# ELÉCTRICA IET

# ELÉCTRICA D0

## DESCRIPCIÓN

## SENSOR DE HUMEDAD EN TEJIDOS

### SECTOR DE LA TÉCNICA

La presente invención se refiere al campo de los sensores, más concretamente a los sensores para detectar en un medio, que en este caso se particularizarán a la detección de humedad en un tejido.

### ANTECEDENTES DE LA INVENCIÓN

En la actualidad, son ampliamente conocidos los sensores de humedad utilizados para detectar el grado de ésta en el ambiente.

En el mercado podemos encontrar sensores de humedad que utilizan diferentes tecnologías: mecánicos, por sales higroscópicas, de conductividad, capacitivos, por infrarrojos y resistivos.
Los mecánicos utilizan los cambios de dimensiones que sufren cierto tipo de materiales en presencia de humedad, como pueden ser las fibras orgánicas, las fibras sintéticas o el propio cabello humano.

Los que utilizan sales higroscópicas obtienen el valor de la humedad en el ambiente a partir de una molécula cristalina con afinidad a la absorción de agua.

Los basados en la conductividad miden la presencia de agua en el ambiente a través de rejillas metálicas por las que circula una corriente, aprovechando la buena conductividad del agua. De forma que, según la medida de la corriente se deduce la humedad.

Los sensores capacitivos utilizan el cambio de capacidad que sufre un condensador en presencia de agua.

También existen los que utilizan infrarrojos, de manera que disponen de dos fuentes infrarrojas que absorben parte de la radiación que contiene el vapor de agua

Por último, los sensores resistivos aplican el principio de conductividad de la tierra, es decir, que cuanto mayor cantidad de agua exista en la muestra, más alta será su conductividad.

Como se puede observar, pese a la gran diversidad de tecnologías utilizadas para medir la humedad de un medio, no existe ninguna que sea aplicable al campo de los tejidos. Por lo que no parece evidente deducir la cantidad de agua presente en uno de ellos a partir de los sistemas pertenecientes al estado

de la técnica.

**EXPLICACIÓN DE LA INVENCIÓN**

El problema técnico que pretende resolver la presente invención es lograr un sistema de medición de la humedad que pueda aplicarse a la medición de la cantidad de agua presente en un tejido.

Para ello, el sistema propuesto utiliza un principio básico de la conductividad del agua. En concreto, el paso de corriente entre dos bornes permite la medición de la resistividad del conjunto tejido más líquido, y su valor se espera inversamente proporcional a la humedad presente. Por tanto, a mayor resistencia eléctrica presentada por el tejido humedecido, menor será la cantidad de líquido presente en él. Por el contrario, cuando menor sea la resistencia eléctrica opuesta por el tejido humedecido, mayor será la cantidad de líquido presente en él.

En una realización preferente, el sistema se acoplará a un aparato auto-desplazable de limpieza que puede estar constituido por un bastidor desplazable con respecto a una superficie a limpiar, medios de desplazamiento autónomo o semi – autónomo, baterías y medios de recarga de las mismas, al menos un sistema de control conectado operativamente a los medios de desplazamiento, estando el sistema de control configurado para hacer funcionar el aparato en uno o varios modos de funcionamiento, y medios de aspiración para aspirar la suciedad presente en la superficie recorrida.

Este aparato auto-desplazable de limpieza contará con medios de fregado de la superficie del suelo, que comprenderán un depósito de líquidos, una mopa de fregado y medios de dosificación de líquidos desde el depósito hasta la mopa.

En este caso, el sistema de medición de humedad del tejido puede utilizarse para controlar la humedad presente en la mopa de fregado de los medios de fregado del aparato auto-desplazable de limpieza.

De esta forma, se utilizarían en combinación con los medios de dosificación, regulando el caudal de aporte de líquido desde el depósito hasta la mopa, manteniendo el valor medido en un intervalo previamente definido, para garantizar que la humedad es la idónea para realizar las tareas de fregado de un aparato auto-desplazable de limpieza.

**BREVE DESCRIPCIÓN DE LOS DIBUJOS**

Para complementar la descripción que se está realizando y con objeto de ayudar a una mejor comprensión de las características de la invención, se acompaña como parte integrante de dicha descripción, un juego de dibujos en donde con carácter ilustrativo y no limitativo, se ha representado

lo siguiente:

**Figura 1**.- Esquema del sensor de humedad.
**Figura 2**.- Gráfica de relación humedad – resistividad del material.

**REALIZACIÓN PREFERENTE DE LA INVENCIÓN**

A la vista de las mencionadas figuras, y de acuerdo con las referencias identificativas adoptadas en ellas, se puede observar un ejemplo no limitativo del método y aparato preconizados, los cuales comprenden las etapas y elementos que se indican y describen en detalle a continuación.

Para facilitar la compresión de cada tecnología, se presentan inicialmente los diferentes elementos que la componen, describiendo seguidamente el modo de funcionamiento.

Más concretamente, la presente invención plantea un sensor de humedad en tejidos comprendido por: al menos dos bornes de conexión 1 y 2, al menos una fuente de corriente eléctrica 3, al menos un divisor resistivo, al menos una PCB, al menos un medio para medir la resistividad 4 y al menos un tejido 5, caracterizados porque la fuente de corriente eléctrica 3, crea una corriente entre los bornes 1 y 2, se realiza la medición de la resistividad eléctrica del tejido 3 humedecido, y un procesamiento de la señal medida para calcular la humedad presente en el tejido 3.

Como se puede apreciar en los gráficos de la Figura 2, la resistividad eléctrica medida debe ser inversamente proporcional a la cantidad de agua presente en el tejido 3.

En una realización preferente, el sensor de humedad se monta en un aparato auto- desplazable de limpieza comprendido por: un bastidor desplazable con respecto a una superficie a limpiar, medios de desplazamiento autónomo o semi – autónomo, baterías y medios de recarga de las mismas, al menos un sistema de control conectado operativamente a los medios de desplazamiento, estando el sistema de control configurado para hacer funcionar el aparato en uno o varios modos de funcionamiento, medios de aspiración para aspirar la suciedad presente en la superficie recorrida, medios de fregado de la superficie con un depósito de líquidos, una mopa de fregado y medios de dosificación de líquido desde el depósito hasta la mopa.

En la realización preferente anterior, el sensor de humedad se utiliza para regular la dosificación de agua desde el depósito hasta la mopa, manteniendo así el parámetro de humedad en un valor predefinido, según las necesidades del usuario.

En una realización particular, el sensor cuenta con una separación entre bornes de 2,54 cm.

En una realización particular del aparato auto-desplazable, éste comprende una placa solar como medio de recarga de baterías.

En otra realización particular del aparato auto-desplazable, éste comprende una batería de ión-litio.

En otra realización particular del aparato auto-desplazable, éste comprende medios para almacenar la ubicación de puntos dentro de un domicilio donde se haya producido exceso de agua. Más concretamente, en una realización particular de ésta última, el aparato auto-desplazable comprende medios de conexión wi-fi para enviar la información a una aplicación móvil, de forma que, en caso de fugas de agua, se pueda notificar al usuario de manera inmediata.

La aplicación industrial de la presente invención es clara, ya que permite obtener un sensor de humedad para calcular el valor de este parámetro en un tejido, utilizando la conductividad del líquido y midiendo la resistividad eléctrica ejercida por el mismo.

## REIVINDICACIONES

1. Sensor de humedad en tejidos caracterizado porque comprende:
   - al menos dos bornes de conexión (1) y (2),
   - al menos una fuente de corriente eléctrica (3),
   - al menos un divisor resistivo,
   - al menos una PCB,
   - al menos un medio para medir la resistividad (4)
   - y al menos un tejido (5)

y que a su vez está configurado para que la fuente de corriente eléctrica (3) produzca una corriente eléctrica entre los bornes (1) y (2), de tal modo que la PCB procese la señal del valor de la resistencia medida entre dichos bornes para calcular la humedad presente en el tejido (5).

2. Sensor de humedad en tejidos según la reivindicación 1, en el cual la separación entre los bornes (1) y (2) es de 2,54 cm.

3. Aparato auto-desplazable de limpieza caracterizado porque comprende el sensor de la reivindicación 1, el cual se utiliza para regular la dosificación de agua desde el depósito hasta la mopa, además de:
   - un bastidor desplazable con respecto a una superficie a limpiar,
   - medios de desplazamiento autónomo o semi – autónomo,
   - baterías y medios de recarga de las mismas,
   - al menos un sistema de control conectado operativamente tanto al sensor de humedad como a los medios de desplazamiento,
   - y medios de fregado de la superficie con un depósito de líquidos, una mopa de fregado y medios de dosificación de líquido desde el depósito hasta la mopa.

4. Aparato auto-desplazable de limpieza según la reivindicación 3, el cual comprende una placa solar como medio de recarga de las baterías.

5. Aparato auto-desplazable de limpieza según la reivindicación 3, el cual comprende una batería de ión-litio.

6. Aparato auto-desplazable de limpieza según la reivindicación 3, el cual comprende medios para almacenar la ubicación de puntos dentro de un domicilio donde se haya producido exceso de agua.

7. Aparato auto-desplazable de limpieza según la reivindicación 6, el cual comprende medios de conexión wi-fi para enviar la información descrita en la reivindicación 6 a una aplicación móvil.

**DIBUJOS**

Figura 1

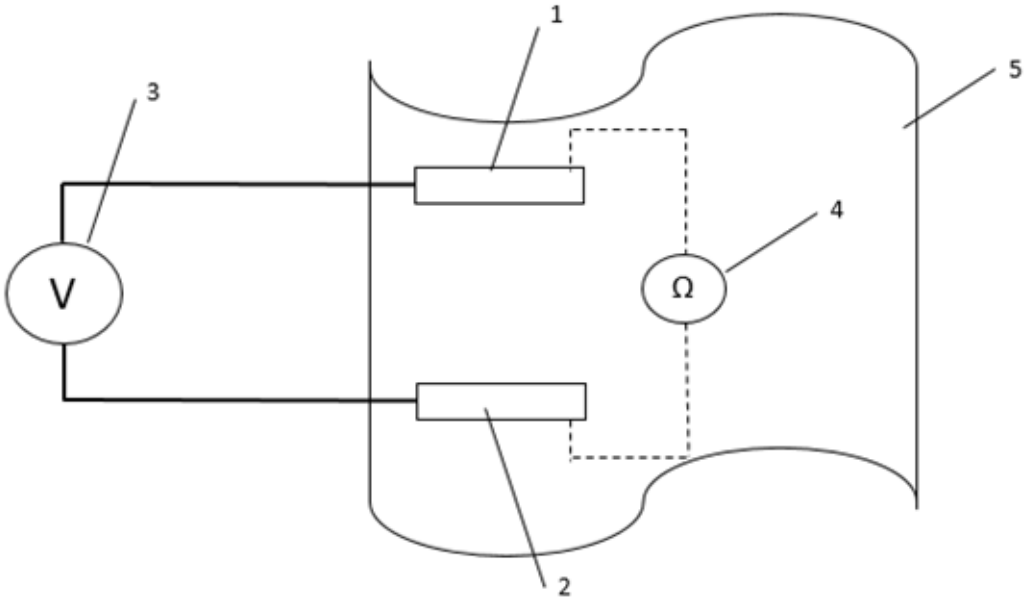
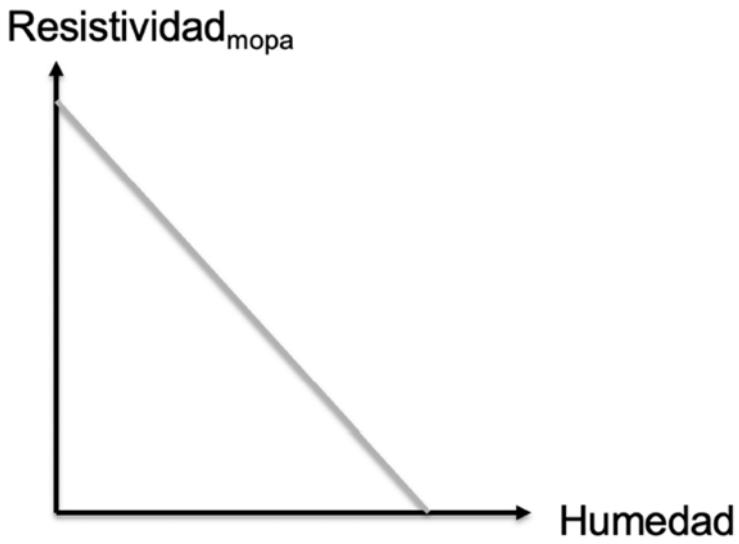



Figura 2



# ELÉCTRICA D01

(19) OFICINA ESPAÑOLA DE PATENTES Y MARCAS

ESPAÑA

(12) SOLICITUD DE MODELO DE UTILIDAD U

(22) Fecha de presentación:

(43) Fecha de publicación de la solicitud:

(71) Solicitantes:

**CECOTEC RESEARCH AND DEVELOPMENT (100.0%)**
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(54) Título: **ROBOT ASPIRADOR CON SISTEMA DE FREGADO INTELIGENTE**

**DESCRIPCIÓN**

# ROBOT ASPIRADOR CON SISTEMA DE FREGADO INTELIGENTE

## SECTOR DE LA TÉCNICA

La presente invención se encuadra en el campo técnico de los aparatos auto desplazables de limpieza doméstica, tales como robots aspiradores de desplazamiento autónomo. Más concretamente, se refiere al campo de los robots aspiradores dotados con medios de fregado.

## ANTECEDENTES DE LA INVENCIÓN

En la actualidad, podemos encontrar en el mercado diferentes tipos de robots aspiradores de limpieza doméstica. Sin embargo, todos ellos están formados por los mismos elementos constructivos: un bastidor desplazable con respecto a la superficie a limpiar, medios de desplazamiento suficientes para que el movimiento sea autónomo o semi autónomo, baterías y medios para recargarlas, y al menos un sistema de control conectado operativamente a los medios de desplazamiento, que permiten la utilización del aparato en uno o varios modos de funcionamiento.

Los que incorporan medios de fregado están dotados, adicionalmente, de un depósito de líquidos (pudiendo albergar tanto agua como soluciones jabonosas o similares), al que se acopla una esponja o mopa, montadas en la parte inferior del propio depósito de líquidos, y quedan en contacto con la superficie a limpiar. El suministro de agua se realiza de manera controlada (utilizando electroválvulas de descarga o bombas de impulsión) o por decantación, desde el depósito hacia el sistema de fregado.

En todos los casos, el suministro de agua o solución jabonosa se realiza de manera fija, lo que presenta inconvenientes prácticos de ineficiencia, puesto que la humedad o impregnación de las mopas no se ajusta a los parámetros del entorno, como puede ser el grado de humedad de la mopa o la cantidad de líquido que queda en el depósito. Un exceso o un defecto de humedad puede tener consecuencias negativas en el resultado final de la limpieza de las superficies.

Adicionalmente, se hace necesaria una manera de controlar la cantidad de líquido disponible en el depósito.

Podemos encontrar antecedentes de esta invención en las siguientes publicaciones:

- JP2015128733 "*Cleaning robot"*
- JP2014147845 "*Cleaning robot"*
- ES2346343T3 "*Autonomous Surface cleaning robot for wet and dry cleaning"*

**EXPLICACIÓN DE LA INVENCIÓN**

El problema técnico que pretende resolver la presente invención es lograr un robot aspirador autónomo con función de fregado inteligente, que sea capaz de gestionar el grado de humedad de la mopa y la cantidad de líquido disponible en el depósito. Con el objetivo de evitar los problemas comentados en el apartado anterior.

La tendencia actual del mercado, nos indica que cada vez son más las personas que apuestan por este tipo de robots aspiradores para realizar la limpieza de sus casas. Los cuales, en las últimas actualizaciones, han incorporado los sistemas de fregado automático, permitiendo realizar una limpieza completa de manera totalmente autónoma e inteligente.

Ante esta perspectiva, y con el objetivo de mejorar el rendimiento y la eficiencia del fregado, y de superar los inconvenientes presentados, se hace necesario realizar un sistema de fregado automático e inteligente, que gestione los recursos de manera eficiente (gestión del líquido disponible en el depósito) y mejorando la experiencia a nivel usuario de la calidad de la limpieza obtenida (gestión del grado de humedad de la mopa).

Con el objetivo de superar lograr los objetivos planteados, la presente solicitud pretende proporcionar dos soluciones: poner un sensor de humedad en la mopa del dispositivo, para regular la cantidad de líquido que se utiliza en el fregado de la superficie, y colocar un sensor que controle la cantidad de líquido disponible en el depósito.

Con el sensor de humedad en la mopa, se propone controlar el grado de humidificación de esta, de manera que se mantenga siempre dentro de unos parámetros establecidos, en los que se mantiene la humedad por encima de un mínimo, que garantice una limpieza eficiente de la superficie, y por debajo de un máximo, que asegure que no se está utilizando una gran cantidad de líquido en el proceso.

Por otro lado, el sensor de cantidad de líquido disponible en el depósito nos garantiza que tenemos controlada de manera instantánea, qué porcentaje del líquido nos queda para continuar realizando la limpieza.

Adicionalmente, se contará con un sistema de regulación de dosificación del líquido, que nos permita controlar la cantidad de agua o solución jabonosa que se aporta a la mopa, utilizando los valores obtenidos de las mediciones de los dos sensores anteriormente mencionados. De forma que, en función de los parámetros obtenidos de humedad de la mopa y de cantidad de líquido disponible, se regule el caudal aportado. Manteniendo todos los registros dentro de unos límites previamente establecidos.

Con la descripción y las reivindicaciones que se describirán a continuación, no se pretenden excluir otras características técnicas, componentes o pasos. Para los expertos en la materia, otros objetos, ventajas y características de la invención se desprenderán en parte de la descripción y en parte de la utilización de la invención. Los siguientes ejemplos y dibujos se proporcionan a modo de ilustración, no se pretende que sirvan de restricción para la presente invención.

## BREVE DESCRIPCIÓN DE LOS DIBUJOS

Para complementar la descripción que se está realizando y con objeto de ayudar a una mejor comprensión de las características de la invención, se acompaña como parte integrante de dicha descripción, un juego de dibujos en donde con carácter ilustrativo y no limitativo, se ha representado lo siguiente:

Figura 1.- Representación de los componentes genéricos del robot

## REALIZACIÓN PREFERENTE DE LA INVENCIÓN

A la vista de las mencionadas figuras, y de acuerdo con las referencias identificativas adoptadas en ellas, se puede observar un ejemplo no limitativo del método y aparato preconizados, los cuales comprenden las etapas y elementos que se indican y describen en detalle a continuación.

Más concretamente, en su realización preferente, el aparato auto – desplazable de limpieza objeto de la presente invención comprende: al menos un bastidor (1) desplazable con respecto a una superficie, medios de desplazamiento autónomo o semi autónomo (2), medios de limpieza (3), medios de filtrado del aire, medios de aspiración, medios de fregado con al menos un depósito de agua (5), y al menos una mopa (6) ubicada inferiormente en el aparato, en contacto, al menos parcialmente con la superficie, así como un sistema de control conectado operativamente a los medios de desplazamiento y a los medios de fregado, estando el sistema de control configurado para hacer funcionar el aparato en uno o varios modos de funcionamiento. También contará con un sensor de humedad, un sensor de llenado del depósito y un sistema de regulación de la dosificación del líquido de limpieza. Se puede apreciar una vista de los componentes en la Figura 1.

El sensor de humedad se colocará de forma que controle la cantidad de líquido presente en la mopa encargada de realizar la limpieza, realizando lecturas de manera indefinida o con intervalos de tiempo definidos. Enviando la información al sistema de control del robot.

El sensor de llenado del depósito se colocará en el propio depósito, controlando la cantidad de líquido disponible, tomando lecturas de manera indefinida o con intervalos de tiempo definidos. Enviando la información al sistema de control del robot.

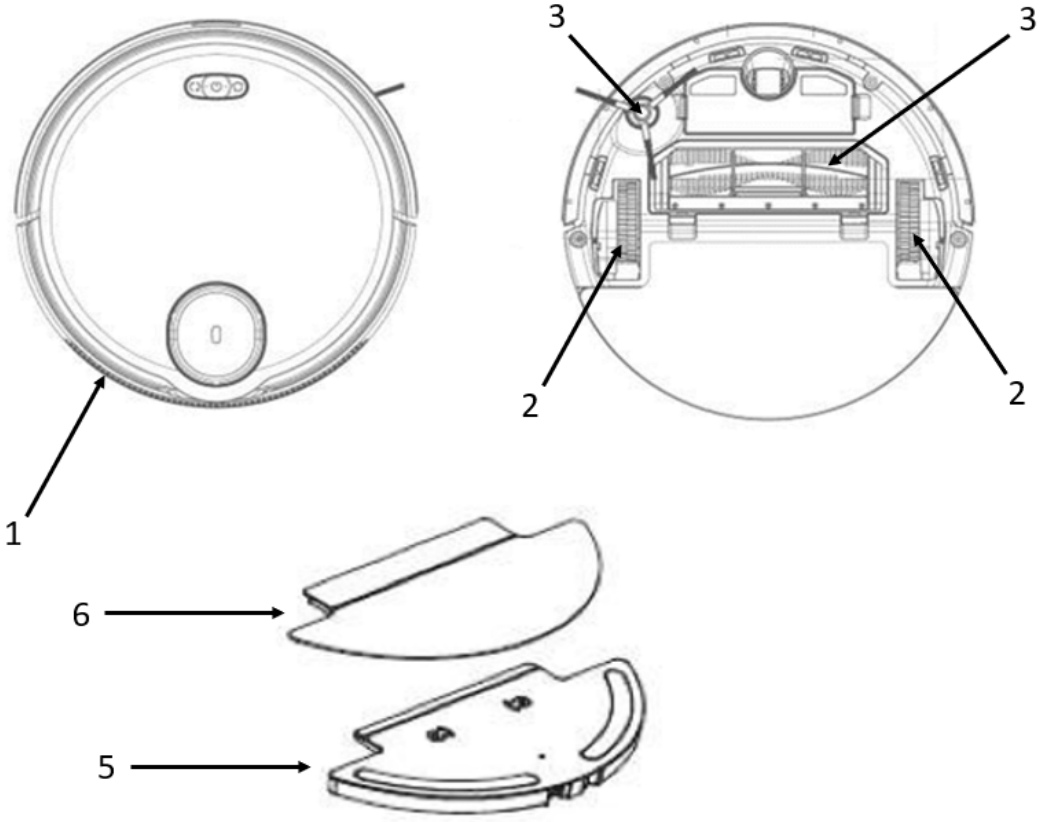
Por otro lado, el sistema de regulación de la dosificación del líquido de limpieza recibirá la información del sistema de control, obtenida a su vez de los dos sensores anteriormente mencionados. Y en función de unos parámetros establecidos de cantidad de agua o solución jabonosa del depósito y de grado de humedad de la mopa, se realiza la regulación del caudal de líquido aportado, manteniendo los valores dentro de los límites establecidos.

La aplicación industrial de la invención es clara, ya que nos permite obtener un robot aspirador con una función de fregado completamente inteligente y autónoma, que dota al dispositivo de capacidades para autorregular los parámetros de la limpieza. Consiguiendo, además, una mejor gestión de los recursos y un ahorro en la cantidad de líquido empleado y de tiempo de limpieza.

**REIVINDICACIONES**

1. **Robot aspirador con sistema de fregado inteligente comprendido por**, un bastidor (1) desplazable, medios de desplazamiento autónomo o semi autónomo (2), medios de limpieza (3), medios de filtrado del aire, medios de aspiración, medios de fregado con al menos un depósito de agua (5), y al menos una mopa (6), y un circuito de circulación del aire aspirado, **caracterizado por** tener un sensor de humedad en la mopa (6), un sensor de llenado en el depósito (5), y un regulador de caudal de líquido entregado desde el depósito (5).

**Figura 1**



# ELÉCTRICA D02

(19) **United States**
(12) **Patent Application Publication**
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(54) **MOISTURE DETECTOR**

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**SUITE 3100, PROMENADE II**
**ATLANTA, GA 30309-3592 (US)**

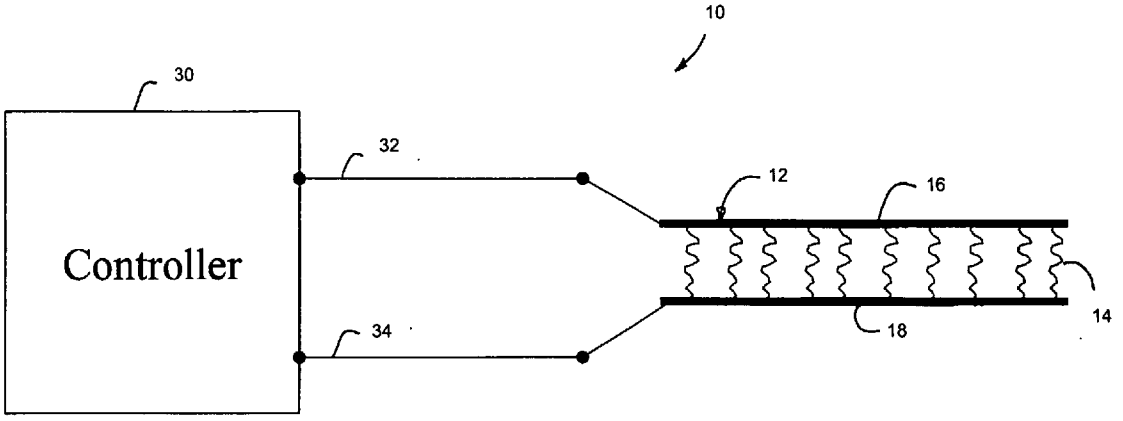
(21) Appl. No.: **10/822,948**

(22) Filed: **Apr. 13, 2004**

(52) **U.S. Cl.** ..... **324/696**

(57) **ABSTRACT**

A moisture detector detects moisture in a closed environment. A microcontroller is connected to an elongated strip sensor, a spot sensor, or a combination of strip sensors and spot sensors. The elongated strip sensors have fabric substrate with parallel conductor strips. The spot sensors comprise point electrodes embedded in a substrate consisting of existing building material. The conductor strips and the point electrodes are connected to the microcontroller. The electrical resistance of the substrates vary based on the amount for moisture absorbed, and the microcontroller may be programmed to detect a threshold resistance indicative of the presence of moisture. Once moisture is detected, the microcontroller can provide various alarm functions and communication functions.



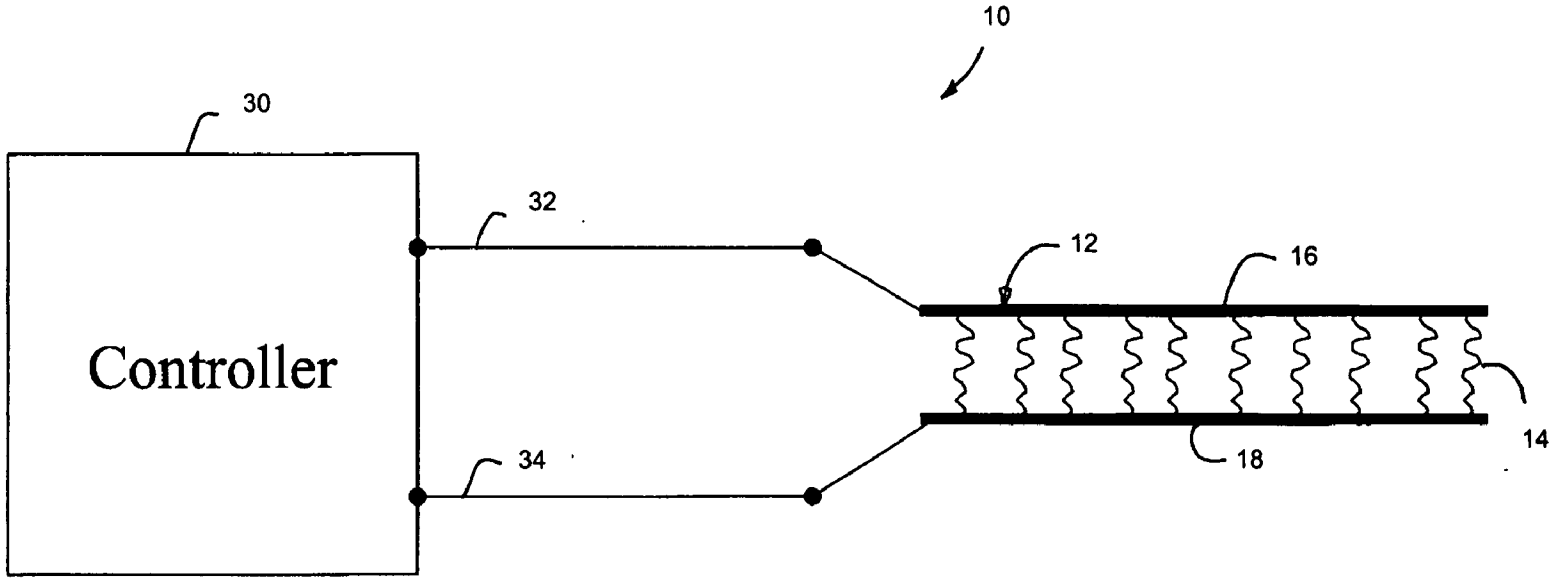



Fig. 1

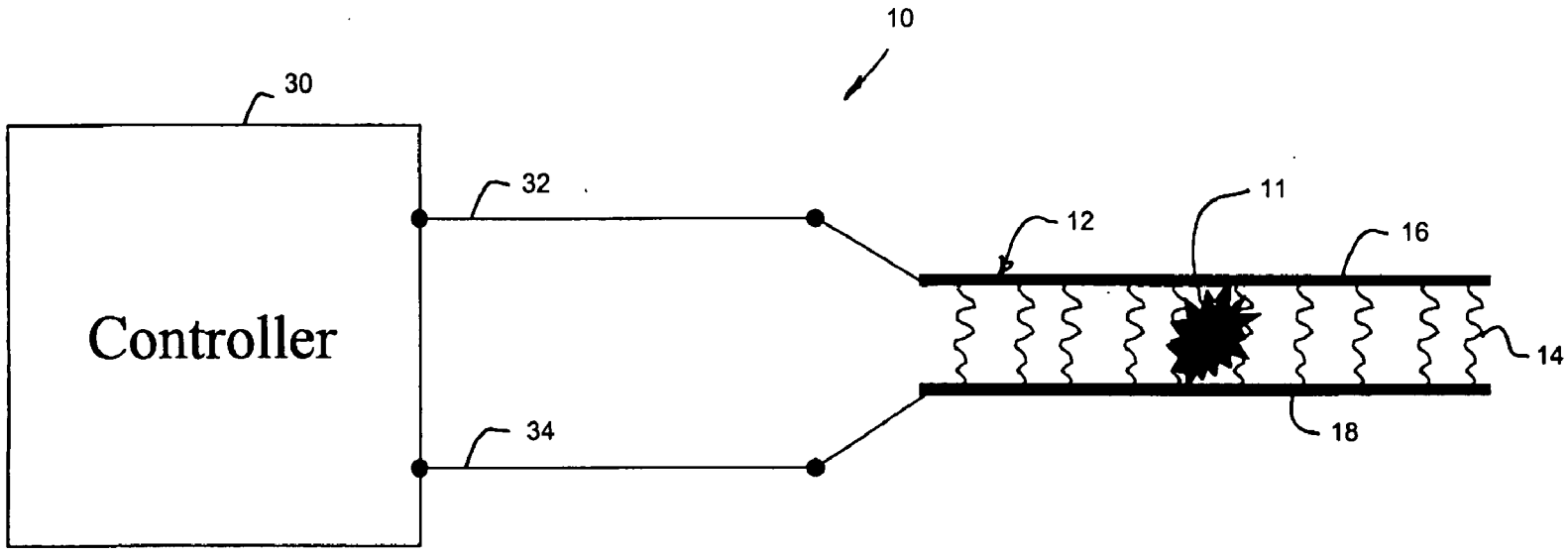



Fig. 2

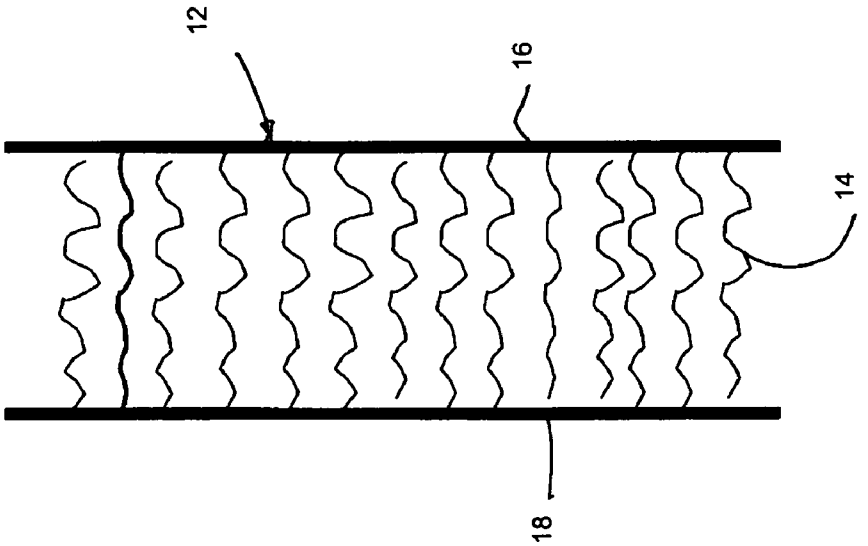



Fig. 3

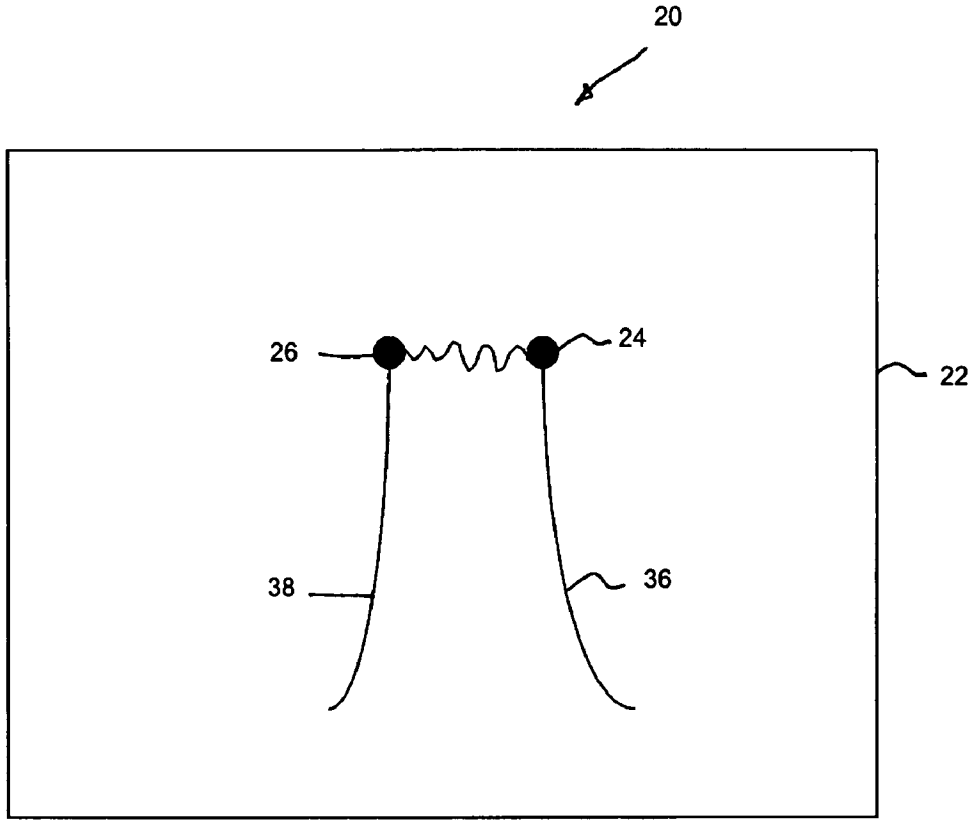



Fig. 4

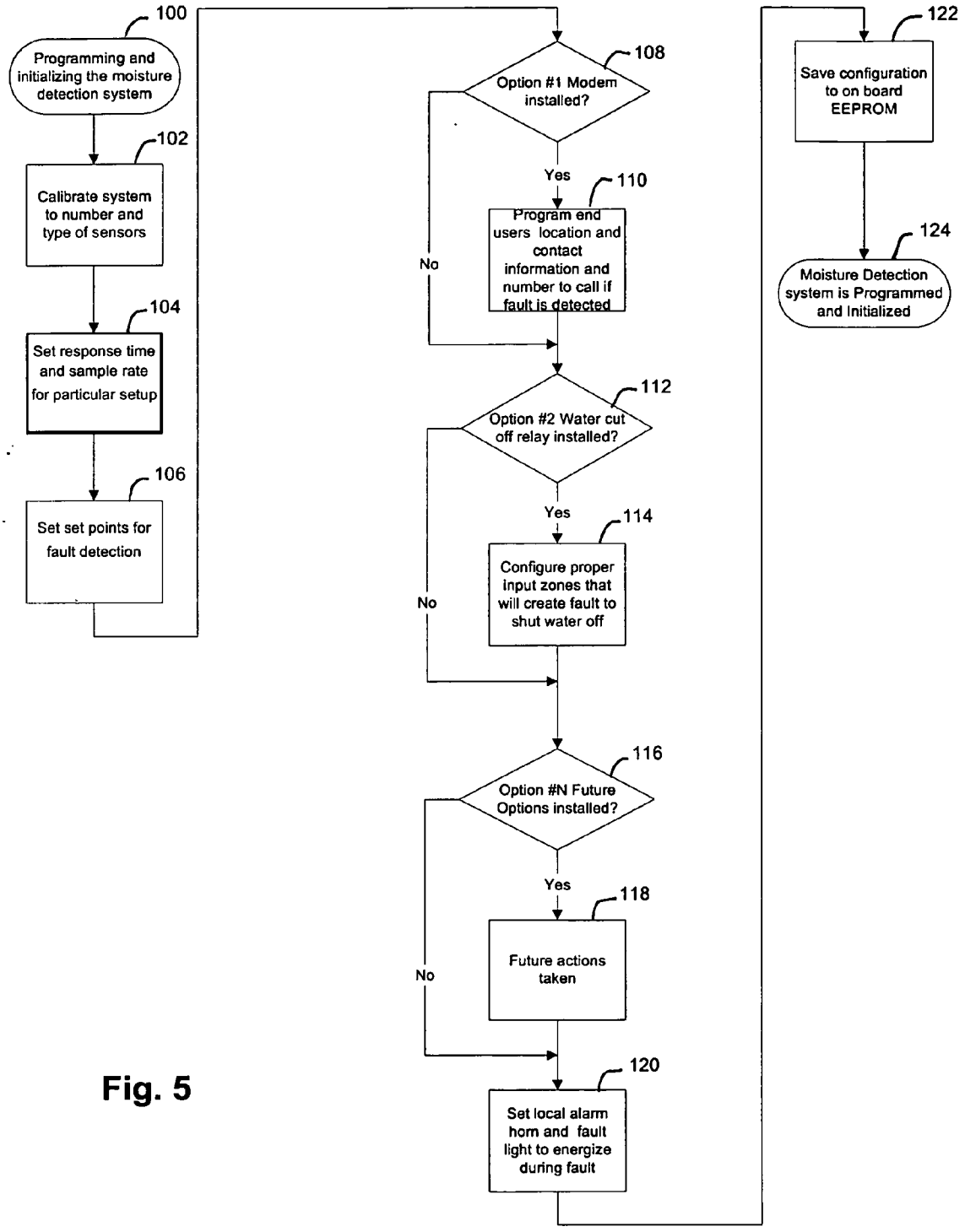

100
Programming and initializing the moisture detection system
102
Calibrate system to number and type of sensors
104
Set response time and sample rate for particular setup
106
Set set points for fault detection
108
Option #1 Modem installed?
Yes
110
Program end users location and contact information and number to call if fault is detected
No
112
Option #2 Water cut off relay installed?
Yes
114
Configure proper input zones that will create fault to shut water off
No
116
Option #N Future Options installed?
Yes
118
Future actions taken
No
120
Set local alarm horn and fault light to energize during fault
122
Save configuration to on board EEPROM
124
Moisture Detection system is Programmed and Initialized

Fig. 5

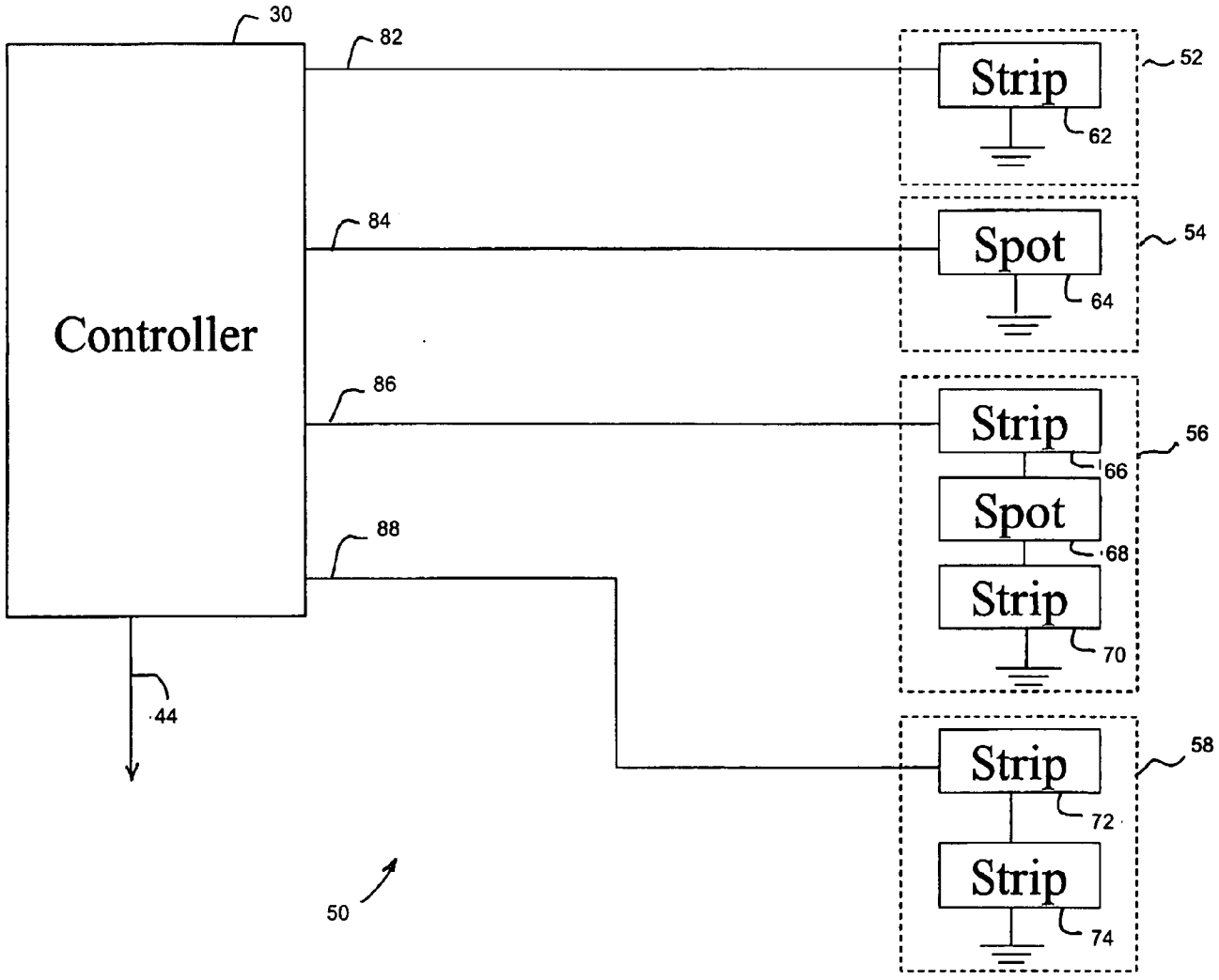

30
Controller
82
84
86
88
44
Strip
62
52
Spot
64
54
Strip
66
Spot
68
Strip
70
56
Strip
72
Strip
74
58
50

Fig. 6

# MOISTURE DETECTOR

## FIELD OF THE INVENTION

[0001] The present invention relates to a method and system for detecting moisture in a closed environment, and more particularly relates to method and system for using a microcontroller connected to an elongated strip sensor, a single point spot sensor, or a combination of strip sensors and spot sensors to detect the presence of moisture in the closed environment.

## BACKGROUND OF THE INVENTION

[0002] The presence of moisture in a home or place of business may be the source of numerous problems. The presence of moisture may be the result of leaking plumbing, a leaking roof, or infiltration through a defective vapor barrier. The damage to a home or place of business as a result of the invasion of large quantities of water from leaking plumbing or a leaking roof is readily apparent. The damage that may result from the presence of small amounts of moisture may also be deleterious to the safety and health of the occupants of a home or place of business. Particularly, mold grows in the presence of moisture, and mold can produce an unhealthy environment for the occupants of a home or place of business.

[0003] Existing moisture detectors generally require expensive sensors that produce accurate outputs based on the existence of moisture at a particular location. Using such sensors to monitor a large space especially the space around all doors and windows and along baseboards would be prohibitively expense.

## SUMMARY OF THE INVENTION

[0004] The present invention provides a system and method for detecting moisture in a closed environment that uses a microcontroller connected to an elongated strip sensor, a spot sensor, or a combination of strip sensors and spot sensors to detect the presence of moisture in the closed environment. The invention provides a cost-effective means for monitoring the presence of moisture in various closed environments. The elongated strip sensors are flexible and can be fit around windows, doors, walls, plumbing points, showers and tubs, air conditioning units, appliances, and any other location where a moisture sensor is desired. The strip sensors use the electrical properties of a fabric material to provide a conductive path between strip conductors. The spot sensors utilize the electrical properties of existing building materials, such as dry wall, to provide a conductive path between embedded electrodes and thereby provide a moisture sensor at a particular localized point.

[0005] Because the strip sensors and spot sensors provide electrical responses that may vary based on the length and width of the strip sensor or the material and spacing of the embedded electrodes of the spot sensor, the microcontroller may be programmed to compensate for inaccuracies or other anomalies introduced by the particular configuration of the strip sensors or spot sensors. Further, the microcontroller can be designed to handle multiple separate strip sensors of various lengths in combinations with spot sensors. Because the microcontroller has the capability of multiple inputs for connection to various separate combinations of strip sensors and spot sensors, the microcontroller can determine the location of the moisture intrusion by identifying the sensor or group of sensors which has been activated by the intrusion of moisture.

[0006] The utilization of a microcontroller also provides a moisture detector system with a full functioning alarm system. For example, the microcontroller can be programmed simply to light a light emitting diode (LED) or to sound a horn if one of the sensors encounters moisture. In addition, the microcontroller can be programmed to contact a remote monitoring service by means of a direct wired connection, a wired network connection, a direct wireless connection, or a wireless network connection. Because the multiple input microcontroller in a moisture detector system can determine the location of the moisture intrusion, the microcontroller can communicate to the remote monitoring service not only the name and address for the home or place of business, but also the location of the moisture intrusion within the home or place of business. Further, the microcontroller can be connected to a plumbing shut off valve so that the water can be shut off in response to the presence of moisture in a particular location.

[0007] Each microcontroller can be programmed by a personal computer using the RS-232 protocol connected to the serial port. The program for the microcontroller can be stored on an onboard EEPROM along with any calibration values needed. The program can be set so that each sensor or group of sensors can be monitored individually with a pre-determined threshold value for that sensor or group of sensors.

[0008] In one embodiment of the presence invention, a strip sensor comprises a strip substrate made of water absorbing fabric such as non-treated polyester. Two conductors strips or wires are mounted on and separated by the sensor substrate fabric. The sensor fabric separating the two conductors wires acts as an insulator with high resistance when the fabric is dry. However, when moisture is absorbed by the sensor fabric, the resistance of the fabric will drop so that electric current can begin flowing between the two conductor wires. For a particular strip substrate comprising a particular material, having a particular length, and having particular separation between the conductor strips, a threshold value for resistance can be determined empirically, and the trigger point for the microcontroller set accordingly.

[0009] In another embodiment of the present invention, a spot sensor comprises two electrodes embedded in a spot substrate material, such as dry wall material or other building material, where moisture is to be monitored. The building material which forms the substrate of the spot detector must have high resistance when dry and reduced resistance in the presence of moisture. The electrical characteristics of the spot detector are also affected by the width of separation between the embedded electrodes. For a particular spot substrate comprising a particular material and having particular separation between the electrodes, a threshold value for resistance can be determined empirically, and the trigger point for the microcontroller set accordingly.

[0010] Other systems, methods, features, and advantages of the present invention will be or become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be

included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention, as defined in the claims, can be better understood with reference to the following drawings. The components within the drawings are not necessarily to scale relative to each other, emphasis instead being placed upon clearly illustrating the principles of the present invention.

[0012] **FIG. 1** is a block diagram showing a microcontroller connected to a strip sensor in accordance with the present invention (moisture not present).

[0013] **FIG. 2** is a block diagram showing a microcontroller connected to a strip sensor in accordance with the present invention (moisture present).

[0014] **FIG. 3** is a schematic diagram of a strip sensor in accordance with the present invention.

[0015] **FIG. 4** is a schematic diagram of a spot sensor in accordance with the present invention.

[0016] **FIG. 5** is a flow chart for programming a microcontroller to monitor moisture sensors in accordance with the present invention.

[0017] **FIG. 6** is a block diagram of a moisture detection system with multiple strip sensors, multiple spot sensors, and combinations of strip sensors and spot sensors in accordance with the present invention.

## DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

[0018] Turning to **FIGS. 1 and 2**, a moisture detector **10** is shown comprising a microcontroller **30** and a strip sensor **12**. In **FIG. 1**, the strip sensor **12** is connected to microcontroller **30** by means of inputs **32** and **34**. When the strip sensor **12** shown in **FIG. 1** is dry, the resistance between inputs **32** and **34** is high, and based on that high resistance, the microcontroller **30** recognizes that there is no moisture present at the strip sensor **12**. Alternatively, in **FIG. 2**, moisture, such as a drop of water **11**, is present at the strip sensor **12**. As will be explained in greater detail, the presence of moisture on strip center **12** causes the resistance across inputs **32** and **34** to decrease. The microcontroller **30** recognizes the decrease in resistance at inputs **32** and **34**, and produces an alarm indicating the presence of moisture at the location of the strip sensor **12**.

[0019] A detailed view of the strip sensor **12** is shown in **FIG. 3**. The strip sensor **12**, in the form of an elongated ribbon, comprises a strip substrate **14** on which are mounted conductor strips **16** and **18**. The conductor strips **16** and **18** extend essentially parallel along the length of the strip sensor **12**. The conductor strips **16** and **18** on the strip substrate **14** are separated by a predetermined distance. The conductor strips **16** and **18** comprise conductive metal strips, such as wire, metal foil, or other suitable conductor.

[0020] The strip substrate **14** may constitute a variety of materials which exhibit the characteristic of having a high electrical resistance in the absence of moisture and a reduced electrical resistance when moisture is present on the strip substrate **14**. The strip substrate **14** in one embodiment of the invention is a water absorbing fabric such as untreated polyester. A particularly useful untreated polyester fabric is available from McMaster Carr, 6100 Fulton Industrial Blvd., Atlanta, Ga. 30336-2852, as a plain weave polyester webbing. That untreated polyester fabric has a dry resistance of greater than 6 megohms and a moisture saturated resistance of less than 5 megohms. The resistance of the fabric changes in a linear fashion based on volume of liquid absorbed and the separation of the conductor strips **16** and **18**. By adjusting the separation of the conductor strips **16** and **18**, the time constant of the drop in resistance can be changed. Once the resistance of the fabric strip substrate **14** between the conductor strips for **16** and **18** drops below about 5 megohms, that resistance at the inputs **32** and **34** of the microcontroller **30** causes the analog to digital converter of the microcontroller **30** to begin registering the presence of moisture. As more moisture is absorbed by the fabric strip substrate **14**, the resistance of the fabric strip substrate **14** continues dropping until the resistance reaches almost 0 ohms thereby allowing current to flow from one conductor strips **16** through the saturated fabric to the other conductor strip **18** driven by 5 volts of potential between the conductor strips **16** and **18**. The microcontroller **30** can thus be programmed to recognize the progressive drop in resistance from a dry fabric to a fully saturated fabric and produce alarms accordingly.

[0021] For the strip sensor **12** for use with the microcontroller **30**, other suitable strip substrate materials include Nylon, polypropylene, and cotton or muslin having a dry resistance of greater than 6 megohms and a wet resistance of less than 5 megohms. By using a microcontroller with a different input impedance, the wet and dry resistance of the strip substrate **14** may be adjusted accordingly.

[0022] An alternative moisture sensor is a spot sensor **20** shown in **FIG. 4**. The spot sensor **20** comprises a spot substrate **22** in which electrodes **24** and **26** are embedded. The electrodes **24** and **26** are connected via wires **36** and **38** to the inputs **32** and **34** of the microcontroller **30**. The electrodes **24** and **26** comprise metal pins or the like embedded directly into the spot substrate **22**. In one embodiment of the spot sensor **20**, the spot substrate **22** is dry wall material that is used to construct a wall where moisture detection is desired. For ordinary dry wall such as that provided by US Gypsum, Georgia Pacific, and for an electrode separation of about 1 inch the dry resistance across the electrodes **24** and **26** is greater than 6 megohms. When the spot substrate **22** is saturated with moisture, the resistance across the electrodes **24** and **26** is reduced to less than 5 megohms. The resistance of the spot substrate **22** changes in a linear fashion based on volume of liquid absorbed and the separation of the electrodes **24** and **26**. By adjusting the separation of the electrodes **24** and **26**, the time constant of the drop in resistance can be changed. Once the resistance of the spot substrate **22** between the electrodes **24** and **26** drops below about 5 megohms, that resistance at the inputs **32** and **34** of the microcontroller **30** causes the analog to digital converter of the microcontroller **30** to begin registering the presence of moisture. As more moisture is absorbed by the spot substrate **22**, the resistance of the spot substrate **22** continues dropping until the resistance reaches almost 0 ohms thereby allowing current to flow from one electrode **24** through the saturated substrate to the other electrode **26** driven by 5 volts of potential between the electrodes **24** and

**26**. The microcontroller **30** can thus be programmed to recognize the progressive drop in resistance from a dry substrate to a fully saturated substrate and produce alarms accordingly.

[**0023**] In use, the strip sensor **12** provides the advantage of monitoring an extended area of an enclosed space. The strip sensor **12** can be mounted around a window or door or along a baseboard to sense the presence of moisture at any point around the window or door or along the baseboard. By contrast, the spot sensor **20** can only monitor the area directly adjacent the space between the electrodes **24** and **26**.

[**0024**] The microcontroller **30** is connected to the strip sensor **12** or the spot sensor **20** and monitors the resistance of those sensors to determine whether or not moisture is present. Because the strip sensor **12** and a spot sensor **20** may be made of different substrate materials, the resistance range may vary from sensor to sensor. Therefore, the microcontroller **30** is programmed to identify the appropriate trigger level for each of the sensors connected to the microcontroller **30**. Moreover, in order to minimize false triggers, the microcontroller **30** has the ability to monitor the resistance of the sensors over time and create a sensor profile. The sensor profile provides a comparison baseline for determining whether the sensor has actually encountered moisture or whether the sensor is operating within the acceptable resistance range for different levels of relative humidity. **FIG. 5** is a flow chart showing the method employed for setting up the microcontroller **30** for monitoring the resistance of the sensors connected to the microcontroller **30**. In that regard, the program method employed to set up the microcontroller **30** begins at step **100** and proceeds to step **102** where the trigger level for the microcontroller **30** is calibrated to the number and type of sensors connected to the microcontroller **30**. The calibration at step **102** is based on the empirically determined resistance values of the strip sensors and a spot sensors connected to the microcontroller **30**. At step **104**, the response time and sampling rate for the particular sensor configuration is set within the microcontroller **30**. Again the response time and sampling rate for the sensor configuration is empirically determined prior to setting the microcontroller **30**. At step **106**, the set points for fault detection by the microcontroller **30** are set.

[**0025**] The set up method then proceeds to step **108** where the microcontroller **30** determines whether a modem is connected to its output. If a modem is connected the set up procedure continues to step **110** where the user location and the call contact information is stored so that upon the detection of a fault (the presence of moisture), the modem will dial the security company and transmit the necessary information to identify the location where the moisture sensors are located. If the modem is not present at step **108**, the method proceeds to step **112** where the microcontroller **30** determines whether a water cut off relay is installed. If a water cut off relay is installed, the setup program moves to step **114** where the microcontroller **30** is configured to activate one or more water cut off relays depending on the location of the sensed fault. If there is no water cut off relay, the program moves from step **112** to step **116** which represents a generic configuration for additional future installation options (step **118**) for communication in the presence of a moisture fault or initiation of a particular remedial action in the presence of a moisture fault.

[**0026**] From step **118**, the set up procedure moves to step **120** where the local alarms or warning light is configured for activation in the presence of a detected moisture fault. From step **120**, the set up procedure moves to step **122** where the configuration for the system is set within the storage medium of the microcontroller **30**. Once the programming has been stored at step **122**, the microcontroller **30** is initialized and ready to begin monitoring the sensors for the presence of moisture.

[**0027**] The program for the microcontroller **30** can be implemented in hardware, software, firmware, or a combination thereof. In the preferred embodiment(s), the program for the microcontroller **30** is implemented in software or firmware that is stored in a memory and that is executed by a suitable instruction execution system in the microcontroller **30**. If the program is implemented in hardware, as in an alternative embodiment, the program can be implemented with any or a combination of the following technologies, which are all well known in the art: a discrete logic circuit(s) having logic gates for implementing logic functions upon data signals, an application specific integrated circuit (ASIC) having appropriate combinational logic gates, a programmable gate array(s) (PGA), a field programmable gate array (FPGA), etc.

[**0028**] The program for the microcontroller **30**, which comprises an ordered listing of executable instructions for implementing logical functions, can be embodied in any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In the context of this document, a "computer-readable medium" can be any means that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The computer readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection (electronic) having one or more wires, a portable computer diskette (magnetic), a random access memory (RAM) (electronic), a read-only memory (ROM) (electronic), an erasable programmable read-only memory (EPROM or Flash memory) (electronic), an optical fiber (optical), and a portable compact disc read-only memory (CDROM) (optical).

[**0029**] **FIG. 6** is a block diagram of a moisture detection system **50** utilizing multiple sensors organized into zones for the purpose of identifying the location of an invasion of moisture in a closed environment. The moisture detection system **50** comprises the microcontroller **30** having multiple separate inputs to, shown illustratively as **82**, **84**, **86**, and **88**. In addition, the microcontroller **30** has an output **44** which can be used to communicate an alarm condition in various well known ways. For example, the microcontroller can be programmed simply to light a light emitting diode (LED) or to sound a horn if one of the sensors encounters moisture. In addition, the microcontroller can be programmed to contact a remote monitoring service by means of a direct wired connection, a wired network connection, a direct wireless

connection, or a wireless network connection. Because the microcontroller **30** in the moisture detector system **50** can determine of the location of the moisture intrusion, as will be more fully described below, the microcontroller **30** can communicate to the remote monitoring service not only the name and address for the home or place of business, but also the location of the moisture intrusion within the home or place of business. Further, the microcontroller can be connected to a plumbing shut off the valve so that the water can be shut off in response to the presence of moisture in a particular location.

[**0030**] Each of the separate inputs **82**, **84**, **86**, and **88** is connected to one or more sensors in each of zones **52**, **54**, **56**, and **58** respectively. While many configurations of sensors and zones is contemplated by the present invention, the moisture detection system **50** shown in **FIG. 6** is merely illustrative of one particular embodiment of such a moisture detection system **50**. In **FIG. 6**, the zone **52** has a single strip sensor **62** connected between ground and the input **82** of microcontroller **30**. The zone **54** has a single spot sensor **64** connected between ground and the input **84** of microcontroller **30**. The zone **56**, however, has a strip sensor **66**, a spot sensor **68**, and a strip sensor **70** all connected in series between ground and the input **86** of the microcontroller **30**. Finally, the zone **58** has two strip sensors **72** and **74** connected in series between ground and the input **88** of the microcontroller **30**. Because each of the inputs **82**, **84**, **86**, and **88** are separate, the microcontroller **30** can determine which of the zones **52**, **54**, **56**, or **58** has been invaded by moisture and that information can be stored and ultimately transmit it to a monitoring service in order to identify where investigation and remediation should be undertaken.

[**0031**] It should be emphasized that the above-described embodiments of the present invention are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiment(s) of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of this disclosure and the present invention and protected by the following claims.

I claim:

**1**. A moisture detector comprising:

a. a strip sensor comprising:

i. a strip substrate which when dry has a dry electrical resistance and when wet has a wet electrical resistance;

ii. conductor strips extending along the length of the strip substrate and electrically separated from each other by the strip substrate;

b. a microcontroller connected to the conductor strips and programmed to detect a change in the resistance of the strip substrate between the conductor strips as a result of the presence of moisture on the strip substrate.

**2**. The moisture detector of claim 1, wherein the strip substrate is an untreated polyester fabric.

**3**. The moisture detector of claim 1, wherein the strip substrate has a resistance that varies with the amount of moisture absorbed by the strip substrate.

**4**. The moisture detector of claim 3, wherein the microcontroller is programmed to identify a threshold resistance for the strip substrate that is indicative of the presence of moisture.

**5**. The moisture detector of claim 3, wherein the strip substrate has a dry resistance greater than 6 megohms.

**6**. A moisture detector comprising:

a. a spot sensor comprising:

i. a spot substrate which when dry has a dry electrical resistance and when wet has a wet electrical resistance;

ii. conductor electrodes embedded in the spot substrate and electrically separated from each other by the spot substrate;

b. a microcontroller connected to the conductor electrodes and programmed to detect a change in the resistance of the spot substrate between the conductor electrodes as a result of the presence of moisture.

**7**. The moisture detector of claim 6, wherein the spot substrate is dry wall.

**8**. The moisture detector of claim 6, wherein the spot substrate has a resistance that varies with the amount of moisture absorbed by the spot substrate.

**9**. The moisture detector of claim 8, wherein the microcontroller is programmed to identify a threshold resistance for the spot substrate that is indicative of the presence of moisture.

**10**. The moisture detector of claim 8, wherein the spot substrate has a dry resistance greater than 6 megohms.

**11**. A moisture detection system comprising:

a. a plurality of moisture sensors, each sensor comprising:

i. a substrate which when dry has a dry electrical resistance and when wet has a wet electrical resistance;

ii. conductors attached to and separated by the substrate;

b. a microcontroller connected to the conductors of the plurality of sensors and programmed to detect a change in the resistance of the substrate between the conductors as a result of the presence of moisture and to identify the moisture sensor of the plurality of moisture sensors where the presence of moisture exists.

**12**. The moisture detector of claim 11, wherein the substrate is an untreated polyester fabric.

**13**. The moisture detector of claim 11, wherein the substrate has a resistance that varies with the amount of moisture absorbed by the substrate.

**14**. The moisture detector of claim 13, wherein the microcontroller is programmed to identify a threshold resistance for the substrate that is indicative of the presence of moisture.

**15**. The moisture detector of claim 13, wherein the substrate has a dry resistance greater than 6 megohms.

**16**. A method for detecting moisture in a closed environment comprising the steps of:

a. placing a moisture sensor along a path where moisture may exist wherein the sensor comprises:

i. a substrate which when dry has a dry electrical resistance and when wet has a wet electrical resistance;

ii. conductors attached to and separated by the substrate;

b. connecting a microcontroller to the conductors and programming the microcontroller to detect a change in the resistance of the substrate between the conductors as a result of the presence of moisture.

**17**. The method of claim 16, wherein the substrate is an untreated polyester fabric.

**18**. The method of claim 16, wherein the substrate has a resistance that varies with the amount of moisture absorbed by the substrate.

**19**. The method of claim 18, wherein the microcontroller is programmed to identify a threshold resistance for the substrate that is indicative of the presence of moisture.

**20**. The method of claim 18, wherein the substrate has a dry resistance greater than 6 megohms.

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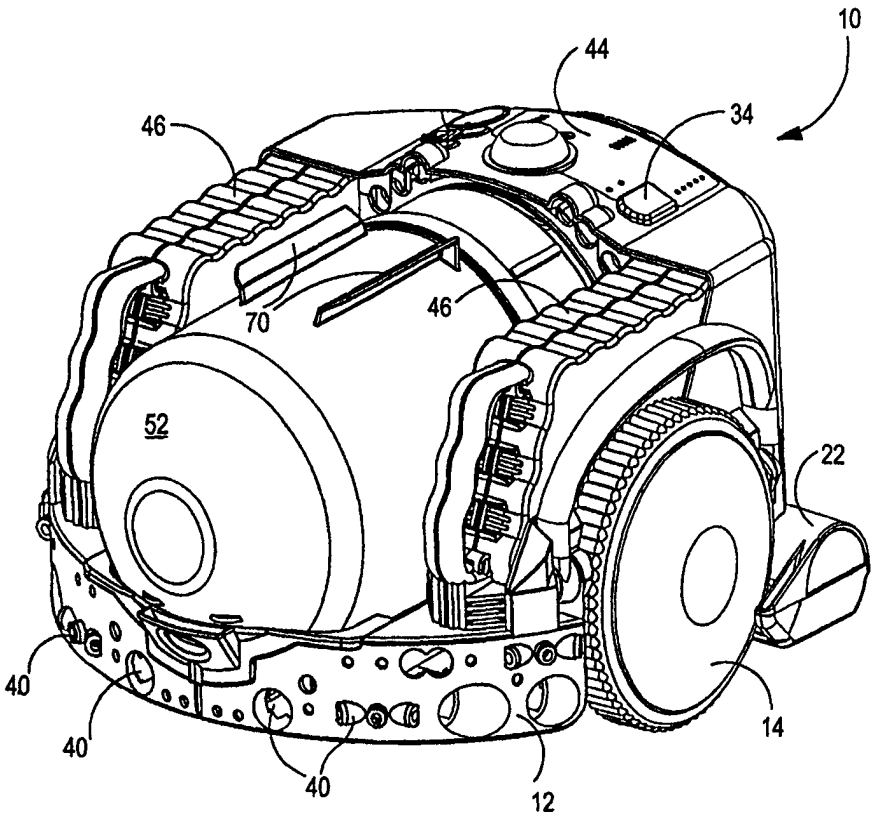
(54) Title: VACUUM CLEANER

(57) Abstract

The invention provides a vacuum cleaner (10) having a chassis (12), supporting wheels (14) mounted on the chassis (12), drive means (15) connected to the supporting wheels (14) for driving the supporting wheels (14) and a control mechanism for controlling the drive means (15) so as to guide the vacuum cleaner (10) across a surface to be cleaned. A cleaner head (22) having a dirty air inlet (24) facing the surface to be cleaned is mounted on the chassis (12) and separating apparatus (52) is supported by the chassis (12) and communicates with the cleaner head (22) for separating dirt and dust from an airflow entering the vacuum cleaner (10) by way of the dirty air inlet (24). The separating apparatus (52) comprises at least one cyclone (54, 56). This type of separating apparatus is not prone to clogging and therefore the pick–up capability of the cleaner (10) is maintained at a high standard.



# Vacuum Cleaner

The invention relates to a vacuum cleaner. Particularly, the invention relates to a vacuum cleaner having a chassis, supporting wheels mounted on the chassis, drive means connected to the supporting wheels for driving the supporting wheels, a control mechanism for controlling the drive means so as to guide the vacuum cleaner across a surface to be cleaned, a cleaner head having a dirty air inlet facing the surface to be cleaned, and separating apparatus supported by the chassis and communicating with the cleaner head for separating dirt and dust from an airflow entering the vacuum cleaner by way of the dirty air inlet. Such a vacuum cleaner is more conveniently termed a robotic vacuum cleaner.

Robotic vacuum cleaners are known. The control mechanism normally includes sensors for detecting obstacles and walls so that the vacuum cleaner is capable of guiding itself around a room so as to vacuum the carpet or other floor covering without human intervention. Examples of robotic vacuum cleaners of this general type are shown and described in, *inter alia*, EP0803224A, US5,534,762, WO97/41451, US5,109,566 and US5,787,545. In the prior art cleaners, the separating apparatus by means of which the dirt and dust is separated from the airflow consists of a bag-type filter or an equivalent container-type filter. The difficulty with arrangements such as these is that, as the bag fills, it becomes clogged with dirt and dust so that the ability of the cleaner to pick up dirt and dust reduces with time. This means that the performance of the cleaner does not remain at a constant standard during operation and may require human intervention to compensate for the reduction in performance. This defeats the object of a robotic vacuum cleaner.

It is an object of the present invention to provide a robotic vacuum cleaner which does not clog as the dirt and dust are separated from the airflow. It is another object of the invention to provide a robotic vacuum cleaner whose pick-up capability does not diminish over time. It is a further object of the invention is to provide a robotic vacuum

cleaner which is simple to use and effective in its operation without being prohibitively expensive to manufacture.

The invention provides a vacuum cleaner having a chassis, supporting wheels mounted on the chassis, drive means connected to the supporting wheels for driving the supporting wheels, a control mechanism for controlling the drive means so as to guide the vacuum cleaner across a surface to be cleaned, a cleaner head having a dirty air inlet facing the surface to be cleaned, and separating apparatus supported by the chassis and communicating with the cleaner head for separating dirt and dust from an airflow entering the vacuum cleaner by way of the dirty air inlet, characterised in that the separating apparatus compri:

Providing cyclonic separating apparatus on a robotic vacuum cleaner removes the problem of the bag- or container-type filters clogging with use. In cyclonic separating apparatus, clogging does not occur and therefore there is no decrease in the pick-up capability which maintains the suction at the dirty air inlet. The performance of the cleaner remains constant because the suction developed at the dirty air inlet is maintained at a constant level.

Preferably, the separating apparatus comprises two cyclones, the upstream cyclone being adapted to remove comparatively large dirt and dust particles from the airflow and the downstream cyclone being adapted to remove comparatively small dirt and dust particles from the airflow. This arrangement allows the downstream cyclone to operate under optimum conditions because the larger dirt and dust particles have already been removed from the airflow before it reaches the downstream, high efficiency cyclone. It is also preferred if the cyclones are arranged concentrically, more preferably one inside the other, so as to provide a compact and convenient arrangement. In this case, the outer, low efficiency cyclone can be generally cylindrical in shape and the inner, high efficiency cyclone can be frusto-conical in shape.

Preferably, the separating apparatus is supported on the chassis with the longitudinal axis of the separating apparatus lying in a substantially horizontal position. This minimises the height of the cleaner.

The cyclonic separating apparatus preferably includes a removable bin or collecting chamber in which, in use, the dirt and dust separated from the airflow is collected. The bin or collecting chamber is removable to allow convenient emptying of the vacuum cleaner of dirt and dust. It is preferable if the bin or collecting chamber is transparent or translucent so that the interior of the bin or collecting chamber can be periodically inspected. The user can then see when the bin needs to be emptied.

An embodiment of the invention will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a perspective view of a vacuum cleaner according to the invention;

Figure 2 is a plan view of the vacuum cleaner of Figure 1;

Figure 3 is a rear view of the vacuum cleaner of Figure 1;

Figure 4 is a side view of the vacuum cleaner of Figure 1;

Figure 5 is an underneath view of the vacuum cleaner of Figure 1;

Figure 6 is a sectional view taken along the line V-V of Figure 2; and

Figure 7 is a sectional view taken along the line VI-VI of Figure 6 showing only the cleaner head and the cyclonic separator of the vacuum cleaner of Figure 1.

The vacuum cleaner 10 shown in the drawings has a supporting chassis 12 which is generally circular in shape and is supported on two driven wheels 14 and a castor wheel 16. The chassis 12 is preferably manufactured from high-strength moulded plastics material, such as ABS, but can equally be made from metal such as aluminium or steel. The chassis 12 provides support for the components of the cleaner 10 which will be described below. The driven wheels 14 are arranged at either end of a diameter of the chassis 12, the diameter lying perpendicular to the longitudinal axis 18 of the cleaner 10. Each driven wheel 14 is moulded from a high-strength plastics material and carries a comparatively soft, ridged band around its circumference to enhance the grip of the

wheel 14 when the cleaner 10 is traversing a smooth floor. The driven wheels 14 are mounted independently of one another via support bearings (not shown) and each driven wheel 14 is connected directly to a motor 15 which is capable of driving the respective wheel 14 in either a forward direction or a reverse direction. By driving both wheels 14 forward at the same speed, the cleaner 10 can be driven in a forward direction. By driving both wheels 14 in a reverse direction at the same speed, the cleaner 10 can be driven in a backward direction. By driving the wheels 14 in opposite directions, the cleaner 10 can be made to rotate about its own central axis so as to effect a turning manoeuvre. The aforementioned method of driving a vehicle is well known and will not therefore be described any further here.

The castor wheel 16 is significantly smaller in diameter than the driven wheels 14 as can be seen from, for example, Figure 4. The castor wheel 16 is not driven and merely serves to support the chassis 12 at the rear of the cleaner 10. The location of the castor wheel 16 at the trailing edge of the chassis 12, and the fact that the castor wheel 16 is swivellingly mounted on the chassis by means of a swivel joint 20, allows the castor wheel 16 to trail behind the cleaner 10 in a manner which does not hinder the manoeuvrability of the cleaner 10 whilst it is being driven by way of the driven wheels 14. The swivel joint 20 is most clearly shown in Figure 6. The castor wheel 16 is fixedly attached to an upwardly extending cylindrical member 20a which is received by an annular housing 20b to allow free rotational movement of the cylindrical member 20a therewithin. This type of arrangement is well known. The castor wheel 16 can be made from a moulded plastics material or can be formed from another synthetic material such as Nylon.

Mounted on the underside of the chassis 12 is a cleaner head 22 which includes a suction opening 24 facing the surface on which the cleaner 10 is supported. The suction opening 24 is essentially rectangular and extends across the majority of the width of the cleaner head 22. A brush bar 26 is rotatably mounted in the suction opening 24 and a motor 28 is mounted on the cleaner head 22 for driving the brush bar 26 by way of a drive belt (not shown) extending between a shaft of the motor 28 and the brush bar 26.

The cleaner head 22 is mounted on the chassis 12 in such a way that the cleaner head 22 is able to float on the surface to be cleaned. This is achieved in this embodiment in that the cleaner head 22 is pivotally connected to an arm (not shown) which in turn is pivotally connected to the underside of the chassis 12. The double articulation of the connection between the cleaner head 22 and the chassis 12 allows the cleaner head to move freely in a vertical direction with respect to the chassis 12. This enables the cleaner head to climb over small obstacles such as books, magazines, rug edges, etc. Obstacles of up to approximately 25mm in height can be traversed in this way. A flexible connection 30 (see Figure 7) is located between a rear portion of the cleaner head 22 and an inlet port 32 (see also Figure 7) located in the chassis 12. The flexible connection 30 consists of a rolling seal, one end of which is sealingly attached to the upstream mouth of the inlet port 32 and the other end of which is sealingly attached to the cleaner head 22. When the cleaner head 22 moves upwardly with respect to the chassis 12, the rolling seal 30 distorts or crumples to accommodate the upward movement of the cleaner head 22. When the cleaner head 22 moves downwardly with respect to the chassis 12, the rolling seal 30 unfolds or extends into an extended position to accommodate the downward movement.

In order to assist the cleaner head 22 to move vertically upwards when an obstacle is encountered, forwardly projecting ramps 36 are provided at the front edge of the cleaner head 22. In the event that an obstacle is encountered, the obstacle will initially abut against the ramps 36 and the inclination of the ramps will then lift the cleaner head 22 over the obstacle in question so as to avoid the cleaner 10 from becoming lodged against the obstacle. The cleaner head 22 is shown in a lowered position in Figure 6 and in a raised position in Figure 4. The castor wheel 16 also includes a ramped portion 17 which provides additional assistance when the cleaner 10 encounters an obstacle and is required to climb over it. In this way, the castor wheel 16 will not become lodged against the obstacle after the cleaner head 22 has climbed over it.

As can be seen from Figures 2 and 5, the cleaner head 22 is asymmetrically mounted on the chassis 12 so that one side of the cleaner head 22 protrudes beyond the general

circumference of the chassis 12. This allows the cleaner 10 to clean up to the edge of a room on the side of the cleaner 10 on which the cleaner head 22 protrudes.

The chassis 12 carries a plurality of sensors 40 which are designed and arranged to detect obstacles in the path of the cleaner 10 and its proximity to, for example, a wall or other boundary such as a piece of furniture. The sensors 40 comprise several ultra-sonic sensors and several infra-red sensors. The array illustrated in Figures 1 and 4 is not intended to be limitative and the arrangement of the sensors does not form part of the present invention. Suffice it to say that the vacuum cleaner 10 carries sufficient sensors and detectors 40 to enable the cleaner 10 to guide itself or to be guided around a predefined area so that the said area can be cleaned. Control software, comprising navigation controls and steering devices, is housed within a housing 42 located beneath a control panel 44 or elsewhere within the cleaner 10. Battery packs 46 are mounted on the chassis 12 inwardly of the driven wheels 14 to provide power to the motors for driving the wheels 14 and to the control software. The battery packs 46 are removable to allow them to be transferred to a battery charger (not shown).

The vacuum cleaner 10 also includes a motor and fan unit 50 supported on the chassis 12 for drawing dirty air into the vacuum cleaner 10 via the suction opening 24 in the cleaner head 22. The chassis 12 also carries a cyclonic separator 52 for separating dirt and dust from the air drawn into the cleaner 10. The features of the cyclonic separator 52 are best seen from Figures 6 and 7. The cyclonic separator 52 comprises an outer cyclone 54 and an inner cyclone 56 arranged concentrically therewith, both cyclones 54,56 having their coaxial axes lying horizontally. The outer cyclone 54 comprises an entry portion 58 which communicates directly with the inlet port 32 as shown in Figure 7. The inlet port 32 is arranged to be tangential to the entry portion 58 which is cylindrical and has an end wall 60 which is generally helical. The entry portion 58 opens directly into a cylindrical bin 62 having an outer wall 64 whose diameter is the same as that of the entry portion 58. The cylindrical bin 62 is made from a transparent plastics material to allow a user to view the interior of the outer cyclone 54. The end of the bin 62 remote from the entry portion 58 is frusto-conical in shape and closed. A

locating ring 66 is formed integrally with the end of the bin at a distance from the outer wall 64 thereof and a dust ring 68 is also formed integrally with the end of the bin 62 inwardly of the locating ring 66. Located on the outer surface of the bin 62 are two opposed gripper portions 70 which are adapted to assist a user to remove the separator 52 from the chassis 12 for emptying purposes. Specifically, the gripper portions 70 are moulded integrally with the transparent bin 62 and extend upwardly and outwardly from the outer wall 64 so as to form an undercut profile as shown in Figure 1.

The inner cyclone 56 is formed by a partially-cylindrical, partially-frusto-conical cyclone body 72 which is rigidly attached to the end face of the entry portion 58. The cyclone body 72 lies along the longitudinal axis of the transparent bin 62 and extends almost to the end face thereof so that the distal end 72a of the cyclone body 72 is surrounded by the dust ring 68. The gap between the cone opening at the distal end 72a of the cyclone body 72 and the end face of the bin 62 is preferably less than 8mm.

A fine dust collector 74 is located in the bin 62 and is supported by the locating ring 66 at one end thereof. The fine dust collector 74 is supported at the other end thereof by the cyclone body 72. Seals 76 are provided between the fine dust collector 74 and the respective support at either end. The fine dust collector 74 has a first cylindrical portion 74a adapted to be received within the locating ring 66, and a second cylindrical portion 74b having a smaller diameter than the first cylindrical portion 74a. The cylindrical portions 74a, 74b are joined by a frusto-conical portion 74c which is integrally moulded therewith. A single fin or baffle 78 is also moulded integrally with the fine dust collector 74 and extends radially outwardly from the second cylindrical portion 74b and from the frusto-conical portion 74c. The outer edge of the fin 78 is aligned with the first cylindrical portion 74a and the edge of the fin 78 remote from the first cylindrical portion 74a is essentially parallel to the frusto-conical portion 74c. The fin 78 extends vertically upwardly from the fine dust collector 74.

A shroud 80 is located between the first and second cyclones 54, 56. The shroud 80 is cylindrical in shape and is supported at one end by the entry portion 58 and by the

cyclone body 72 of the inner cyclone 56 at the other end. As is known, the shroud 80 has perforations 82 extending therethrough and a lip 83 projecting from the end of the shroud 80 remote from the entry portion 58. A channel 84 is formed between the shroud 80 and the outer surface of the cyclone body 72, which channel 84 communicates with an entry port 86 leading to the interior of the inner cyclone 56 in a manner which forces the incoming airflow to adopt a swirling, helical path. This is achieved by means of a tangential or scroll entry into the inner cyclone 56 as can be seen from Figure 7. A vortex finder (not shown) is located centrally of the larger end of the inner cyclone 56 to conduct air out of the cyclonic separator 52 after separation has taken place. The exiting air is conducted past the motor and fan unit 50 so that the motor can be cooled before the air is expelled to atmosphere. Additionally, a post-motor filter (not shown) can be provided downstream of the motor and fan unit 50 in order to further minimise the risk of emissions into the atmosphere from the vacuum cleaner 10.

The entire cyclonic separator 52 is releasable from the chassis 12 in order to allow emptying of the outer and inner cyclones 54, 56. A hooked catch (not shown) is provided adjacent the inlet port 32 by means of which the cyclonic separator 52 is held in position when the cleaner 10 is in use. When the hooked catch is released (by manual pressing of a button 34 located in the control panel 44), the cyclonic separator 52 can be lifted away from the chassis 12 by means of the gripper portions 70. The bin 62 can then be released from the entry portion 58 (which carries with it the shroud 80 and the inner cyclone body 72) to facilitate the emptying thereof.

Electronic circuitry for controlling operation of the robotic vacuum cleaner is housed in a lower portion of chassis 12 (see region 90, Figure 6). Other circuitry is located beneath control panel 44. The circuitry is electrically shielded from electrostatic fields generated by the cyclone by positioning the circuitry between sheets of electrically conductive material. A first sheet underlies the bin 62. Circuitry is mounted beneath this first sheet and a second sheet lies on the base of the chassis, underneath the circuitry. The sheets are electrically grounded.

The vacuum cleaner 10 described above operates in the following manner. In order for the cleaner 10 to traverse the area to be cleaned, the wheels 14 are driven by the motors 15 which, in turn, are powered by the batteries 46. The direction of movement of the cleaner 10 is determined by the control software which communicates with the sensors 40 which are designed to detect any obstacles in the path of the cleaner 10 so as to navigate the cleaner 10 around the area to be cleaned. Methodologies and control systems for navigating a robotic vacuum cleaner around a room or other area are well documented elsewhere and do not form part of the inventive concept of this invention. Any of the known methodologies or systems could be implemented here to provide a suitable navigation system.

The batteries 46 also provide power to operate the motor and fan unit 50 to draw air into the cleaner 10 via the suction opening 24 in the cleaner head 22. The motor 28 is also driven by the batteries 46 so that the brush bar 26 is rotated in order to achieve good pick-up, particularly when the cleaner 10 is to be used to clean a carpet. The dirty air is drawn into the cleaner head 22 and conducted to the cyclonic separator 52 via the telescopic conduit 30 and the inlet port 32. The dirty air then enters the entry portion 58 in a tangential manner and adopts a helical path by virtue of the shape of the helical wall 60. The air then spirals down the interior of the outer wall 64 of the bin 62 during which motion any relatively large dirt and fluff particles are separated from the airflow. The separated dirt and fluff particles collect in the end of the bin 62 remote from the entry portion 58. The fin 78 discourages uneven accumulation of dirt and fluff particles and helps to distribute the dirt and fluff collected around the end of the bin 62 in a relatively even manner.

The airflow from which dirt and larger fluff particles has been separated moves inwardly away from the outer wall 64 of the bin 62and travels back along the exterior wall of the fine dust collector 74 towards the shroud 80. The presence of the shroud 80 also helps to prevent larger particles and fluff traveling from the outer cyclone 54 into the inner cyclone 56, as is known. The air from which comparatively large particles and

dirt has been separated then passes through the shroud 80 and travels along the channel between the shroud 80 and the outer surface of the inner cyclone body 72 until it reaches the inlet port 86 to the inner cyclone 56. The air then enters the inner cyclone 56 in a helical manner and follows a spiral path around the inner surface of the cyclone body 72. Because of the frusto-conical shape of the cyclone body 72, the speed of the airflow increases to very high values at which the fine dirt and dust still entrained within the airflow is separated therefrom. The fine dirt and dust separated in the inner cyclone 56 is collected in the fine dust collector 74 outwardly of the dust ring 68. The dust ring 68 discourages re-entrainment of the separated dirt and dust back into the airflow.

When the fine dirt and dust has been separated from the airflow, the cleaned air exits the cyclonic separator via the vortex finder (not shown). The air is passed over or around the motor and fan unit 50 in order to cool the motor before it is expelled into the atmosphere.

The provision of cyclonic separating apparatus on a robotic vacuum cleaner avoids the need to make use of bag-type filters to separate the dirt or dust from the airflow. This in turn avoids the inevitable clogging of bag-type filters which can result in a reduction in pickup (and therefore reduced efficacy in cleaning). The invention herein described is not concerned with the specific means by which the cleaner is propelled across a surface to be cleaned, nor with the specific means by which the cleaner avoids contact with obstacles or obstructions. Indeed, the cleaner could be powered via a mains supply using a cable if desired, although it is preferred that the cleaner be operated in a cordless manner. The nature and arrangement of the sensors described above are also immaterial and can be replaced by equivalent arrangements which will be apparent to a skilled reader. It will be understood that the means by which the batteries providing power to the cleaner are charged is also immaterial to the invention, as is the arrangement by which they are attached to and released from the cleaner. The same goes for the exact design and configuration of the cleaner head and the manner by which it is mounted on the chassis. All of these features are to be regarded as non-essential to the central

concept of providing a robotic or autonomous vacuum cleaner with cyclonic separating means in the manner described above.

**Claims:**

1. A vacuum cleaner having a chassis, supporting wheels mounted on the chassis, drive means connected to the supporting wheels for driving the supporting wheels, a control mechanism for controlling the drive means so as to guide the vacuum cleaner across a surface to be cleaned, a cleaner head having a dirty air inlet facing the surface to be cleaned, and separating apparatus supported by the chassis and communicating with the cleaner head for separating dirt and dust from an airflow entering the vacuum cleaner by way of the dirty air inlet, characterised in that the separating apparatus comprises at least one cyclone.

2. A vacuum cleaner as claimed in Claim 1, wherein the separating apparatus is supported on the chassis with the longitudinal axis of the separating apparatus lying in a substantially horizontal position.

3. A vacuum cleaner as claimed in Claim 1 or 2, wherein the separating apparatus comprises two cyclones arranged in series.

4. A vacuum cleaner as claimed in Claim 3, wherein the upstream cyclone is adapted to remove comparatively large-sized dirt and dust particles from the airflow and the downstream cyclone is adapted to remove comparatively small-sized dirt and dust particles from the airflow.

5. A vacuum cleaner as claimed in Claim 3 or 4, wherein the cyclones are arranged concentrically.

6. A vacuum cleaner as claimed in any one of Claims 3 to 5, wherein the downstream cyclone is arranged inside the upstream cyclone.

7. A vacuum cleaner as claimed in any one of Claims 3 to 6, wherein the upstream cyclone is generally cylindrical in shape.

8. A vacuum cleaner as claimed in any one of Claims 3 to 7, wherein the downstream cyclone is frusto-conical in shape.

9. A vacuum cleaner as claimed in Claim 1 or 2, wherein the separating apparatus comprises a single cyclone which is frusto-conical in shape.

10. A vacuum cleaner as claimed in any one of the preceding claims, wherein the separating apparatus comprises a removable bin or collecting chamber in which, in use, dirt and dust is collected.

11. A vacuum cleaner as claimed in Claim 10, wherein the removable bin or collecting chamber is transparent or translucent.

12. A vacuum cleaner as claimed in any one of the preceding claims, wherein the cleaner head is connected to the chassis in a manner which allows the cleaner head to float on the surface to be cleaned.

13. A vacuum cleaner as claimed in Claim 12, wherein the cleaner head is connected to the chassis by means of an arm which is pivotally connected to the chassis at a first end and pivotally connected to the cleaner head at a second end.

14. A vacuum cleaner as claimed in any one of the preceding claims, wherein at least one power pack is carried by the chassis and is connected to the drive means and the control mechanism.

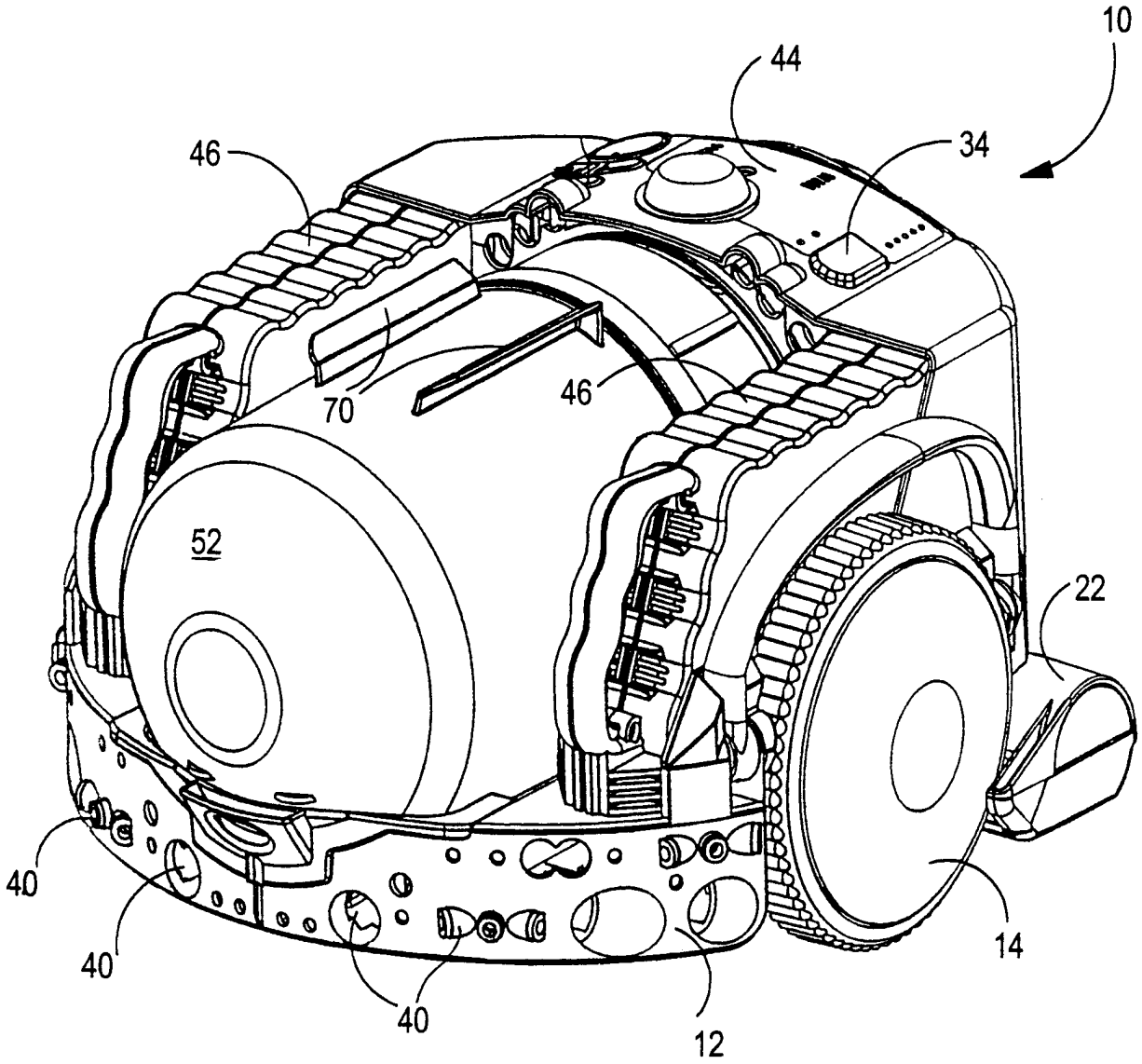



FIG.1.

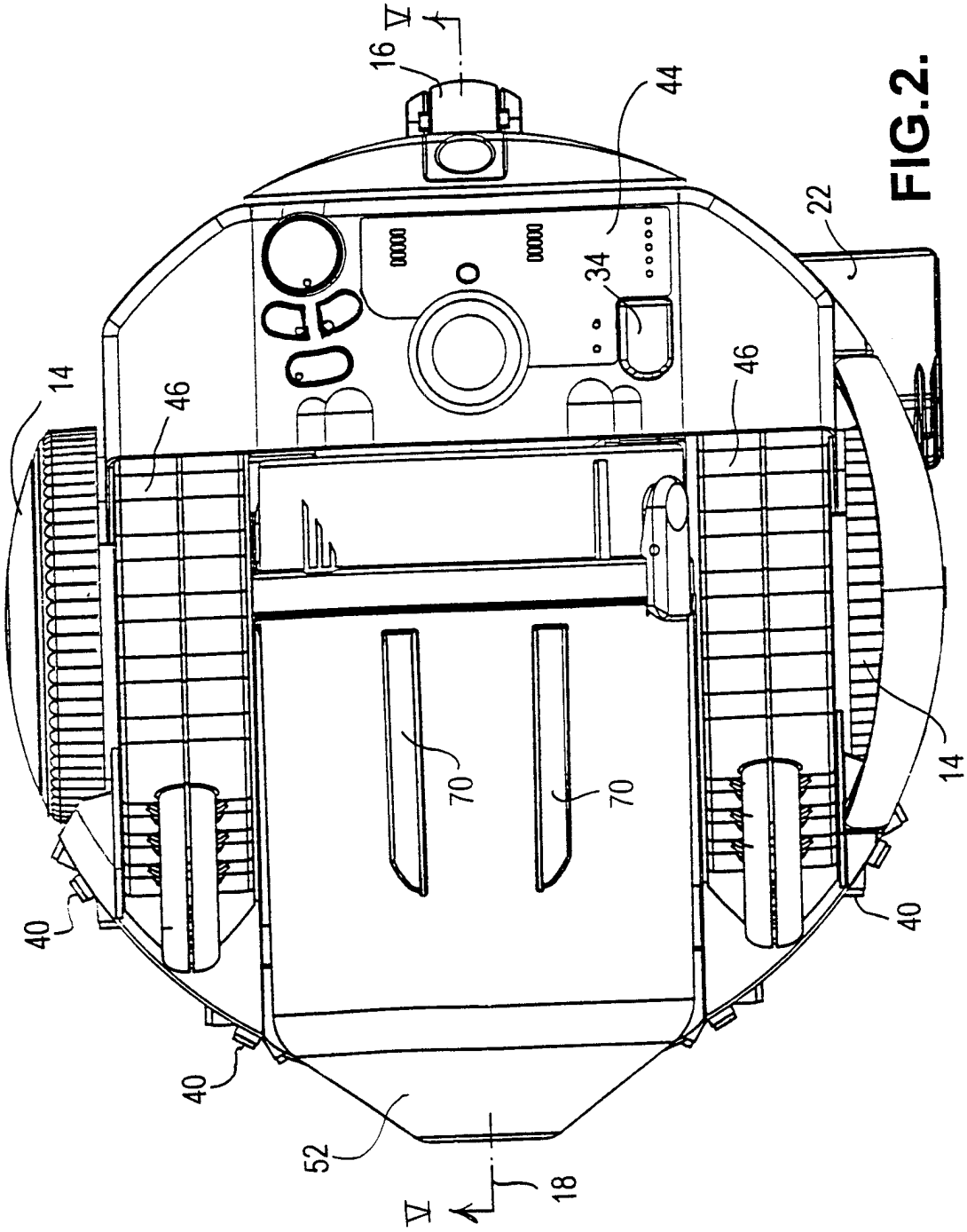



FIG.2.

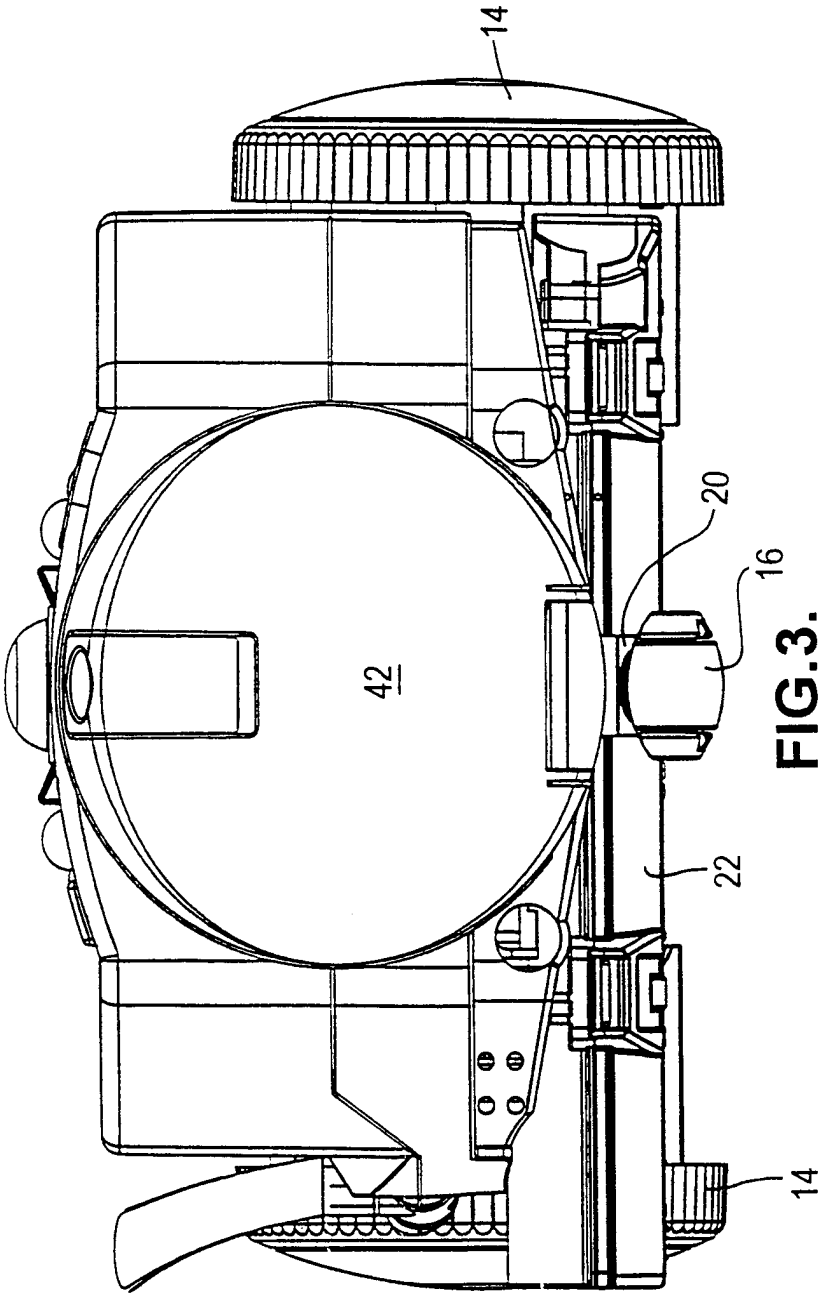



FIG.3.

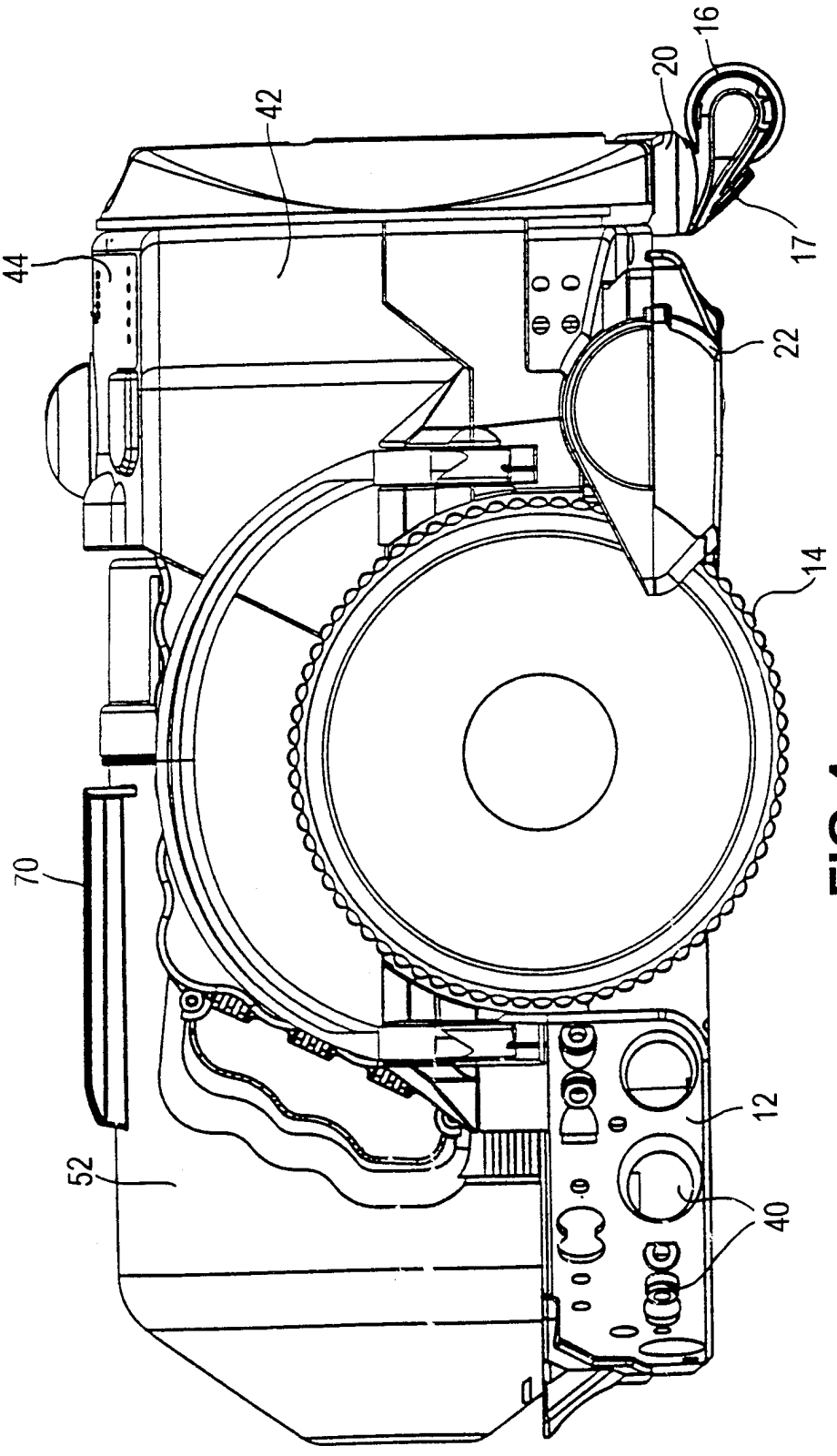



FIG.4.

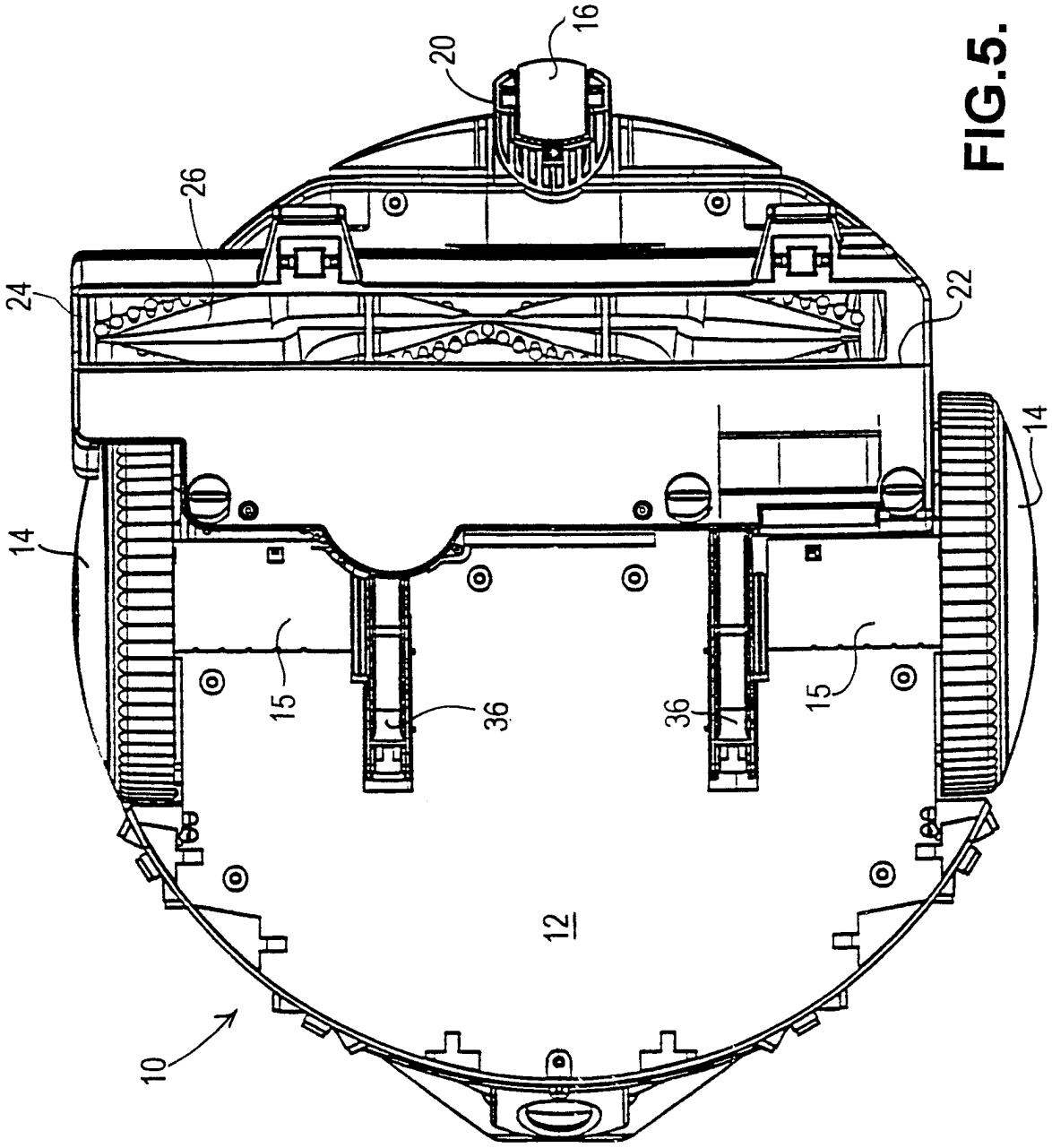
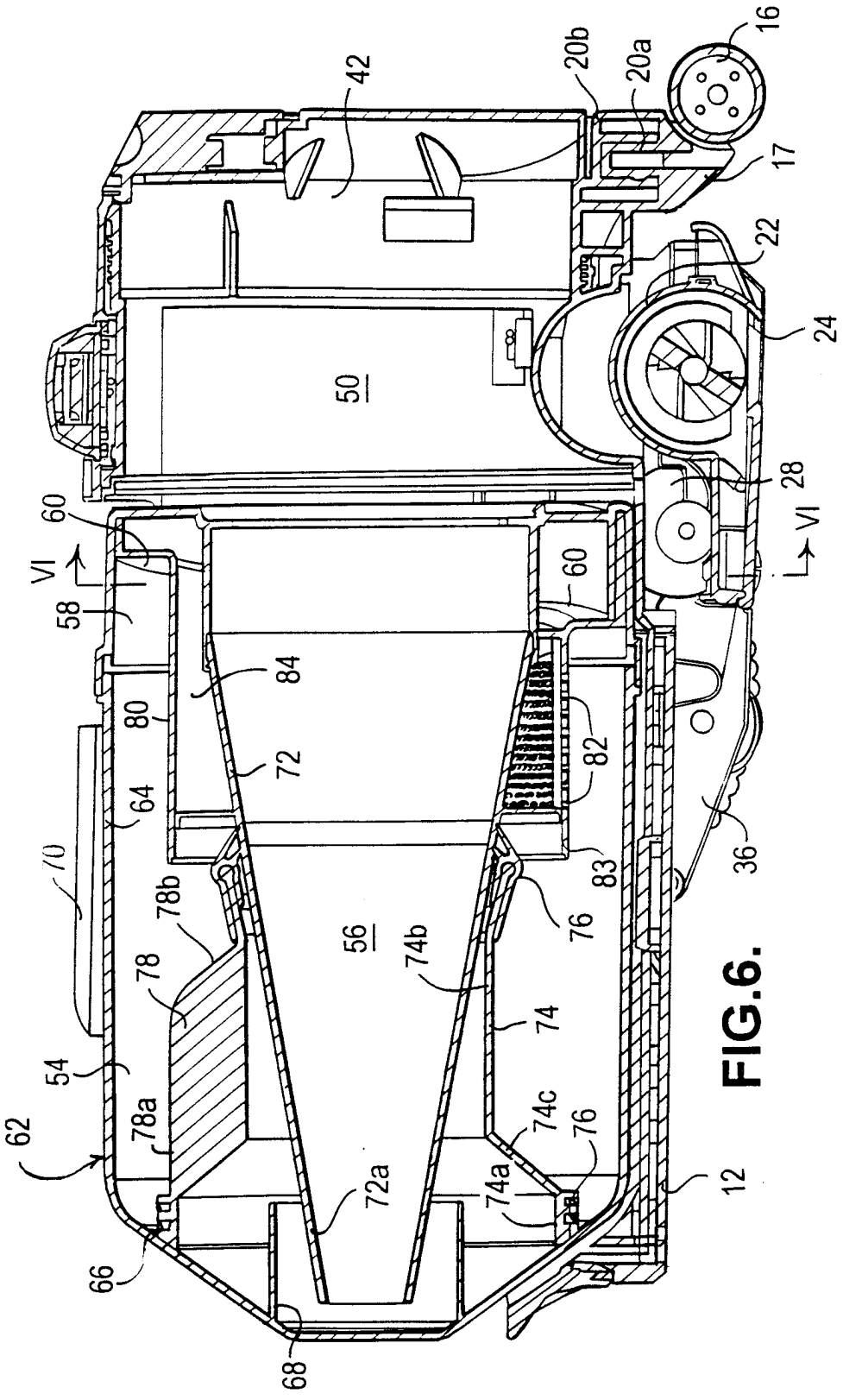



FIG.5.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20b
20a
42
17
22
24
50
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VI
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58
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80
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64
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10
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36
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78a
72a
74a
12
66
68

FIG.6.

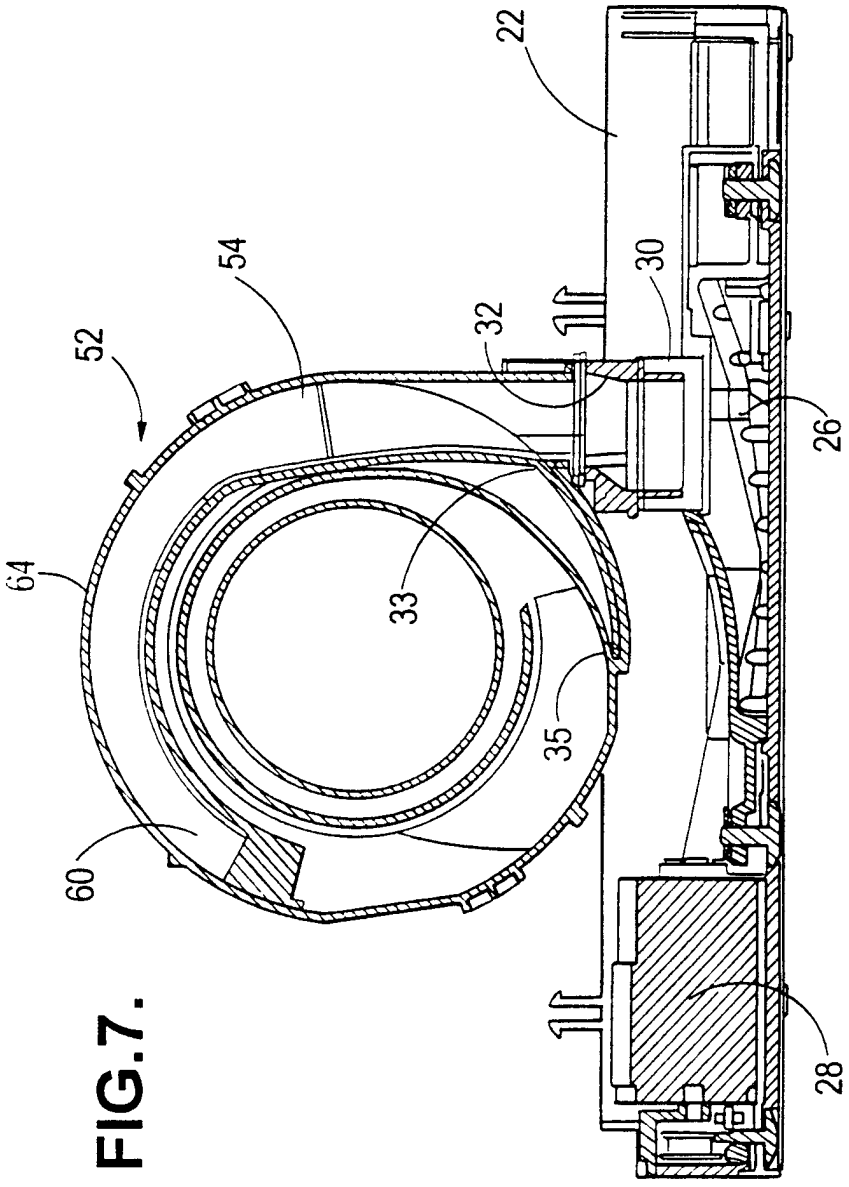


FIG.7.