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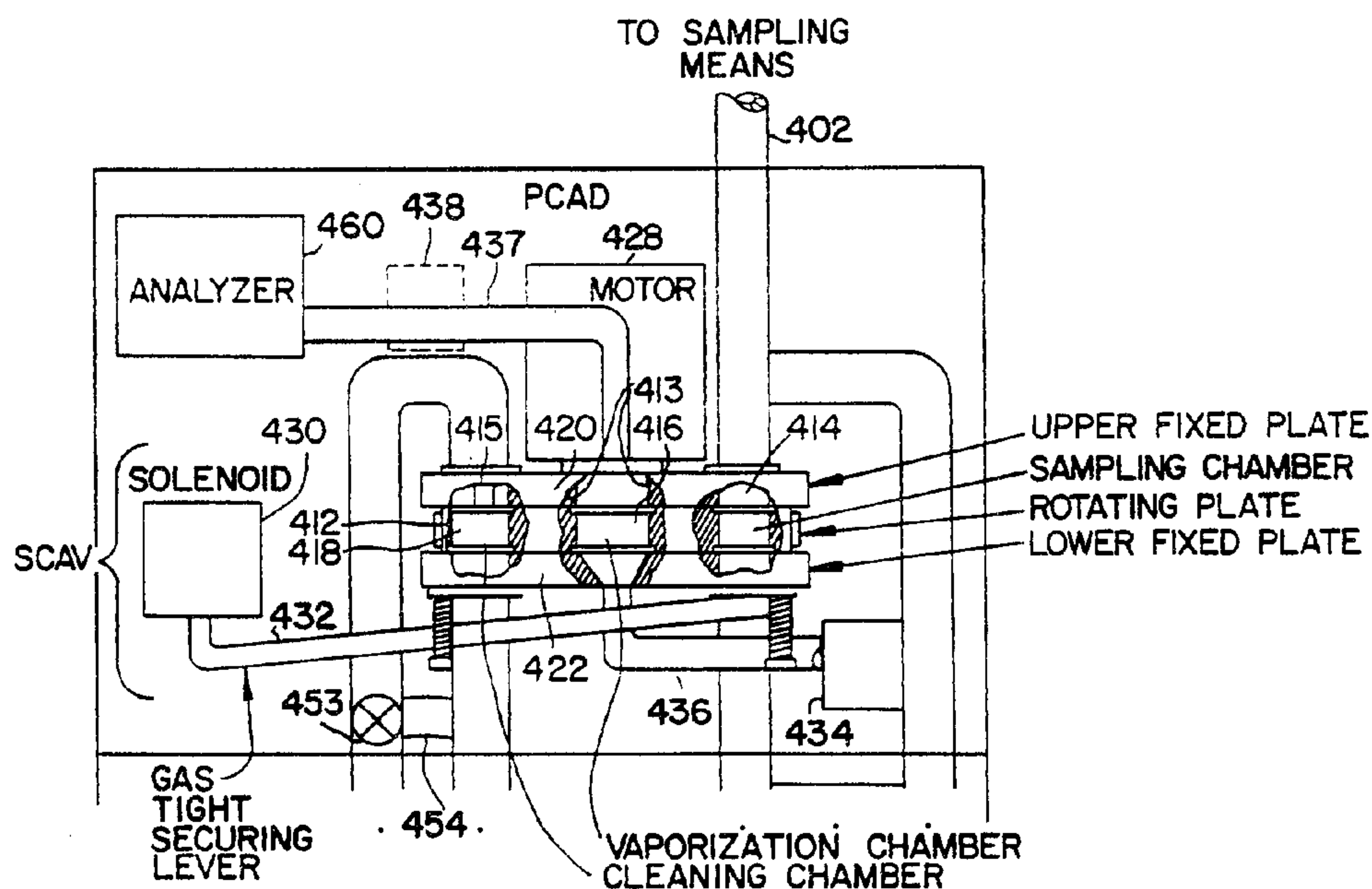
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(54) **SYSTEME DE DETECTION D'EXPLOSIFS**

(54) **EXPLOSIVE DETECTION SCREENING SYSTEM**



(57) Système de détection d'explosifs (10) utilisé pour la détection d'explosifs et d'autres substances contrôlées telles que les drogues et narcotiques. Ce système de dépistage détecte les émissions de vapeur et/ou de particules des substances susmentionnées et enregistre leur présence sur une personne ou un objet et la concentration de chaque substance détectée. Ledit système de détection comporte une chambre à échantillons (20) destinée au recueil des émissions de vapeur et/ou de particules, un système de concentration et d'analyse (45) permettant de purifier les émissions de vapeur et/ou de particules recueillies et d'effectuer l'analyse chimique détaillée ultérieure des émissions, et un système de commande et de traitement des données (50) pour la commande de l'ensemble du système.

(57) An explosive detection screening system (10) used for the detection of explosives and other controlled substances such as drugs or narcotics. The screening system detects the vapor and/or particulate emissions from the aforementioned substances and reports that they are present on an individual or object and the concentration of each substance detected. The screening system comprises a sampling chamber (20) for the collection of the vapor and/or particulate emissions, a concentration and analyzing system (45) for the purification of the collected vapor and/or particulate emissions and subsequent detailed chemical analysis of the emissions, and a control and data processing system (50) for the control of the overall system.

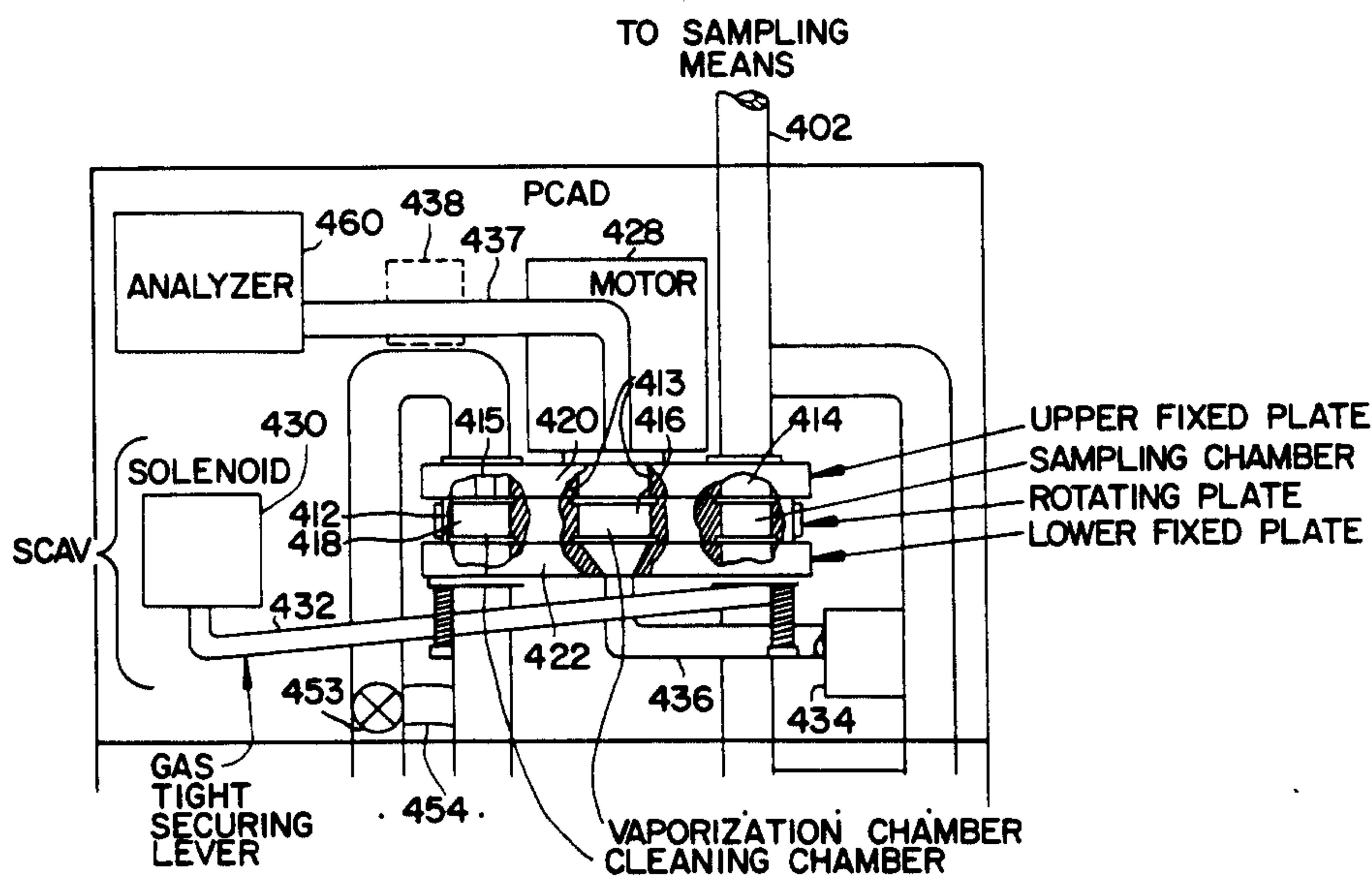


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(54) Title: EXPLOSIVE DETECTION SCREENING SYSTEM



(57) Abstract

An explosive detection screening system (10) used for the detection of explosives and other controlled substances such as drugs or narcotics. The screening system detects the vapor and/or particulate emissions from the aforementioned substances and reports that they are present on an individual or object and the concentration of each substance detected. The screening system comprises a sampling chamber (20) for the collection of the vapor and/or particulate emissions, a concentration and analyzing system (45) for the purification of the collected vapor and/or particulate emissions and subsequent detailed chemical analysis of the emissions, and a control and data processing system (50) for the control of the overall system.

EXPLOSIVE DETECTION SCREENING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to systems for the detection of explosives and other controlled substances such as drugs or narcotics. More particularly, the present invention relates to an integrated system consisting of a sampling chamber, a detection system, and a control and data processing system, for the detection of the vapor emissions and particulates associated with explosives and controlled substances in a non-invasive manner.

2. Discussion of the Prior Art

In recent years there has been a steady increase in the illegal use of explosives as well as an increase in the transportation of contraband substances such as drugs or narcotics. It is impossible to detect the existence or prevent all of the cases of bombings and drug smuggling going on; however, it is possible to detect explosives and contraband substances in particular areas where high visibility and/or vulnerability exists such as in airports or airplanes. There are numerous ways in which an individual can place drugs or explosives on an airplane, and even more places an individual can hide the drugs or explosives once on the airplane. The illegal substances can be brought on the airplane by a knowing or unknowing

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1 individual by concealing the substance on his/her person
or by placing the substances in baggage to be placed in
the cargo section of the aircraft.

5 The methods for detecting substances such as
explosives and drugs or narcotics have been studied for
many years, and various techniques have been developed
which range from explosives/drug sniffing dogs to highly
sophisticated vapor detection devices. Basically, the
detection of the aforementioned substances is accomplished
10 in one of two ways; namely, non-vapor detection and vapor
detection. Non-vapor detection methods include x-ray
detection, gamma-ray detection, neutron activation detec-
tion and nuclear magnetic resonance detection. These
methods of detection are more applicable to the detection
15 of the various substances when the substances are con-
cealed and are carried or associated with non-living items
such as baggage to be carried onto an aircraft in that the
detection techniques might pose a threat to living items.
Vapor detection methods include electron capture detec-
20 tion, gas chromatography detection, mass spectroscopy
detection, plasma chromatography detection, bio-sensor
detection and laser photoacoustic detection. These
methods of detection are more applicable to the detection
of substances that are concealed and associated with
25 living items such as those that can be carried by indi-
viduals including the residuals left on the individual who
handled the various substances. All of the above methods
are presently utilized, including explosive and drug
sniffing dogs.

30 Today, there are many private and government
research studies devoted to the development of systems and
methods for the detection of explosives and drugs or

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1 narcotics. With the advances in explosives technology,
such as the advent of the plastique explosives, which can
be disguised as common items, it is becoming increasingly
difficult to detect these substances. The problems that
5 must be overcome in the detection of these substances as
well as others, include low vapor pressure of the
particular vapors escaping from the particular substance,
the search time and the throughput of the various systems,
the low concentration of vapor or particulate emissions
10 from the particular substance, isolation of the particular
substance with a high degree of reliability, and
maintaining the integrity of the systems environment.

There is substantial prior art dealing with the
technology of explosive and drug detection devices. The
15 article "Air Flow Studies For Personnel Explosive
Screening Portals" authored by R.L. Schellenbaum of
Scandia National Laboratories, which was published in 1987
as part of the Carnahan Conference on Securities Tech-
nology in Atlanta, Georgia (July 15, 1987), discloses a
20 study on various types of integrated systems for the
detection of contraband explosives. The study outlined a
three step process, which includes the collection of
vapor, preconcentration, and detection of the vapors
emanating from explosive substances. The article dis-
25 closes various types of collection devices for collecting
the sample. Various portal configurations and air flow
mechanics within each of the portals were studied to see
which one provided the best sample. The Atmos-Tech Air
Shower Portal, a Modified Atmos-Tech Portal and a Cylin-
30 drical Portal were used in the study with various air flow
configurations. The study concluded that downward,
semi-laminar flow over the body cross-sectional area

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1 combined with a vacuum flow collection funnel of approxi-
mately twelve inches in diameter placed beneath the
grating in the floor of the portal was the best way to
collect the explosives vapor or particulate emissions from
an individual passing through the portal.

5 For the detection part of the study, various
detection devices were used including the Phemto-Chem 100
Ion Mobility Spectrometer in combination with a precon-
centrator developed by Ion Track Instruments Inc. The ion
mobility spectrometer is a plasma chromatograph which uses
10 an atmospheric ion-molecule reactor that produces charged
molecules which can be analyzed by ion mobility. The
preconcentrator comprises a motor-driven, coated metal
screen disc rotated with a cast metal casing. The coating
on the screen adsorbs the vapor and is then heated for
15 desorption of the vapor. This adsorption-desorption
process is a necessary preconcentration step which is used
to increase the vapor and/or particulate concentration in
the collected air sample.

20 The major problem encountered in the use of the
portal detection systems in the study was maintaining the
integrity of the sample air volume. In maintaining the
integrity of the sample air volume, it is necessary to
prevent the sample air volume to be contaminated with the
25 ambient environment at the same time trying to maintain a
steady flow of traffic through the portal, which is
essential to efficient operation of any type of screening
system in which heavy traffic is common place. The
aforementioned article suggests that the integrity of the
sample air volume was not maintained in portals without
30 doors. If ambient drafts were present, such as those from
air conditioners or just the flow of pedestrian traffic, a

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1 reduction of ten percent in detection was encountered.
The addition of doors on the portals effected a rise in
the detection rate; however, it produced unacceptable
pedestrian traffic problems which would not meet the
5 requirements for high throughputs required by airports.

5 In the patent art, there are a group of refer-
ences which disclose various methods and devices for
detecting contraband substances, including both drugs and
explosives. These references are all directed to the
10 detection of contraband substances within a container or
luggage, and not those carried on a person. U.S. Patent
4,580,440 and U.S. Patent 4,718,268 both assigned to
British Aerospace Public Company Limited disclose a method
and apparatus for detecting contraband substances sealed
15 in freight type cargo. Basically, the method consists of
sealing the cargo in a container, agitating the cargo in
order to shake off the vapor or particulate matter
emanating from the cargo into the surrounding atmosphere,
sampling the atmosphere, heating the collected sample and
20 analyzing the sample utilizing gas chromatography. U.S.
Patent 4,202,200 assigned to Pye Limited discloses an
apparatus for detecting explosive substances in closed
containers. Basically, objects such as luggage are passed
through a controlled axis tunnel wherein the objects are
25 swept by circulating air flows, and then the air sample is
collected and analyzed. It is also suggested that if a
larger tunnel is constructed, people as well as objects
can be passed through it. The aforementioned inventions
provide a means and method for detecting contraband
30 substances by using vapor sampling; however, none of the
inventions provide or suggest the use of a preconcentrator
means for increasing the sensitivity and selectivity of

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1 the detection means. Additional patent references which
disclose similar type systems are U.S. Patent 3,998,101
and U.S. Patent 4,111,049.

5 There are numerous patent references in the
testing and monitoring art which disclose a concentration
step which includes the filtration or absorption of the
molecules of interest over time. After a predetermined
period of exposure, the filtering/absorption media is
removed and desorbed with heat, while a new filter/
10 absorption media is placed in the air stream. U.S. Patent
3,768,302 assigned to Barringer Research Limited discloses
a system used in the geological testing area and in which
the system receives an air stream containing particulates.
The sample undergoes a concentration step which includes
15 passing the air sample over two paths with adsorbing/
desorbing steps, and finally analyzed. U.S. Patent
4,056,968 assigned to the same assignee as the above
patent also discloses a system which is also used in the
geological testing area. In this invention, the concen-
20 trated molecules could be desorbed from a moving tape as
well as from a moving disk. U.S. Patent 4,775,484 dis-
closes a rotating filter media which is used to absorb
particulate material during one stage of its rotation, and
which is purged or cleaned at a separate and second stage
25 of its rotation. U.S. Patent 4,127,395 also discloses a
common absorption/desorption circuit using a pair of
absorbent media, wherein one of the pair is absorbing,
while the other is desorbing. U.S. Patent 3,925,022, U.S.
Patent 3,997,297 and U.S. Patent 3,410,663 all disclose
30 absorption/desorption type devices. All of the aforemen-
tioned devices disclose systems for the absorption and

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1 subsequent desorption of particulate or vapor matter;
however, none disclose a portal type sampling chamber.

SUMMARY OF THE INVENTION

5 The present invention is directed to a system
for the detection of explosives, chemical agents and other
controlled substances such as drugs or narcotics by
detecting their vapor emissions or the particulates
10 associated with these materials. The system comprises a
sampling means, first and second sample collection and
analysis subsystems, and a control and data processing
system. The system is particularly useful in field
environments, such as airports, where it can be used to
15 detect the aforementioned substances on an individual or
in the baggage of the individual. The system meets the
requirement to detect the aforementioned substances in a
non-invasive manner at any required level, and to do it so
quickly that the free passage of people and baggage is not
20 unduly interrupted.

The sampling means takes on a variety of forms
including a sampling chamber portal; a hand-held wand, and
an automated baggage/parcel sampling chamber. The sam-
pling chamber portal is a portal with internal dimensions
25 of approximately six feet in length, seven feet in height
and three feet in width. The dimensions of the portal are
such as to allow an average sized individual as well as a
wheel chair bound individual to easily pass through. The
portal is designed in such a way as to have an internal
30 air flow sweep over an individual walking or passing
through the portal at a normal walking pace, and at the
same time have the air sample swept from the individual

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1 contain a meaningful concentration of vapors or particu-
late matter to be analyzed. To accomplish this, the
sampling chamber or portal is designed with a unique
geometry and contains air guides or jets for providing an
5 air flow which effectively isolates the internal air
volume from the ambient environment while efficiently
sweeping the individual passing through the portal. The
air volume or sample inside the portal is collected
through a sampling port located within the ceiling
10 section of the portal. The air sample is then transported
to the first and second sample collection and analysis
subsystems for analysis.

The hand-held wand is a sampling means for
gathering a sample volume of air from a specific area on
15 an individual or object and for removing particulate
matter from the individual or object and introducing the
particulate matter into a sample volume of air for analy-
sis while preventing contamination of the sample with the
ambient environment. The hand-held wand includes a
20 rotating brush located at the inlet part of the wand. The
rotating brush effectively sweeps any particulate matter
attached to the individual or object into a vacuum flow
created by a vacuum fan in the main system. The hand-held
wand is uniquely designed such that it may forms a sub-
25 stantially air tight seal with an individual or object,
such as a piece of luggage. The sample volume of air
containing vapors and/or particulates is then transported
to the first and second sample collection and analysis
subsystems for analysis.

30 The automated baggage/parcel sampling chamber is
a sampling means for gathering a sample volume of air
surrounding an object, such as luggage, and for removing

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1 particulate matter from all exposed surfaces of the object
and introducing the particulate matter into the sample
volume of air. The automated baggage/parcel sampling
chamber is of a rectangular open ended tunnel form.
5 Typically, the size of the automated baggage/parcel
sampling chamber would be approximately the size of the
baggage scanning x-ray devices currently utilized in
airports. It is fitted over a conveyer belt which is used
to carry the baggage parcels through the tunnel. The
10 automated baggage/parcel sampling chamber is fitted with
at least four sampling heads which brush over all exposed
surfaces of the object. These sampling heads contain
rotating brushes that sweep the exposed surfaces and
introduce the particulates and any vapor emanating from
15 the object into a sample volume of air. The sample volume
of air containing vapors and/or particulates is then
transported to the first and second sample collection and
analysis subsystems for analysis.

20 The plurality of sampling means are capable of
collecting and delivering to the first and second sample
collection and analysis subsystems vapor and/or particu-
late matter when they are present in as low a concentra-
tion as several parts per trillion of ambient air.

25 The first and second sample collection and
analysis subsystems are devices which are used to collect
vapors emanating from and particulates associated with the
particular class of materials discussed above. The first
sample collection and analysis subsystem in a sample
collector and vaporizer which converts collected particu-
30 lates into a first vapor sample for analysis. This first
vapor sample for analysis is delivered to a fast response
chemical analyzer which may be either a gas chromatograph/

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1 electron capture detector or an ion mobility spectrometer
or both. The basic principle of operation is the collec-
tion of particulate matter on a filter element and the use
of flash heating to vaporize the collected matter. The
5 second sample collection and analysis subsystem is a vapor
collector and detector which through a series of steps of
decreasing sample volume and increasing sample concentra-
tion, delivers a concentrated sample to a fast response
chemical analyzer which may be either a gas chromatograph/
10 electron capture detector or an ion mobility spectrometer
or both. The principle of operation is one of adsorbing
the sample onto a selected substrate with subsequent
selective thermal desorption to create a second vapor
sample for analysis. This process is repeated through a
15 series of steps of decreasing sample volume and increasing
sample concentration. Upon completion of the preconcen-
tration steps, the purified sample material is analyzed by
the aforementioned devices wherein the analysis consists
of identifying the various materials and determining the
20 amount of material present.

The total system and all system processes are
controlled by the control and data processing system which
comprises a digital computer and associated software. The
system is configured and controlled to make all required
25 measurements and prepare the results in a usable and
intelligible format. The control and data processing
system controls the collection of the vapors and partic-
ulates, the vaporization of collected particulates, the
preconcentration of collected vapors, the various chemical
30 analysis steps, and the data analysis and data formatting.

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1 In addition, the computer continuously performs self diagnostic and self calibration procedures on the total system and alerts the user to any potential problems.

5 The system for the detection of explosives and other controlled materials of the present invention provides for the efficient detection of explosives, chemical agents or other controlled materials such as drugs or narcotics by detecting the vapor emissions and particulates associated with these substances. The vapor emissions and particulates can come from substances
10 concealed on the individual, the individual's baggage, or from a residue left on an individual who handled the particular substance. The present invention provides a system with a high degree of sensitivity and selectivity to a wide range of substances. The high degree of sensitivity and selectivity is accomplished by employing a system which utilizes the combination of unique sampling means and a multi-stage preconcentrator and vaporizer that decreases sample volume while maximizing sample
20 concentration thereby allowing much larger sample volumes to be taken as well as much shorter sample collection times. The system provides a high reliability rate which is accomplished by utilizing the computer control and data processing system for automatic calibration and self diagnostic procedures. In addition, the system provides a
25 high degree of versatility in that by changing the programming of the computer, a wide range of explosives, controlled chemical agents, and drugs and narcotics which have differing physical and chemical properties can be detected. Having the total system under software control
30 provides a more versatile system and one that is easily reconfigurable.

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1 The present invention has a wide variety of
applications where a high throughput of people is re-
quired. In airports, the detection of explosives and
controlled substances is of paramount importance due to
5 the rise in terrorist attacks and drug smuggling. The
present invention allows for the fast and reliable de-
tection of the aforementioned substances in a non-invasive
manner in a variety of field environments such as in
airports. The system of the present invention is appli-
10 cable where the detection of concealed substances is
absolutely required.

BRIEF DESCRIPTION OF THE DRAWINGS

15 For the purpose of illustrating the invention,
there is shown the drawings the forms which are presently
preferred; however, it should be understood that the
invention is not necessarily limited to the precise
arrangements and instrumentalities here shown.

20 Figure 1A is a high level block diagram of the
explosive detection screening system of the present
invention;

 Figure 1B is a detailed block diagram of the
explosive detection screening system of the present
25 invention;

 Figure 2 is a sectional side view of the sam-
pling chamber portal of the present invention;

 Figure 3 is a sectional end view of the sampling
chamber portal of the present invention taken along
30 section lines 2-2' in Figure 1;

 Figure 4 is an under-side view of the hand-held
wand of the present invention;

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1 Figure 5 is a side view of the hand-held wand of
the present invention;

 Figure 6 is a top view of the hand-held wand of
the present invention;

5 Figure 7 is a diagrammatic representation of the
automated baggage/parcel sampling chamber of the present
invention;

 Figure 8 is a diagrammatic representation of the
automated baggage/parcel sampling chamber and first
10 automated sampling head of the present invention.

 Figure 9 is a diagrammatic representation of the
automated baggage/parcel sampling chamber and second
automated sampling head of the present invention;

 Figure 10 is a diagrammatic representation of
15 the automated baggage/parcel sampling chamber and third
and fourth automated sampling heads of the present inven-
tion;

 Figure 11A is a diagrammatic representation of
the first sample collection and analysis subsystem of the
20 present invention;

 Figure 11B is a diagrammatic representation of
the second sample collection and analysis subsystem of the
present invention;

 Figure 11C is a diagrammatic representation of
25 the first sample collection and analysis subsystem of the
present invention, wherein the subsystem utilizes a
six-port valve configuration;

 Figure 11D is a diagrammatic illustration of the
chemical analyzer utilized by the first sample collection
30 and analysis subsystem of the present invention;

 Figure 11E is a diagrammatic representation of
the desorption chamber of the present invention;

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1 Figure 12 is a diagrammatic representation of
the filter element configuration utilized in the first
sample collection and analysis subsystem of the present
invention;

5 Figure 13A is a diagrammatic representation of
the six-port valve used in the present invention with the
six-port valve in the load position;

10 Figure 13B is a diagrammatic representation of
the six-port valve used in the present invention with the
six-port valve in the inject position;

15 Figure 14A is a diagrammatic representation of
the top side of the filter elements utilized in the first
sample collection and analysis subsystem of the present
invention;

20 Figure 14B is a diagrammatic representation of
the top plane of the filter elements utilized in the first
sample collection and analysis subsystem of the present
invention;

25 Figure 14C is a diagrammatic representation of
the bottom side of the filter elements utilized in the
first sample collection and analysis subsystem of the
present invention.

30 Figure 15A is a diagrammatic representation of
the top side of the filter elements utilized in the second
sample collection and analysis subsystem of the present
invention;

35 Figure 15B is a diagrammatic representation of
the side view of the filter elements utilized in the
second sample collection and analysis subsystem of the
present invention;

40 Figure 16 is a block diagram of the control and
data processing system of the present invention;

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Figure 17 is a flow chart of the software routine utilized to control the operation of the present invention;

Figure 18 is a flow chart of an alternate software routine utilized to control the operation of the present invention; and

Figure 19 is a timing chart illustrating the various time parameters for the various processes of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The explosive detection screening system of the present invention is designed to detect explosives, chemical agents or other controlled materials such as drugs or narcotics by detecting vapors emanating from or particulates associated with each of these materials. These substances are assumed to be concealed on individuals or in their baggage in airports or in other high vulnerability, high visibility environments. It is necessary to detect these substances in a non-invasive manner at any required level, and to do it so quickly that the free passage of people and baggage is not unduly interrupted. The system is an integrated system comprising a sampling means, a first and second sample collection and analysis subsystem and a control and data processing system.

In a first embodiment, the sampling means is a sampling chamber portal in which internally generated air flows sweep the vapor emissions emanating from or particulates associated with an individual or object passing through the chamber to a collection area

The sampling chamber portal is designed in such a way as to capture a high enough concentration of vapor emissions and/or particulates so as to be able to detect the presence of the aforementioned substances with a high degree of reliability and dependability. The internal volume of air is recirculated with a small amount being removed at the sampling time. At the sampling time, or more commonly referred to as the sampling period, an external air pump or fan draws a sample of the collected air volume into the first and second sample collection and analysis subsystems.

In a second embodiment, the sampling means is a hand-held wand. The hand-held wand is a sampling means for gathering a sample volume of air from a specific area on an individual or object and for removing particulate matter from the individual or object and introducing the particulate matter into the sample volume of air for analysis while preventing contamination of the sample with the ambient environment. The hand-held wand consists of a rotating brush located at the inlet port of the wand. The rotating brush effectively sweeps any particulate matter attached to the individual or object into an air flow created by a vacuum fan in the base system. The hand-held wand is uniquely designed such that it forms a substantially air tight seal with the individual or object. The sample volume of air containing vapors and/or particulates is then transported to the first and second sample collection and analysis subsystems.

In a third embodiment, the sampling means is an automated baggage/parcel sampling chamber. The automated

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1 baggage/parcel sampling chamber is a sampling means for
gathering a sample volume of air surrounding an object and
for removing particulate matter from all exposed surfaces
of the object and introducing the particulate matter into
the sample volume of air. The automated baggage/parcel
5 sampling chamber is of a rectangular open ended tunnel
form. Typically, the size of the automated baggage/parcel
sampling chamber would be approximately the size of the
baggage scanning x-ray devices currently utilized in
airports. It is fitted over a conveyer belt which is used
10 to carry the baggage or parcels through the tunnel. The
automated baggage/parcel sampling chamber is fitted with
at least four sampling heads which brush over all surfaces
of the object. These sampling heads contain rotating
brushes that sweep the exposed surfaces and introduce the
15 particulates and any vapor emanating from the object into
the sample volume of air. The sample volume of air
containing vapors and/or particulates is then transported
to the first and second sample collection and analysis
subsystems.

20 The plurality of sampling means are capable of
collecting and delivering to the first and second sample
collection and analysis subsystems vapor and/or particu-
late matter when they are present in as low a concentra-
tion as several parts per trillion of ambient air in a
25 short period of time.

The first and second sample collection and
analysis subsystems are devices which are used to collect
vapors emanating from and particulates associated with the
particular class of materials discussed above. The first
30 sample collection and analytical subsystem in a sample

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1 collector and vaporizer which converts collected particu-
lates into a first vapor sample for analysis. This first
vapor sample for analysis is delivered to a fast response
chemical analyzer which may be either a gas chromatograph/
5 electron capture detector or an ion mobility spectrometer
or both. In the preferred embodiment, an ion mobility
spectrometer is utilized as the chemical analyzer. The
second sample collection and analysis subsystem is a vapor
collector and detector which through a series of steps of
10 decreasing sample volume and increasingly sample concen-
tration, delivers a concentrated sample to a fast response
chemical analyzer which may be either a gas chromatograph/
electron capture detector or an ion mobility spectrometer
or both. In the preferred embodiment, a gas
15 chromatograph/electron capture detector is used as the
chemical analyzer. The principle of operation is one of
adsorbing the sample onto a selected substrate with
subsequent selective thermal desorption. This process is
repeated through a series of steps of decreasing sample
20 volume and increasing sample concentration. Upon comple-
tion of the preconcentration steps, the purified sample
material is analyzed by the aforementioned devices wherein
the analysis consists of identifying the various materials
and determining the amount of material present.

25 The control system is a control and data proc-
essing system of which the primary requirement is to
report the presence of, and if required, the level of a
specified substance. The system may also be capable of
distinguishing between background levels of a substance
and alarm levels. The system also controls the operation
30 of the entire system by automatic control methods which is
run by a microprocessor or digital computer. The control

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1 system is easily reprogrammed to detect various substances
because of modularized programming techniques.

Referring to Figure 1A, there is shown a block
diagram of the explosive detection screening system 10 of
the present invention. As is shown in the Figure, the
5 explosive detection screening system comprises a sampling
means 20, a first sample collection and analysis subsystem
30 which comprises a particulate collector and detector
35, a second sample collection and analysis subsystem 40
which comprises a vapor collector and detector 45, and a
10 control and data processing system 50 which controls all
phases of system operation.

The particulate collector and detector 35, PCAD,
comprises a sample collector and vaporizer, SCAV, and a
chemical analyzer which may be either a gas chromatograph/
15 election capture detector or an ion mobility spectrometer
or both. The primary function of the PCAD 35 is to
collect and analyze particulates in the sample volume of
air collected by the sampling means for the chemical
compounds of interest. The primary function is accom-
20 plished by first collecting and converting the particu-
lates to vapor in the SCAV and then submitting the vapors
to the chemical analyzer for analysis.

In the collection of particulate matter and the
subsequent vaporization of the particulate matter, there
25 are various problems that are encountered and which must
be solved. The first problem encountered is the collec-
tion of the particulates of interest. The particulates of
the various compounds are varied in size and thus differ-
ent size collection elements must be utilized. In addi-
30 tion, the particulates may be attached to larger particles
such as water vapor or dust. Since it is possible for

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1 many types of particulates to be contained in a specific
volume of air, the collection element must be such that it
selectively adsorbs only particulates of interest. The
present invention utilizes varying size filter mesh
5 elements, or a plurality of adsorbent materials adjacent
or on the filter elements to adsorb the various particu-
lates. The second problem encountered is that the partic-
ulate matter collected must be vaporized. The vaporiza-
tion process is an extremely important and complicated
10 procedure. Different particulates have different vapor-
ization temperatures and thus the vaporization temperature
must be precisely controlled so as to effectively vaporize
target particulates, and prevent excessive heat damage to
the molecules of interest in the target particulates. The
15 third problem encountered is the problem of concentration.
For the best analysis results, the concentration of
particulates in a specific volume of air must be as high
as possible. Therefore, the vaporization process is
combined with the use of a carrier gas, which is utilized
20 to inject the vaporized sample into the chemical analyzer.
The solution to these problems as well as others solved by
the present invention are more fully discussed in the
detailed description of the SCAV.

The vapor collector and detector 45, VCAD, is
25 comprised of a sample collector and preconcentrator, SCAP,
and a chemical analyzer which is either a gas
chromatograph/electron capture detector or ion mobility
spectrometer or both. The primary function of the VCAD 45
is to collect, preconcentrate and analyze the air sample
collected for the target vapors. This function is accom-
30 plished by first selectively collecting and preconcen-
trating the targeted molecules in the SCAP and then
submitting the vapors to the chemical analyzer for analy-
sis.

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1 In the collection of vapor matter for analysis,
there are two major problems that are encountered. The
first problem encountered is that of low concentration of
target vapors in the air sample. In any particular sample
5 volume of air collected in the sampling chamber portal,
the hand-held wand or in the automated baggage/parcel
sampling chamber, the concentration of target vapors is
going to be low. Therefore, the SCAP in at least one
concentration stage must selectively concentrate the
10 target vapors into a concentrated sample volume while
discarding non-target vapors. The second problem encoun-
tered is that of heat damage to the molecules in the
target vapors. The concentration process involves adsorp-
tion and subsequent desorption of the target vapors. This
15 process requires a certain amount of heat to desorb the
target vapors from the adsorbent. If too much heat is
utilized, the molecules in the target vapors can be
destroyed or unduly fragmented and if too little heat is
utilized, the target vapors will not be desorbed. The
20 solution to these problems as well as others are discussed
in the detailed description of the VCAD.

Figure 1B illustrates a more detailed block
diagram of the overall system 10. The control system 50
comprises a processor 51 which runs a stored digital
25 program that controls the overall operation of the system
10, a process control module 53 which is an interface
between the processor 51 and the remaining components of
the system 10, and a display 55 which provides a read out
of the sampling results and the condition or current
30 status of the system 10. The actuator and interface units
module 60 is a collection of a plurality of control units
which convert the control signals from the processor

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1 system 51 into electrical signals that operate the various
actuators utilized by the system 10. The power unit 70 is
utilized by all components of the system 10 as a power
source. The power unit 70 provides power to the control
5 system 50, the actuator and interface units 60, the PCAD
35 and the VCAD 45. Additionally, Figure 1B illustrates
the use of the various analyzers 80 and 90 that are used
in conjunction with the PCAD 35 and the VCAD 45.

As is illustrated in Figure 1B, the PCAD 35 is
10 connected to an ion mobility spectrometer and gas
chromatograph/electron capture detector combination 80.
In the preferred embodiment only an ion mobility spec-
trometer is utilized; however, the gas chromatograph/
electron capture detector can be utilized instead or a
15 combination of the two can be utilized. The VCAD 45 is
connected to a gas chromatograph/electron capture detector
and ion mobility spectrometer combination 90. In the
preferred embodiment only a gas chromatograph/electron
capture detector is utilized; however, the ion mobility
20 spectrometer can be utilized instead or a combination of
the two can be utilized. It is important to note that
more than one electron capture detector may be utilized
with a single gas chromatograph. If multiple electron
capture detectors are utilized, they can be cascaded.

25 The gas chromatograph is a device utilized to
separate the molecules of the volatile compounds for
detection over time. The device utilizes a separation
technique which involves the passage of a gaseous moving
phase through a volume containing a fixed absorbent phase.
30 Gas chromatography is used primarily as a quantitative
analytical technique. The gas chromatograph is typically
used in conjunction with a final detection device such as

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1 an electron capture detector which is an ionization
chamber that is used to determine the presence of certain
ions. The ion mobility spectrometer is a device which
ionizes and detects sample molecules so as to identify
5 particular molecules by their time of arrival at the
detector.

SAMPLING CHAMBER

10 The sampling chamber portal for people is a
portal that is designed in such a way that as a person
walks through this chamber, at a normal walking pace, an
internal air flow carries a sample of vapors and/or
particulate matter from them to a sampling port where it
15 will be collected for analysis. There are three major
design requirements that the chamber was designed to meet.
First, the sampling chamber portal must gather a mean-
ingful sample of the environment surrounding a person or
object passing through the chamber. In considering a
20 solution to the problem posed by the first design require-
ment, it is necessary to consider that the sampling
chamber portal must be large enough for an average size
individual to comfortably pass through the chamber;
therefore, there is a considerable volume of air located
25 within the chamber resulting in possibly only several
parts vapor or particulate per trillion parts of air or
possibly even less. The solution to this problem of
dilution is to design the chamber long enough so the
individual or object passing through the chamber remains
30 in the chamber for a duration of time so as a meaningful
sample of the environment can be gathered. Second, for
the purposes of sensitivity, selectivity and preventing

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1 cross-contamination of the sample to be analyzed, the
sample to be collected must be isolated as much as pos-
sible from the ambient environment. In considering a
solution to the problem posed by the second design re-
5 quirement, it is necessary to once again consider the
problem of dilution caused by having a larger chamber.
Since there already exists a dilution problem, the chamber
must be designed with a unique geometry and internal
aerodynamics so as to prevent further dilution and con-
10 tamination by the mixing of internal air with the ambient
air to the greatest extent possible. The third design
requirement is that the sample must be gathered in as
complete form as possible in as short as time as possible.
In considering a solution to the problem posed by the
15 third design requirement, it is necessary to consider the
problems and solutions considered above and find a balance
between them. The time an individual or object spends in
passing through the chamber must be long enough so as to
gather a meaningful sample, but not long enough to cause
20 unduly long pedestrian traffic delays. Secondly, since
there is a dilution problem, the chamber was designed in a
unique way so as to prevent cross-contamination with the
ambient environment, and this unique design must not
prevent the normal flow of traffic; therefore, the aero-
25 dynamics discussed in the solution to the second problem
must be such that the meaningful sample is gathered
quickly.

Referring to Figures 2 and 3, there is shown a
sectional side view and end view of the sampling chamber
30 portal 100. The sampling chamber portal 100 has a rec-
tangular geometry having internal dimensions of approxi-
mately six feet in length, seven feet in height, and three

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1 feet in width. These dimensions allow an average size
individual, walking at an normal walking pace to remain in
the chamber 100 for approximately two to three seconds
which is enough time to gather the aforementioned mean-
5 ingful sample. The rectangular chamber 100 has two walls
102a and 102b, which run the length of the chamber 100, a
floor 104, a convergent or conically shaped ceiling 106
the importance of which will be discussed subsequently and
a roof 107. In order to maintain the uninhibited flow of
10 pedestrian traffic through the chamber 100, no doors and
only two walls, 102a and 102b, were used. Hand rails 108a
and 108b attached to walls 102a and 102b respectively are
provided to aid individuals in passing through the chamber
100 quickly and safely. The floor 104 of the chamber 100
15 is not a necessary component, and in other configurations
it is not utilized. The chamber 100 can be constructed
utilizing a variety of materials including aluminum and
plastics; however, clear materials such as plexiglass or
fiberglass is preferred so individuals passing through the
20 chamber 100 can be observed. In addition, a video camera
109 or even an electronic still picture camera may be
utilized to capture an image of the individual passing
through the chamber 100 which will be electronically
stored along with the collected data.

25 The sampling chamber portal 100 operates on an
air recirculating principle and the only air removed from
the internal recirculating volume is a comparatively small
amount leaving by sampling port 118a. The internal air
volume is circulated through internal air flow guides or
30 jets and is collected by collection duct 110 which is a 16
inches x 20 inches x 6 inches rectangular duct connected
to the center of the conical ceiling 106 and which empties

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1 into the space created between the ceiling 106 and the
roof 107. This results in a large volume of controlled
recirculating air flow capable of delivering a vapor
and/or particulate sample from anywhere in the chamber 100
5 to the sampling port 118a in approximately one second.

The conical ceiling 106 aids in the collection
of the sample volume by creating an inverted funnel for
the air sample flow which serves to concentrate a larger
volume of air across a smaller cross section for sampling
10 purposes. A dynamic low pressure zone is created in the
region of the collection duct 110 when the air is drawn
through the collection duct 110 into the ceiling plenum by
four exhaust fans two of which are shown in Figure 2 as
114, and 114a. In each corner of the chamber 100, there
15 are six inch diameter end columns 112a-d. Each of the
four end columns 112a-d are mounted vertically in the
chamber 100 and run from the floor 104 to the ceiling 106.
Each column 112a-d has six slots of one foot in length and
a half inch in width with inch and a half internal guide
20 vanes (not shown) for directing the air flow at a forty-
five degree angle towards the center of the chamber 100.
The air flow through the columns 112a-d is provided by
four independent fans, two of which are shown in Figure 2
as fans 114 and 114a. The four fans are mounted in the
25 chamber 100 above the conical ceiling 106 and below the
outer roof 107. Each fan is connected to one of the end
columns 112a-d and provide 1000 CFM of air to each column
112a-d. The suction side of the fans are open to a common
plenum located in the same space that the fans occupy. In
30 addition to these inwardly directed vertical air jets
113a-d there are two upwardly directed air guides or jets
located in side air flow pipes 116a and 116b which are

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1 mounted along the floor 104 and against walls 102a and
102b. The side flow pipes 116a and 116b are connected to
end columns 112a-d and receive air from them. In each
side flow pipe 116a and 116b there are twelve inch by half
5 inch air slots one of which is shown as 117a, located in
the center of each pipe and directed towards the center of
the chamber at a forty-five degree angle as shown in
Figure 2. The combined effect of the air flow created by
the end columns 112a-d and the side flow pipes 116a and
10 116b is a dynamic high pressure region created in the
center region of chamber 100. The recirculating fans
which draw air through collection duct 110 create a
dynamic low pressure zone within chamber 100, which
creates a net air flow up towards the collection duct 110.
15 This air flow is the flow that sweeps individuals or
objects passing through the chamber. The effect of the
high pressure region and the low pressure region created
by the exhausting of the air sample through conical
ceiling 106 and into the collection duct 110 is a balance
20 of atmospheric conditions which results in very little
external air entering or leaving the chamber 100. Basi-
cally, the high pressure region inhibits air from entering
the chamber 100. The majority of the moving air mass goes
through the collection duct 110 and to the common plenum
25 where it will once again be used by the four fans to
recirculate the internal volume of the chamber 100. A
portion of the recirculated air is collected through a
sampling port 118a, which is the open end of a pipe 118
which is used to transport a selected sample from the
30 chamber 100 to the second stage of operation; namely, the
preconcentration and vaporization stage which shall be
discussed subsequently. The pipe 118 which is presently

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1 utilized is constructed of ABS plastic; however any
suitable piping material may be used such as stainless
steel.

5 The four end columns 112a-d and the two side air
flow pipes 116a and 116b represent one embodiment for
delivering the air supplied by the four independent fans
as separate and directional air jet streams. The fans can
be connected to various types of air ducts or plenums with
10 guide vanes or nozzles to form the exiting air into jet
streams. In addition, partitioned hollow walls also with
guide vanes or nozzles can be used as an alternate ap-
proach for forming the air from the fans into separate and
directional air jet streams. The manner in which the air
15 flow is supplied to the guide means and the manner in
which the jet streams are formed is not critical; however,
the specific directions of the jets streams are. It is
important that the proper angle and orientation of the jet
streams be maintained so as to provide a net flow of air
20 capable of sweeping an individual or object passing
through said sampling chamber means 100 while maintaining
the integrity of the volume of air within the sampling
chamber means 100.

HAND-HELD WAND

25 The hand-held wand is a device for gathering a
sample volume of air from a specific area on an individual
or object and for removing particulate matter from the
individual or object and introducing the particulate
30 matter into the sample volume of air while preventing
undue contamination of the sample volume of air from the
ambient environment. Whereas the sampling chamber portal

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1 gathers vapors surrounding an individual and sweeps
particulates from the individual, the hand-held wand
gathers a more concentrated sample volume of air con-
taining vapors and particulate matter from a specific area
5 on the individual or object.

Referring to Figure 4, there is shown the
under-side view of the hand-held wand 200. The hand-held
wand 200 basically comprises two main sections, the head
210 and the handle 240. The head 210 and the handle 240
10 are connected by a swivel joint 223 that allows the head
210 to pivot into hard to reach places or accommodate
difficult angles. The head 210 comprises a rotating brush
212 disposed within the inlet port 214 of the head 210.
The rotating brush 212 is utilized to sweep and remove
15 particulate matter attached to an individual or an object.
The rotating brush 212 is driven by an air turbine 216 via
a belt drive 218. The air turbine 216 is located towards
the outlet end of the head 210 and is driven by the flow
of air over the turbine blades of the turbine 216. The
20 air flow which drives the turbine 216 is caused by a
suction fan located in the second sample collection and
analytical subsystem. This suction fan is utilized to
draw the sample volume of air during a sampling period. A
complete description of the sampling procedure is given in
25 detail in subsequent sections. The effect of the sweeping
action and the drawing of the sample volume of air com-
bines to create a sample volume of air containing both
vapors and particulate matter.

It is important to note that some of the various
30 materials of interest leave "sticky residues" or "sticky
particulates" on the individuals or objects that come in
contact with these materials; therefore, in order to

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remove them, it is necessary to physically sweep them, from the individual or object.

The "sticky particulates" are from a particular class of target materials; namely, plastic explosives such as the military high explosive C4, DM-12, and *SEMTEX. It is important that these particulates be collected because they exhibit extremely low vapor pressures, and are therefore not detectable with vapor detectors. Typically, these explosives have vapor pressures of 10,000 to 1,000,000 times lower than conventional explosives. Therefore, if the particulates themselves are not collected, it is virtually impossible to detect the presence of these explosives. These particular explosives cannot be handled without the sticky residue remaining on whatever comes in contact with the explosives. A complete description of this phenomenon is given in the Analysis section.

The suction fan utilized to draw the sample volume of air is capable of developing a flow rate of 70 to 85 CFM. This flow rate translates into a vacuum capable of raising 115 to 140 inches of water when the hand-held wand 200 is sealed against the side of a piece of luggage, and a vacuum capable of raising 33 to 40 inches of water when the hand-held wand 200 is opened to the ambient environment through a one inch orifice. Through experimentation, it has been established that this vacuum enables the hand-held wand 200 to draw vapors through the side of cloth and vinyl suitcases as well as through the sidewalls of plastic bags in which explosives have been concealed. The determination of whether a meaningful sample of vapors has been gathered depends upon the concentration of the initial sample and the porosity of the particular container.

*Trade mark

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1 The inlet port 214 comprises edges 220 formed of
a rigid material such as a hard plastic or metal. These
edges 220 are attached to the inlet port 214 by a spring
loading mechanism in such a manner that allows the edges
220 to be pushed into crevices on an individual or object.
5 This enables a sealing edge 222 of soft elastomeric
material located on the outside perimeter of the edges 220
to be brought into contact with the object to provide a
vacuum seal that prevents contamination of the sample
volume of air by the ambient environment.

10 The head 210 is connected to the handle 240
through a conduit 224 and swivel joint 223. As is stated
previously, this joint is a swivel connection that allows
for greater accessibility of the head 210 to certain
locations. The conduit 224 runs through the length of the
15 handle 240 and is flexible thereafter. It connects the
hand-held wand 200 to the first and second sample col-
lection and analytical subsystems and to transport the
sample volume of air collected to these subsystems for
preconcentration and/or vaporization, which as stated
20 previously will be discussed subsequently. The union
between pipe 224 and the handle 242 may also be a swivel
connection to allow a greater freedom of movement.

25 Referring to Figure 5, a side view of the
hand-held wand 200 is shown to better illustrate the
design of the handle 240. The handle 240 comprises a main
section 242 through which the pipe 224 runs through, and a
grip section 244 by which the user holds onto. A control
cable 246 runs through the grip section 244 and carries
30 all the control and signal display wires from the control
and data processing system, to be discussed subsequently,
to the controls and displays of the hand-held wand 200.

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1 Figure 6 illustrates a top view of the hand-held wand 200 and shows the control panel 248 and the display panel 250. The controls and displays may utilized to operate the detection screening system from a remote location.

5 The control panel 248 comprises control switches used to actuate a single cycle function, a continuous cycle function, a pause function and the reset function of the detection and screening system. The single cycle, continuous cycle, and pause functions are associated with the collection of the target materials. The reset func-
10 tion is utilized to reinitialize the system after an alarm condition. The display panel 250 comprises an alarm display area and a numeric display area. The alarm display area is used to indicate whether a target material has been detected by the first sample collection and
15 analysis subsystem, the second sample collection and analysis subsystem or both. Additionally, the alarm display comprises an audio alarm which indicates to the system user that a target compound has been detected. The
20 numeric display area is normally used to display an identification number associated with the sample being taken, but may also be used to display the identification number of the sample which triggered the alarm.

25 AUTOMATED BAGGAGE/PARCEL SAMPLING CHAMBER

30 The automated baggage/parcel sampling chamber is a device for gathering a sample volume of air surrounding an object and for removing particulate matter from all exposed surfaces of the object and introducing the particulate matter into the sample volume of air. Like the hand-held wand, the automated baggage/parcel sampling

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1 chamber gathers a more concentrated sample volume of air
containing vapors and particulate matter than the sampling
chamber portal. As is the case with the hand-held wand,
the automated baggage/parcel sampling chamber has means
5 for gathering the sample of volume of air directly from
the object.

Referring to Figure 7, there is shown the basic
configuration of the automated baggage/parcel sampling
chamber 300. The automated baggage/parcel sampling
chamber 300 is a rectangular open ended tunnel structure.
10 The size of the chamber 300 may vary, however, for conven-
ience the size of the chamber 300 is chosen to match that
of a baggage scanning x-ray device of the kind used in
airports today. In this embodiment, the automated
baggage/parcel sampling chamber 300 is approximately six
15 feet in length, 38 inches in width and 32 inches in
height. The automated baggage/parcel sampling chamber 300
is fitted over a conveyor belt 350 which is utilized to
carry the baggage or parcels through the chamber 300 at a
rate of speed that would enable the baggage or parcels to
20 be sampled for a duration ranging between approximately
three to seven seconds although the range may be extended
if desired. The automated baggage/parcel sampling chamber
300 also comprises at least four automated sampling heads
310, 320, 330, and 340 which are utilized to gather the
25 sample volume of air.

The four automated sampling heads 310, 320, 330,
and 340 each contain rotating brushes which are utilized
to remove the "sticky" particulates from the luggage or
other object of interest. The first automated sampling
30 head 310 is located at the entrance of the chamber 300
immediately before the conveyor belt 350 as shown in

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1 Figure 8. The inlet of the first automated sampling head
310 extends the entire width of the chamber 300 and is set
so that the rotating brush gently sweeps and draws vapors
and particulates from the bottom of the baggage or parcel
5 302 as it is pushed onto the conveyor belt 350. As was
stated previously, the various materials of interest leave
a "sticky residue" on the objects they come in contact
with, and thus it is necessary to sweep the particulate
matter from the object. The first automated sampling head
10 310 is valve connected to a common plenum (not shown)
through a pipe or conduit 312.

The second automated sampling head 320 is
hingedly connected to the roof of the sampling chamber 300
inside the entrance of the chamber 300. A representation
15 example of a typical sampling head 320 is shown in Figure
9. The inlet of the second automated sampling head 320
extends the entire width of the sampling chamber 300, and
as the baggage or parcel 302 moves through the sampling
chamber 300, the second sampling head 320 sweeps and draws
20 vapors from the top portions of the baggage or parcel 302.
The second automated sampling head 320 is connected to the
roof of the sampling chamber 300 by two pairs of paralever
arms 321 and 323. First and second offset springs 325 and
327 are attached between each set of paralever arms 321
25 and 323 in order to bias the sampling head into the path
of the luggage, and provide tension between the sampling
head 320 and the baggage or parcel 302 as it travels
through the chamber. The offset springs 325 and 327
maintain the second automated sampling head 320 in firm
30 contact with the baggage or parcel 302 as the paralever
arms 321 and 323 are forced upward. The second automated

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1 sampling head 320 is valve connected to the common plenum
through a pipe or conduit 322.

5 As illustrated in Figure 10, the third and
fourth automated sampling heads 330 and 340 are hinged
connected on opposite sides of the sampling chamber 300 so
as to not interfere with the second automated sampling
head 320. The third and fourth sampling heads 330 and 340
10 automatically adjust to the width of the baggage or parcel
302, by spring loading or by the use of sensors and servos
(not shown), in a manner such that the sides of the
baggage or parcel 302 are gently swept by the sampling
heads. The third and fourth sampling heads 330 and 340
are valve connected to the common manifold through pipes
or conduits 332 and 342.

15 The sampling of a piece of baggage or parcel
involves three sampling sequences. First, the baggage or
parcel 302 moves across the first automated sampling head
310 located at the entrance of the sampling chamber 300.
During this process, the suction and air flow generated by
the suction fan located in the second sample collection
20 and analytical subsystem is totally dedicated to this
sampling head 310. The valve system (not shown) at this
sampling step provides for the valve for sampling head 310
to be open to the common manifold while the valves to the
remaining sampling heads 320, 330, and 340 are closed. At
25 the second sampling step, the second automated sampling
head 320 is activated. When the baggage or parcel reaches
a set point in the sampling chamber 300, the second
sampling head 320 is activated by its sensor. A valve
(not shown) controlling the air flow to the common mani-
30 fold is opened and the valve leading to the second auto-
mated sampling head 320 is opened while the valves asso-
ciated with the remaining sampling heads 310, 330, and 340

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1 are closed. The air flow and suction is now totally
dedicated to the second automated sampling head 320. At
the third and final step, the third and fourth sampling
heads 330 and 340 are activated. When the baggage 302 or
5 parcel reaches another set point in the sampling chamber
300, the third and fourth sampling heads 330 and 340 are
activated by the dedicated sensor. At this final stage,
the valving system provides for air flow and suction only
from these two automated sampling heads 330 and 340. As
10 the baggage 302 or parcel is moved forward on the conveyor
belt 350, the third and fourth sampling heads 330 and 340
close in on the sides of the baggage 302, and gently brush
and draw in vapors and particulates.

The vacuum fan utilized to draw the sample
15 volume of air is capable of developing a flow rate of 70
to 85 CFM at each sampling head, which enable the sampling
heads to draw vapors through the seams and closure joints
of the baggage. It will also draw vapors through cloth
and vinyl suitcases as well as through the plastic
20 material used to conceal explosives. The determination of
whether a meaningful sample of vapors has been gathered
depends upon the concentration of the initial sample and
the porosity of the particular container.

The common manifold (not shown) is connected to
25 the first and second sample collection and analytical
subsystems. In one embodiment, the sample volume of air
collected by each automated sampling head 310, 320, 330,
and 340 is directly sent to the first and second sample
collection and analytical subsystems, and thus three
30 separate analysis' are done on a particular piece of
baggage 302. In a second embodiment, the sample volumes
of air collected by all four automated sampling heads 310,

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1 320, 330, and 340 can be gathered and then released to the first and second sample collection and analytical subsystems for a single analysis.

5 FIRST SAMPLE COLLECTION AND ANALYTICAL SUBSYSTEM

10 The first sample collection and analysis subsystem 400, shown in Figure 11A, is the particulate collector and detector. It is located in line between the sampling means, which is either the walk through sampling chamber portal, the hand-held wand, or the automated baggage/parcel sampling chamber, and the second sample collection and analysis subsystem 500. The PCAD 400 is comprised of the sample collector and vaporizer 410 and the chemical analyzer 460 which may be either a gas chromatograph/electron capture detector(s), GC/ECD, or an ion mobility spectrometer, IMS or both. The PCAD 400 is used to collect and analyze particulates in a sample volume of air collected in one of the three sampling means for the chemical compounds of interest. This is accomplished by first collecting and converting the particulates to vapor in the SCAV 410 and then submitting the vapors to the chemical analyzer 460 for analysis. A description of the SCAV 410 operating in conjunction with both types of chemical analyzers 460 is given in the following paragraphs.

25 SAMPLE COLLECTOR AND VAPORIZER (SCAV)

30 The SCAV 410 is located in line between either of the three sampling means and the second sample collection and analysis subsystem 500. The SCAV 410 is used

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1 to collect and vaporize particulate samples from an air
stream as it moves from one of the three sampling means
through the PCAD 400 and on to the second sample col-
lection and analysis subsystem 500. The SCAV 410 is
5 supplied with the air stream by a pipe 402 which extends
and connects to either of the three sampling means.
During sampling periods a high suction fan 404 draws the
sample volume of air from one of the three sampling means
thereby causing the air stream to flow into the SCAV 410.
10 The suction fan 404 is connected to pipe 402 on the
suction side, and the discharge of the fan 404 is con-
nected to a vent or exhaust system to the ambient environ-
ment.

The SCAV 410 comprises a rotating circular plate
15 412, a collection chamber 414, a vaporization chamber 416,
and a cleaning chamber 418. The collection, vaporization
and cleaning chambers 414, 416, and 418 are formed from
the union of first and second fixed SCAV plates 420 and
422. The first and second fixed SCAV plates 420 and 422
20 each comprise approximately one half of the volume of each
of the three chambers 414, 416, and 418. The first and
second fixed SCAV plates 420 and 422 are aligned such that
the collection chamber 414, the vaporization chamber 416
and the cleaning chamber 418 are configured 120 degrees
25 apart from each other. The rotating circular plate 412 is
disposed between the first and second fixed plates 420 and
422 and is mounted for rotation therebetween. The ro-
tating circular plate 412 has three circular holes 412a, b
and c equally spaced 120 degrees apart and covered with
30 three mesh filter elements 426a, b and c. The configura-
tion of the three filter elements 426a, b and c on the
rotating circular plate 412 is shown in Figure 12. The

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1 rotating circular plate 412, is rotated by a motor 428,
through 120 degrees of rotation during every sampling
period so that each of the mesh filter elements 426a, b,
and c occupies one of the collection chamber 414, the
5 vaporization chamber 416 or the cleaning chamber 418
during any given sampling period. The motor 428 utilized
to rotate the rotating circular plate 412 is a gear head
motor which is controlled by the PCAD actuator unit which
is an integral part of the control and data processing
10 system to be described in detail in subsequent paragraphs.
A stepper motor can also be utilized. On completion of
each rotation, a lever mechanism 432, which is actuated by
a solenoid 430, pulls the first and second fixed SCAV
plates 420 and 422 together so that each of the three
15 filter elements 426a, b, and c are sealed in either of the
three chambers 414, 416, and 418 during a particular
sampling period. The solenoid 430 and the lever mechanism
432 are controlled by the PCAD actuator unit. The three
filter elements 426a, b, and c are completely sealed, in
20 an air tight fashion, in each of the three chambers 414,
416, and 418. The air tight seal is accomplished by an
O-ring seal which surrounds each of the three chambers
414, 416, and 418. The O-ring seals are placed around the
perimeter of the chambers, or more accurately, around each
25 of the half chambers in each of the first and second fixed
SCAV plates 420 and 422. To completely illustrate the
design and operation of the SCAV 410, a complete 360
degree rotation of the rotating circular plane 412 is
described.

30 To illustrate the three sampling periods which
corresponds to one 360 degree rotation of the rotating
circular plate 412, it is necessary to state or assume

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1 that filter element 426a is inside the collection chamber
414, filter element 426b is inside the vaporization
chamber 416, and filter element 426c is inside the
cleaning chamber 418 at the system start-up time. In this
5 position, the filter element 426a and hole 412a are
directly in line with pipe 402 and thus filter element
426a is capable of selectively collecting, or more pre-
cisely, physically trapping target particulates which are
drawn from any of the three sampling means during a
10 sampling period. The particulate matter drawn in is
physically trapped or adsorbed on filter element 426a. A
complete description of the filter elements 426a, b and c
are given in subsequent paragraphs. Vapors collected by
any of the three sampling means pass through the filter
15 element 426a and proceed directly to the second sample
collection and analysis subsystem 500 for concentration.
The filter elements 426a b, and c can be varied in mesh
size so as to be able to collect specific size particu-
lates and still allow vapors to pass easily therethrough.
20 Upon completion of this first sampling period, the sole-
noid 430 is actuated by the control and data processing
system thereby causing lever mechanism 432 to separate the
first and second fixed SCAV plates 420 and 422. Once the
separation of the first and second fixed SCAV plates 420
25 and 422 is completed, the gear head motor 428 is engaged
by the PCAD actuator unit of the control and data proc-
essing system and rotates the circular plate 412 120
degrees, placing filter element 426a, with trapped par-
ticulates, inside the vaporization chamber 416 while
30 filter element 426b is placed inside the cleaning chamber
418 and filter element 426c is placed inside the col-
lection chamber 414.

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1 The vaporization chamber 416 is a sealed chamber
which contains a pair of electrical terminals 413 which
connect to filter element 426a when that particular filter
element occupies the vaporization chamber 416. The pair
5 of electrical terminals 413 provide a computer controlled
current directly to the filter element 426a in order to
generate a specific amount of ohmic heat energy to effec-
tively vaporize the collected particulate matter. The
current is controlled by the control and data processing
10 system. Through experimentation, it has been established
that a flash heat of 250 millisecond duration vaporizes
the targeted materials and creates an instantaneous
increase in gas pressure within the vaporization chamber
416 of very short duration which acts to aid in the
15 vaporization and injection of a controlled volume of the
sample into the chemical analyzer 460. As the flash
heating and vaporization is taking place a small quantity
of carrier gas from gas supply means 434 is continuously
fed into the vaporization chamber 416 via gas line 436.
20 The gas flow is used to sweep or carry the molecules from
the vaporized particulates into the chemical analyzer 460.
In the preferred embodiment, the gas utilized is an inert
gas; however, other non-reactive gases can be utilized. In
one embodiment, the vaporization chamber 416 is connected
25 directly to the chemical analyzer 460 and the carrier gas
sweeps the vaporized material or first sample volume
directly into the chemical analyzer 460, and in a second
embodiment, a three-way valve 438 is utilized as an
interface between the vaporization chamber 416 and the
30 chemical analyzer 460. Pipe 437 carries the sample volume
from the vaporization chamber 416 to the chemical analyzer
460 either directly or through the three way valve 438.

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1 Figure 11D diagrammatically illustrates the
analyzer 460 for the preferred embodiment of the PCAD
unit. An ion mobility spectrometer 460 is equipped with a
collector plate 461, a shutter grid 462, and a repeller
5 plate 463 which are biased by a 3,000 volt bias source
464. The IMS device is made up of the sequential series
of conducting and insulating rings which provide a voltage
gradient across the drift region 465 in a conventional
manner. A ring of nickel 63 466 is provided as the
10 ionizing source in the middle of reaction chamber 467.
Nickel 63 is a beta emitter that emits low energy elec-
trons for ionization of molecules of interest vaporized in
the PCAD unit.

 The ion mobility spectrometer 460 illustrated in
15 Figure 11D is a high duty cycle device engineered to
analyze a new sample every four to six seconds. While
conventional mass spectrometers would be suitable for the
PCAD analyzer at low duty cycles, the ion mobility spec-
trometer is a better choice for high duty cycles. The
20 PCAD device is intended to analyze and detect minute
particulates of plastic explosives such as C 4, DM 12 and
Semtex which may be analytically identified by the RDX and
PETN molecules therein. The plastic explosive particles,
however, also include substantial amounts of polymers,
25 oil, and plasticizers in addition to the explosive crys-
tals, and in a high duty cycle environment, conventional
GC/MS detectors may become packed with unwanted contam-
inants. In addition, conventional MS/MS and API/MS
devices, which require a high vacuum for operation, may
30 become saturated from the high duty cycle, and their
accuracy impaired. In the ion mobility spectrometer of
the present invention, the vaporized particulate matter is

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1 introduced through a tube 437 from the flash vaporization
chamber 416 into the reaction chamber 467. The drift gas
is introduced at the collector end of the device through
port 468, and exhausted through exhaust port 469 along
5 with the unwanted contaminants introduced by the particles
of plastic explosive. In the reaction region 467, the
vaporized sample is ionized by the nickel 63 ring and the
ionized molecules are then admitted into the drift region
465 by the shutter grid 462. All non-ionized molecules,
10 including most of the unwanted contaminants are evacuated
through exhaust 469. This means that the walls of the
drift region 465 remain relatively clean and uncontam-
inated by the high duty cycle since only the ionized
molecules are introduced into the drift region.

15 When CPU 475 initiates process control 473 and
the flash vaporization cycle, it also resets the sample
and hold circuitry 472, which in turn initiates the grid
pulse generator 470. The grid pulse generator 470 then
sequentially pulses trigger grid 462 every 25 milliseconds
20 to admit a new ion sample into drift region 465. The
output of the collector plate 461 is amplified and con-
verted to digital form by analog to digital converter 471
and the output thereof passed a sample and hold circuit
472. Sample and hold circuit 472 is initiated by process
25 control 473 in synchronization with the flash vaporization
in the PCAD unit.

In operation, a typical duty cycle includes at
least a collection cycle and a vaporization cycle, and
preferably a cleaning cycle, not illustrate in Figure 11D.
30 As illustrated in Figure 11D, the filters 466, 467 are
rotated between a collection chamber 414 and a flash

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1 vaporization chamber 416. When filter unit 466 is posi-
tioned within the collection chamber, it preferentially
retains particulate matter in the matter hereinbefore
described. When filter means 467 is positioned within the
5 flash vaporization chamber 416, a supply of carrier gas is
admitted through conduit 476 into the flash vaporization
chamber 416. Process control 473 then initiates the flash
vaporization by applying a direct electrical current to
filter 467 to thereby ohmically heat the filter in the
10 matter hereinbefore previously described. The flash
vaporization takes approximately 250 milliseconds and
simultaneously vaporizes the collected particulate matter
present on screen 467 while heating the surrounding
carrier gas that has entered the chamber through conduit
476. As the gas and the flash vaporization chamber is
15 heated, a pulse of high energy heated gas is created with
the molecules of interest entrained therein, which pulse
then travels through the injection means 437 into the
reaction chamber 467 of analyzer 460. In this region, the
molecules of interest are ionized and, every 25 milli-
20 seconds, another sample is admitted into the drift region
265. While the grid pulse generator 470 continuously
pulses the trigger grid 462, the screen 467 is only heated
once in a given duty cycle, or once every four to six
seconds.

25 After process control 473 has initiated a flash
vaporization of the sample, it delays the sample and hold
circuitry 472 for approximately two seconds before sam-
pling the output of the A to D converter 471. The sample
and hold circuitry will be enabled for approximately
30 one-half second, and during that one second, it will
receive approximately 20 spectral sweeps or plasmagrams

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1 from collector plate 461 and A to D converter 471. As
sample and hold circuit 472 samples the amplified output
signal at collector plate 461 at periodic intervals, and
averages them to form a digital pattern representative of
5 the collected and averaged signals. At the end of the
averaging period, the collected digital pattern is then
compared by CPU 475 with other digital patterns stored in
memory. If a match is found between the digital pattern
in the sample and hold circuit 472 and one of the patterns
10 at CPU memory, the CPU activates an alarm condition.

In a preferred embodiment, digital patterns for
the spectra from RDX and PETN molecules are stored in CPU
memory 475.

If a gas chromatograph/electron capture detector
15 is utilized as the chemical analyzer 460, a six-port valve
600 is utilized as an interface between the vaporization
chamber 416 and the chemical analyzer 460 as shown in
Figure 11C. In this embodiment, the vaporization process
is identical to that previously described; however, the
20 carrier gas sweeps the vaporized material into the six-
port valve 600 instead of directly to the chemical ana-
lyzer 460 or through the three-way valve 438. The six-
port valve is used to vent more volatile and less volatile
vapors from the vaporized sample, and to preferentially
25 retain the vapor sample of interest for separation by the
GC. This venting of unwanted vapors is desirable to avoid
clogging the GC, or unduly extending the cycle time.
Figures 13A and 13B illustrates the operation of the
six-port valve and represent the two positions that the
30 six-port valve 600 can occupy. The interface control
unit, which is part of the control and data processing
system, comprises a stepper motor, and is operable to

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1 switch the six-port valve 600 between the two positions.
In either position, only pairs of ports are connected.
In position 1, illustrated in Figure 13B, ports 1 and 2,
3 and 4, and 5 and 6 are connected, and in position 2,
5 illustrated in Figure 13A, ports 2 and 3, 4 and 5, and 6
and 1 are connected. Position 2 places an adsorb-desorb
tube 604 in the load position. The gas flow line 436
shown in Figure 11B carries the gas containing the vapor-
ized target materials and some possible contaminants into
10 port 1 indicated at 606 in Figure 13A of valve 600 wherein
the gas automatically flows through an internal passageway
608 to port 6, indicated at 610 in Figure 13A. Connected
between port 6 and port 3 is the external adsorption/
desorption tube 604 in which the gas containing the target
15 material and some minor contaminants pass through. The
adsorbing material inside the tube 604 is specifically
targeted for the target molecules in vapor form; there-
fore, the carrier gas and the contaminants flow through
the tube 604 to port 3, indicated at 612 while the target
20 material is adsorbed within the tube 604. The carrier gas
and contaminants flow from port 3 indicated at 612 in
Figure 13A to port 2 indicated at 614 in Figure 13A
through internal passageway 616, and is vented to the
external atmosphere through exhaust line 618. Pure
25 carrier gas supplied from a second gas supply means 620 is
fed into port 4 indicated at 622 via line 624. The pure
carrier gas automatically flows from port 4 indicated at
622 to port 5 indicated at 626 via internal passageway
628. The carrier gas then flows from port 5, indicated at
30 626 to the chemical analyzers 460 via line 630. The
chemical analyzer 460, which includes a gas chromatograph,
requires a continuous gas flow to remain operational. The

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1 use of the six-port valve 600 allows pure carrier gas to
be fed continuously to the chemical analyzer 460, even
when the adsorb/desorb tube 604 is in the adsorb cycle.

At the end of the adsorption cycle, the inter-
5 face control unit of the control and data processing
system then automatically switches the six-port valve 600
into position 1 which is the desorb mode as shown in
Figure 13B. Port 1, indicated at 606 in Figure 13B still
receives gas from the gas supply means 434 via line 436;
10 however, the gas flows from port 1, indicated at 606 to
port 2, indicated at 614 via internal passageway 632 and
is vented to the atmosphere via exhaust line 618. Port 4,
indicated at 622 is injected with pure carrier gas from
supply 620 via line 624 which flows to port 3, indicated
15 at 612 via internal passageway 634. As stated before,
port 3, indicated at 612 and port 6, indicated at 610 are
connected via an external adsorption/desorption tube 604;
however, in this position, the carrier gas is flowing
through the tube 604 in the opposite direction. There-
20 fore, when the tube 604 is heated to desorption temper-
ature, the gas will sweep the desorbed target material and
carry it to port 6, indicated at 610, essentially free of
contaminants. From port 6, indicated at 610, the target
material flows to port 5, indicated at 626, via internal
25 passageway 636 and to the chemical analyzer 460 via line
630.

The external adsorption/desorption tube 604 is
electrically insulated from the valve body and contains a
selected quantity of the adsorbing material which has the
30 best characteristics for adsorbing the vaporized target
material. High current connections are made to the ends
of this tube 604 and are shown in Figures 13A and 13B as

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1 electric lines 640 and 642. Lines 640 and 642 are con-
nected to the other end to a controlled current source
644. The controlled current source 644 is controlled by
the interface control unit. A thermocouple 646 is shown
5 attached to tube 604 in Figures 13A and 13B. This thermo-
couple 646 as stated previously, is used to monitor the
rise in the temperature of the tube 604 so as to achieve
the proper temperatures for desorption. The gas sample
which contains the target material, contaminants and
10 excess gas, passes through the tube 604 and because it is
cold, and the adsorber material has been selected to be a
strong adsorber for the target material, most of the
sample will be adsorbed at the end of the tube 604 near
port 6. The contaminants are less strongly adsorbed and
thus any adsorption of them will be throughout the length
15 of the tube 604. Also, because the contaminants are not
strongly adsorbed a larger portion of them will pass
through the tube to the exhaust vent 618 and be discarded.

A desirable property of thermal desorption of
20 gases or vapors on solid or liquid substrates is that the
process can be highly thermally sensitive and thermally
dependent. At a specified temperature the amount of any
material desorbed is related to its physical and chemical
properties and the physical and chemical properties of the
adsorbing material. It is possible to choose adsorbing
25 materials such that the contaminating materials are
desorbed at a workable lower temperature than the target
materials.

Careful thermal programming allows one to use
30 these properties. An example is to heat the desorber tube
604 in a controlled fashion with the six-port valve 600 in
position 2. The contaminants such as water vapor etc. are

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1 not strongly adsorbed and a low temperature will cause a
major portion of them to leave the adsorber and pass out
of the system through the vent. At the same time, the
target materials will not be desorbed and will remain at
the end of the adsorber tube 604 adjacent port 6. If the
5 position of the rotor in the six-port 600 valve is now
changed to position 1, two important changes are made.
The adsorber tube 604 is now connected to the next stage
in the sequence and the pure carrier gas flows through the
adsorber tube 604 in the opposite direction to the pre-
10 vious gas flow direction. A rapid controlled increase in
temperature will now cause the sample to be desorbed in a
short period of time. This results in a sample which has
been purified by the previously described adsorption and
desorption process passing to the next stage in the
15 process, contained in the minimum of pure carrier gas.
Thus the sample has been twice purified of contaminants
and concentrated in a much reduced volume of pure inert
carrier gas.

20 During the vaporization process, and as illus-
trated in Figure 11c, filter element 426a is in the
vaporization chamber 416, filter element 426c is in the
collection chamber 414 collecting the next sample of
particulate matter, and filter element 426b is in the
cleaning chamber 418. Upon completion of this second
25 sampling period the solenoid 430 is actuated by the PCAD
actuator control unit of the control and data processing
system thereby causing lever mechanism 432 to separate the
first and second fixed SCAV plates 420 and 422. Once the
separation of the first and second fixed SCAV plates 420
30 and 422 is completed, the stepper motor 428 is engaged by
the PCAD actuator unit of the control and data processing

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1 system and rotates the circular plate 412 120 degrees,
placing filter element 426a inside the cleaning chamber
418, filter element 426b into the collection chamber 414
and filter element 426c, with trapped particulates, in the
5 vaporization chamber 416.

5 The cleaning chamber 418 is a sealed chamber
similar to the vaporization chamber 416. In this chamber
418, a second pair of electrical terminals 415 are con-
nected to filter element 426a when that particular filter
10 element occupies the cleaning chamber 418. The second
pair of electrical terminals 415 are connected to each
of the filter elements 426a, b and c when each of them
occupies this particular chamber 418. This second pair of
electrical terminals 415 provides a computer controlled
15 current to generate a specific amount of ohmic heat energy
to vaporize any remaining particulate matter remaining on
the filter element 426a. A cleaning suction fan 450,
located in the second sample collection and analysis
subsystem 500, draws any remaining vaporized material from
20 the filter element 426a and the collection chamber 418 and
vents it to the ambient environment. The cleaning suction
fan 450 is connected to the cleaning chamber 418 via pipe
452. In one embodiment, pipe 451 is connected to both the
cleaning chamber 418 and the flushing chamber 518 of the
25 second sample collection and analysis subsystem 500. In
this embodiment it is assumed that any vapors in the
second sample collection and analytical subsystem 500 will
pass directly through the filter element 426a in the
cleaning chamber 418 and be vented to the ambient envi-
30 ronment. In a second embodiment, pipe 454 branches off of
main pipe 452 and thus provides a separate, parallel path
for cleaning cycles. In this embodiment, a valve 453 is

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1 utilized to control the direction of the vacuum flow.
Note that during the cleaning process, filter element 426b
is inside the collection chamber 414 collecting the next
sample, and filter element 426c is inside the vaporization
5 chamber 416. This completes one 360 degree rotation and
enables the process to start over again.

The SCAV 410 is designed in such a way that the
movement of the circular plate 412 places filter elements
426a, b, and c in tightly sealed positions at each lo-
10 cation so there is no contamination with the ambient air.
The precise movement of the rotating circular plate 412
via the stepper motor 428 and the movement of the first
and second fixed plates 420 and 422 are controlled by the
PCAD actuator unit. The precise control of the three-way
15 valve 438 and the six-port valve 600 as well as the gas
flows are controlled by the interface control unit. Both
the PCAD control unit and the interface control units are
part of the control and data processing system which is
described in detail subsequently.

20 Figures 14a, b, and c illustrate the various
views of the unique filter construction of the present
invention. For purposes of illustration, the term sample
filters or filter elements is construed to mean any of the
three filter elements 426a, b or c. The sample filters
25 are uniquely designed to enable the collection of sample
particulates while facilitating the passage of vapor
samples to the second sample collection and analysis
system 500. They are also uniquely designed to facilitate
vaporization of particulates and subsequent cleaning
30 through pyrolysis and vacuuming.

Referring to Figure 12, a rotatable plate with
three removable filter elements is illustrated. The

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1 filter elements are inserted into the edge of rotating
plate 412 with the hole in the filter element aligned with
the hole of the filter unit as illustrated. Entrance
to each filter cavity is from the circumference of the
rotating circular plate 412. Each of the sample filter
5 elements 426a, b, or c is uniquely designed to facilitate
electrical current conduction, and as well as a gas tight
fit while still providing for easy insertion and removal.

As illustrated in Figure 14a-c, the sample
10 filter's frame 427 is constructed from anodized aluminum
and then hard anodized. The hard anodized coating has
been found to provide electrical insulation qualities
which may be used in the design of the device. This also
facilitates manufacturing, either by casting or machining.
15 The frame 427 includes an electrical conductor 429 fitted
at each end as indicated in the Figure 14A. Each con-
ductor 429 has a fitted piece or securing plate 433 which
acts to hold a nickel or stainless steel mesh 431 in a
firm electrical connection in place over the hole 412a, b,
20 or c which may be circular, rectangular or square. The
electrical conductors 429 extend through the frame 427 and
end up as electrical terminals 435. In operation, when
one of the filters 426 a, b or c rotates into the vapor-
ization chamber or the cleaning/purging chamber, the
25 electrical terminals 435 engage commutator contacts which
are provided for each of the chambers. Figure 12 illus-
trates the contact points located on the commutator. The
contact points 900 and 902 are for the cleaning chamber
and contact points 904 and 906 are for the vaporization
30 chamber. As is shown in the figure, the contact points
900-906 provide for spring loaded direct electrical
contact in the direction of rotation. When process

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1 control initiates flash heating, an electrical current is
passed to each of the terminals 435. The circuit between
conductor 429 is completed by the stainless steel or
nickel mesh screen which is ohmically heated by the
current passing therethrough.

5 The frame 427 has a lip which fits against a
planar portion formed in the circumference of the rotating
circular plane 412. On the lip is a groove which holds a
viton or other appropriate O-ring 439 in place so that
when inserted into the cavity it makes a gas tight fit
10 when snugged into place by a holding pin (not shown). The
holding pin is braced against the top and bottom edges of
the circumference of the rotating circular plane 412 by
insertion into securing notches so that turning a single
screw secures and seals the sample filter in place.
15 Removal of the filter is easily accomplished by unscrewing
the screw on the holding pin and removing it from the
securing notches. A special tool is then sprung into
slots at the protruding ends of the electrical terminals
435 and the sample filter is pulled from the cavity.
20 Figure 14B illustrates a top plate 443 which fits over the
top side of the filter element 426a, b, or c shown in
Figure 14A. Figure 14C illustrates the under side of
filter element 426a, b, or c.

25 It is important to note that it is possible to
replace the three filter SCAV 410 with a two filter SCAV
410 or even a single filter SCAV 410. In a two filter
embodiment, there would be no cleaning chamber 418. The
SCAV 410 would only have a collection chamber 412 and a
30 vaporization chamber 414 for a continuous two step process
per sampling period. In a single filter element embodi-
ment, either one chamber suffices for the sampling and

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1 vaporization processes, or the single filter element is rotated or reciprocated between the two positions.

SECOND SAMPLE COLLECTION AND ANALYTICAL SUBSYSTEM

5 The second sample collection and analysis subsystem 500, shown in Figure 11B, is the vapor collector and detector. It is located in line between the first sample collection and analysis subsystem 400 and the main suction fan 404 and the cleaning suction fan 450. The
10 VCAD 500 is comprised of a sample collector and preconcentrator 510, SCAP, and the second chemical analyzer 560 which in the preferred embodiment is a gas chromatograph/electron capture detector, GC/ECD. In a second embodiment, the chemical analyzer 560 is an ion mobility spec-
15 trometer, or combination gas chromatograph/electron capture detector and ion mobility spectrometer. The VCAD 500 is used to collect, concentrate and analyze an sample volume of air for the targeted molecular vapor. This is
20 accomplished by first selectively collecting and concentrating the molecular vapor in the SCAP 510 and then submitting the vapors to the second chemical analyzer(s) 560 for analysis. A description of the SCAP 510 operating in conjunction with both types of second chemical ana-
25 lyzers 560 is given in the following paragraphs.

SAMPLE COLLECTOR AND PRECONCENTRATOR (SCAP)

30 The SCAP 510 is used as part of the overall system to enhance overall system sensitivity and selectivity. In general terms, the SCAP 510 must simply discard, in a multi-step process, non-required molecules

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1 of air while not losing the targeted molecules of inter-
est. In the sample collection and preconcentration step,
the targeted materials are adsorbed onto a selected
substrate, and then selectively desorbed into a smaller
5 and more concentrated volume for analysis.

The SCAP 510 is used to collect and concentrate
vapor samples from the air stream as it moves from one of
the three sampling means through the SCAV 410 and onto the
SCAP 510. The SCAP 510 is supplied with sample volume of
10 the air by pipe 402 which extends from the SCAV 410 to the
SCAP 510. During a sampling period, the high suction fan
404 draws the sample volume of air from one of the three
sampling means thereby causing the air stream to flow into
the SCAV 410. The filter elements in the SCAV 410 are
15 designed to only physically trap certain target materials
and allow the vapors to continue onto the SCAP 510. The
vapors easily pass through the SCAV 410 and end up in the
SCAP 510 where they will be physically trapped or ad-
sorbed.

20 The SCAP 510 comprises a rotating circular plate
512, a sampling chamber 514, a desorption chamber 516, and
a flushing chamber 518. The sampling, desorption, and
flushing chambers 514, 516, and 518 are formed from the
union of first and second fixed SCAP plates 520 and 522.
25 The first and second fixed SCAP plates 520 and 522 each
comprise approximately one half of the volume of the three
chambers 514, 516, and 518. The desorption chamber 516 is
of slightly different design and is more fully described
in subsequent paragraphs. The first and second SCAP fixed
30 plates 520 and 522 are aligned such that the sampling
chamber 514, the desorption chamber 516, and the flushing
chamber 518 are configured 120 degrees apart from each

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1 other. The rotating circular plane 512 is disposed
between the first and second fixed SCAP plates 520 and 522
and is capable of rotation therebetween. The rotating
circular plane 512 has three circular holes 512a, b, and c
5 equally spaced 120 degrees apart and covered with three
mesh filter elements 526a, b, and c. The configuration of
the three filter elements 526a, b and c on the rotating
circular plane 512 is the same as that of rotating circular
plane 412 utilized in the SCAV 410 and shown in Figure
10 12. The rotating circular plane 512, which is actuated by
a motor 528, is rotated 120 degrees every sampling period
so that each of the mesh filter elements 526a, b, and c
occupies either the sampling chamber 514, the desorption
chamber 516 or the flushing chamber 518 during a sampling
15 period. The motor 528 utilized to rotate the rotating
circular plane 512 is a stepper motor which is controlled
by the VCAD actuator unit which is an integral part of the
control and data processing system. On completion of each
rotation, a lever mechanism 532, which is actuated by a
20 solenoid 530, pulls the first and second fixed plates 520
and 522 together so that each of the three filter elements
526a, b, and c are sealed in either of the three chambers
514, 516, and 518 during a particular sampling period.
The solenoid 530 and the lever mechanism 532 are con-
25 trolled by the VCAD actuator unit. The three filter
elements 526a, b, and c are completely sealed in an air
tight fashion in each of the three chambers 514, 516, and
518. The air tight seal is accomplished by the force
supplied by the lever mechanism 532 and because each of
30 the three chambers 514, 516, and 518 contain an O-ring
seal. The O-ring seals are placed around the perimeter of
the chambers, or more accurately, the half chambers in

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1 each of the first and second fixed plates 520 and 522. To
completely illustrate the design and operation of the SCAP
510, a complete 360 degree rotation of the rotating
circular plane 512 is described.

5 To illustrate the three sampling periods which
corresponds to one 360 degree rotation of the rotating
circular plane 512, it is necessary to state or assume
that filter element 526a is inside the sampling chamber
514, filter element 526b is inside the desorption chamber
10 516, and filter element 518 is inside the flushing chamber
518 at the system start-up time. In this position, the
filter element 526a and hole 512a are directly in line
with pipe 402 and thus filter element 526a is capable of
selectively collecting target vapor molecules which may be
15 drawn from any of the three sampling means during a
sampling period. A complete description of the filter
elements 526a, b, and c is given in subsequent paragraphs.
Upon completion of the first sampling period, the solenoid
530 is actuated by the control and data processing system
20 thereby causing lever mechanism 532 to separate the first
and second fixed SCAP plates 520 and 522. Once the
separation of the first and second fixed SCAP plates 520
and 522 is completed, the stepper motor 528 is engaged by
the control and data processing system and rotates the
25 circular plane 512 120 degrees placing filter element
526a, with adsorbed vapors, inside the desorption chamber
516 while filter element 526b is placed in the cleaning
chamber 518 and filter element 526c is placed inside the
sampling chamber 514.

30 The desorption chamber 516 is a sealed chamber
comprising a gas heating element (not shown) which is
connected to a power source of the control and data

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1 processing system. An external carrier gas flow from gas
supply 534 and carried by pipe 536 enters the desorption
chamber 516 through a fitting 517 in the second fixed SCAP
plate 522. The gas flow passes over the gas heating
5 element where it is heated to a predetermined level to
cause desorption of the targeted material from the ad-
sorbates as it passes over and through them. In the
preferred embodiment, the gas utilized is an inert gas;
however, other less non-reactive gases can be utilized.
10 It has been found through experimentation that the heating
element may be a stainless steel screen fitted in a hard
anodized aluminum frame, or a tungsten or wire wound
ceramic frame. The fitting 521 on the first fixed SCAP
plate 520 is designed to gather the carrier gas with vapor
15 sample in as small an area as possible to enhance concen-
tration of the sample as well as to maintain a fixed heat
in a thermally insulated manner so, as to minimize the
transfer of heat to the body of the desorption chamber
516. In the preferred embodiment, fitting 521 is coni-
20 cally shaped and insulated from the first fixed plate 520
by the insertion of a ceramic bushing. The fitting 521 is
maintained at a predetermined temperature to facilitate
the free passage of the sample in the carrier gas to the
next preconcentration stage without adsorption on the wall
25 of the fitting 521. The carrier gas, once it has reached
the desired temperature, sweeps the desorbed material from
the desorption chamber 516 via line 519 into the next
concentrator stage.

Referring the Figure 11E, there is shown a more
30 detailed diagram of the desorption chamber 516. The
rotating circular plate 512 with filter element 526a is
positioned between the first fixed plate 520 and the

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1 second fixed plate 522. Two O-ring seals 550 and 552 are
shown between the first fixed plate 520 and the rotating
circular plate 512 and between the rotating circular plate
512 and the second fixed plate 522. A ceramic heating
5 screen holder 554 is shown holding heating element 556.
The carrier gas enters the chamber 516 through gas line
536 and travels upward over the heating element 556 where
it is heated to a temperature high enough to desorb any
vapors on filter element 526a. The upper half of the
10 chamber 516 is of smaller volume. As is shown in the
figure, the upper half is conically shaped. The upper
half has a stainless steel jacket 558 and a ceramic
bushing 560 for insulation. The concentrated sample
exists for the desorption chamber 516 through fitting 521
15 which is part of steel jacket 558.

The secondary preconcentrator 538 is a six-port
valve identical to the one utilized in the first sample
collection and analysis system. The concentrated sample
from the desorption chamber 516 is swept into the six-port
20 valve 538 along with some unwanted materials via the
carrier gas flow. The pipe 519 is heated to a certain
extent to prevent the possible absorption of the vapors
onto the wall of the pipe 519. Once inside the six-port
valve 538, the sample either passes through a sample loop
25 to either a vent to the ambient environment or to the
chemical analyzer 560 depending upon the position of the
six-port valve 538. The sample loop is the desorption
tube 604 shown in Figures 13A and 13B. The operation of
the six-port valve 538 is identical to the operation of
30 the six-port valve 600 utilized by the first sample
collection and analysis subsystem 400.

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1 In a slight variation of the previously de-
scribed process, it has been found that a further puri-
fication of the sample volume can be effected by venting
unwanted material to the ambient atmosphere through
manipulating the route and timing of the carrier gas flow
5 so that a purer sample of the target material is fed to
the chemical analyzer 560. Normally the six-port valve
538 is positioned so that it is supplying pure gas to the
chemical analyzer 560 from a gas supply like gas supply
620 in Figures 13A and 13B and receiving carrier gas and
10 sample from the desorption chamber 516 and passing it
through the sample loop then back to the six-port valve
538 and out to the ambient environment. The more volatile
vapors containing the unwanted materials are desorbed
first in the desorption process carried on in the desorp-
15 tion chamber and are the first to arrive at the six-port
valve 538. The time of positioning the six-port valve 538
so that it transfers the vapor in the sample loop is such
that the unwanted lighter vapors have already passed
through the sample loop and have been vented before the
20 sample is fed into the chemical analyzer 560.

During the desorption process wherein filter
element 526a is in the desorption chamber 516, filter
element 526b is in the cleaning chamber 518, and filter
25 element 526c is in the sampling chamber 514 collecting
the next sample of vapor. Upon completion of the second
sampling period, the solenoid 530 is actuated by the
control and data processing system thereby causing lever
mechanism 532 to separate the first and second fixed
plates 520 and 522, and upon completion of the separation
30 of the first and second fixed plates 520 and 522, the
stepper motor 528 is engaged by the control and data

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1 processing system and rotates the circular plane 512 120
degrees placing filter element 526a inside the cleaning
chamber 518, filter element 526b into the sampling chamber
514 and filter element 526c, with adsorbed vapors, into
5 the desorption chamber 516.

5 The concentrated sample volume is swept from the
desorption chamber 516 or the six-port valve 538 into a
gas chromatograph/electron capture detector combination.
The process of gas chromatography consists of separations
10 of vaporized components by a combination of partition
chromatography, varied degrees of adsorption chroma-
tography, and the varied relative volatility of the
vaporized components. The concentrated sample volume
containing compounds of interest are swept into a long gas
15 chromatograph column which is coiled in a constant high-
temperature compartment. The column is packed with inert,
organic solid supports coated with one or more non-
volatile organic coatings. The support with its organic
coating constitutes the stationary phase of gas liquid
20 partition chromatographic systems. As the volatilized
components pass through the column they partition between
the stationary phase material in the column and the
volatile phase, which is a stream of inert carrier gas.
This partitioning reflects the relative volatility of the
25 vaporized components. Compounds exhibiting lower vola-
tility have less affinity for the stationary phase and
accordingly exit the gas chromatograph first. The con-
centrated vapor sample exits the gas chromatograph as a
continuous stream with varying volatility compounds
30 separated spatially. This continuous stream then enters
the electron capture detector.

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1 The electron capture detector is a device
utilized to measure the concentration of electron-
capturing chemical species in the effluent from a gas
chromatographic column. The ECD is insensitive to amines,
5 alcohols and hydrocarbons, but very sensitive to halogens,
anhydrides, peroxides, ketenes and nitro groups and thus
particularly lends itself to this particular application.
The electron capture detector is a gas ionization chamber
within which conduction electrons are produced at a known
10 rate, typically by a radioactive source, and captured by
the electro-negative species within the sample of output
from the gas chromatograph. Electrical measurements made
at the chambers electrodes are made to determine the free
electron density and then determine the concentration of
15 electron capturing compounds. The electrical measurements
result in a pulse train whose frequency is linearly
related to the concentration of the compounds present in
the sample.

 The computer of the control and data processing
20 system, to be described in a subsequent section, is
preprogrammed to detect certain signature molecules, which
are also discussed in subsequent sections. The time of
travel from initial injection through capture by the
electron capture detector is determined by the particular
25 compound. Through experimentation, it has been determined
that the time of travel of the signature molecules for
dynamite and nitroglycerine began at approximately 1.5
seconds and end at 2.5 seconds, with a peak at approxi-
mately two seconds. Therefore, the computer will open a
30 25 ms window at two seconds to determine if any signature
molecules are present. In addition, since the pulse
train's frequency varies with the concentration of the

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1 various compounds, the concentration of the particular
signature molecules for dynamite and nitroglycerine may
also be determined by logging the frequency of the re-
sultant pulse train.

5 The cleaning chamber 518 is a sealed chamber
similar to the desorption chamber 516. It provides for a
thermal cleansing of any vapors or particulates which may
remain after the desorption process. When filter element
526a or any filter element 526a, b, or c is in the
10 cleaning chamber 518, a pure gas flow from gas supply
means 534 is routed to the filter element 526a over a
second heating element not shown. A computer controlled
current generates heat energy to desorb any remaining
vapor and particulates from the filter element 526a. The
15 gas flow is used to sweep the desorbed material through a
fitting 523 and into pipe 452 which is connected to the
vacuum cleaning fan 450 which draws the debris from the
cleaning chamber and vents it to the ambient environment.
During the cleaning process, filter element 526b is inside
the sampling chamber 514 collecting the next sample, and
20 filter element 526c is inside the desorption chamber 516.

The SCAP 510 is designed in such a way that the
movement of the rotating circular plane 512 places filter
elements 526a, b, and c in tightly sealed positions at
25 each location so there is no contamination with the
ambient air. The precise movement of the rotating cir-
cular plane 512 via the stepper motor 528 and the movement
of the first and second fixed SCAP plates 520 and 522 are
controlled by the VCAD actuator unit. The precise control
30 of the six-port valve as well as all the gas flows are
controlled by the interface control unit. Both the VCAD
control unit and the interface control units are part of

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the control and data processing system which is described in detail subsequently.

Referring to Figure 15A and B, there is shown two views of the unique filter element design for the SCAP 510. For purposes of illustration, the term sample filters or filter elements is construed to mean any of the three filter elements 526a, b or c. The sample filters 526a, b and c each consist of a frame 527 which holds two stainless steel screens 529 and 531 such that a cavity is formed between them. The cavity is filled with a measured amount of adsorbent material with an affinity to adsorb molecules of the target materials. The two filter screens 529 and 531 are held in place by a plate 533 which fits onto the frame 527 and is secured by four bolts 535. The frame 527 has a lip on which is fitted an O-ring seal 537 to provide a sealed surface when the filters 526a, b, or c are inserted into the cavities located on the rotating circular plane 512.

The sample filters frame 527 is constructed from aluminum which is then hard anodized. This has been found to provide the inert surface and thermal qualities required in this type of work. Normally a material such as stainless steel, nickel or a ceramic material such as Maycor would be used to achieve these ends. Through experiment it has been found that the hard anodized aluminum may be used. This facilitates manufacture either by casting or machining.

The adsorbent material used in the various stages of concentration of the target materials may be selected from a vast group of materials commonly used for vapor sampling including *Tenax and *Carbotrap. There are other adsorbing materials that can be used with the

*Trade mark

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1 present invention depending on the particular materials
that are to be detected and isolated.

5 The three filter SCAP 510 can be replaced with a
two filter SCAP 510 or a single filter SCAP 510. In the
two filter embodiment, there would be no cleaning chamber
518. The SCAP 510 would only have a sampling chamber 512
and a desorption chamber 514 for a continuous two step
process per sampling period. In a single filter element
embodiment, either one chamber suffices for the sampling
and desorption processes, or the single filter is switched
10 between the two positions.

ANALYSIS

15 The analysis of the purified target material
consists of identifying the materials and determining the
amounts present. Because the original concentrations were
so low with respect to many other common ambient materials
it is possible for there to be, even under the best of
purification and concentration systems, some remaining
20 impurities of materials with similar characteristics to
the target materials. Thus the analysis system must be
capable of separating the target material response from
the response due to interfering materials.

25 Two forms of analysis systems are used either
separately or in combination in both the first and second
sample collection and analysis subsystems 400 and 500.
The first sample collection and analysis subsystem 400
utilizes an ion mobility spectrometer, a gas
30 chromatograph/electron capture detector, or both. The
final detector for the gas chromatograph is usually an
electron capture detector, however the ion mobility

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1 spectrometer can also be used as the second detector if
desired. Depending on the application, a photo ionization
detector or a nitrogen-phosphorus detector or some other
detector may be also used following the gas chromatograph.
5 The gas chromatograph may be of the "packed column" type
or the capillary column type. If both a gas
chromatograph/electron capture detector and ion mobility
spectrometer are utilized, they can be used separately or
in a combined fashion. A valve can be utilized to direct
10 the collected and purified sample to either or both of the
analyzers. The second sample collection and analysis
subsystem 500 also utilizes a gas chromatograph/electron
capture detector and/or an ion mobility analyzer. The
first and second sample collection and analysis subsystems
15 400 and 500 can be run simultaneously or separately and
thus both sets of chemical analyzers can be run simulta-
neously or separately.

In the preferred embodiment, an ion mobility
spectrometer is the analyzer 460 for the first sample
20 collection and analysis subsystem 400. The first sample
collection and analysis subsystem 400 is used to collect
particulates and vaporize these particulates for chemical
analysis. The particulates of interest are associated
with plastique explosives such as C4, DM-12, and SEMTEX.
25 As was stated previously, plastique explosives have
extremely low vapor pressures ranging from 10,000 to
1,000,000 times less than that of conventional explosives
such as dynamite, nitroglycerin, and trinitrotoluene. The
analysis of these particulates is based upon the detection
30 of certain signature molecules. For plastique explosives,
these signature molecules are cyclotrimethylenetrini-
tramine, RDX, or pentaerythritol tetranitrate, PETN. The

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1 ion mobility spectrometer is set to detect these signature
molecules by creating a sample window for each of them. A
window is utilized as opposed to trying to develop a
direct match because one cannot expect a pure sample of
the signature molecule. If a particular compound analyzed
5 fits into one of the above windows, the sample sampled is
deemed to have been in contact with a plastique explosive.

In the preferred embodiment, a gas
chromatograph/electron capture detector(s) is the analyzer
560 for the second sample collection and analysis sub-
10 system 500. The second sample collection and analysis
system 500 is used to collect vapors and concentrate them
for chemical analysis. The vapors of interest are asso-
ciated with the conventional explosives enumerated above.
The analysis of these vapors is also based upon the
15 detection of certain signature molecules. For dynamite,
the signature molecule is ethylene glycol dinitrate or
EGDN. For nitroglycerin, the signature molecule is
nitroglycerin, or NG. For trinitrotoluene, or TNT, the
signature molecule is dinitrotoluene or DNT. Like the ion
20 mobility spectrometer, the gas chromatograph/electron
capture detector(s) is set to detect these signature
molecules by creating a sample window for each of them.

There are presently a variety of international
groups including national security agencies, the military
25 and international manufacturers of explosives, that are
working or deciding on a particular tagent to be added to
all explosives so that they may be more readily detected.
The particular tagent that is decided upon will become one
of the signature molecules that will be searched for in
30 the analysis phase of the explosive screening process. A
list of the signature molecules currently tested for is

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1 given in Table 1 set forth below. The table indicates the
name, code, formula and use of each compound. Explosives
are typically categorized as primary, secondary, or high
explosives and propellants in order of decreasing sensi-
5 tivity to energy input. In other words a primary explo-
sive is more sensitive to heat for example, than a sec-
ondary explosive.

	<u>Name</u>	<u>Code</u>	<u>Formula</u>	<u>Use</u>
10	ethylene glycol dinitrate	EGDN	$O_2NOCH_2CH_2ONO_2$	liquid explosive
15	nitroglycerin	NG	H_2CONO_2 $HCONO_2$ H_2CONO_2	liquid secondary explosive ingredient in commercial explosives and propellants
20	2,4,6 - trinitrotoluene	TNT	CH_3 O_2N NO_2 NO_2	secondary high explosive
25	cyclotrimethylene trinitramine	RDX	NO_2 N N N O_2N NO_2	secondary high explosive used as a booster
30	pentaerythritol tetranitrate	PETN	O_2NOCH_2 CH_2ONO_2 C O_2NOCH_2 CH_2ONO_2	secondary high explosive used as a booster

TABLE 1

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1 Whatever analysis system is used the analysis
must be completed in a time that is short enough that the
free flow of people, luggage and baggage is not unduly
inhibited. This also implies that the time for the
5 concentration and purification process is short as well.

10 If all the valves in the system are motor driven
or solenoid driven valves, the flow directions timings and
magnitude may be controlled and varied. The time and
temperature parameters are controlled and variable. Thus
the physical characteristics of the complete system may be
adjusted to detect a wide range of target materials and
the sensitivities may be adjusted to accommodate a wide
range of threats as perceived by the authorities using the
system.

15 All the processes involved in the collection and
concentration as well as the final analysis of the col-
lected material is controlled by the computer of the
control and data processing system and will be fully
explained in the following section.

20 CONTROL AND DATA PROCESSING

25 The primary requirement for the control and data
processing system of the screening system is that it
reports the presence of, and if required, the level of
specified substances. This means that the equipment must
be configured and controlled to make the required measure-
ment and it also means that the result must be presented
to the user in a usable form. The subject or target
30 materials may be present in varying amounts in the envi-
ronment of the system and therefore, the system must be
capable of distinguishing between this background level

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1 and an alarm level. It may also be a requirement to
report on this background level.

5 A secondary requirement for the control and data
processing system of the integrated system is self diag-
nostic, as there may be considerable time between alarms,
the control and data processing system must be capable of
performing confidence checks that are satisfactory to the
operator on demand. There must also be routine self
checks and calibration procedures performed on the total
10 system by the control and data processing system. Basi-
cally, this ensures that the test results, whether posi-
tive or negative, are believable.

15 A third requirement for the control and data
processing system is ease of reconfiguration and versa-
tility. The range of target materials may be changed from
time to time, and the system must be capable of varying
its internal operation parameters under program control to
detect these materials. It is desirable that the rigor of
the measurement in terms of time constraints and number
and types of substances detected be alterable in an
20 expeditious fashion at any time. The user's requirements
in terms of level of threat and types of materials may
quickly change and the equipment must respond to these
changing needs.

25 The final requirement for the control and data
processing system is that the parameters and operations of
all of the sampling chambers and the first and second
sample collection and analytical subsystems must be
monitored and controlled. This means that all internal
30 timings, temperatures and mechanical components must be
controllable by the control and data processing system.

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1 The primary method of achieving these require-
ments is to put the total system under the control of a
stored program digital computer. This computer through a
series of modularized software routines performs the data
5 analysis and presents the results in the required form to
the user. The computer through another series of modu-
larized software routines continuously performs self
diagnostic and self calibration procedures on the total
system, and alerts the user to any potential problems.
10 The computer through still another set of modularized
software routines controls all the processes of the total
system and shall be more fully explained in subsequent
paragraphs.

 One primary benefit of this system of control is
15 reliability. By themselves the components are rugged and
reliable and not prone to failure. However, any system
made up of many items is subject to drifts due to ambient
changes and time. By having all components under program
control and by arranging for a known input to the system
20 such as a controlled injection of target material or
target stimulant, there can be a calibration and self-
diagnostic program. The function of this program is to
calibrate the entire system and determine and store the
required time, and temperature parameters etc. If these
25 parameters are not within specified limits for any reason,
the program can alert the user. Guided by a service
program the user response can range from immediate shut-
down to scheduling service at a later date, to simply
noting the circumstances. By use of a modem this infor-
30 mation can be easily transmitted to anywhere in the world.
The other aspect of reliability in a system of this type
is that the user must know that the system is reliable.

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1 Hopefully there will be very long periods of time between
actual alarm events. However, if there is a calibration
and self diagnostic program and associated hardware for
realistic sample injection, the user can generate, at
5 anytime, an actual/simulated alarm event as a confidence
check.

The second primary benefit of this system of
control is versatility. It is advantageous for the system
to have the capability of detecting a wide range of
10 explosives, a range of controlled chemical agents, drugs,
and narcotics etc. All these materials have differing
physical and chemical properties. These properties give
rise to a set of internal parameters for optimum detec-
tion. However these parameters will be less than optimum
15 for some other materials. But, if these parameters are
all controllable and easily changed such as by simply
reading in or activating a different program in the
computer memory, then the user can effectively change the
system to meet what is considered to be the threat at that
20 time without making any hardware changes.

Referring now to Figure 16, there is shown a
block diagram representation of the control and data
processing system 700 and its associated peripheral
elements. The digital computer 702 or processor is an AT
25 type personal computer running at 10MHz and has a standard
video display terminal 704. The computer 702 is respon-
sible for process control, data acquisition, data analysis
and display of analysis results. In addition, as men-
tioned previously, the computer 702 also contains software
30 routines for self diagnostic and self calibration proce-
dures. The computer 702 receives power from the power
distribution unit 706 as does the sampling chamber portal

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1 100, the hand-held wand 200, the automated baggage/parcel
sampling chamber 300, and the process control unit 708.
The process and control unit 708 under the control of the
computer 702 interfaces and provides the necessary signals
5 to run the sampling actuator unit 710, the interface
actuator unit 712, the PCAD actuator unit 714, and the
VCAD actuator unit 716.

The process and control unit 708 is a standard
interface unit between the computer 702 and the various
10 actuators. The sampling actuator unit 710 controls or
actuates all processes involved in the collection of the
sample volumes of air from the sampling chamber portal
100, the hand-held wand 200, and the automated baggage/
parcel sampling chamber 300. Under software control, the
15 process control unit 708 outputs commands to the sampling
actuator unit 710, to control the suction of air from the
various sampling means, and the actuation of the rotating
brushes. The interface actuator unit 712 comprises the
stepper motors which control the operation of the six-port
20 valves, and the gas supplier means utilized for sweeping
the samples into the chemical analyzers. The stepper
motors and the gas supply means are run under software
control. The interface actuator unit 712 is utilized to
rotate the six-port valves between the adsorb and desorb
25 positions and regulate the various gas flows. The PCAD
actuator unit 714 comprises a stepper motor for the
rotation of the rotating circular plate, and provides the
signal for control of the solenoid utilized to operate the
lever mechanism which either joins or separates the first
30 and second fixed plates. The VCAD actuator unit 716
comprises a stepper motor for the rotation of the second
rotating circular plate, and provides for the control of

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1 the second solenoid utilized to operate the second lever
mechanism which either joins or separates the second set
of first and second fixed plates. Data from the chemical
analyzers 460 and 560 is brought directly into the com-
puter 702 for processing through a data acquisition plug
5 in card. Data from the gas chromatograph/ECD system is
taken into the computer 702 as a varying frequency, and
data from the IMS system is taken into the computer 702 as
a varying analog voltage. The data input to the control
and data processing system 700 is correlated by processor
10 702 to the process control module 708 which generates the
necessary interrupts for processor 702 so the data can be
input at the proper time intervals.

The computer 702 has an internal clock which
provides the reference clock for all timing sequences.
15 Therefore, because all the valves and mechanical motions
are being actuated by the computer, all gas and sample
flows in the equipment are controllable with respect to
the time of actuation. The relative sequencing and timing
of actuations are simply steps in a stored program in the
20 memory of the computer. In addition, all the temperatures
in the equipment are read into the computer and all
heating functions are actuated by the computer. There-
fore, all the temperatures and their magnitudes at any
time and rate of change with respect to time are under
25 program control. The data output from the chemical
analyzers from both the first and second sample collection
and analytical subsystems are processed as necessary and
the required information is extracted and displayed by the
same computer.
30

A unique feature of the present invention is
that of the use of a correlation and detection system. In

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1 a high throughput environment, such as an airport, with
overlapping sample acquisition and analyzer periods, there
exists a need for a means to positively verify the indi-
vidual or object sampled at the time the sample is taken,
5 in the event the sample contains the target molecules. In
the preferred embodiment, the analysis occurs approxi-
mately 12 seconds after the sample is taken, and in a fast
moving stream of luggage or individuals, identification
would be difficult if not impossible. Therefore, a video
10 imaging camera, either motion or still is provided to
record the image of the individual or luggage sampled.
This image is then correlated with the results of the
sample taken by computer 702. This video imaging means or
image capturing means is placed in a location such that it
15 can capture an image of whatever is in the sampling area
being sampled. For example, the imaging means can be
placed inside the sampling chamber portal 100, as illus-
trated by video camera 109 shown in Figure 3, or at a
convenient location to capture images(s) of luggage or
20 other objects entering or exiting the automated baggage/
parcel sampling chamber 300, and at a location convenient
to capture images(s) of individuals or objects being
sampled by the hand-held wand 200, shown in Figures 4
through 6.

25 The imaging means is placed in a location so as
to capture an image of an individual or object being
sampled by one of the various sampling means. The imaging
means can be placed in close proximity to the sampling
area or in a remote location where it can be more easily
30 hidden if desired. Whatever type of imaging means is
utilized, the captured image must be stored. The captured
image is either stored on a video cassette recorder or a

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1 separate storage device. If the image is stored on a
separate storage device, the video signal must be
digitized by any type of standard digitizing circuit.
Each stored image is given an identification code by the
control and data processing system because of the delay
5 between capturing an image and the analysis of the person
or object sampled. If either or both of the first and
second sample collection and analysis subsystems 400 and
500, shown in Figures 11A-11C, detect the presence of any
of the target materials, then an alarm is set. The
10 control and data processing system then requests the image
associated with a particular stored image from either the
video cassette recorder or the separate storage means by
its identification number. The control and data proc-
essing system then correlates the particular stored image
15 with the results of the chemical analysis. In normal
operation the images are saved only until the analysis is
completed. In the event of an alarm, the associated image
is flagged to prevent erasure. In addition, the correla-
tion and detection system comprises a video display so one
20 can view the image to determine the identity of the object
or individual who set off an alarm.

The computer program utilized to run the detec-
tion and screening system of the present invention in-
cludes the steps of defining target vapor and target
25 particulate parameter windows, wherein each window brack-
ets the systems response to each of the selected molecules
of interest that are indicative of a target material. The
program also includes the steps of defining a sampling
sequence having at least one sampling period, defining an
30 actuation sequence, enabling system operation, acquiring
data from the system, and then correlating or matching the

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1 acquired data with the parameters previously developed for
the target vapors and target particulates. The program
then enables a detection signal upon a match or corre-
lation between the acquired data and the target param-
eters. In addition, the computer program correlates the
5 acquired data with an image of the object or individual
being screened, so that when there is a correlation
between the acquired data and the target parameters, a
positive identification of the object or individual can be
made.

10 The step of defining target vapor and target
particulate parameter windows includes loading the CPU
memory attached to the chemical analyzers with the spe-
cific signature molecule profiles or signal patterns. The
step of defining a sampling sequence includes initializing
15 the parameters associated with the first and second sample
collection and analysis subsystems. The step of defining
the actuation sequence and the step of enabling system
operation includes the sequencing of the various oper-
ations associated with the collection, vaporization, and
20 desorption processes involved in the operation of the
detection screening system, as hereinbefore previously
described. The step of acquiring data and correlating the
acquired data with the target vapor and target particulate
parameters includes the step of performing the analysis,
25 collecting the output data and comparing the collected
data with the window parameters to determine if there is a
match. When different detectors are used for the first
and second subsystem, different profiles or signal pat-
terns are developed which are representative of that
30 detector's response to a specific target molecule of
interest.

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1 Figure 17 is a flow chart 800 showing the
overall process control as accomplished by the control and
data processing system and run by the digital computer
702. Block 802 of the flow chart 800 is simply the
5 starting point or entry into the entire software package.
The Run Diagnostics block 804 represents the block of
software that is responsible for self diagnostic and self
calibration. Basically, this block of software runs
various programs for exercising various aspects of the
10 detection and analysis routines. The Sample Air and
Enable Camera block 806 represents the block of software
that causes the air sample to be drawn from the portal,
the hand-held wand or the automated baggage/parcel sam-
pling chamber, and drawn into the first and second sample
15 collection and analytical subsystems. This software
controls the operation of the sampling actuator unit 710
shown in Figure 16. The Sample Air and Enable Camera
block 806 also represents the block of software respon-
sible for enabling a camera to capture an image of the
20 object or individual being sampled. The captured image is
then correlated to the chemical analysis data associated
with the sample drawn from the individual or object and is
then saved in memory for an archival record to be used as
an identification means. Typically, the images of an
25 individual or object will be saved for the last three to
six sampling periods, unless where one or more of the
target materials has been detected. After the Sample Air
and Enable Camera block 806, the flow chart 800 diverges
into two paths that run simultaneously. One path repre-
30 sents the operation of the first sample collection and
analytical subsystem while the second path represents the
operation of the second sample collection and analytical
subsystem.

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1 The first path in flow chart 800 is as follows:
The Rotate PCAD Filters block 808 represents the block of
software that is responsible for the rotation of the
rotating circular plane and the union and separation of
the first and second fixed plates. Basically, this block
5 of software controls the PCAD actuator unit 714 shown in
Figure 15. The Heat Collected Particulate Matter block
810 represents the block of software that is responsible
for the controlling of the vaporization process. This
10 block of software controls the flash heating process as
well as the gas flows utilized to inject the vaporized
sample into the chemical analyzer. This block of software
controls the interface actuator unit 712 shown in Figure
16. The Acquire Data block 812 represents the block of
15 software that is responsible for the acquisition of data
from the chemical analyzer(s) and the subsequent analysis
and preparation for display of the resultant data. In
addition, this block of software correlates the collected
data with the image of the individual or objects captured
20 by the camera means.

 The second path in the flow chart 800 is as
follows: The Rotate VCAD Filter block 814 represents the
block of software that is responsible for the rotation of
the second rotating circular plane and the union and
25 separation of the second pair of first and second fixed
plates. This block of software controls the VCAD actuator
unit 716 shown in Figure 16. The Desorb Vapor block 816
represents the block of software that is responsible for
the controlling of the heating means and the flow of pure
30 gas in the desorption process. The Rotate Six-Port Valve
block 818 represents the block of software that is respon-
sible for controlling the six-port valve utilized as the

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1 interface between the VCAD and the chemical analyzers of
the VCAD so that the concentrated sample volume of air is
properly routed to the analyzers. The Desorb Vapor block
816 and the Rotate Six-Port Valve block 818 both control
5 the operation of the interface actuator unit 712 shown in
Figure 16. The Acquire Data block 820 represents the
block of software that is responsible for the acquisition
of data from the chemical analyzer(s) 560 and the subse-
quent analysis and preparation for display of the re-
10 sultant data. In addition, this block of software cor-
relates the collected data with the image of the indi-
vidual or objects captured by the camera means.

Upon completion of the two Acquire Data blocks
812 and 820, the flow chart 800 is united once again. The
15 Display Data/Camera Picture block 822 represents the block
of software that is responsible for formatting the ac-
quired chemical analysis data in a format that is readily
displayed on a standard CRT and is easily understood. The
captured image or picture can also be displayed utilizing
20 standard display techniques. The entire software struc-
ture indicated in Figure 17 is a cyclic process and
following the step of block 822, returns to the Sample Air
and Enable Camera block 806 and continues until stopped.
The software further enables the system to run in a single
25 cycle mode, a continuous cycle mode or a pause mode. As
stated previously, the software routine is modularized and
therefore can be easily changed, updated, removed or added
on to.

Figure 18 is a flow chart 800' which shows an
30 identical process as does the flow chart 800 in Figure 17
with one exception. In flow chart 800', an additional
Rotate Six-Port Valve block 824 is inserted between the

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1 Heat Collected Particulate Matter block 810 and the
Acquire Data block 812. As before the Rotate Six-Port
Valve block 824 represents the block of software that is
responsible for controlling the six-port valve is utilized
5 as an interface when a gas chromatograph analyzer is
utilized.

There are basically three concepts that exist in
the screening process. The first concept involves both
the collection of vapors and particulates and their
subsequent analysis. Therefore, the first concept uti-
10 lizes both the first and second sample collection and
analytical subsystems. The second concept involves only
the collection of particulates and their subsequent
analysis. Therefore, the second concept utilizes only the
first sample collection and analytical subsystem. The
15 third concept involves just the collection of vapors and
their subsequent analysis. Therefore, the third concept
utilizes only the second sample collection and analytical
subsystem. The software is designed so that all three
concepts for screening require approximately 11.0 seconds
20 to complete whether run individually or simultaneously.
An initial delay is added to the PCAD cycle so that the
analysis of the PCAD system is completed at the same point
in time that the analysis of the PCAD system is completed.
This prevents confusion of test results when the system is
25 run in continuous mode. When run in continuous mode,
there is an overlap between the end of one screening cycle
and the beginning of a second screening cycle, with each
of the next screening cycles being completed each seven
seconds. This overlap occurs between the analysis and
30 display period of one screening cycle and the sample air
through vaporize/desorb periods of a second cycle. This

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1 overlap requires that the software tasks in the screening
process be run in a multi-tasking environment. In a
multi-tasking environment, the software routines are run
in a foreground/background scenario in a true interrupt
mode. The mechanical operations under software control
5 are run in background while the analysis and data processing functions are run in foreground. The flow charts of Figures 17 and 18 are general representations of the software and should not be construed as timing diagrams. Table 2 given below illustrates the required steps associated times involved in the screening procedure utilizing this multi-tasking environment.

	<u>STEP</u>	<u>PCAD</u>	<u>VCAD</u>
15	SAMPLE AIR	2.0	2.0
	ROTATE FILTERS	1.0	1.0
	VAPORIZE/DESORB	0.25-0.5	2.0
	INJECTION	0.25-0.5	1.0
20	ANALYSIS AND DISPLAY	1.0 AND 0.75	5.0

TABLE 2

It is important to note that the times given in
Table 2 reflect the absolute times for each of the processes and do not reflect the total time for one sampling cycle. Figure 19 is a sequence/timing diagram which better illustrates the various time parameters for each process in a sampling cycle or period. From 0.0 to 2.0
seconds, a sample volume of air is collected from either
the sampling chamber portal, the hand-held wand or the
automated baggage/parcel sampling chamber. From 2.0

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1 seconds to 3.0 seconds, the filters are rotated carrying
the collected materials to the next stage of processing.
From 3.0 to 5.0 seconds, the VCAD is concentrating the
vapors collected. During this time period, the PCAD is
5 idle. The vaporization and injection the collected
particulates collected is accomplished from 6.0 to 6.25-
6.50 seconds. From 5.0 to 6.0 seconds the concentrated
vapors from the VCAD are injected into the chemical
analyzers. From 6.0 to 11.0 second the analysis and
10 display of the VCAD sample is accomplished. From 8.0 to
9.0 seconds the analysis of the PCAD sample is accom-
plished and from 10.25 to 11.0 seconds the display of the
PCAD sample is accomplished. Therefore, both PCAD and
VCAD operations are completed simultaneously. A second
15 cycle or sampling period is shown starting at 7.0 seconds.
The second cycle is identical to the first.

Although shown and described in what is believed
to be the most practical and preferred embodiments, it is
apparent that departures from specific methods and designs
described and shown will suggest themselves to those
20 skilled in the art and may be used without departing from
the spirit and scope of the invention. The present
invention is not restricted to the particular construc-
tions described and illustrated, but should be constructed
to cover of all modifications that may fall within the
25 scope of the appended claims.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A portable detection and screening system for the detection of target vapors and/or target particulates associated with a defined class of target materials that includes explosives, chemical agents, drugs or narcotics, said system comprising:

a) a sampling means having a sequential series of sampling periods for gathering a sample volume of air from an individual or an object;

b) a first sample collection and analysis subsystem for collecting target particulates contained in said sample volume of air and for converting said collected target particulates into a first vapor sample for analysis;

c) a second sample collection and analysis subsystem for concentrating said target vapors contained in said sample volume of air, said second subsystem having first means for selectively concentrating said target vapors into a second vapor sample for analysis; and,

d) detection means in communication with said first and second subsystems and responsive to said target materials to generate a signal in response to the presence of said target materials in either said first or second vapor sample.

2. The portable detection and screening system of Claim 1, wherein said detection means further includes a first detector means for chemical analysis of said first vapor sample and a second detector means for chemical analysis of said second vapor sample for analysis.

3. The portable detection and screening system of Claim 2, wherein said sampling means includes a sample collection means, said sample collection means further comprises a suction fan for drawing said sample volume of

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1 air from said sampling means during a sample period and
delivering said sample volume of air to said first and
said second sample collection and analysis subsystems.

5 4. The portable detection and screening system
of Claim 3, wherein said sampling means is a hand-held
wand.

10 5. The portable detection and screening system
of Claim 3, wherein said first sample collection and
analysis subsystem includes a particulate collector which
further comprises:

(a) at least one filter element for preferen-
tially retaining target particulates contained in said
sample volume of air; and

15 (b) a vaporization chamber adapted to receive
said filter element, said vaporization chamber having
means for heating said filter element to flash vaporize
the retained target particulates into said first vapor
sample for analysis.

20 6. The portable detection and screening system
of Claim 3, wherein said first sample collection and
analysis subsystem further comprises:

(a) first, second and third filter elements for
selectively retaining target particulates contained in
said sample volume air;

25 (b) a collection chamber for receiving said
sample volume of air, said collection chamber adapted to
sequentially receive one of said first, second and third
filter elements to selectively enable one of said filter
elements to preferentially retain said target particulates
30 during said sampling period;

(c) a vaporization chamber adapted to receive
one of said first, second and third filter elements, said

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1 vaporization chamber having a first means for heating said
one of said filter elements to flash vaporize the retained
target particulates into said first vapor sample for
analysis; and

5 (d) a cleaning chamber adapted to receive said
one of said first, second, and third filter elements
following flash vaporization, said cleaning chamber having
a second means for heating said one of said filter ele-
ments to effectively vaporize any remaining particulate
matter retained thereon.

10 7. The portable detection and screening system
of Claim 6, wherein said first means for heating one of
said first, second and third filter elements is a first
pair of electrodes which supply a heating current directly
15 to said one of said filter elements to rapidly heat said
filter elements and flash vaporize said target particu-
lates into said first vapor sample for analysis.

20 8. The portable detection and screening system
of Claim 7, wherein said first sample collector and
vaporizer further comprises a first gas supply means which
continuously provides a first gas flow into said vapori-
zation chamber during flash vaporization to sweep vapor-
ized particulates into said first detector.

25 9. The portable detection and screening system
of Claim 8, wherein said vaporization chamber provides a
flash heat of 250 millisecond duration which results in a
rapid injection of said first vapor sample into said first
detector means.

30 10. The portable detection and screening system
of Claim 6, wherein said cleaning chamber includes a
second pair of electrodes which supply an electrical
current directly to said one of said filter elements in

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1 said cleaning chamber to thereby heat said filter element
and vaporize any remaining particulates.

5 11. The portable explosive detection screening
system of Claim 10, wherein said second pair of electrodes
supply a computer controlled current to generate a spe-
cific amount of heat energy to vaporize any particulate
matter remaining on said filter element, and a second gas
supply to provide a second gas flow which sweeps said
vaporized particulates into the ambient environment.

10 12. The portable detection and screening system
of Claim 3, wherein said second sample collection and
analysis subsystem further comprising:

15 (a) at least one filter element for preferen-
tially adsorbing said target vapors contained in said
sample volume of air; and

(b) a desorption chamber adapted to receive
said filter element, said desorption chamber having means
for generating a specific amount of heat energy to desorb
and adsorbed target vapors from said filter elements.

20 13. The portable detection and screening system
of Claim 3, wherein said second sample collection and
analysis subsystem further comprises:

25 (a) a first, second and third filter element
for preferentially adsorbing said target vapors contained
in said sample volume of air;

30 (b) a sampling chamber for receiving said
sample, said sampling chamber adapted to receive one of
said first, second and third filter elements to selec-
tively adsorb said target vapors during one of said
sampling periods;

(c) a desorption chamber adapted to receive
another said first, second and third filter elements, said

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desorption chamber having a first means for generating a first specific amount of energy to desorb any adsorbed target vapors from said filter means; and

(d) a flushing chamber adapted to receive the remaining one of said first, second and third filter elements, said flushing chamber having a second means for generating a second specific amount of heat to effectively desorb any remaining adsorbed vapor.

14. The portable explosive detection screening system of claim 13, wherein said first means is an electric heating element mounted in said desorption chamber which receives a first controlled current to raise the temperature of a first sweep gas, supplied by a first gas supply means, to a level sufficient to effectively desorb said target vapors from said filter elements and to sweep said concentrated vapor sample for analysis into said second detector means.

15. The portable explosive detection screening system of Claim 13, wherein said second means for heating is an electric heating element mounted in said flushing chamber and which receives a second controlled current to raise the temperature of a second sweep gas, supplied by a second gas supply means to a level sufficient to effectively desorb any remaining vapors from said filter elements.

16. The portable detection and screening system of Claim 1, wherein said detection means comprises a first detector means for chemical analysis of said first vapor sample and a second detector means for chemical analysis of said second vapor sample for analysis, said first detector means being included in said first sample collection and analysis subsystem, and said second detector means being included in said second sample collection and analysis subsystem.

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17. The portable detection and screening system of Claim 16, wherein said sampling means includes a sample collection means, said sample collection means further comprises a suction fan for drawing said sample volume of air from said portable sampling means during a sample period and delivering said sample volume of air to said first and second sample collection and analysis subsystems.

18. The portable detection and screening system of Claim 17, wherein said first sample collection and analysis subsystem further comprises:

(a) first, second and third filter elements for selectively retaining target particulates contained in said sample volume of air;

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1 (b) a collection chamber for receiving said
sample volume of air, said collection chamber adapted to
sequentially receive one of said first, second and third
filter elements to selectively enable one of said filter
elements to preferentially retain said target particulates
5 during said sampling period;

(c) a vaporization chamber adapted to receive
one of said first, second and third filter elements, said
vaporization chamber having a first means for heating said
one of said filter elements to flash vaporize the retained
10 target particulates into said first vapor sample for
analysis; and

(d) a cleaning chamber adapted to receive one
of said first, second, and third filter elements following
flash vaporization, said cleaning chamber having a second
15 means for heating said one of said filter elements to
effectively vaporized any remaining particulate matter
retained thereon.

19. The portable detection and screening system
of Claim 18, wherein said first means for heating one of
20 said first, second, and third filter elements is a first
pair of electrodes which supply a heating current directly
to one of said filter elements to rapidly heat said filter
elements and flash vaporize said target particulates into
said first vapor sample for analysis.
25

20. The portable detection and screening system
of Claim 19, wherein said first sample collector and
vaporizer further comprises a first gas supply means which
continuously provides a first gas flow into said vapori-
zation chamber during flash vaporization to sweep vapor-
30 ized particulates into said first detector.

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21. The portable detection and screening system of Claim 20, wherein said vaporization chamber provides a flash heat of 250 millisecond duration which results in a rapid injection of said first vapor sample into said first detector means.

22. The portable detection and screening system of Claim 20, wherein said cleaning chamber includes a second pair of electrodes which supply an electrical current directly to said one of said filter elements in said cleaning chamber to thereby heat said filter element and vaporize any remaining particulates.

23. The portable detection and screening system of Claim 22, wherein said second pair of electrodes supply a computer controlled current to generate a specific amount of heat energy to vaporize any particulate matter remaining on said filter element, and a second gas supply to provide a second gas flow which sweeps said vaporized particulates into the ambient environment.

24. The portable detection and screening system of Claim 23, wherein said collection chamber, said vaporization chamber and said cleaning chamber are formed from first and second plates, said first and second plates each defining a plurality of half chambers which together define each of said collection, vaporization, and cleaning chambers.

25. The portable detection and screening system of Claim 16, wherein said second sample collection and analysis subsystem further comprises:

(a) a first, second and third filter element for preferentially adsorbing said target vapors contained in said sample volume of air;

(b) a sampling chamber for receiving said sample volume, said sampling chamber adapted to receive one of said first,

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second and third filter elements to selectively adsorb said target vapors during one of said sampling periods;

(c) a desorption chamber adapted to receive another said first, second and third filter elements, said desorption chamber having a first means for generating a first specific amount of energy to desorb any adsorbed target vapors from said filter means; and

(d) a flushing chamber adapted to receive the remaining one of said first, second and third filter elements, said flushing chamber having a second means for generating a second specific amount of heat to effectively desorb any remaining adsorbed vapor.

26. The portable detection and screening system of Claim 25, wherein said first means is an electric heating element mounted in said desorption chamber which receives a first controlled current to raise the temperature of a first sweep gas, supplied by a first gas supply means, to a level sufficient to effectively desorb said target vapors from said filter elements and to sweep said second vapor sample for analysis into said second detector.

27. The portable detection and screening system of Claim 26, wherein said second means for heating is an electric heating element mounted in said cleaning chamber and which receives a second controlled current to raise the temperature of a second sweep gas, supplied by a second gas supply means to a level sufficient to effectively desorb any remaining vapors from said filter elements.

28. The portable detection and screening system of Claim 27, wherein said sampling chamber, said desorption chamber and said cleaning chamber are formed from the union of a first and second plate, said first and second plates each comprise half chambers having approximately one half the volume of each of said chambers.

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29. The portable detection and screening system of Claim 24, wherein said first plate further includes an O-ring sealing means fastened around the perimeter of each of said half chambers to create an air tight seal when said second plate is joined thereto; wherein said collection chamber, said vaporization chamber and said cleaning chamber are each arranged 120 degrees apart; wherein said system further includes a rotating plate disposed between said first and second plates, said first, second, and third filter elements being arranged 120 degrees apart therein in alignment with said collection, vaporization and cleaning chambers, said first, second, and third filter elements being wholly contained within one of said collection, vaporization, and cleaning chambers when said first and second plates are joined together; wherein said first sample collection and analysis subsystem further comprises a first motor means for rotating said rotating plate 120 degrees between said sampling periods to rotate said first filter element between said collection chamber, said vaporization chamber, and said cleaning chamber, and an electro-mechanical means for reciprocally joining the first and second plates together during a sampling period and separating said first and second plates during the rotation of said rotating plate; wherein said first filter element is within said collection chamber, said second filter element is within said vaporization chamber, and said third filter element is within said cleaning chamber during a first sampling period, and said first filter element is within said vaporization chamber, said second filter element is within said cleaning chamber, and said third filter element is within said collection chamber during the next sequential sampling period; wherein said rotating plane is disposed between said first and second plates, said three holes covered with said first, second and third filter elements are arranged 120 degrees apart from each other such that they line up with said sampling chamber, said desorption chamber and said flushing chamber and are wholly contained within one of said sampling, desorption, and flushing chambers

when said first and second plates are joined together; wherein said second sample collection and analysis subsystem further comprises a second motor means for rotating said rotating plate 120 degrees between said sampling periods to rotate said first filter element between said sampling chamber, said desorption chamber, and said flushing chamber, and an electromechanical means for reciprocally joining the first and second plates together during a sampling period and separating said first and second plates during the rotation of said rotating plate; and wherein said first filter element is within said sampling chamber, said second filter element is within said desorption chamber, and said third filter element is within said flushing chamber during a first sampling period, and said first filter element is within said desorption chamber, said second filter element is within said flushing chamber, and said third filter element is within said sampling chamber during the next sequential sampling period.

30. A portable detection and screening system as defined in claim 1, wherein said first sample collection and analysis subsystem comprises:

first, second and third filter elements for selectively retaining target particulates contained in said sample volume of air, and a first detector means for chemical analysis of said first vapor sample; and wherein

said second subsystem has first means for selectively concentrating said target vapors into a second vapor sample for analysis, said second sample collection and analysis subsystem comprising first, second and third filter elements for preferentially adsorbing said target vapors contained in said sample volume of air, and a second detector means for chemical analysis of said second vapor sample.

31. The portable detection and screening system of Claim 30, wherein said first sample collection and analysis subsystem further comprises:

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(a) a collection chamber for receiving said sample volume of air, said collection chamber adapted to sequentially receive one of said first, second and third filter elements to selectively enable one of said filter elements to preferentially retain said target particulate during said sampling period;

(b) a vaporization chamber adapted to receive one of said first, second and third filter elements, said vaporization chamber having a first means for heating said one of said filter elements to flash vaporize the retained target particulates into said first vapor sample for analysis, said second means for heating comprises a second pair of electrodes which supply an electrical current directly to one of said filter elements in said cleaning chamber to thereby heat said filter element and vaporize any remaining particulates; and

(c) a cleaning chamber adapted to receive said one of said first, second, and third filter elements following flash vaporization, said cleaning chamber having a second means for heating said one of said filter elements to effectively vaporize any remaining particulate matter retained thereon, said second means for heating comprises a second pair of electrodes which supply an electrical current directly to said one of said filter elements in said cleaning chamber to thereby heat said filter element and vaporize any remaining particulates.

32. The portable detection and screening system of claim 31, wherein said vaporization chamber provides a flash of heat of 250 millisecond duration which results in a rapid injection of said first vapor sample into said first detector means.

33. The portable detection and screening system of Claim 31, wherein said vaporization chamber provides a flash of heat of 250 millisecond duration which results in a rapid injection of said first vapor sample into a multi-port valve.

34. The portable detection and screening system of Claim 33, wherein said multi-port valve is a three-way valve which acts as an interface between said vaporization chamber and said first detector, which vents said first vapor sample for analysis into said first detector means during an analysis phase of said sampling period and vents said first gas flow to the ambient environment during a non-analysis phase of said sampling period.

35. The portable detection screening system of Claims 31 or 34, wherein said first detector means includes an ion mobility spectrometer.

36. The portable detection and screening system of Claim 31, wherein said first sample collection and analysis subsystem further includes a six-port valve, said six-port valve is an interface between said vaporization chamber and said first detector means and vents said first vapor sample for analysis into said first detector means during an analysis phase of said sampling period and vents a second gas flow supplied from a second gas flow means to said first detection means during a non-analysis phase of said sampling period.

37. The portable detection and screening system of Claim 36, wherein said six-port valve includes an adsorption/desorption tube connected across two of said six ports, said six-port valve having means for rotating said six-port valve between a first adsorb position and a second desorb position; wherein said means for rotating said six-port valve is a first gear head motor; wherein said sample volume is passed through said adsorption/desorption tube when said six-port valve is in said first adsorb position; wherein said sample volume is desorbed and swept into said first detector means by said first gas flow from said first gas supply means, when said six-port valve is in said desorb position; wherein a controlled electric current is used to heat said adsorption/desorption tube to a

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predetermined temperature; and wherein said first detector means is a gas chromatograph/ECD which detects the presence of said target materials.

38. The portable detection and screening system of Claim 30, wherein said second sample collection and analysis subsystem further comprises:

(a) a rotating plate for mounting said first, second and third filter elements therein;

(b) a sampling chamber for receiving said sample volume, said sampling chamber adapted to receive one of said first, second and third filter elements to selectively adsorb said target vapors during one of said sampling periods;

(c) a desorption chamber adapted to receive another said first, second and third filter elements, said desorption chamber having a first means for generating a first specific amount of energy to desorb any adsorbed target vapors from said filter means, said first means is an electric heating element mounted in said desorption chamber which receives a first controlled current to raise the temperature of a first sweep gas, supplied by a first gas supply means, to a level sufficient to effectively desorb said target vapors from said filter elements and to sweep said concentrated vapor sample for analysis into a multi-port valve; and

(d) a cleaning chamber adapted to receive the remaining one of said first, second and third filter elements, said cleaning chamber having a second means for generating a second specific amount of heat to effectively desorb any remaining adsorbed vapor, said second means for heating is an electric heating element mounted in said cleaning chamber and which receives a second controlled current to raise the temperature of a second sweep gas, supplied by a second gas supply means to a level sufficient to effectively desorb any remaining vapors from said filter elements.

39. The portable detection and screening system of

Claim 29, wherein the upper half of said desorption chamber is conically shaped to enhance the vapor concentration process, said conically shaped upper half is formed by placing a ceramic bushing inside said first plate; wherein said second sample collector and analysis system further comprises a vacuum motor which draws debris from said cleaning chamber, said vacuum motor is connected to said cleaning chamber through a fitting in the second plate; wherein said second sample collection and analysis system further comprises a six-port valve which is an interface between said desorption chamber and said second detector means and vents said second vapor sample for analysis into said second detector during an analysis phase of said sampling period and vents a second gas flow from a second gas supply means to said second detector during a non-analysis phase of said sampling period; and wherein said second detector is a gas chromatograph/electron detection system which detects the presence of said target materials and outputs a second alarm signal if said target materials are detected.

40. The portable detection and screening system of Claim 39, wherein said second detector is an ion mobility spectrometer detection system which detects the presence of said target materials and outputs a second alarm signal if said target materials are detected.

41. The portable detection and screening system of Claim 40, wherein said first sample collection and analysis subsystem further comprises:

(a) first, second and third filter elements for selectively retaining target particulates contained in said sample volume of air;

(b) a collection chamber for receiving said sample volume of air, said collection chamber adapted to sequentially receive one of said first, second and third filter elements to selectively enable one of said filter elements to preferentially retain said target particulate during said

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sampling period;

(c) a vaporization chamber adapted to receive one of said first, second and third filter elements, said vaporization chamber having a first means for heating said one of said filter elements to flash vaporize the retained target particulates into said first vapor sample for analysis, said first means for heating said one of said first, second and third filter elements is a first pair of electrodes which supply a heating current directly to said one of said filter elements to rapidly heat said filter elements and flash vaporize said target particulates into said first vapor sample for analysis; and

(d) a cleaning chamber adapted to receive said one of said first, second and third filter elements following flash vaporization, said cleaning chamber having a second means for heating said one of said filter elements to effectively vaporize any remaining particulate matter retained thereon, said second means for heating comprises a second pair of electrodes which supply an electrical current directly to said one of said filter elements in said cleaning chamber to thereby heat said filter element and vaporize any remaining particulates.

42. The portable detection and screening system of Claim 40, wherein said second sample collection and analysis subsystem further comprises:

(a) a rotating plate for mounting first, second and third filter elements therein;

(b) a sampling chamber for receiving said sample volume, said sampling chamber adapted to receive one of said first, second and third filter elements to selectively adsorb said target vapors during one of said sampling periods;

(c) a desorption chamber adapted to receive another said first, second and third filter elements, said desorption chamber having a first means for generating a first specific amount of energy to desorb any adsorbed target vapors from said

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filter means, said first means is an electric heating element mounted in said desorption chamber which receives a first controlled current to raise the temperature of a first sweep gas, supplied by a first gas supply means, to a level sufficient to effectively desorb said target vapors from said filter elements and to sweep said concentrated vapor sample for analysis into a multi-port valve; and

(d) a cleaning chamber adapted to receive the remaining one of said first, second and third filter elements, said cleaning chamber having a second means for generating a second specific amount of heat to effectively desorb any remaining adsorbed vapor, said second means for heating is an electric heating element mounted in said cleaning chamber and which receives a second controlled current to raise the temperature of a second sweep gas, supplied by a second gas supply means to a level sufficient to effectively desorb any remaining vapors from said filter elements.

43. The portable detection and screening system of Claim 42, wherein said first, second and third filter elements each comprise:

(a) a hard anodized aluminum frame, said frame having a groove for receiving an O-ring mounted around said vaporization chamber, said vaporization chamber or said cleaning chamber to provide air tight seal when reciprocally joined thereto,

(b) first and second electrodes mounted on said first frame to conduct said current to said filters during flash vaporization,

(c) a stainless steel mesh screen which is engaged by said first and second electrodes.

44. The portable detection and screening system of Claim 43, wherein said filter elements comprise:

(a) a hard anodized aluminum frame, said frame defining a groove for receiving an O-ring around said vaporization chamber when reciprocally joined thereto;

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(b) first and second electrodes mounted on said frame to conduct said current to said filters; and

(c) a nickel mesh screen which is engaged by said first and second electrodes.

45. The portable detection and screening system of Claim 42, wherein each of said first, second, and third filter elements comprises:

(a) a frame constructed from anodized aluminum which is hard anodized, said frame having a lip with a groove in which an O-ring is set to provide an air tight seal when in said sampling chamber, said desorption chamber and said cleaning chamber;

(b) first and second stainless steel mesh screens held in said frame by a plate, said first and second stainless steel mesh screens forming a cavity therebetween, said cavity comprising a measured adsorbent material with an affinity to adsorb the targeted materials; and

(c) a holding pin for placing the filter in a tight fit within said rotating plate.

46. A portable detection and screening system for the detection of target vapors and/or target particulates associated with a defined class of target materials that includes explosives, chemical agents, drugs or narcotics, said system comprising:

a) sampling means for gathering a sample volume of air from a specific area on an individual or object that may contain vapor or particulate emissions of said target materials, said sampling occurring in a first sampling period;

b) means for concentrating said target vapors or vapors emanating from said target particulates contained in said sample volume of air, said means including means for collecting said target vapors or particulate emissions at a first location;

c) means for transporting said collected target vapors or

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particulate emissions to a second location;

d) means for desorbing said target vapors or particulate emissions at said second location in a second sampling period; and

e) detection means responsive to said target vapors or particulate emissions desorbed at said second location to generate a signal in response to the presence of said target materials in said sample volume,

wherein said sampling means is capable of collecting a new sample volume of air containing target vapors or particulate emissions at said first location during said second sampling period.

47. A portable detection and screening system as claimed in Claim 1, further comprising:

(e) a sampling area in which said sampling means is utilized to sample said individual or object;

(f) video imaging means for capturing an image of said individual or object sampled;

(g) means for analyzing a sample collected by said means for sampling; and

(h) a data processing means for correlating said captured image with data output from said means for analyzing.

48. The system of Claim 47, wherein said sampling means is a hand-held wand.

49. The system of Claim 47, wherein said sampling means is a sampling chamber portal.

50. The system of Claim 47, wherein said sampling means is an automated baggage/parcel sampling chamber.

51. The system of Claim 47, wherein said means for analyzing comprises:

(a) first means for generating a first alarm upon

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detection of said target vapors; and

(b) second means for generating a second alarm upon detection of said vapors from target particulates.

52. The system of Claim 51, wherein said video imaging means is a video recorder.

53. The system of Claim 51, wherein said video imaging means is a still video image camera.

54. The system of claims 52 or 53, wherein said correlation and detection system further comprises a video cassette recorder connected to said video imaging means.

55. The system of Claims 52 or 53, wherein said correlation and detection system further comprises a separate storage means connected to said video imaging means.

56. The system of Claim 54, wherein said data processing means transmits an identification code to said video cassette recorder.

57. The system of Claim 55, wherein said data processing means transmits an identification code to said separate storage means.

58. The system of Claims 56 or 57, wherein said data processing means receives said stored image upon a first or second alarm.

59. The system of Claim 58, wherein the system further comprises a video display means to display said captured image.

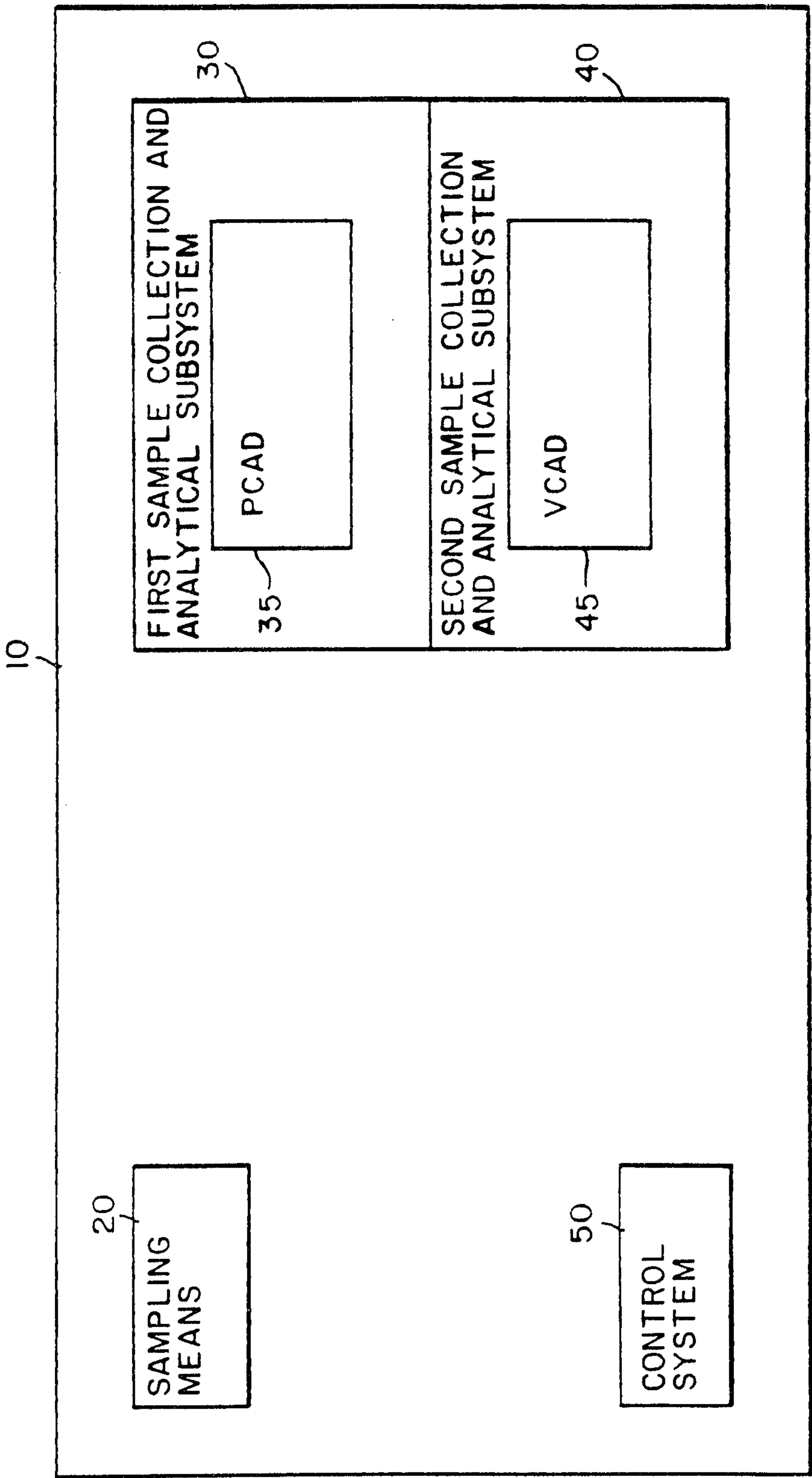


FIG. 1A

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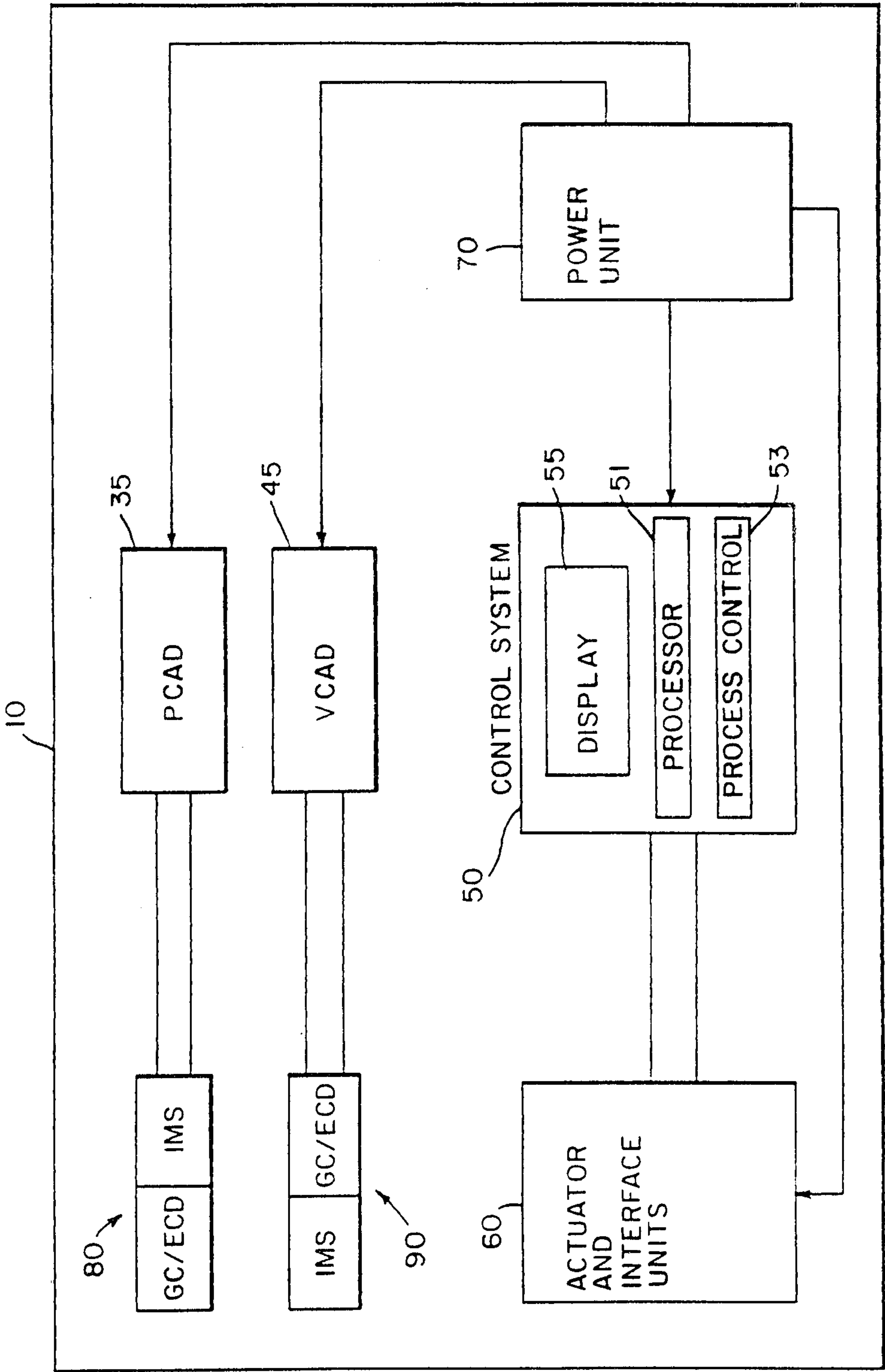


FIG. 1B

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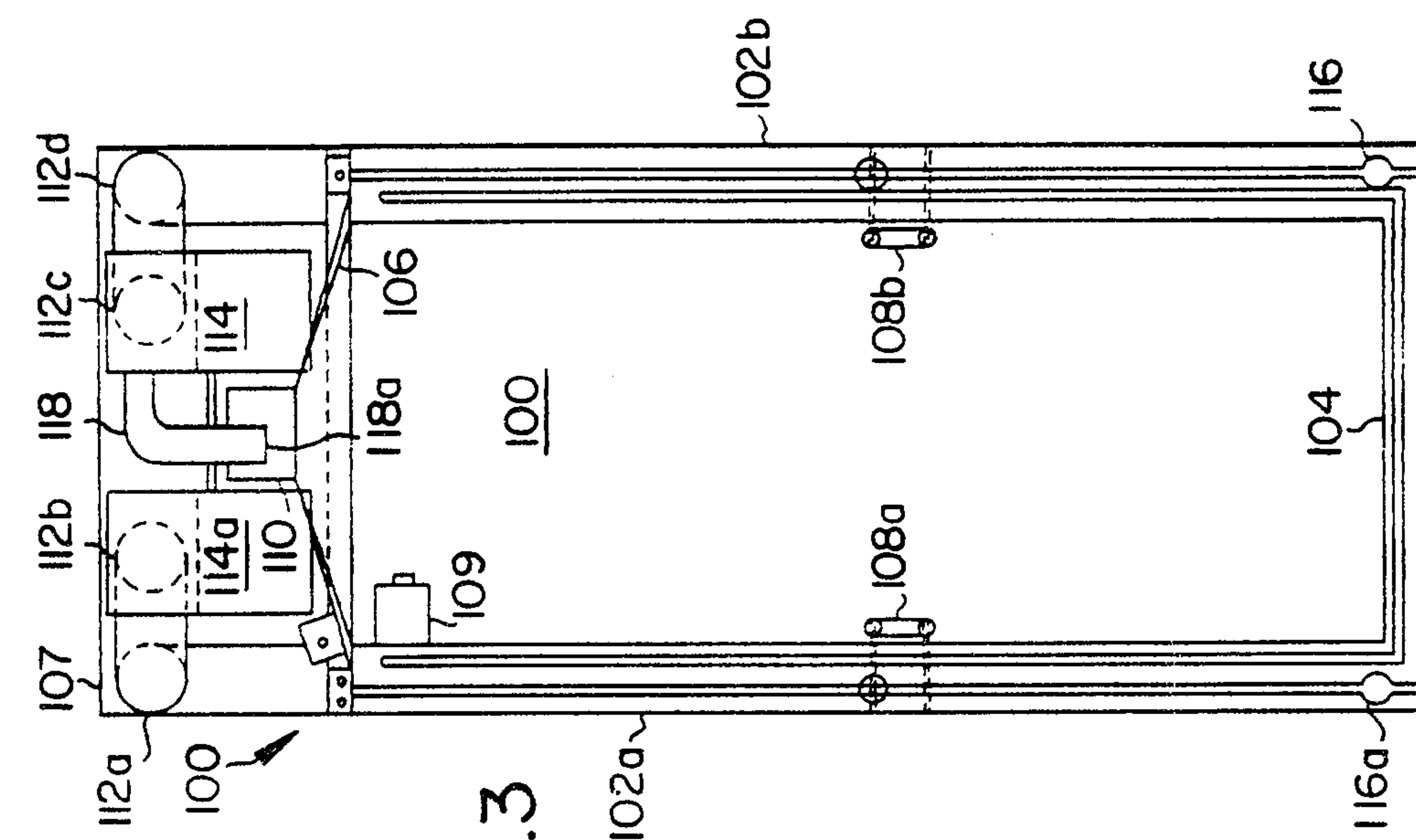


FIG. 3

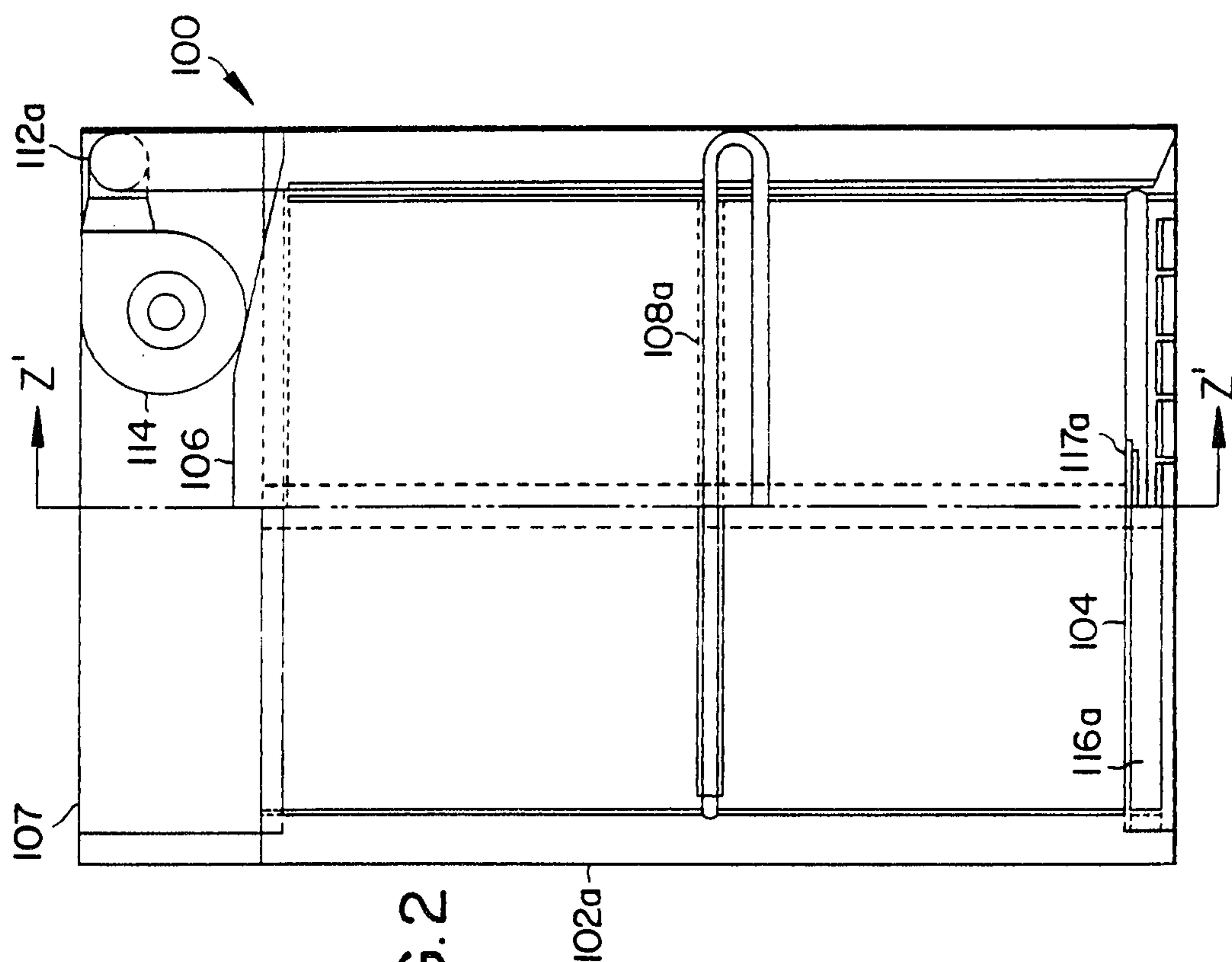


FIG. 2

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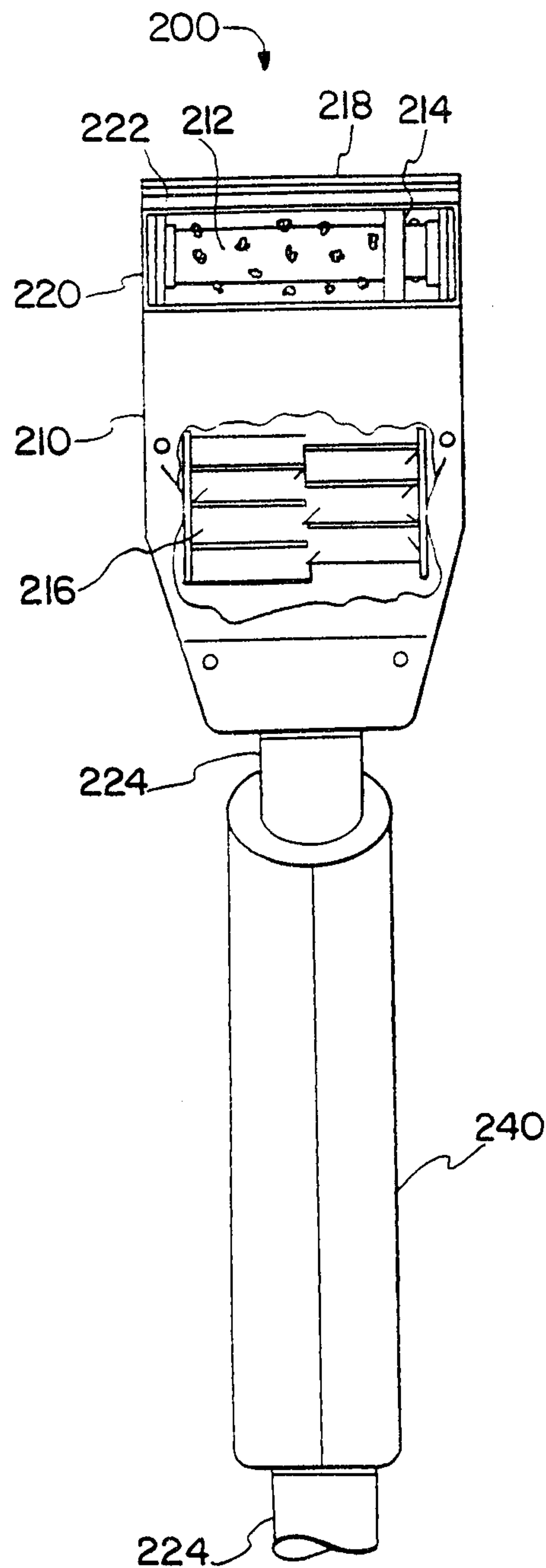


FIG. 4

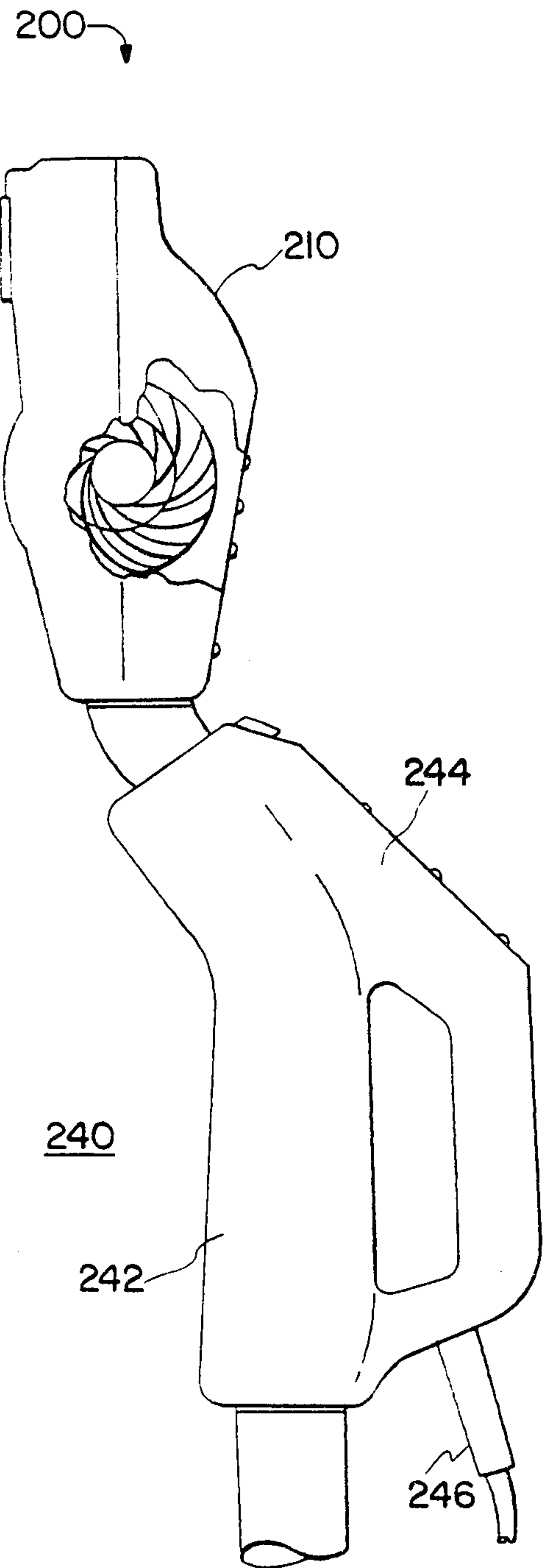
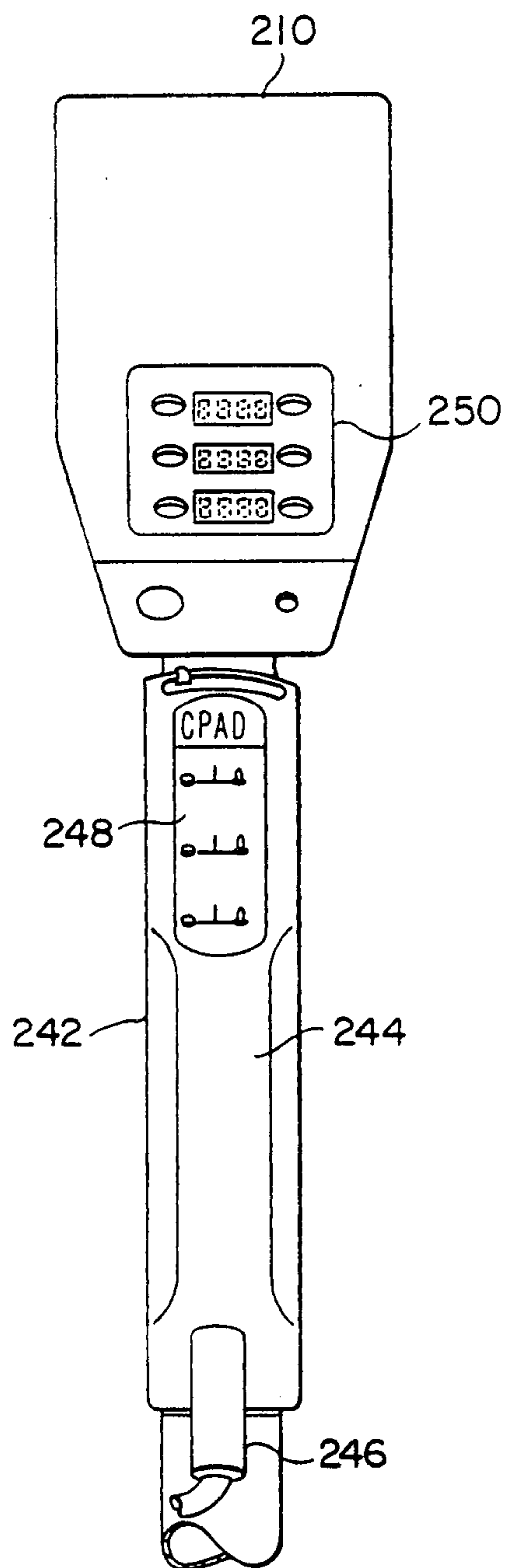


FIG. 5

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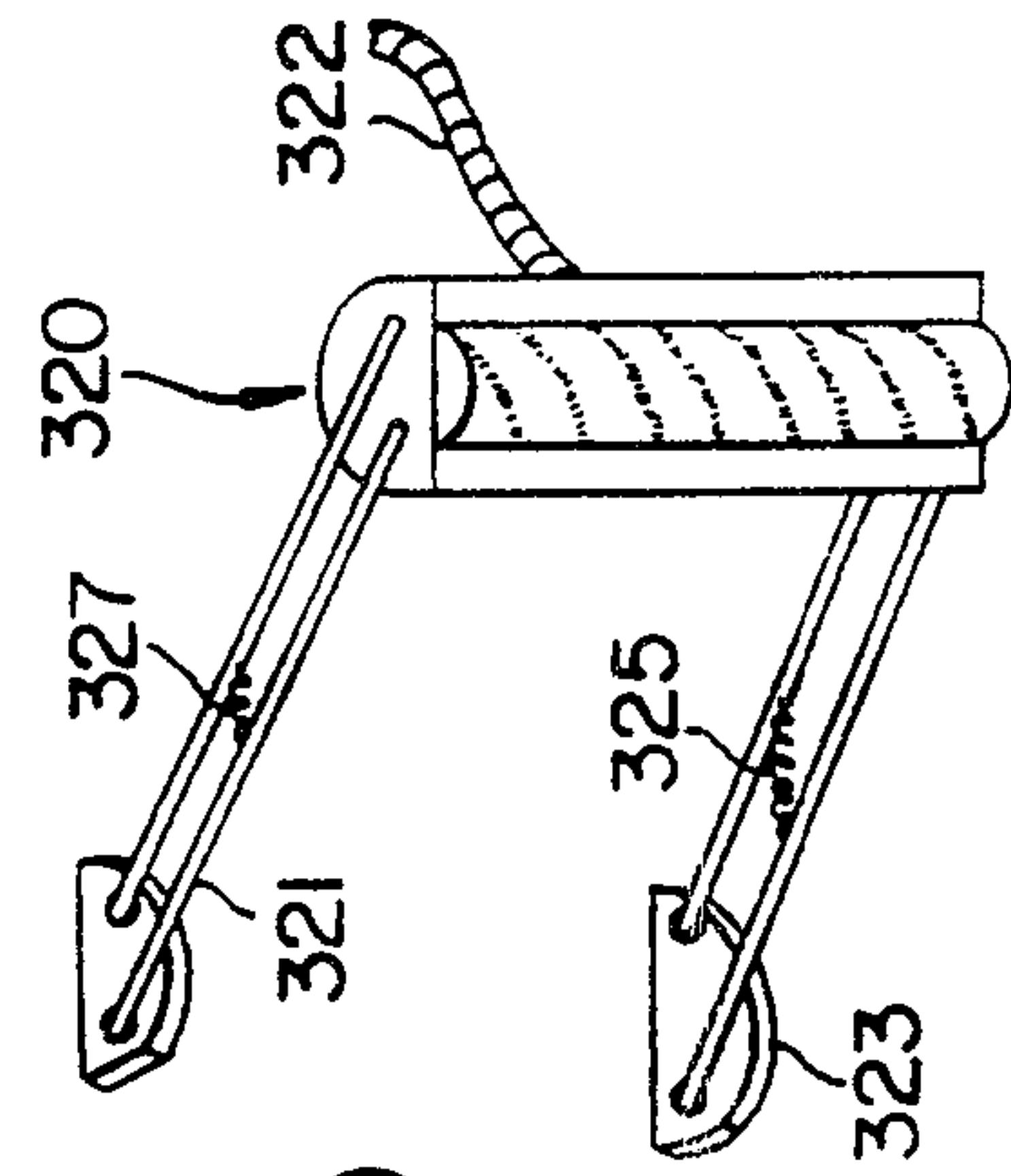
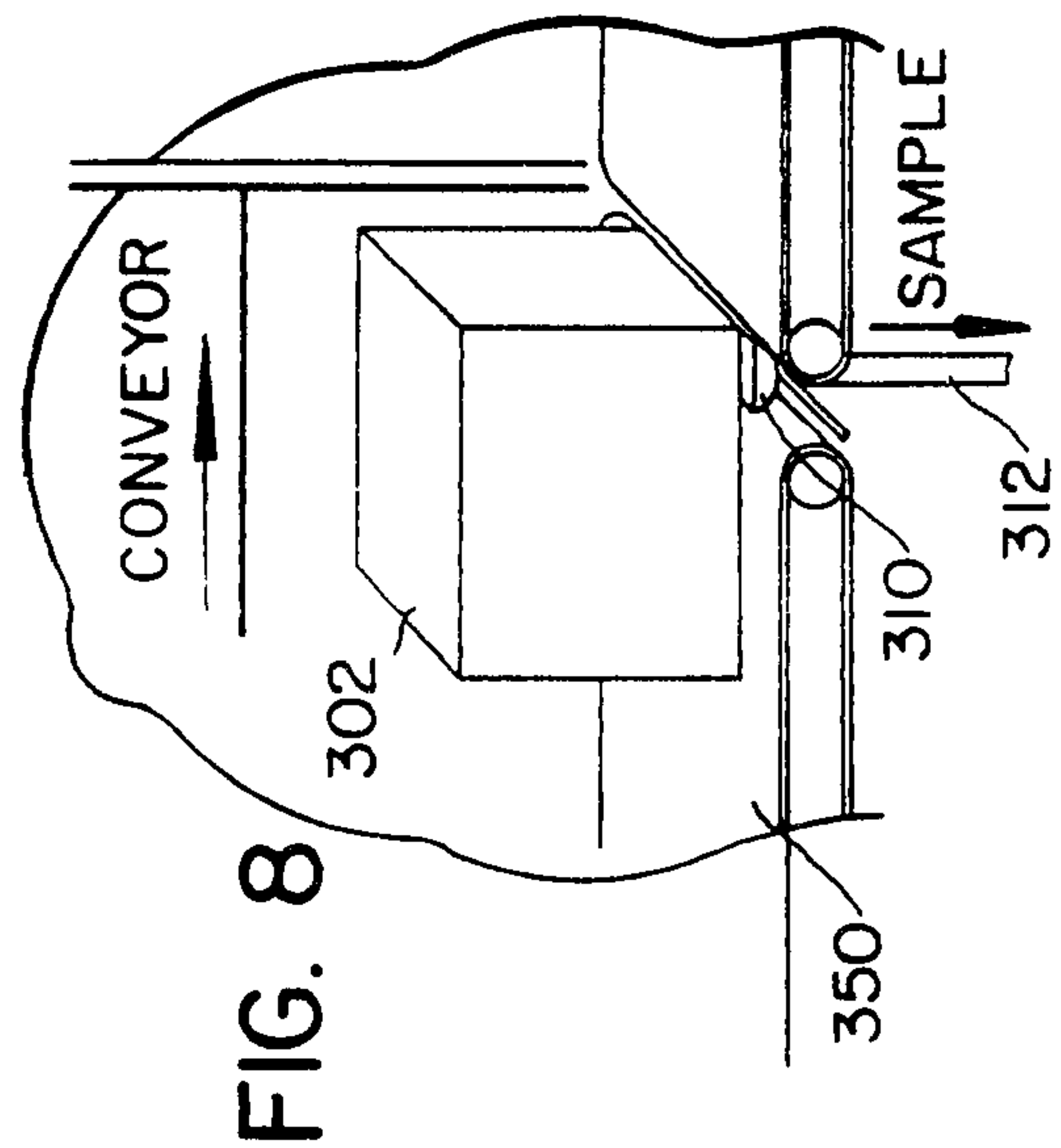
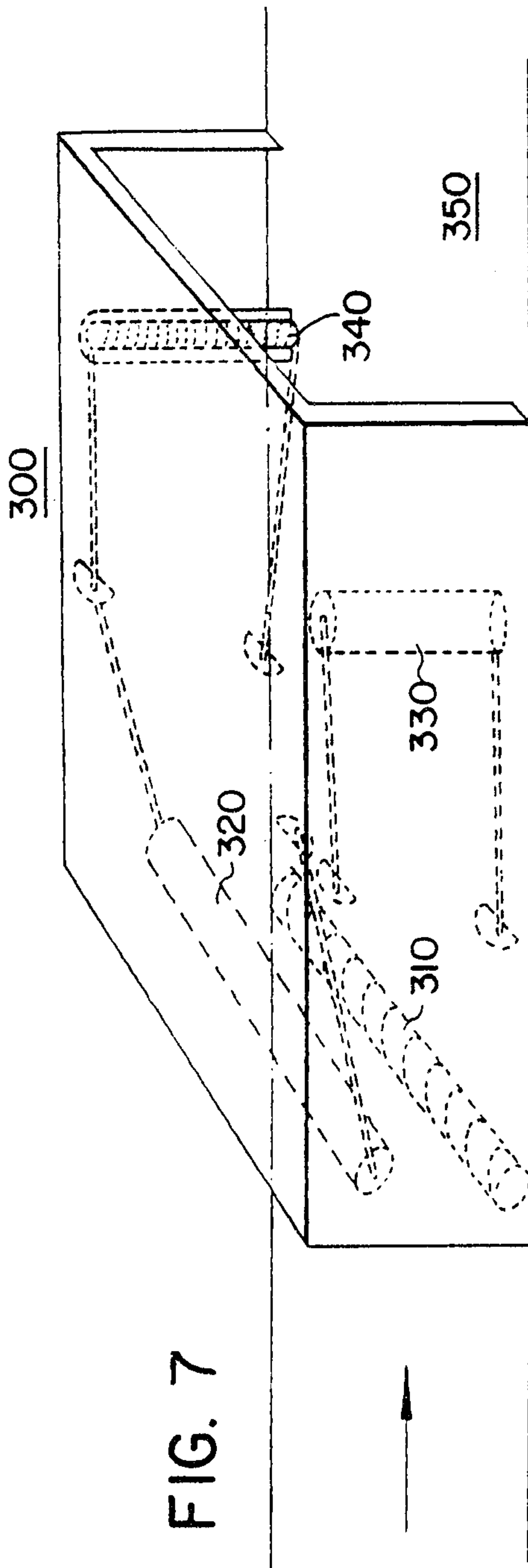
FIG. 6



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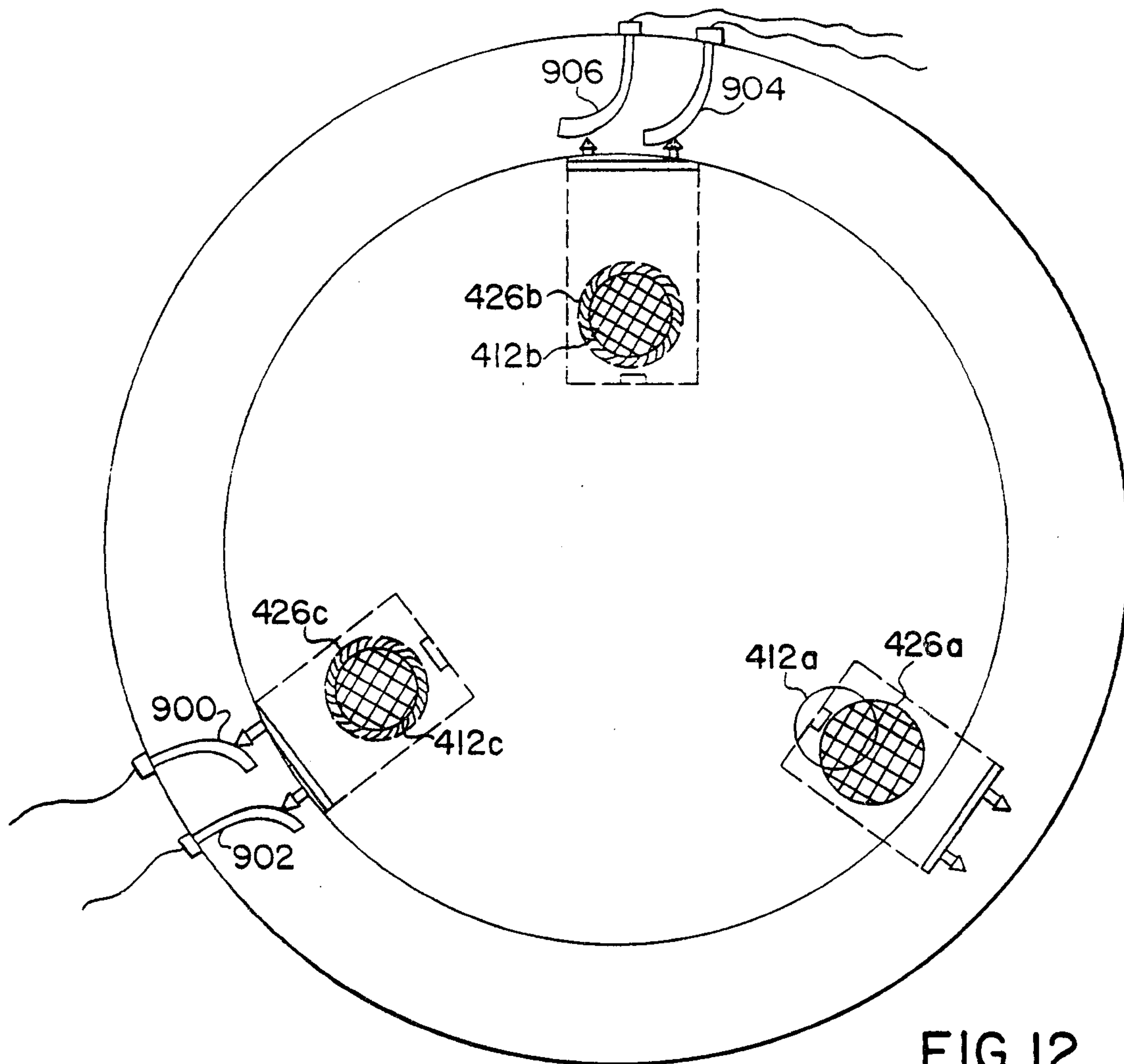


FIG. 12

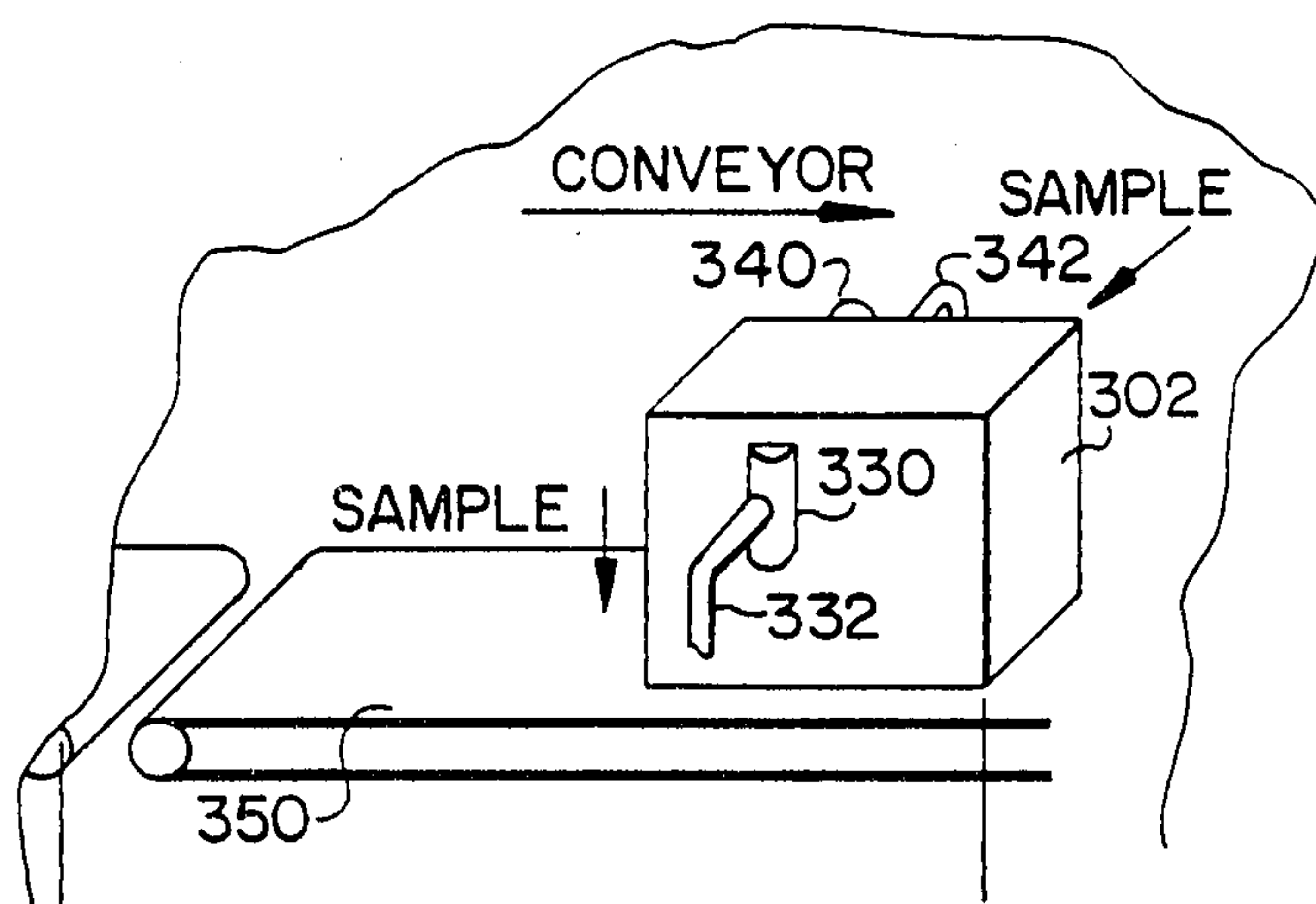
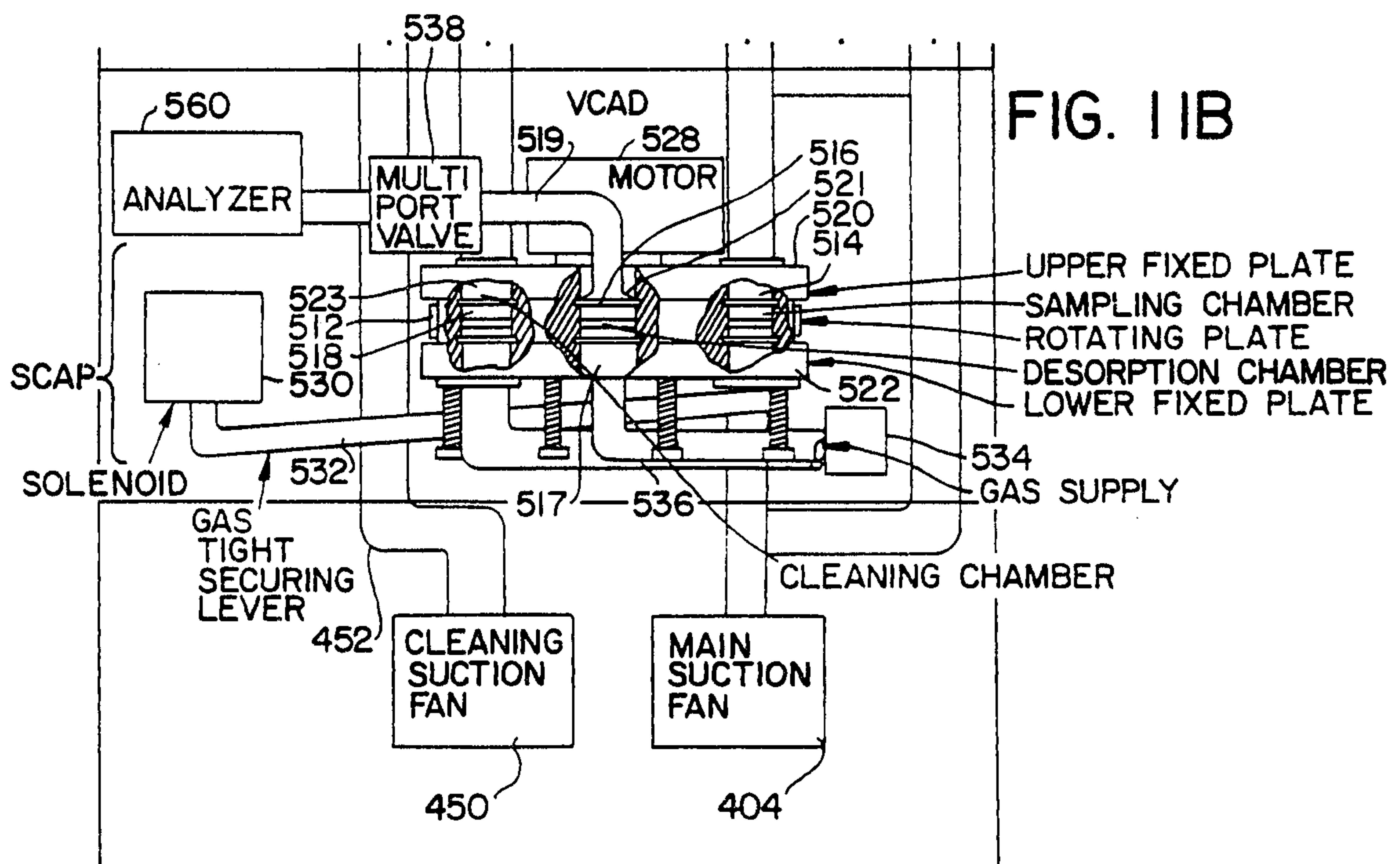
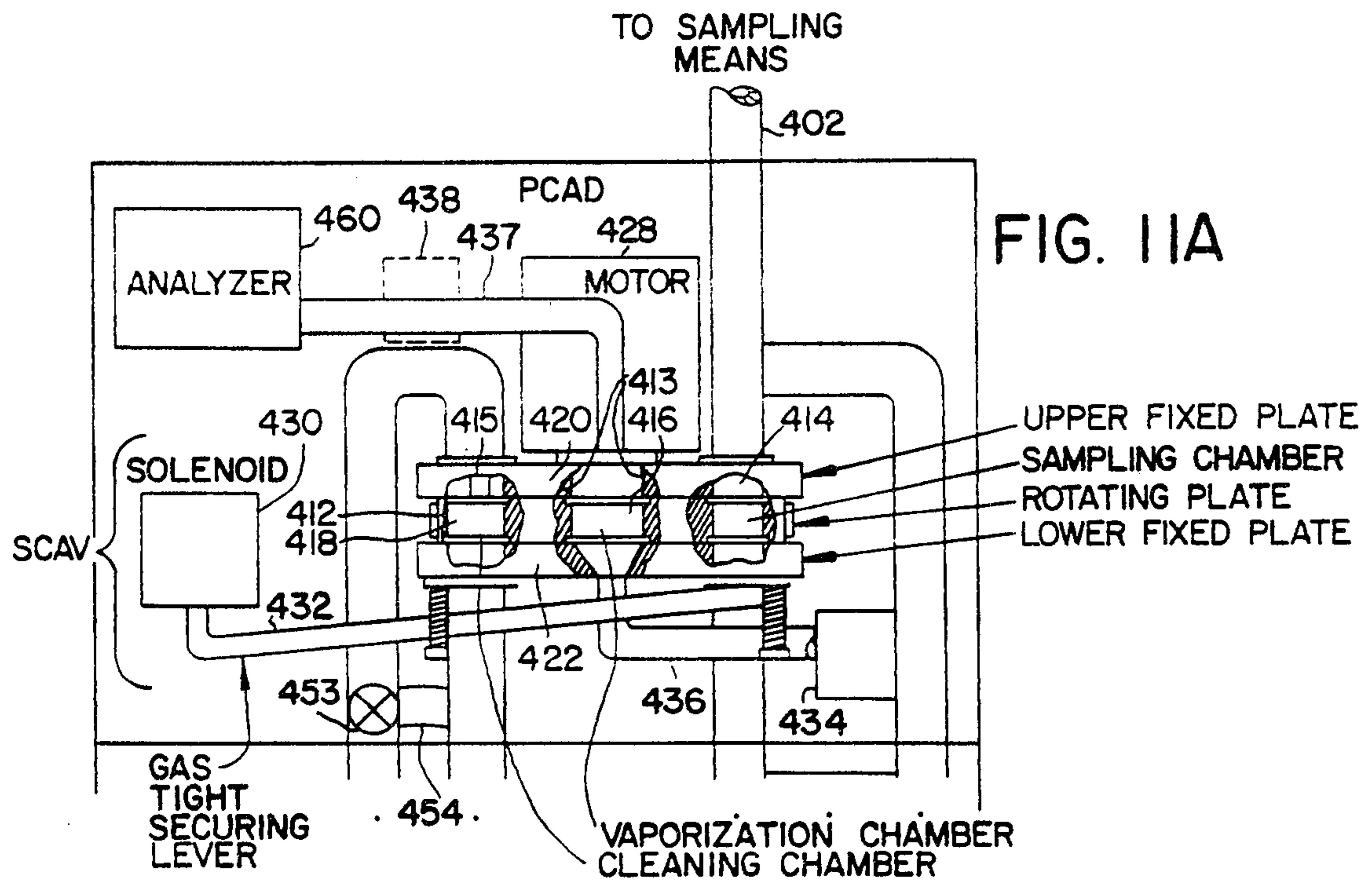


FIG. 10

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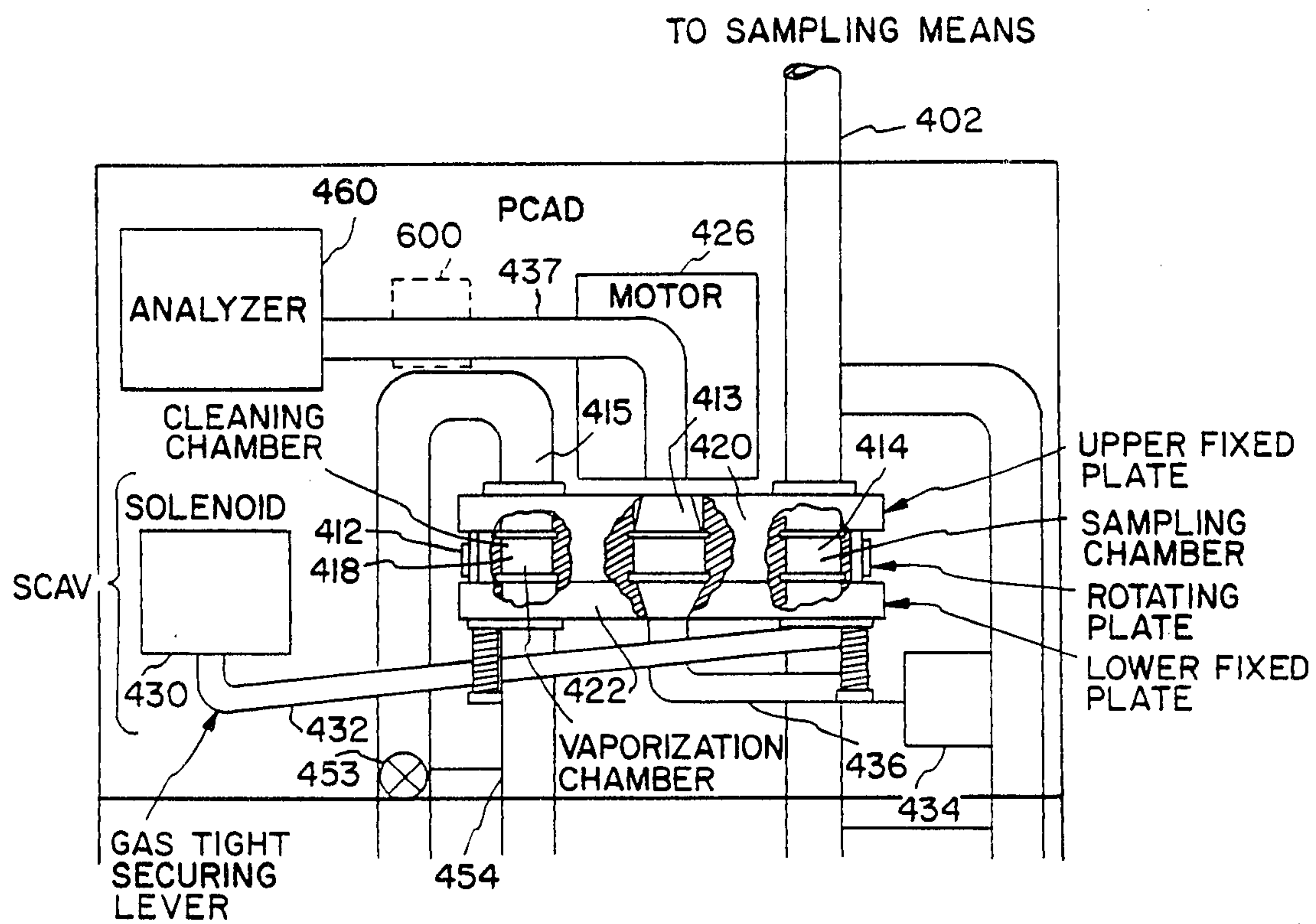


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FIG. 11C

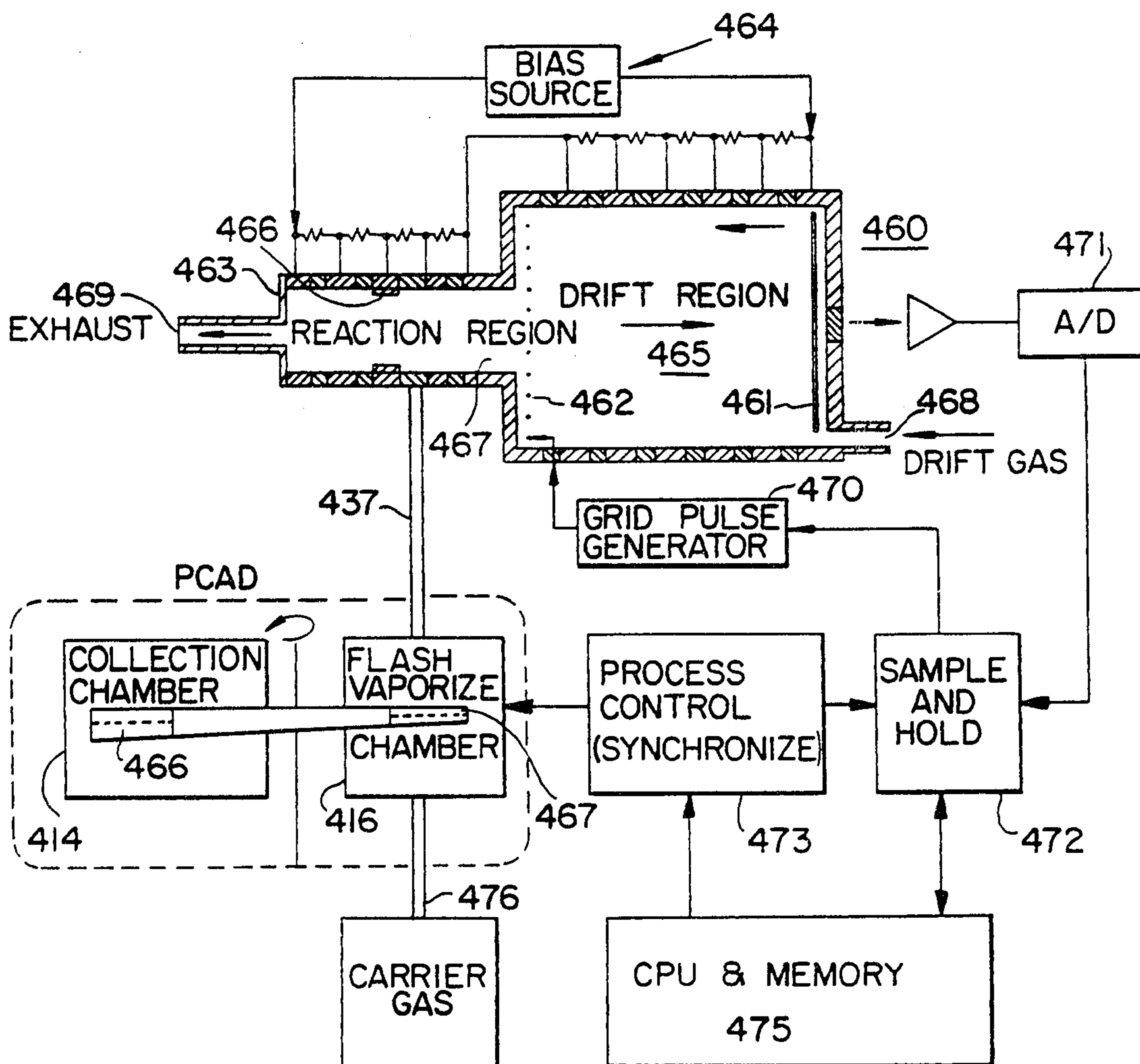


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FIG. IID

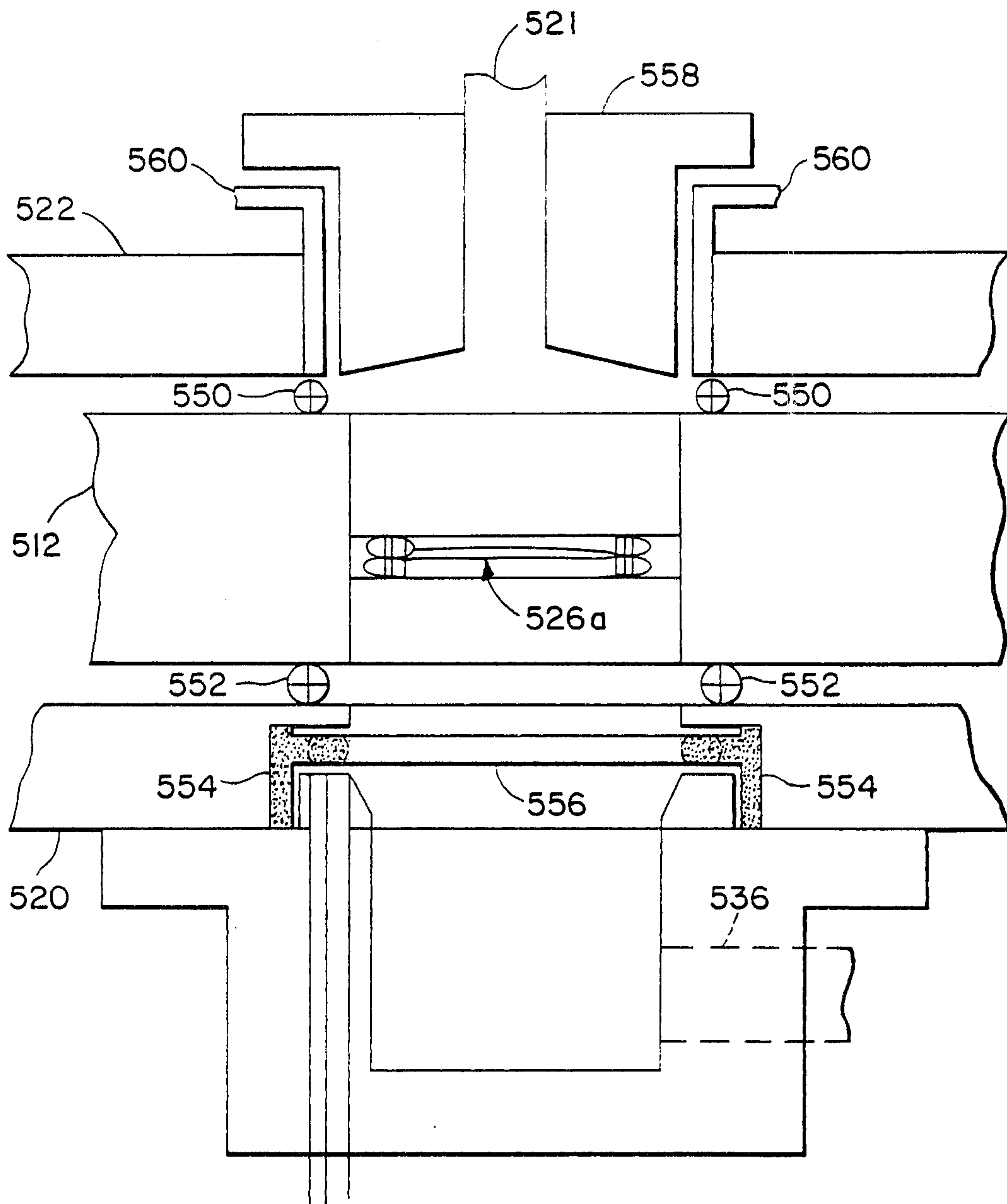


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FIG. IIE



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FIG. 13A

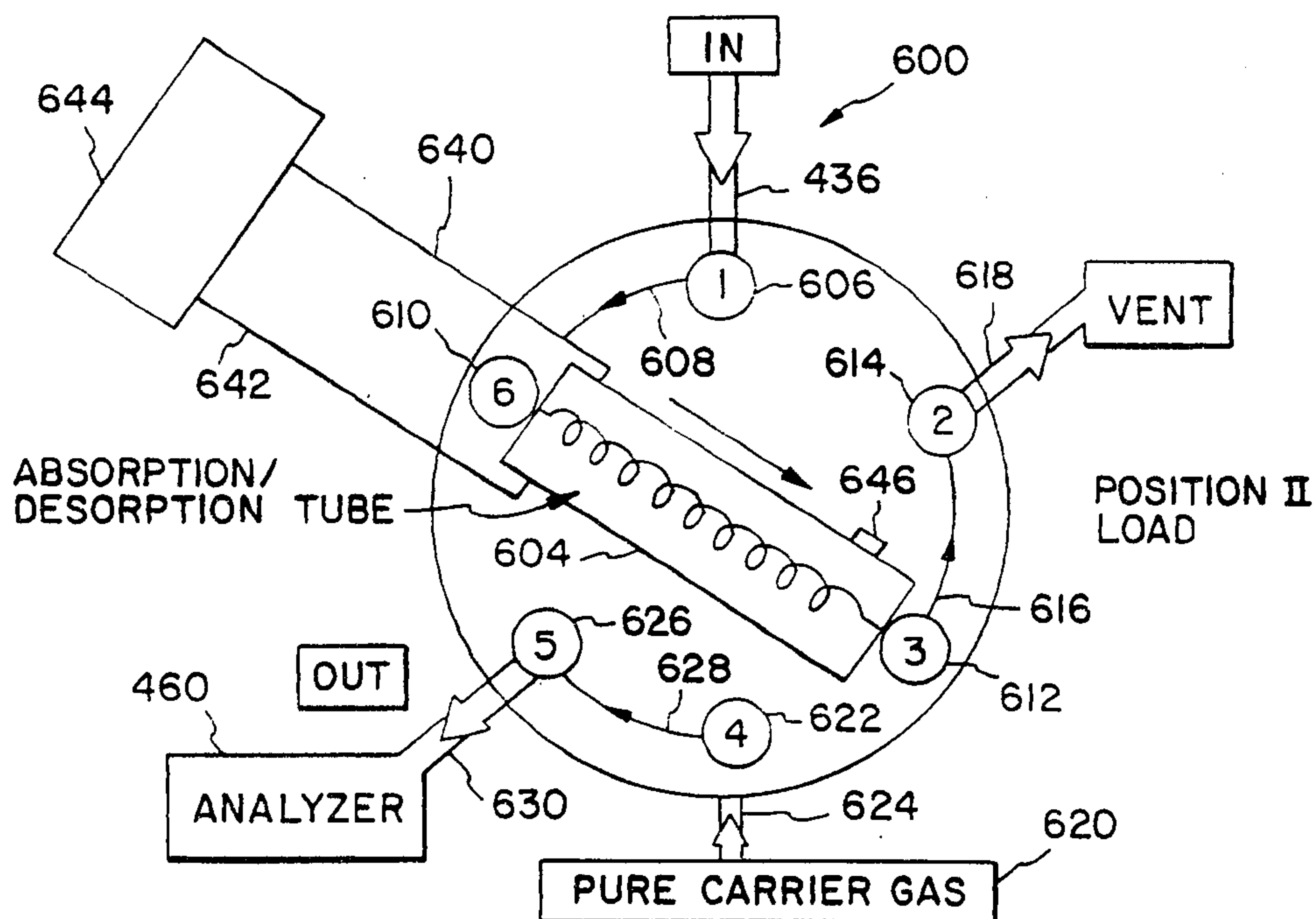
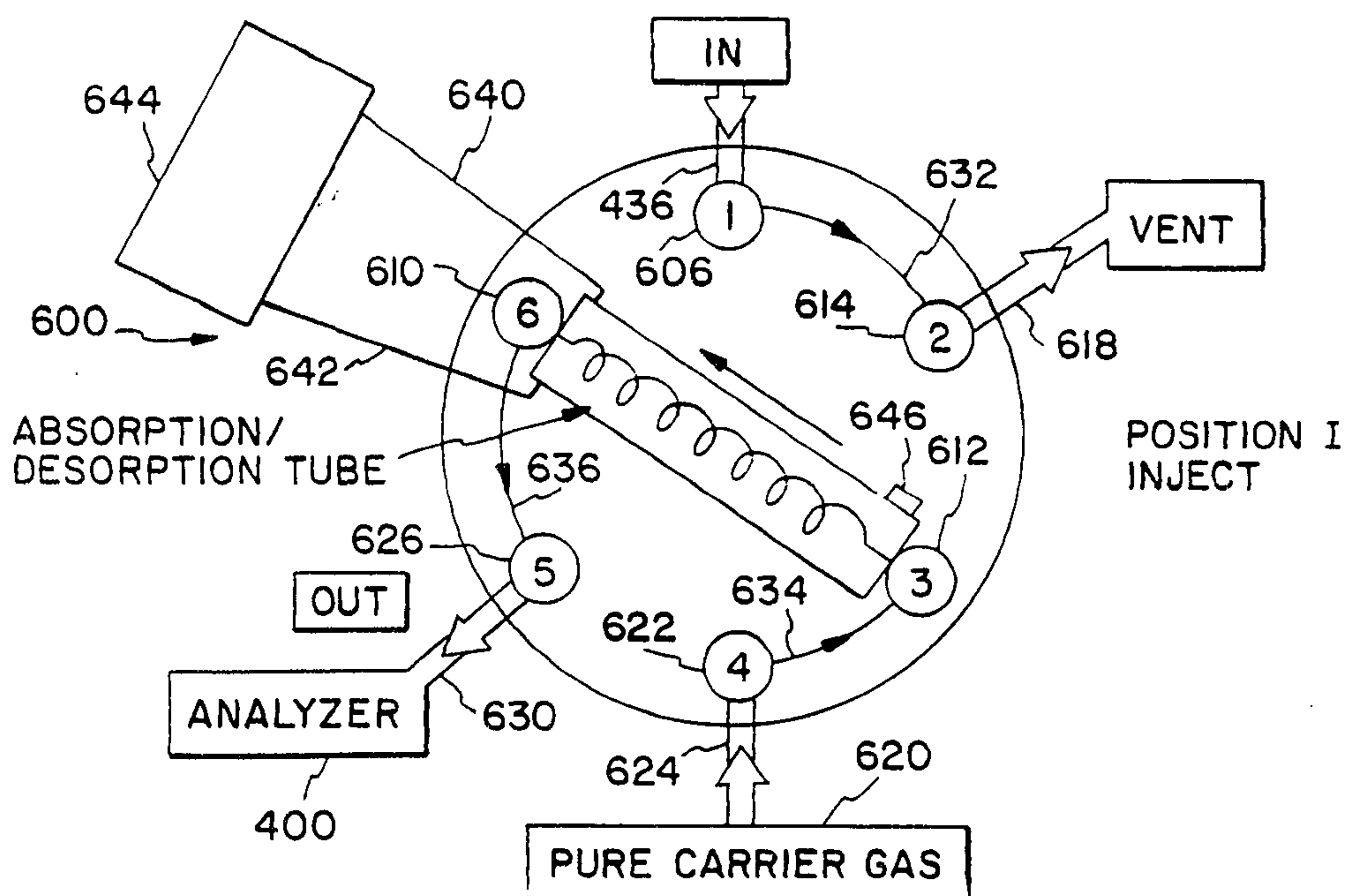


FIG. 13B



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FIG. 14A

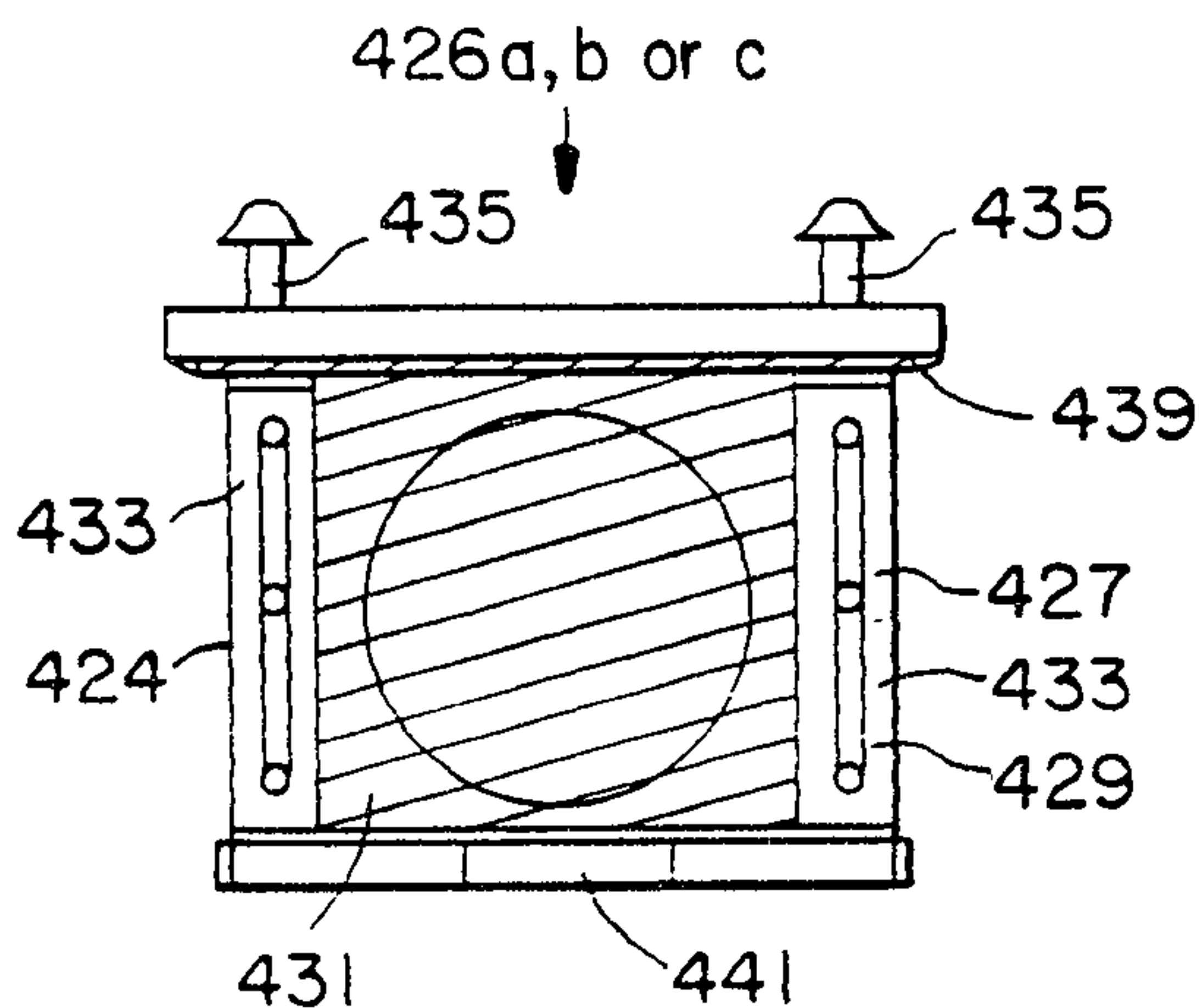


FIG. 14C

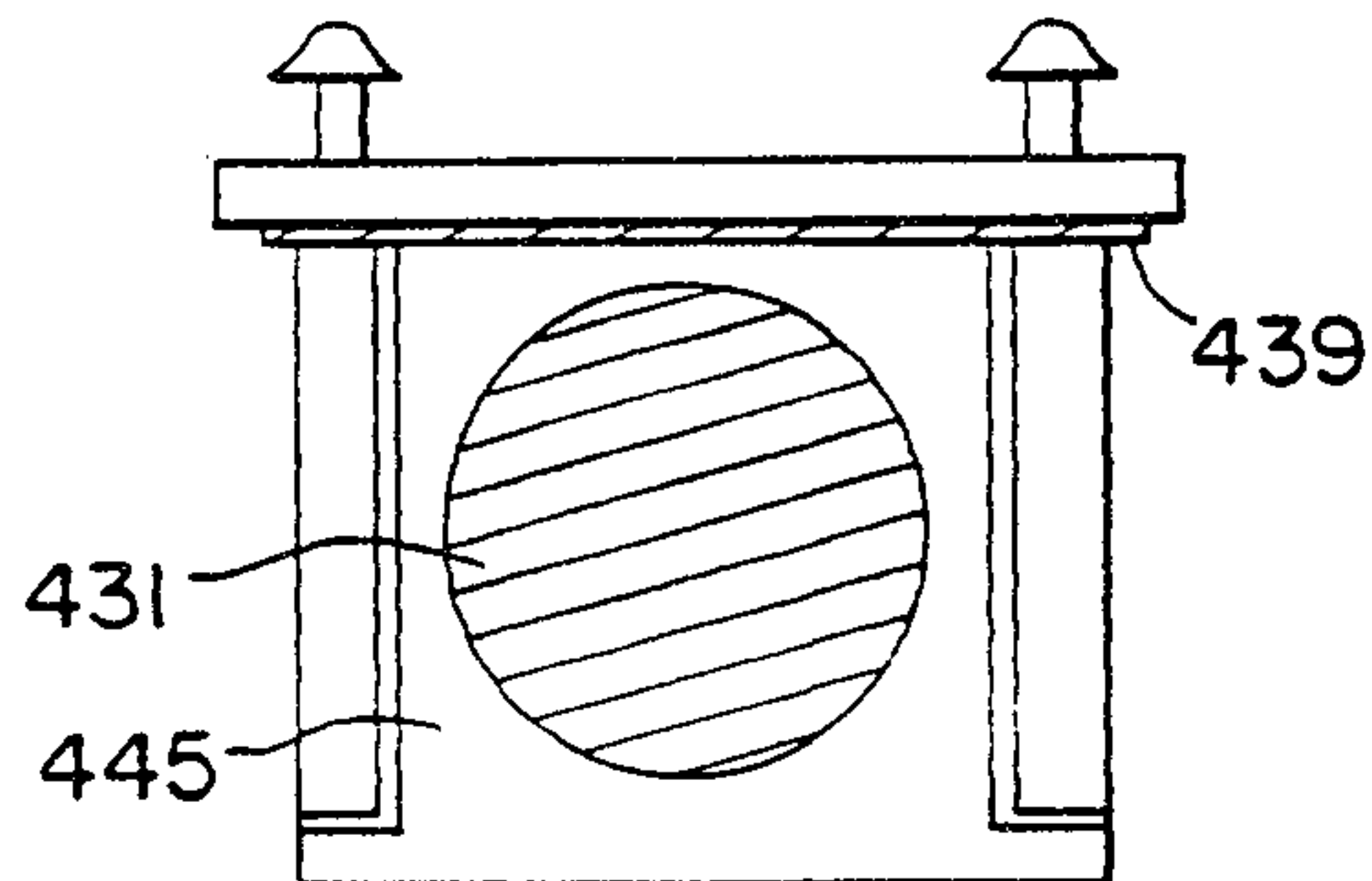


FIG. 14B

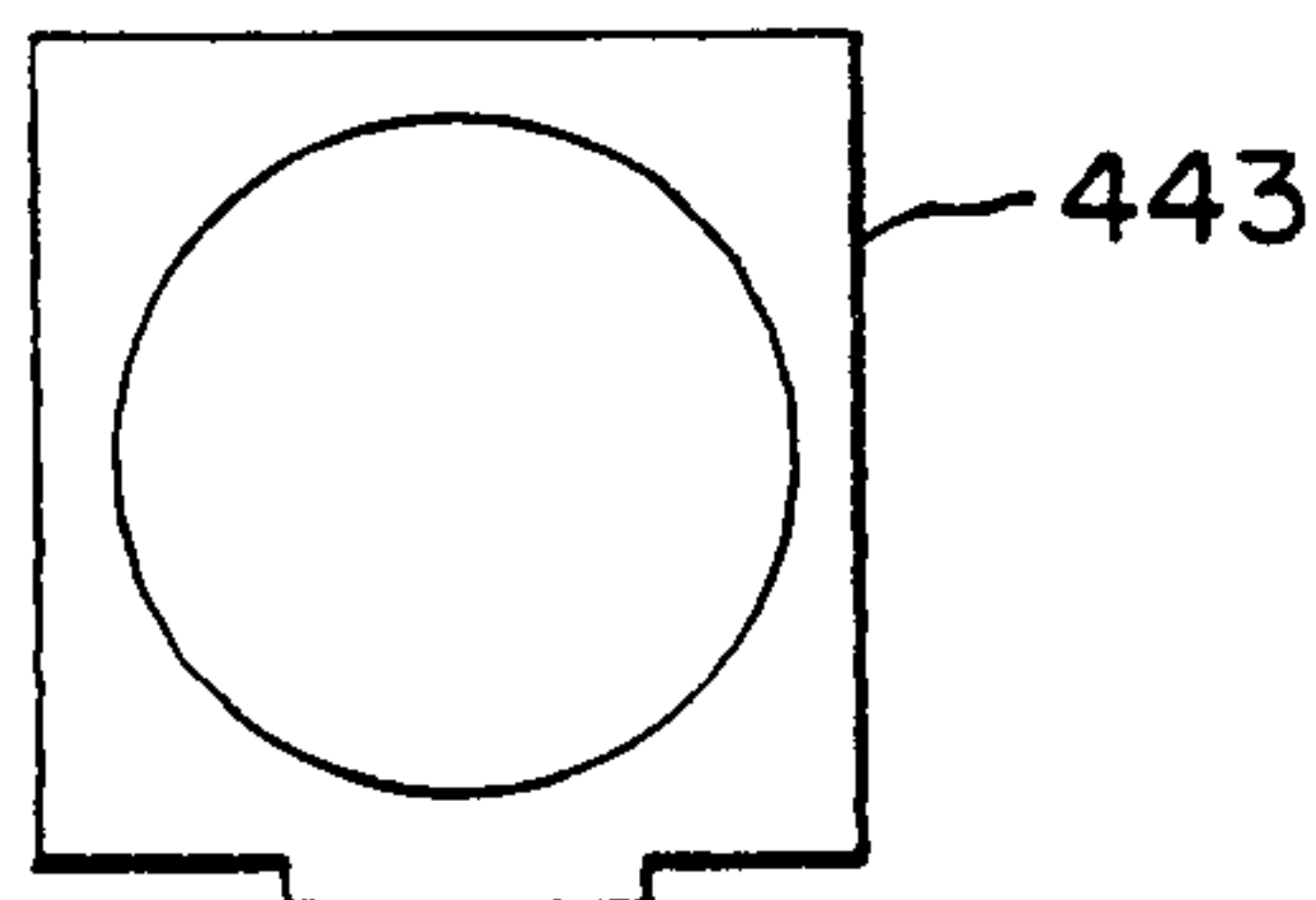


FIG. 15A

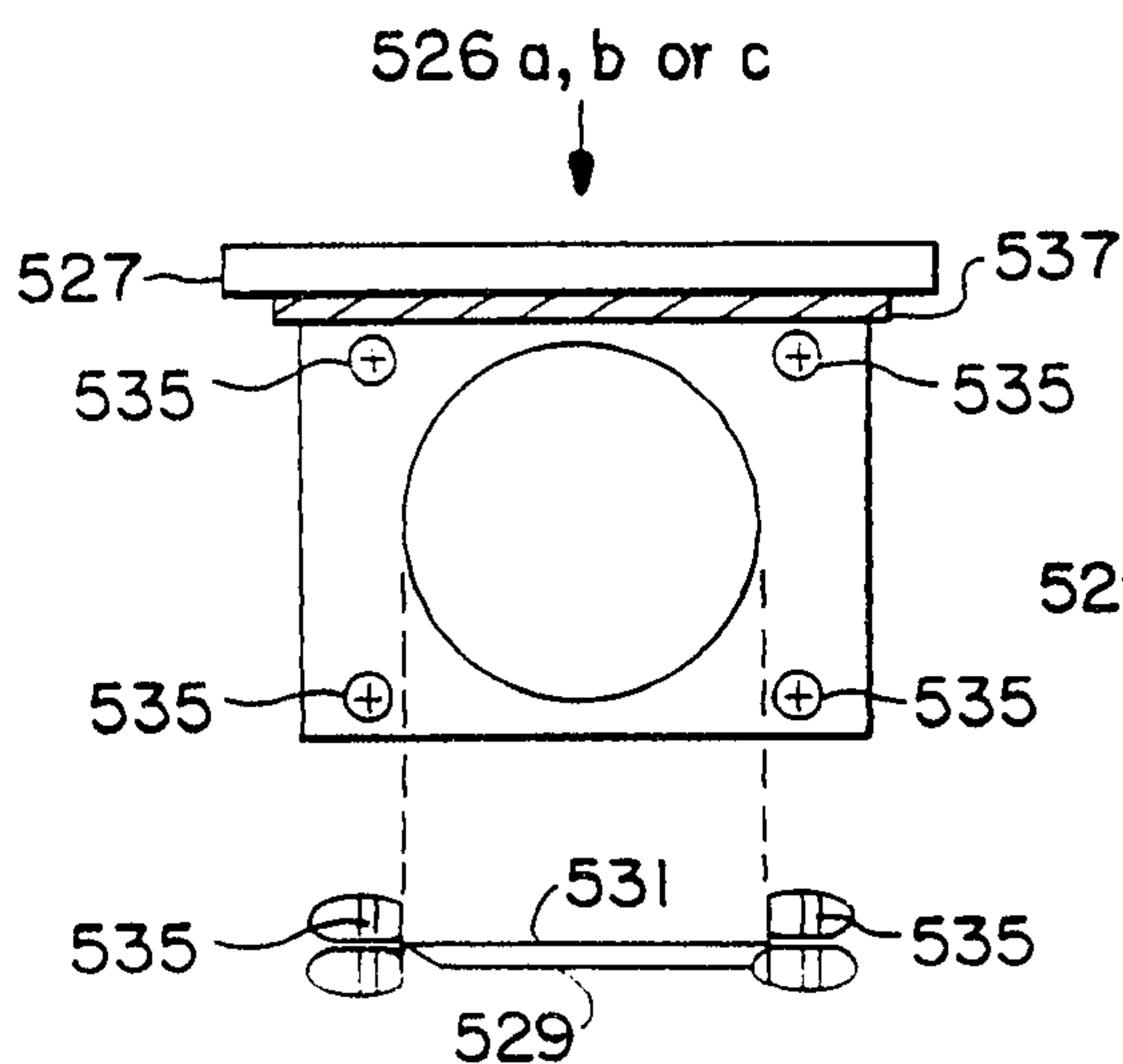
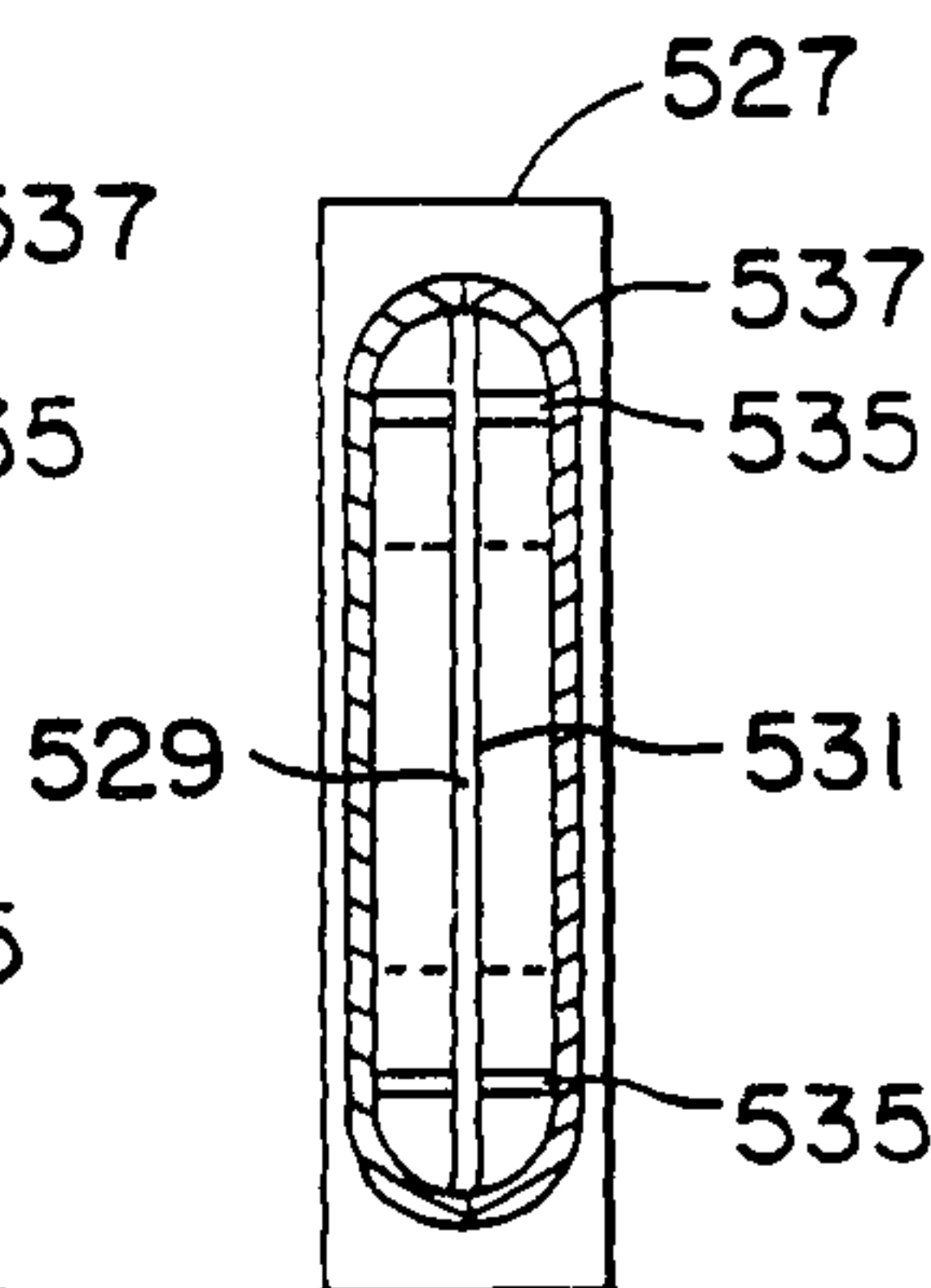
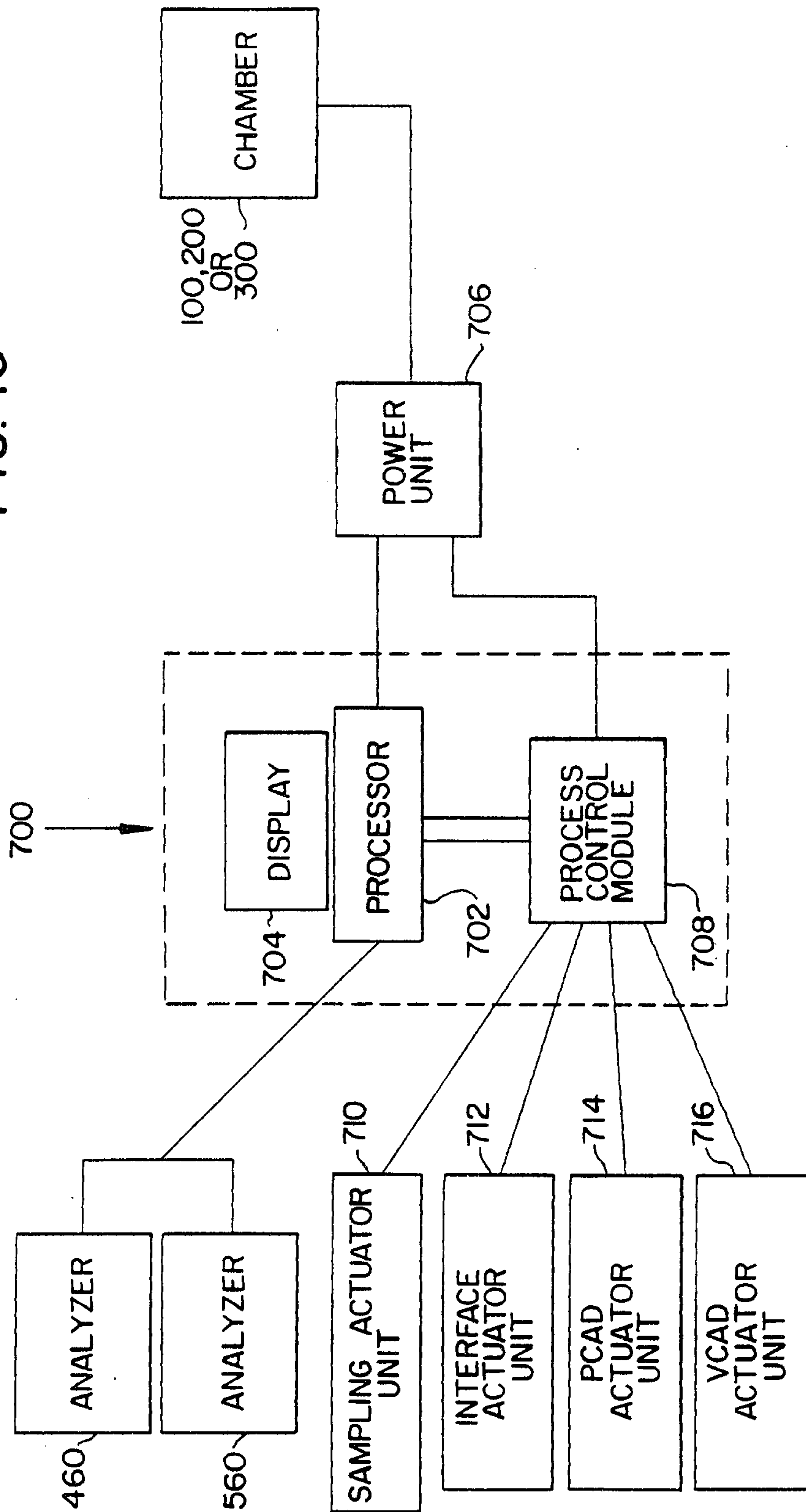


FIG. 15B



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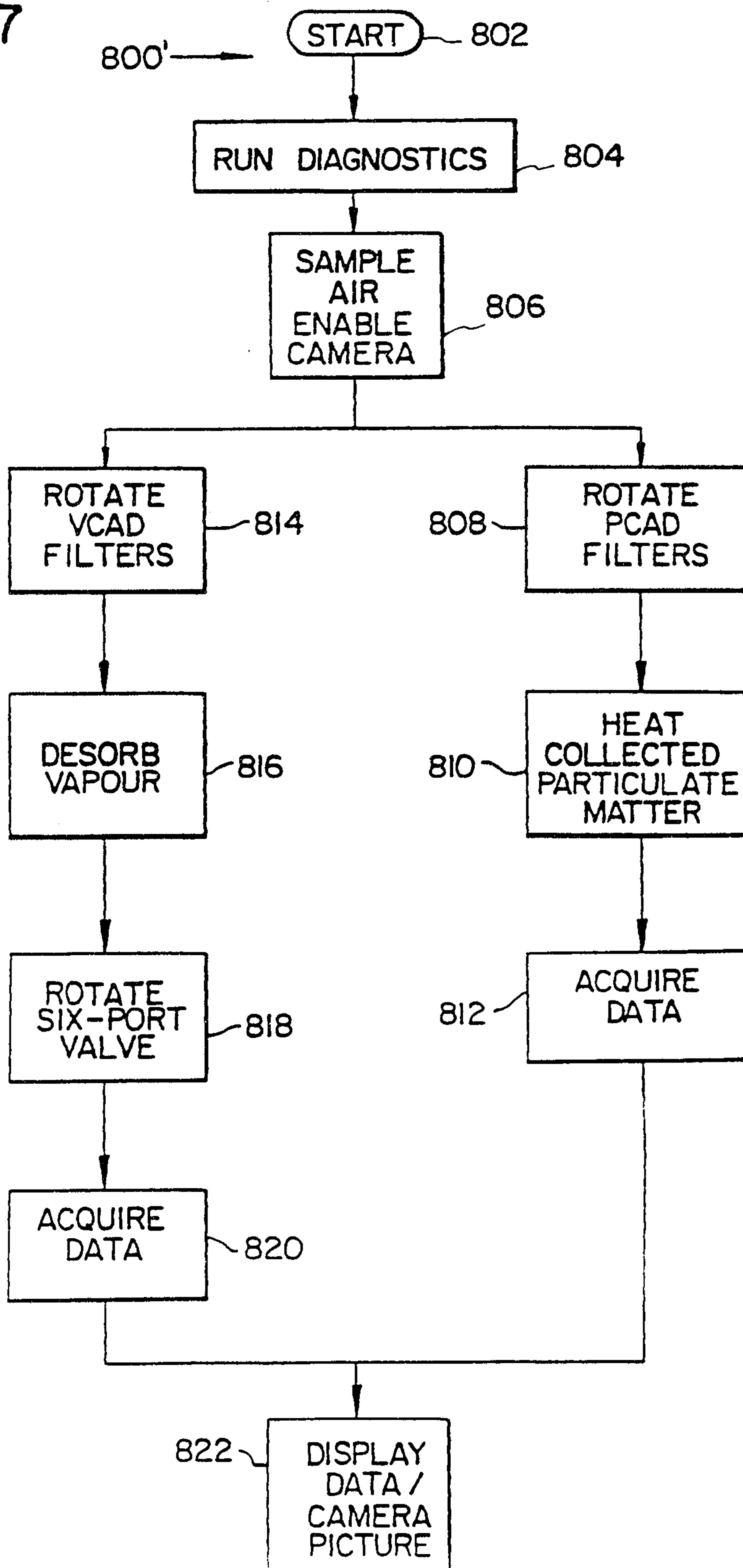
FIG. 16



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FIG. 17

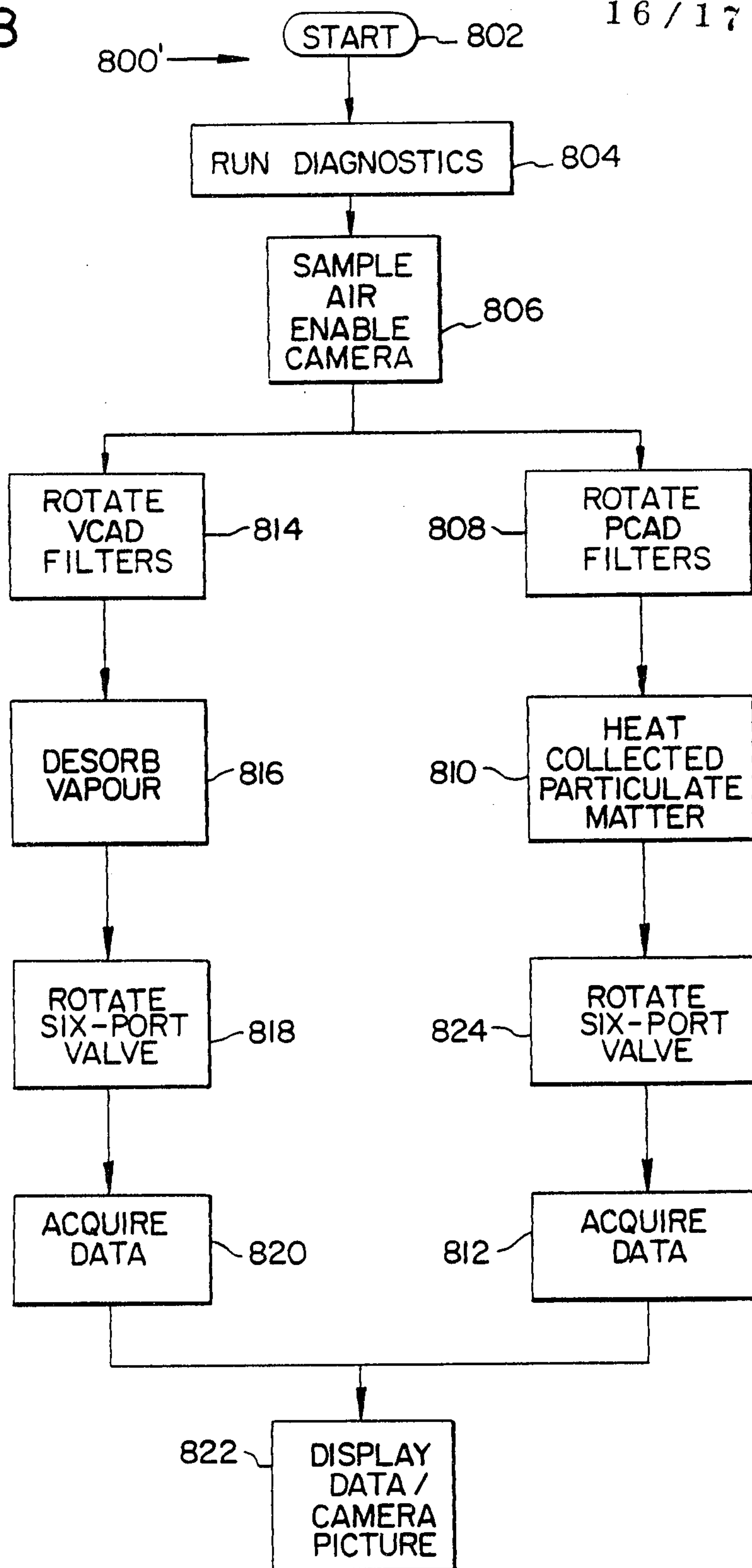


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FIG. 18

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