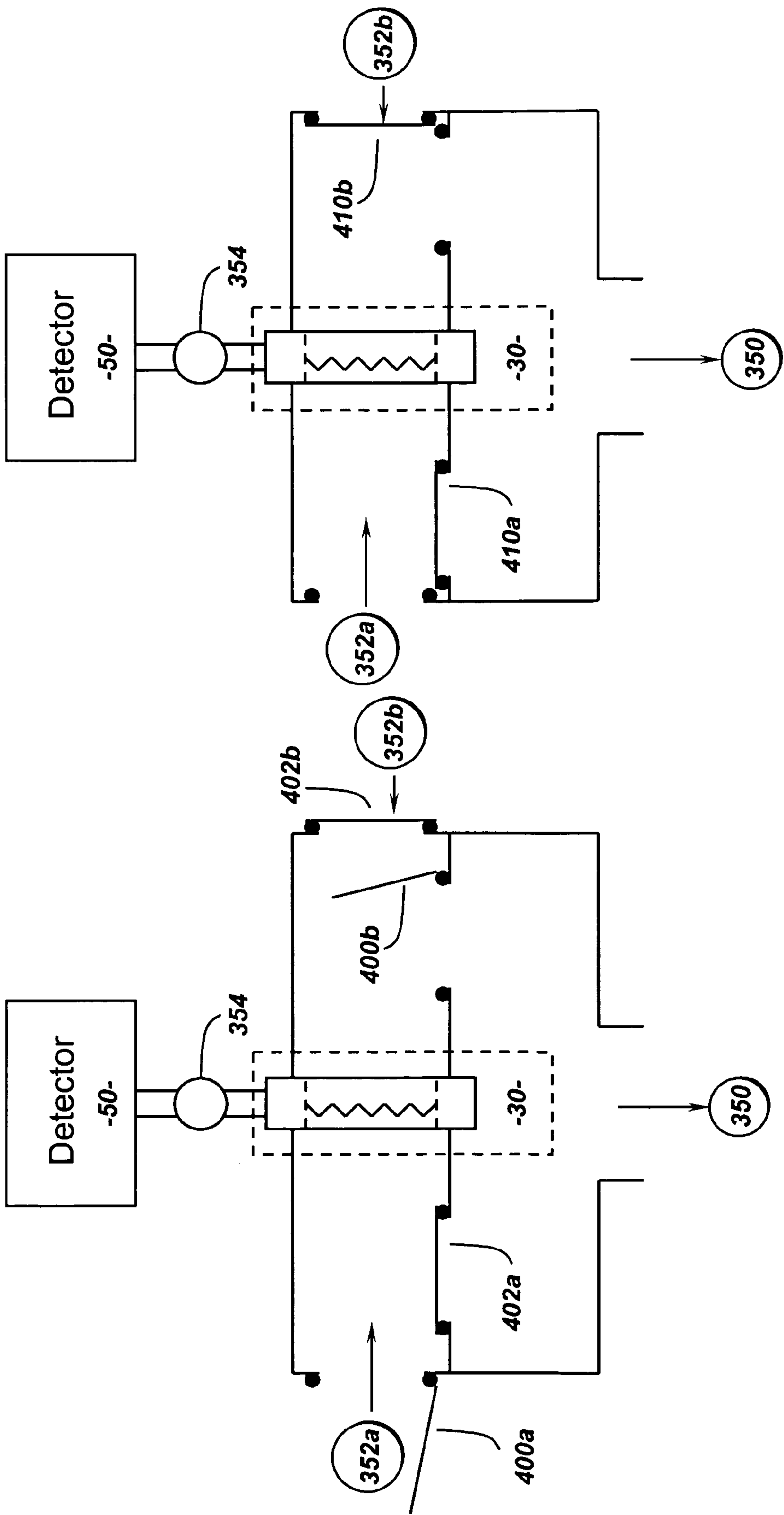
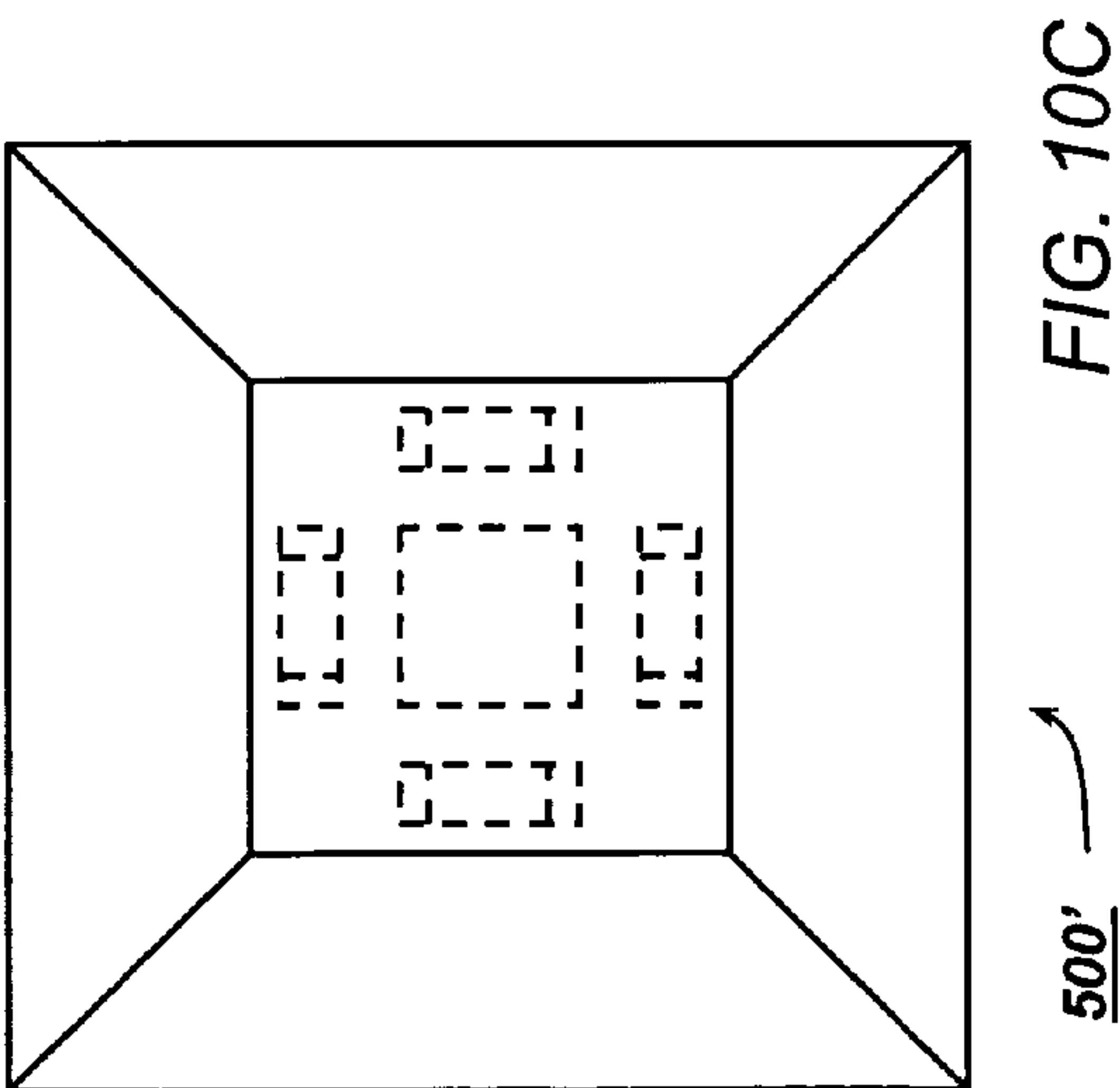
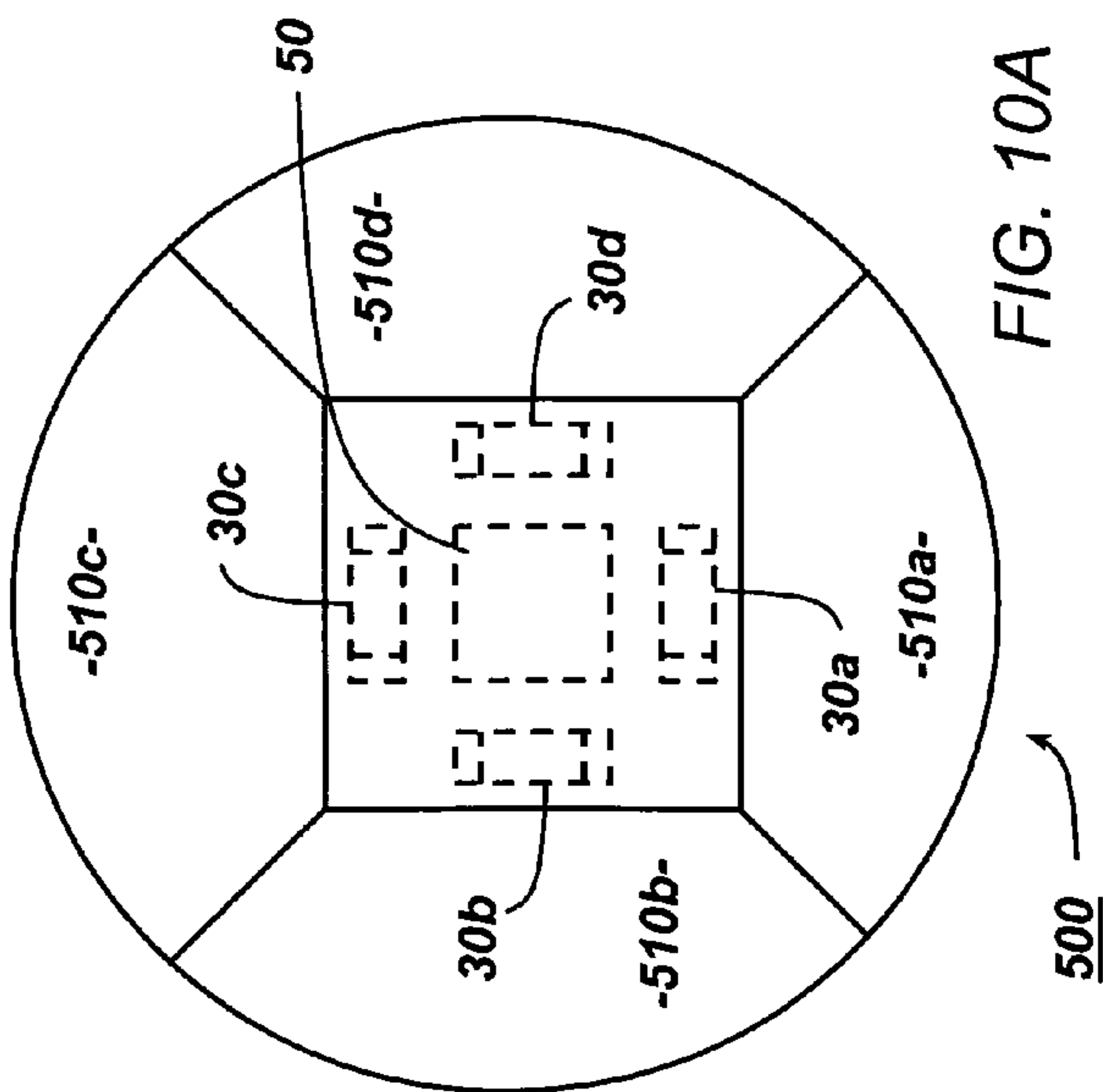
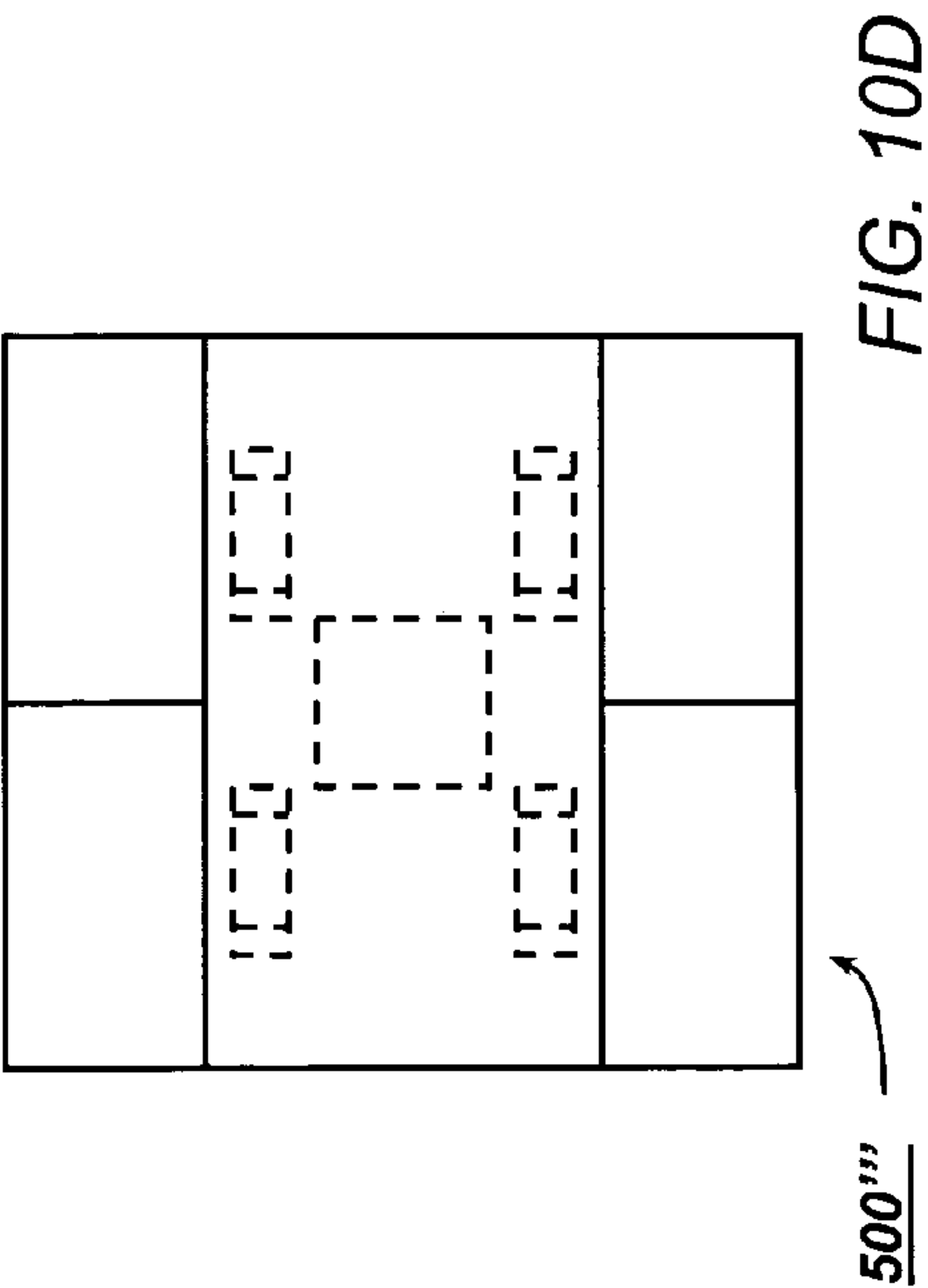
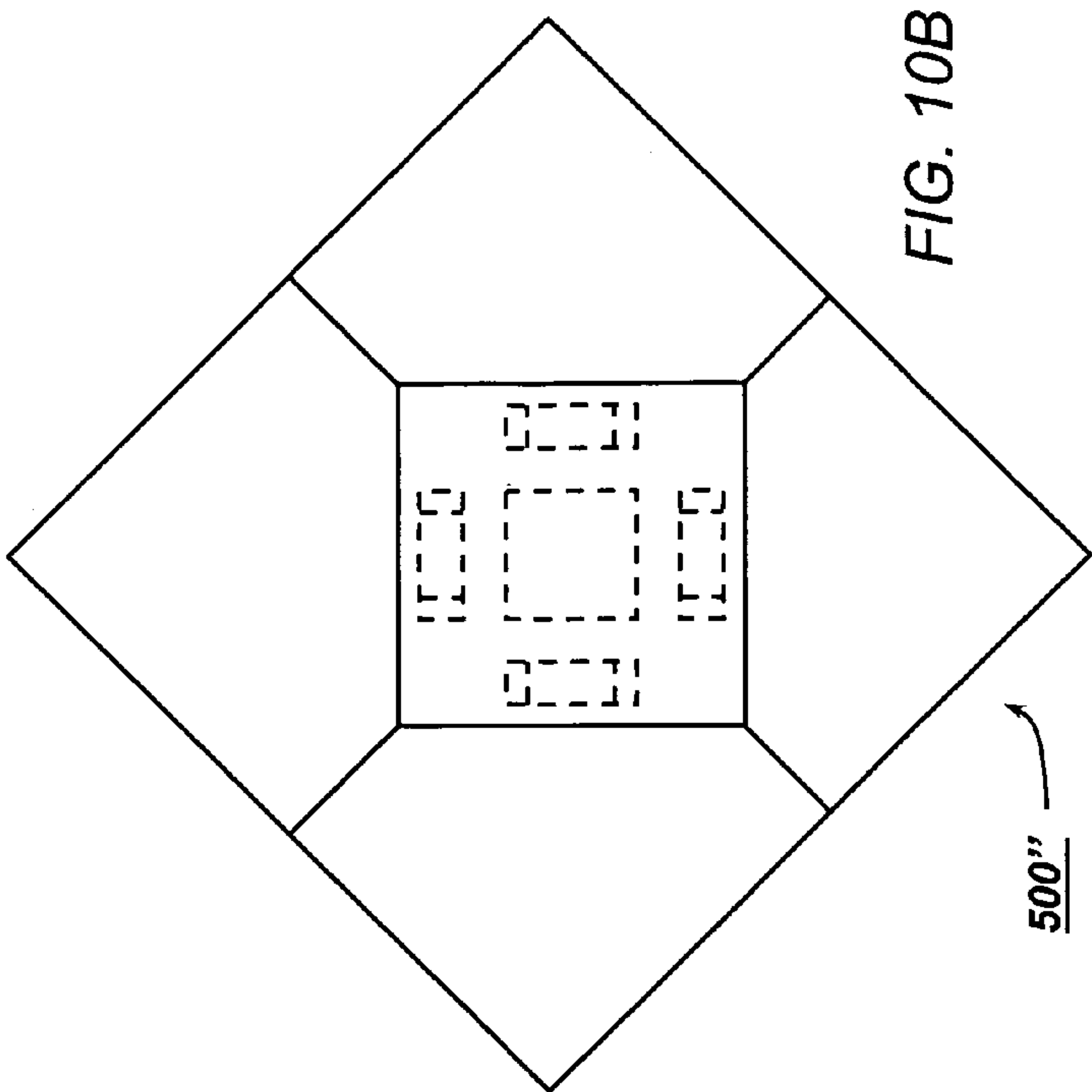


FIG. 9

FIG. 8



MULTIPLE TRACE PORTAL DETECTION SYSTEMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of detection apparatus used to screen individuals for the presence of explosives and other chemical entities.

2. Background Information

The growing concern over security in public venues has led to development of new technologies capable of rapidly detecting the presence of illicit and hazardous materials. One of the lead organizations in this effort is the Transportation Security Agency (TSA), who is responsible for ensuring safety of air travel and has invested significantly in developing technologies to combat the potential for attacks by explosive devices.

Two types of detectors are used for screening baggage and people. Explosive detection systems (EDSs) detect bulk explosives hidden in checked baggage and frequently operate using dual x-ray tomography. Explosives trace detectors (ETDs) detect vapor or particles of explosives that are contaminated on people and the surface of baggage. ETDs are also used to resolve alarms from EDSs. Currently ETDs are used on a selective basis to screen for personal items and carry-on bags, but not for directly screening individuals. The lack of a capability to screen for explosives hidden on an individual is arguably the greatest vulnerability in aviation security. Though most of the attention for explosives threat detection is focused on aviation security, in fact security is an issue for many venues including other types of transportation, buildings, ports, stadiums, military base and field operations, and in general any high traffic environment.

Several portal concepts using ETDs have been developed and tested. The most promising are based on non-intrusive (non-contact) removal of particles from clothing, followed by high-flow collection of the particles on the surface of a mesh or substrate, and then thermal desorption into an ETD. For examples Linker et al. disclosed in U.S. Pat. No. 5,915,268 a portal device that uses air jets to dislodge particles from a person and a downward flow of air to entrain and carry the particles to a concentrator device. Another portal method was disclosed by Settles in U.S. Pat. No. 6,073,499, which involves a passive method of particle collection relying on the upward flow of air around people due to thermal conductivity in what is called the human thermal plume (HTP). Jenkins et al disclosed in U.S. Pat. No. 6,708,572 a similar method that uses air jets to assist the upward flow of the HTP. Each of these portal methods involves a flow of particle and vapor laden air and uses a concentration device that removes the target particles and vapor from the large volume of air by collecting them onto a mesh or substrate. The target particles and vapor are then thermally desorbed and mixed with a low volume flow of gas that leads to a chemical analyzer. Another portal method was disclosed by Bromberg et al in U.S. Pat. No. 5,760,314 and, which unlike the above non-contact portals, uses samplings tubes that make contact with individuals to efficiently collect particles and vapor.

A two-stage concentrator for vapor/particle detection was disclosed by Linker and Brusseau in U.S. Pat. No. 6,345,545. Their device enables concentrating particles from a high-volume gas flow to a sufficiently low-volume gas flow to be coupled efficiently to a detector. The first stage of the concentrator contains a metal mesh for collecting particles and vapor that are entrained in the high-volume gas flow. The desorbed vapors from the first-stage concentrator are col-

lected on the second-stage concentrator and provided to the detectors with a low-volume gas flow.

The chemical detectors used in all of the portals mentioned above use some form of ETDs including ion mobility spectrometry (IMS), mass spectrometry (MS), and gas chromatography/chemiluminescence (GC/CL) detectors.

An important characteristic of a personnel screening portal is that it operate sufficiently fast so as not to significantly impede the flow of people going through it. Current portals operate with a sampling interval of about 10-15 s from one person to another. This is much longer than the interval of about 4-6 s for which standard metal detectors are capable. Methods to improve the sampling interval of a vapor/particle detecting portal are highly desirable.

Another important characteristic of a portal is that it have reasonable upfront and recurring costs per unit. Given the large number of passenger lanes in U.S. and international airports (about 3000 each) and limited available budgets, inevitable compromises are made with regard to cost and the number of units that can be deployed. Solutions that reduce the cost per passenger screened would allow greater distribution of deployed screening portals.

BRIEF SUMMARY OF THE INVENTION

A detector system that can analyze multiple samples with a single detector. The detector may contain a portal with a first opening and a second opening. A first sample is obtained from the first opening and a second sample is obtained from the second opening. The openings are coupled to a single detector that can analyze both samples. dr

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a portal for screening two persons.

FIG. 2 is an illustration of a portal for screening a person and baggage.

FIG. 3 is a schematic showing two particle/vapor concentrators coupled to a single detector by way of valves.

FIG. 4 is a schematic of a detector coupled to two second stage concentrators that are each coupled to a first stage concentrator.

FIG. 5 is a schematic of a single-second stage concentrator and a detector that are coupled to two first-stage concentrators by way of a valve.

FIG. 6 is a timing diagram comparing a portal with two concentrators versus a portal with one concentrator.

FIG. 7 is an illustration showing an embodiment with two concentrators and one airflow blower.

FIG. 8 is an illustration of an embodiment that has one concentrator, one blower, and four valves.

FIG. 9 is an illustration of embodiment that has one concentrator, one blower, and two valves.

FIGS. 10A-D are illustrations of embodiments of a portal with a single detector that can screen more than two persons.

DETAILED DESCRIPTION

Disclosed is a personnel explosives-detecting portal capable of screening multiple persons at once or a combination of persons and baggage. Referring to the drawings more particularly by reference numbers, FIG. 1 shows an embodiment of a multiple trace portal detection system 10. The portal 10 allows two persons to be screened simultaneously. The portal has openings 20a and 20b. By way of example, the openings 20a and 20b may each be at least six feet high to

3

allow people to pass through. Individuals do not have to enter at the same time. Each opening can operate independently.

The portal **10** may have two concentrators **30a** and **30b**. Vapor and particles of interest are collected off of individuals in openings **20a** and **20b** and are collected on concentrators **30a** and **30b**, respectively. The collection from both openings **20a** and **20b** can occur simultaneously or separately. The portal **10** may further have slots **40a** and **40b** that are in fluid communication with the openings **20a** and **20b** and allow vapor flow onto the concentrators **30a** and **30b**. Vapor and particles are pulled through the slots **40a** and **40b** and collected onto the concentrators **30a** and **30b**. The concentrators **30a** and **30b** then deliver the extracted vapor and particle content to a detector **50** by a heating process that leads to thermal desorption. The detector **50** may be of various types including mass spectrometry.

Though individuals may be screened simultaneously and collection of vapor and particles may occur simultaneously, the thermal desorption and detection process from the concentrators **30a** and **30b** may be conducted in sequence and not simultaneously in order to be able to differentiate which passageway is being analyzed. This sequence does not impede the ability to screen two passengers simultaneously because many steps are involved in the overall screening process. However, it is also feasible to thermally desorb from both concentrators simultaneously if differentiation of the analysis is not needed. This is reasonable since the probability of a positive detection for a target compound is low and having to do a follow-up screen on both individuals would not be unduly inconvenient.

FIG. **2** shows another embodiment of a portal **10'** that can screen people and baggage. The opening **20b'** of portal **10'** is intended for screening baggage. By way of example, the opening **20b** may be no greater than four feet high. The concentrator **30b** is similar or the same as in the portal **10** shown in FIG. **1**, and particle and vapor are drawn through slot **40b'** similarly to slot **40b** in portal **10**. Other types of screening may be used in combination with people or baggage including document screening, such as a boarding pass, or hand screening of people.

The multiple portal trace detection system may also contain other detection capabilities, such as a metal detector by prior art methods, in order to further improve the utilization with respect to maintaining high throughput for persons and baggage and to minimize floor space. The opening for people may also make use of doors to prevent people from passing through before an analysis has been conducted. A multiple portal configured for scanning baggage for targeted particle and vapor compounds may also include an x-ray detector to conduct internal screening by prior art methods.

The embodiments shown in FIGS. **1** and **2** can be applied to a variety of concentrators and also to a variety of methods to collect target vapor and particles. FIG. **3** is an embodiment showing two concentrators **30a** and **30b** coupled to a single detector **50**. The concentrators **30a** and **30b** may contain meshes **32a** and **32b**, respectively, that collect vapor and particles from air that is pulled through using a blower or pump. The portal may include valves **36a** and **36b** that are placed in the conduits **34a** and **34b**, respectively, and control fluid flow between the concentrators **30a** and **30b** and the detector **50**. Because concentrators can hold vapor and particle content until a releasing event, such as thermal desorption by heating, it is also possible to operate without valves and use the heating event to deliver the vapor and particle content to the detector **50** as desired.

FIG. **4** shows an embodiment that includes second-stage concentrators **210a** and **210b**. The second-stage concentra-

4

tors **210a** and **210b** may include channels **212a** and **212b** for passage of the desorbed vapor from the first-stage concentrators **30a** and **30b** to meshes or substrates **214a** and **214b** for collection of the desorbed vapor, and valves **216a** and **216b** for switching the path of the collected vapor from the first-stage concentrators **30a** and **30b** to the detector **50**. The valve switching may be achieved by rotating the assembly as shown in FIG. **4**. The collection phase is achieved using a pump **222** to force a fluid flow through the meshes **214a** and **214b** to capture particles and vapor. The delivery phase to the detector **50** is achieved using a pick-up flow from pump **224** to carry a desorbed vapor from the meshes **214a** and **214b** through channels **226a** and **226b** to the detector **50**. The pump **224** may operate at a lower flow rate than pump **222**. This allows for rapid collection with pump **222** and a flow rate more acceptable for conventional detectors **50** with pump **224**.

The use of a second-stage preconcentrator coupled to a first-stage preconcentrator is a convenient means to control the switching of multiple concentrators to a single detector **50**. It is possible for example for one concentrator **210a** to be collecting vapor while the other concentrator **210b** is delivering desorbed vapor to the detector **50** as illustrated in FIG. **4**.

FIG. **5** shows another embodiment that includes a single valve **232** to switch the flow from the first-stage concentrators **30a** and **30b** to a single second stage concentrator **210**. An advantage of this configuration is potential savings of cost and complexity by using only one second-stage preconcentrator.

FIG. **6** shows a timing diagram that illustrates the advantage of a multiple portal system with regard to increasing the speed and throughput of screening people and/or baggage. By way of example, FIG. **6** shows an example of a portal with a single-stage concentrator, but the timing diagram could also apply to a two- or more-staged concentrator. The concentrator **30** has two principal functions; to collect vapor and particles and to desorb them to the detector **50**. The detector **50** operates during the desorb step as this is when the desorbed vapor enters the detector. Prior art portals use one opening **20**, one concentrator assembly **30**, and one detector **50**. As shown in FIG. **6**, the detector is required to operate only a fraction of the total screening cycle time.

A dual portal improves the utilization of the detector. For examples while concentrator **30a** is desorbing and being analyzed by detector **50**, concentrator **30b** can be collecting sample. When **30a** is done desorbing, **30b** can then be switched to desorb with the detector analyzing that vapor stream, while concentrator **30a** is now collecting. The dual portal is able to operate at twice the sampling rate while using only one detector. Depending on the concentrator collection time versus the concentrator desorb and detector analysis time, it is possible to increase the number of portal openings to more than two. For example, if the collection time was 8 sec and the desorb and analysis time was 2 sec, then it is possible to have five openings and achieve up to five times the throughput with the single detector. Some dead time between switching may partially reduce the effective sampling rate.

It is also advantageous for a multi-opening portal to share other components besides the detector **50**. FIG. **7** shows another embodiment that uses a single pumping system or blower **350** to pull a large-volume flow from portal openings **352a** and **352b** through the concentrators **30a** and **30b**. One means to switch the flow from one or the other concentrator is to use valves **36a** and **36b** to isolate the concentrators **30** from the large-volume flow. The valves may be a sliding gate valve, a hinged butterfly valve, or a shutter-iris type valve, for example. Other valve methods may also be used. This

5

embodiment may have components **354a** and **354b** that control the flow of samples to the detector **50**.

The components **354a** and **354b** can be either valves, such as **36** in FIG. 3, or second-stage concentrators, such as **210** in FIG. 4. It is also possible to have a combination of valve and second-stage concentrator **210** as illustrated in FIG. 5.

FIG. 8 shows another embodiment of a multi-opening portal that uses a single concentrator **30**, a single blower **350**, second-stage concentrator or valve **354**, and a single detector **50**. This embodiment may have four valves **400a**, **402a**, **400b** and **402b** that can control fluid flow through openings **352a** or **352b** and across the concentrator **30**. FIG. 9 shows another embodiment that utilizes only two valves **410a** and **410b** to control flow through the openings **352a** and **352b** and across the concentrator **30**. The type of valve shown is general and can be a gate valve, butterfly valve, iris or shutter, or other means.

Although dual port portals have been shown, and described, it is possible to perform sampling with more than two openings and a single detector. FIG. 10A-D show various configurations **500**, **500'**, **500"**, and **500'''** of four sampling openings **510a-d** that are coupled to concentrators **30a-d**. The concentrators **30a-d** are coupled to the same detector **50**. The entry and exit points may be the same doorway or two doorways.

While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

What is claimed is:

1. A detector system, comprising:

a portal that has a first opening and a second opening;
a first concentrator that is coupled to said first opening;
a second concentrator that is coupled to said second opening;
a single detector coupled to said first and second concentrators; and,

6

a pump coupled to said first and second openings so that said first concentrator collects vapor and particles through said first opening and said second concentrator collects vapor and particles through said second opening, simultaneously with said first concentrator collecting vapor and particles.

2. The system of claim 1, wherein said portal includes a first slot that contains said first concentrator and a second slot that contains said second concentrator.

3. The system of claim 1, wherein said first and second openings each have a height of at least six feet.

4. The system of claim 1, wherein said first opening has a height of at least six feet and said second opening has a height no greater than four feet.

5. The system of claim 1, further comprising a first valve coupled to said first concentrator and said detector.

6. The system of claim 1, further comprising a second stage concentrator coupled to said first and second concentrators and said detector.

7. The system of claim 1, further comprising a pair of second stage concentrators coupled to said first and second concentrators and said detector.

8. The system of claim 1, wherein said detector includes a mass spectrometer.

9. A method for analyzing samples, comprising:
obtaining a first sample from the first opening of a portal;
and,
obtaining a second sample from a second opening of the portal, simultaneously with obtaining the first sample from a first opening; and, analyzing the first sample with a single detector.

10. The method of claim 9, wherein the first and second samples are analyzed sequentially by the single detector.

11. The method of claim 9, wherein the first sample is obtained by a first concentrator and the second sample is obtained by a second concentrator.

12. The method of claim 9, wherein the first and second samples are obtained by a single concentrator.

13. The method of claim 12, wherein the first and second samples are pulled through the concentrator with a pump.

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