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| **FORM 2**  THE PATENTS ACT, 1970  (39 of 1970)  &  THE PATENTS RULES, 2003  **COMPLETE SPECIFICATION**  (See section 10 and rule 13) | | |
| **1. Title of the Invention**  **A pipeline traversing Robot** | | |
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| **3. Preamble to the description**  The following specification particularly describes the invention and the manner in which it is to be performed. | | |

**A pipeline traversing robot**

##### **FIELD OF INVENTION**

The present invention relates to the industrial gas pipe leakage detection and more particularly it relates to a pipeline traversing robot.

**BACKGROUND OF INVENTION**

**JPH0791600A** employs a double-structured gas supply pipe with an inner pipe for toxic, high-pressure gas and an outer pipe made of fluororesin, which contains potential leaks and prevents gas from escaping into the environment. It uses nitrogen gas (N₂) flowing between the inner and outer pipes to catch any leaking gas and carry it safely to a central leak detection unit, helping to contain the leak and detect it in a controlled way. Built-in safety features like using special fluororesin pipes, flushing with nitrogen gas, and sealing pipe joints are not included in our robot design. Instead, our robot works from the outside and focuses on real-time inspection, not managing gas flow inside the pipes or strengthening their structure

**CN213985561U** includes a special sliding device that moves along the pipeline to find and locate gas leaks using helium gas and sensors. The system works without opening or dismantling the pipeline, while our robot inspects externally. It also uses a sleeve system that fits around the pipe section to help detect leaks more precisely and safely, even in dangerous or hard-to-reach places. It can test leaks section by section, even in pipelines with bends or diameter changes.

**CN117073924A** designed specifically to test the leakage rate at weld joints in spacecraft pipelines. It uses a helium mass spectrometer, a highly accurate device, to detect tiny helium gas leaks from welds. It includes a robotic arm that can move in six directions to reach complex areas on the spacecraft. Our robot is for general purpose gas leak detection, not specifically spacecraft pipelines. It focuses on automated, localized, and precise helium-based leak testing of spacecraft welds using advanced tools like laser scanners, robotic arms, and helium spectrometry.

**CN114414571B** uses *crawler-type rolling mechanisms* on the *sides* of the detector body, with multiple gears and toothed transmission systems. Uses air spring loop bars and hinged rods for suspension and flexibility of the crawler. Includes waterproof bearing, modular camera components, and interchangeable parts. It is powered by an internal electric motor and gear transmission system to enable the robot to move in narrow, bent, and vertical spaces without external wires.

**CN108225685B** uses mass spectrometry for high-precision detection and identification of specific gas components. It collects and concentrates leaked gas into a vacuum chamber, improving detection efficiency in low-pressure conditions. It uses a creeping motion mechanism with suckers or magnetic adsorption for controlled movement across large curved surfaces. A dedicated fan circulates the collected gas into the mass spectrometer, optimizing flow and ensuring uniform sampling.

**JP4203836B2** uses a *double-pipe system* where an outer pipe surrounds the inner gas pipe, creating an intermediate gap for carrier gas flow and leak detection. It introduces a *viscous flow carrier gas* (like nitrogen or air) along with a *leak inspection gas* (typically helium). Our robot uses sensors, imaging, and magnets to physically navigate pipes and detect leaks in real-time without using tracer gases or controlled flow environments. It uses the *time taken* for the tracer gas to travel through a leak and get detected to estimate both *leak location and severity*.

**EP2831557B1** employs a passive method wherein a tracer gas, such as helium, is introduced into the secondary containment vessel surrounding a primary pipe. It is inherently stationary, relies on gas diffusion through leak points, and does not involve any mechanical mobility or real-time inspection features. This method is primarily applicable to double-walled pipe systems, such as those used in fuel stations, cryogenic pipelines, or radioactive liquid waste transport systems.

**CN114280251A** focuses on finding the exact source of a gas leak using a rotating head, multi-channel gas sensors, and smart movement based on gas concentration. It also includes an air pump that draws in surrounding air, allowing the robot to detect gas from multiple directions without needing to move its entire body. The robot decides its next move based on the gas concentration gradient. It uses special gas sensor made up of many tiny sensors based on MEMS or nanomaterials, which can detect different gases more accurately.

**CN116892664A** uses a hybrid system combining gas and electric power to drive the robot. It has an active rotation unit that adjusts the direction and position of wheels automatically to pass complex paths. It uses spherical wheels with support-wheel mechanisms that help in turning and adapting to pipeline shape, whereas our robot uses regular wheels and castor wheels for vertical climbing and obstacle crossing. It includes a pipe diameter adjustment system allowing the robot to operate in pipes of different sizes. The robot’s movement is highly dependent on video data and a central control unit making decisions based on it.

**GB2544529A** primarily emphasizes pipeline inspection for structural faults, material degradation, or blockages. It uses tracked or caterpillar drives, aerofoil shapes, or differential steering to navigate. These designs are often limited to smooth surfaces or require larger body volumes and complex mechanics. It lakes IoT integration and real-time alerting for gas leakage detection.

However, there does not exist a system that involves an IoT enabled robot that moves horizontally and verticaly on gas pipes providing 360-degree rotation to remotely monitor and detect LPG leakages in real-time even in low-light conditions with image capture.

**OBJECTIVE OF THE INVENTION**

* The primary objective of the invention is to offer an affordable solution for the real-time monitoring and detection of industrial gas pipe leakages.
* Another key objective of the present invention is to make a robot that can navigate through confined or hazardous spaces where human access is limited or risky. The robot is designed to traverse the pipes both horizontally as well as vertically and overcome obstacles such as joints and bends along the route.

**SUMMARY**

The present invention is described hereinafter by various embodiments. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiment set forth herein.

According to the first aspect of the present invention, there is an A pipeline traversing robot. The A pipeline traversing robot comprises a processing unit, an ultrasonic sensor, magnets,motors, a motor driver, an imaging device, a gas sensor, a temperature and humidity sensor, a castor wheel, wheels, a data store and a monitoring and control center.

Further, the processing module is made to receive data from the gas sensor, temperature and humidity sensor to detect for gas pipe leakages.

In accordance with an embodiment of the present invention, the processing unit tracks the location of gas leakage and sends this information to the monitoring and control center.

In accordance with an embodiment of the present invention, processing unit sends alerts to the monitoring and control center in the event of a gas leak.

In accordance with an embodiment of the present invention, the ultrasonic sensor measures the distance to obstacles, preventing the robot from colliding with them.

In accordance with an embodiment of the present invention, the monitoring and control center can instruct the processing unit to capture images using the imaging device and provide illumination with the torch in low-light conditions. . In accordance with an embodiment of the present invention the magnets help the robot to climb vertically on the pipes .

**BRIEF DESCRIPTION OF THE DRAWINGS**

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may have been referred to by embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments. These and other features, benefits, and advantages of the present invention will become apparent by reference to the following text figure, with like reference numbers referring to like structures across the views, wherein:

FIG.1 is a perspective view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.2 is a top view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.3 is a bottom view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.4 is a frontal view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.5 is a rear view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.6 is a left view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.7 is a right view of a pipeline traversing robot in accordance with an embodiment of the present invention;

FIG.8 illustrates how the robot vertically climbs the pipe in accordance with an embodiment of the present invention;

**LIST OF COMPONENTS**

1 -     Processing Unit

2 -     Gas Sensor

3 -     Magnets

4 -     Imaging Device

5 -     Ultrasonic Sensor

6 -    Temperature and Humidity Sensor

7 -     Motors

8- Motor Driver

9-     Castor Wheels

10 -   Wheel

11- Screws

12 -   Monitoring and Control Center

13 -   Data Store

14- Torch

15- A Base

**DETAILED DESCRIPTION OF THE DRAWINGS**

Figure 1. is the perspective view of a pipeline traversing robot. The IoT enabled robot continuously monitors the gas sensor (2) and temperature and humidity sensor (6) readings to detect any gas pipe leakages. A processing unit (1) sends the data of these sensors to a data store (13) which is then displayed to a monitoring and control center (12). An ultrasonic sensor (5) prevents the robot from colliding into any obstacle by measuring the distance between the robot and the obstacle using ultrasonic sound waves. The magnets(3) provide grip and stability while climbing vertically on the pipes. The torch(14) provides illumination in low light conditions, an imaging device (4) is used to provide visual inspection. The castor wheels (9) rotate 360 degrees which enables smooth and easy movement. A motor driver (8) is used to rotate the wheels (10) through motors (7).

Figure 2. is the top view of a pipeline traversing robot. It illustrates the positioning of the processing unit (1), the gas sensor (2), the temperature and humidity sensor (6), the plurality of wheels (10), the ultrasonic sensor (5), the imaging device (4), the torch (14) , and the motor driver (8).

Figure 3. is the bottom view of a pipeline traversing robot. This figure illustrates the positioning of the magnets (3) and castor wheels (9) and the wheels (10).

Figure 4. is the frontal view of a pipeline traversing robot. This figure illustrates the positioning of a processing unit (1), a gas sensor (2), an ultrasonic sensor (5), an imaging device (4), a temperature and humidity sensor (6), the wheels (10), and a castor wheel (9).

Figure 5. is the rear view of a pipeline traversing robot. This figure illustrates the positioning of a processing unit (1), a gas sensor (2), an ultrasonic sensor (5), an imaging device (4), a temperature and humidity sensor (6), the magnets (3), the motors (7), the wheels (10), and a castor wheel (9).

Figure 6. is the left-side view of a pipeline traversing robot. This figure illustrates the positioning of a processing unit (1), a gas sensor (2), an ultrasonic sensor (5), an imaging device (4) , a motor driver (8), the magnets (3), the motors (7), the wheels (10), and a castor wheel (9).

Figure 7. is the right-side view of a pipeline traversing robot. This figure illustrates the positioning of a processing unit (1), an ultrasonic sensor (5), an imaging device (4), a temperature and humidity sensor (6), a motor driver (8), the magnets (3), the motors (7), the wheels (10), and a castor wheel (9).

Figure 8. is the top view of a pipeline traversing robot which illustrates how the robot vertically climbs the pipe. This figure illustrates the positioning of a processing unit (1), a motor driver (8), the motors (7), the wheels (10).

**DETAILED DESCRIPTION OF THE INVENTION**

The present invention is described hereinafter by various embodiments with reference to the accompanying drawing, wherein reference numerals used in the accompanying drawing correspond to the like elements throughout the description.

While the present invention is described herein by way of example using embodiments and illustrative drawings, those skilled in the art will recognize that the invention is not limited to the embodiments of drawing or drawings described and are not intended to represent the scale of the various components. Further, some components that may form a part of the invention may not be illustrated in certain figures, for ease of illustration, and such omissions do not limit the embodiments outlined in any way. It should be understood that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the scope of the present invention as defined by the appended claim.

The present invention is a pipeline traversing robot that has a processing unit (1), a gas sensor (2), a temperature and humidity sensor (6), an ultrasonic distance sensor (5), motors (7), a motor driver (8), an imaging device (4), a castor wheel (9), wheels (10) as seen in figure.1. and a monitoring and control center (12) and a data store (13) as seen in figure.4.

A pipeline traversing robot is made to address the critical need for real-time gas pipe leakage detection and remote monitoring using IoT technology. At its core, the project incorporates a processing unit (1) orchestrating the intricate functionalities of the robot.

The robot is designed to climb and traverse both vertically and horizontally along industrial gas pipes to ensure thorough leakage detection and monitoring and overcoming obstacles as seen in figure 4.

The robot’s movement mechanism adopts a fidget spinner-inspired design, where the wheel arrangement ensures continuous contact with the pipe surface. This design improves grip, weight distribution, and orientation, allowing the robot to climb vertically, overcome obstacles, and navigate bends and joints with enhanced stability and reliability.

The best method of performing the invention, a pipeline traversing robot is disclosed as follows:

The IOT robot connects to the Internet and is positioned on the industrial gas pipes to begin leak detection. A monitoring and control center (12) manages the robot's movements, including left, right, forward, and backward directions. It sends a command to a data store (13), which then transmits a signal to a processing unit (1). Upon receiving the signal, the processing unit (1) forwards it to a motor driver (8), which directs the motors (7) to rotate in a specific direction. As the motors (7) rotate, the attached wheels (10) turn, causing the robot to move accordingly.

To enhance grip and stability while traversing metallic gas pipes, the robot is equipped with strategically placed magnets (3). These magnets (3) help the robot adhere firmly to vertical, horizontal, and inclined pipe surfaces, enabling it to climb and move securely without slipping. Also ,the presence of a castor wheel (9) allows for 360-degree movement, improving the robot's mobility.

An ultrasonic sensor (5) positioned at the front continuously measures the distance to any obstacles that could hinder the robot's movement using ultrasonic sound waves. When an obstacle is detected, the ultrasonic sensor (5) sends a signal to the processing unit (1), which then instructs the motor driver (8) to stop the motors (3). Consequently, the motors (7) cease rotating, causing the wheels (10) to stop, thereby halting the robot, and preventing a collision with the obstacle.

The robot is equipped with a temperature and humidity sensor (6) as well as a gas sensor (2), both crucial for detecting gas leaks. The temperature and humidity sensor (6) continuously monitors the surrounding conditions and sends this data to the processing unit (1), which then forwards it to the data store (13). This information is subsequently retrieved by the monitoring and control center (12). At the same time, the gas sensor (2) continuously checks for the presence of gas leaks and sends the data to the processing unit (1) for further processing.

Data from both the temperature and humidity sensor (6) and the gas sensor (2) is transmitted from the processing unit (1) to a machine learning (ML) model deployed on the data store (13). The ML model analyzes parameters such as temperature, humidity, and gas levels to determine the likelihood of a gas leak. The gas leakage status is then stored in the data store (13) and subsequently updated to the monitoring and control center (12). By incorporating multiple parameters like temperature, humidity, and gas levels, the model enhances its accuracy in detecting gas leaks.

In addition to its sensing capabilities, the robot is equipped with an imaging device (4) that enables remote visual inspection through image capture and viewing. The monitoring and control center (12) communicates with the imaging device (4) via the processing unit (1) to capture images, which are then stored in the data store (13). These images are later retrieved to help assess the robot’s surroundings and potentially identify the source of any gas leaks. This feature adds versatility, allowing users to visually evaluate the situation and make more informed decisions.

Additionally, the robot is equipped with a torch (14) to provide illumination in low-light conditions, ensuring visibility and functionality in challenging environments. The torch (14) can be activated remotely by the monitoring and control center (12). It provides essential lighting in dim settings, assisting with visual inspections and enabling the capture of clear images in darkness, which would not be possible without the torch (14).

The robot's location is continuously tracked and relayed to the monitoring and control center (12). This real-time tracking is valuable for monitoring the robot's movements and enabling swift action at the site in the case of a detected gas leak.

Finally, the robot has the capability to send immediate alerts in the event of gas leaks to the monitoring and control center (12), ensuring that they are promptly informed and can take prompt action.

The seamless integration of the data store (13) with the monitoring and control center (12) and the processing unit (1) facilitates efficient data exchange and synchronization. This cloud-based architecture allows for real-time updates, remote management, and data storage, significantly enhancing the project's scalability and responsiveness.

In summary, the pipeline traversing robot represents an integration of hardware, software, and cloud technologies made for the early detection of leaks in industrial gas pipes. Utilizing a temperature and humidity sensor (6), a gas sensor (2), and a machine learning algorithm, the robot effectively monitors for leaks and promptly sends alerts to the monitoring and control center (12). The ultrasonic sensor (5) helps prevent collisions with obstacles, thereby avoiding damage. Additionally, the imaging device (4) enhance the robot's functionality by capturing images of its surroundings. Magnets (3) embedded within the robot provide firm adhesion to the surface of metallic pipes, enabling it to climb and traverse both vertically and horizontally without slipping. The robot's location tracking capabilities provide valuable information about its position, enabling appropriate responses in the event of gas leaks. Its functionalities extend beyond detection, incorporating real-time monitoring, remote management, and visual inspection. This comprehensive approach to gas leak detection and safety highlights the potential of IoT applications in addressing critical environmental and safety challenges in various industrial sectors.

We claim:

1. A pipeline traversing robot (100) comprising :

a processing unit (1);

a gas sensor (2);

a base(15)

plurality of magnets(3);

an ultrasonic sensor (5);

a motor driver (8);

plurality of motors (7) attached to their respective wheel (10);

an imaging device (4);

a torch (14);

plurality of screws(11) attached to the joints;

a gas sensor (2);

a temperature and humidity sensor (6);

a castor wheel (9);

a monitoring and control center (12);

a data store (13);

wherein the ultrasonic sensor (5), motor driver (8), imaging device (4), torch (14), gas sensor (2), and temperature and humidity sensor (6) are mounted on a base (15) having a fidget spinner design, and are electrically connected to the processing unit (1);

wherein screws (11) are positioned at the terminal ends of the base (15);

wherein the angular adjustments facilitated by screws (11) allow the accommodation of pipes with varying diameters;

wherein the magnetic assembly (3) is fixed on the rear side of the base, maintaining sufficient distance from touching the pipes;

wherein the motor driver (8) is electrically connected to the motor (7), and the motor (7) is mechanically coupled to the wheel (10);

wherein the imaging device (4) is mounted on the robot in a position configured for environmental visual data acquisition.

2.A pipeline traversing robot (100) as claimed in claim 1, wherein the wherein the magnetic assembly (3) is configured to generate sufficient magnetic force for stable adherence to metallic surfaces.

3. A pipeline traversing robot (100) as claimed in claim 1, wherein the surface obstacles like joints and bends are traversed.

4. A pipeline traversing robot (100) as claimed in claim 1, wherein the claws adjust based on the pipe diameter.

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Applicant