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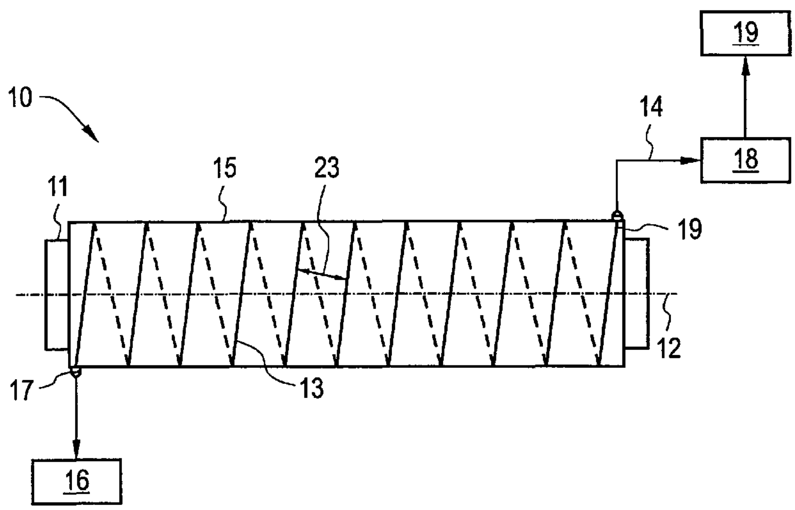
(54) **Title**: FLUID PIPE AND METHOD FOR DETECTING A DEFORMATION ON THE FLUID PIPE

FIG 1



(57) **Abstract**: A fluid pipe comprising a fluid pipe wall enclosing a passage for a fluid and a signal transmission cable mechanically coupled to the fluid pipe wall such that a deformation of the pipe wall leads to a disruption of a transmission of a signal through the signal transmission cable is disclosed. The signal is transmitted through the signal transmission cable to a signal scanning unit for analyzing the signal to detect if there is any disruption of the signal. The deformation on the fluid pipe can be at least one of a damage of the fluid pipe wall or a deterioration of the protective coating on the pipe wall.

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Description

Fluid pipe and method for detecting a deformation on the fluid pipe

The present invention relates to a fluid pipe and a method of detecting a deformation on the fluid pipe.

It is generally known that damages due to a deformation on a fluid pipe such as a formation of a crack or a pinhole on the pipe wall often causes dangerous leakages. The formation of any such impairment if not detected and rectified timely can lead to catastrophic destruction of the structure.

Various techniques are provided for detecting leakages in fluid pipes. One example of such a technique for detecting leak is known from US4066095. Therein, a plurality of flow meter probes is placed at intervals along the length of the pipeline to measure the flow rate of the fluid, wherein the presence of a leak developed at any point along the pipeline is detected by the probe adjacent to the leak and will read a higher measurement. But this method demands expensive equipment in order to detect changes in overall mass flow rate caused by small leak especially for trunk pipelines with relatively large cross-sectional area.

The patent W02008149092 discloses a method of tracking leaks by using various detectors along outside or inside a pipe line. Thereby, a device is passed along the interior of the pipeline to detect the location of one or more leaks within a pipeline. The device transmits signals indicative of its position to an outside unit. This type of detectors however does not provide the possibility of permanent pipeline monitoring. Also, such methods demands auxiliary infrastructure for implementation and is more expensive in case of large-scale trunk pipelines.

The application EP1386131 refers to a method of detecting a leak by measuring a change in the properties of the surrounding medium. Therein, a sensor line is provided along the length of the outer surface of the pipe and enclosed within a covering layer. Here, the covering layer traps the leaking fluid and directs it in the vicinity of the sensor line to detect the leak and the extent of the leak. This is however a complex and time consuming process.

Another example of such a technique for detecting leak is known from US5355720. Therein, a corrosion resistant cable is disclosed for use in electrical detection systems for detecting leaks. The cable is useful in fluid leak containment systems and other applications such as clean rooms, computer rooms, and other raised floor applications and with applications related to buried pipeline, where a plurality of pipes is arranged to form a pipeline. The contact of the fluid with the cable changes the conductive characteristics of the cable such that the presence and also the approximate location of the leak can be ascertained. However, currently this method for continuously monitoring pipelines is limited to detection of relatively large cracks. For detection of small cracks, the method demand precise equipments to detect characteristic changes caused by small breakages.

It is an object of the invention to reduce delay and increase the accuracy in the detection of damages on a fluid pipe.

These problems are solved by a fluid pipe according to claim 1 and a method according to claim 16.
The invention uses a signal transmission cable mechanically coupled to the wall of a fluid pipe for detecting deformations of the wall by a disruption of a signal transmission trough the cable. The disruption of the signal transmission can easily be detected in a secure way and hence allows an accurate identification of a wall deformation. As the signal transmission cable is coupled to the fluid pipe wall, it can be frequently or permanently used to transmit signals and de-

tect their potential disruption so that damages of the fluid wall are detected with little delay.

According to a preferred embodiment, the signal transmission cable is mechanically coupled to the pipe wall continuously along a substantial length of the signal transmission cable. This strengthens the coupling between the cable and the pipe such that the deformation is more likely to be detected by the cable, which in turn increases the detection sensitivity of the cable.

According to a preferred embodiment, the disruption of the signal transmission is an interruption of a signal transmitted by the signal transmission cable. This helps to identify and prioritize the area of breaks on the fluid pipe to make the pinpointing of the break easier. Also, an interruption of the signal transmission is easy to detect and hence provides a clear indication of the damage.

According to a preferred embodiment, a rupture of the signal transmission cable caused by the deformation of the fluid pipe wall leads to the interruption of the signal. This helps to identify the location of the deformation of the pipe wall with more precision.

According to a preferred embodiment, the signal transmission cable changes signal transmission properties under a mechanical stress caused by the deformation of the fluid pipe wall. A deformation usually leads to a local stretching of the pipe wall which will be transferred to the cable through the mechanical coupling, leading to a stress on the cable. Thereby, detecting the deformation through a change in transmission property due to the stress helps in easy and secure detection of the deformation.

According to a preferred embodiment, the deformation of the fluid pipe wall is a fissure. The fissure formed on the pipe wall exerts a strong stress on the cable located across the fissure and lead to a clear distortion of the signal, which can be detected easily.

According to a preferred embodiment, the signal transmission cable is coupled to the fluid pipe wall such that the signal transmission cable is oriented parallel to an axis of the fluid pipe. The orientation makes it easy to attach the cable to the pipe and to easily detect the deformation in the axial direction.

According to another preferred embodiment, the signal transmission cable is arranged such that the signal transmission cable circumferentially encloses the fluid pipe wall. This helps to easily detect the deformation of the pipe wall in a circumferential direction.

According to another preferred embodiment, the signal transmission cable is arranged spirally around the axis of the fluid pipe. This orientation allows detecting deformations in the spiral direction more easily and also it is easy to attach the cable to the pipe wall with relative continuous longitudinal and translational drift.

According to a preferred embodiment, the signal transmission cable is arranged on the fluid pipe wall with a cable spacing selected to detect a predefined leak size. This helps to balance the cost involved in employing the detection method with the required sensitivity to detect the leak.

According to a preferred embodiment, the signal transmission cable is embedded in a protective coating of the fluid pipe wall. This helps to conveniently predict the deterioration of protective coating caused by electrochemical corrosion or other environmental factors. Also, embedding the transmission cable in the protective coating is an easy and inexpensive way to mechanically couple the signal transmission cable to the fluid pipe wall.

According to a preferred embodiment, the deformation of the fluid pipe wall is a deterioration of the protective coating.

According to a preferred embodiment, the signal transmission cable is adapted to transmit at least one of an electrical and optical signal. The cable suitable for transmitting these signals is thin which have higher sensitivity, cheaper and is readily available. Also, the thin cables avoid changes of protective coating material properties and provide for cable rupture instead of elongation during coating deformation.

According to a preferred embodiment, at least one connector is adapted to connect a signal source to the signal transmission cable. This enables quick engagement and disengagement of the signal source to the cable.

According to yet another preferred embodiment, the fluid pipe includes a plurality of the signal transmission cables to locate the deformation on the fluid pipe by identifying the cable from which the signal is disrupted. This enables localization of damages on the pipe wall.

Another aspect of the invention is a method of detecting a deformation on a fluid pipe including transmitting a signal through the signal transmission cable and analyzing the signal transmitted by the signal transmission cable to detect if there is any disruption of the signal. The method herein verifies the status of the output signal from the cable to check the signal integrity. Any change in the signal integrity helps to identify the presence of any leaks or protective coating rupture and the precise location of the damage.

According to another embodiment herein, the signal scanning unit analyzes the signal received from the signal transmission cable to detect a disruption of signal transmission in the cable. This helps to decide whether or not a leak is present and the magnitude of leak, for example the leak size, at any location on the fluid pipe.

According to yet another preferred embodiment, the status of the signal from the signal scanning unit is collected and processed at a control station distant from fluid pipe. This helps to monitor the pipe remotely, particularly in case of long distance pipelines made of a large number of fluid pipes.

The present invention is further described hereinafter with reference to illustrated embodiments shown in the accompanying drawings, in which:

FIG 1 illustrates a schematic view of a fluid pipe with a signal transmission cable in accordance with an embodiment herein;

FIG 2 illustrates a cross-sectional view of a portion of the fluid pipe shown in FIG.1;

FIG 3 illustrates a schematic view of an arrangement of a pipeline monitoring network wherein the invention is applied;

FIG 4 shows a schematic view of a fluid pipe having a signal transmission cable arranged in an alternative manner, according to an embodiment herein;

FIG 5 shows a schematic view of a fluid pipe having a signal transmission cable arranged in another alternative mode, according to an embodiment herein;

FIG 6 illustrates a fluid pipe having a pair of signal transmission cables, according to an embodiment herein;

FIG 7 illustrates an another alternative arrangement of signal transmission cables, according to an embodiment herein; and

FIG 8 shows an exemplary illustration of a fluid pipe with a pipe wall deformation, according to an embodiment herein.

Various embodiments are described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident that such embodiments may be practiced without these specific details.

FIG 1 illustrates a schematic view of a fluid pipe 10 with a signal transmission cable 13, according to an embodiment herein. Referring to FIG.1, the fluid pipe 10 is provided with a protective coating 15 on the outer surface of the fluid pipe wall 11 to prevent pipe wall 11 corrosion and to protect the fluid pipe 10 from mechanical damage. The thickness of the protective coating 15 may depend on fluid pipe 10 diameter and may vary for example approximately from 8 to 25mm.

The fluid pipe 10 includes a signal transmission cable 13 mechanically coupled to the fluid pipe 10. The signal transmission cable 13 can be either glued or connected through a wire or any other coupling means to the fluid pipe wall 11. The mechanical coupling to the pipe wall 11 is strong compared to the strength of the cable 13 and is thus capable of withstanding the mechanical stress in the direction of the cable 13. With other words, the signal transmission cable 14 will rather be affected, e.g. break, in case of stress than come loose from the pipe 10. This helps in more securely detecting local damages in the pipe wall 11.

The signal transmission cable 13 is mechanically coupled along a substantial length of the fluid pipe 10. The signal transmission cable 13 herein is coupled to the fluid pipe 10 in such a way that it is spiraling around the axis 12 of the fluid pipe 10. The signal transmission cable 13 functions as a transmission line for transmitting a signal 14 indicative of the structural integrity of the fluid pipe wall 11.

The occurrence of any structural deformation on the pipe wall 11 due to mechanical influences leads to a disruption of the signal 14 transmitted by the signal transmission cable 13. The disruption depends on the pattern by which the cable 13 is coupled to the pipe wall 11. As the signal transmission cable 13 is winded along the length of the fluid pipe 10, it provides a good surface coverage to detect any damage on the surface of the pipe wall 11.

The disruption can be an interruption of the signal 14 transmitted due to a breakage of the signal transmission cable 13 caused by fluid pipe wall 11 deformation. The deformation herein, for example, can be a fissure, a crack or a hole in the pipe wall 11 caused by the mechanical influences such as pressure variation, change in flow rate, ageing due to environmental influence, corrosion caused by the fluid, any other external interception associated with the fluid pipe 10 or the like.

The deformation also refers to deterioration or other damages on the protective coating 15 caused by electrochemical corrosion or other environmental factors. The signal transmission cable 13 can be also embedded within the protective coating 15 around the fluid pipe wall 11 in order to reduce the effect from surrounding environment. The embedding of the cable 13 does not vary the mechanical properties of the protective coating 15 as the signal transmission cable 13 is of a less diameter. Here the protective coating 15 is a part of the fluid wall 11 which encloses the signal transmission cable 13, such that any coating 15 failure can be detected, even if no leakage is associated with fluid pipe 10.

The signal transmission cable 13 transmits the signal 14 to a signal scanning unit 18 at a remote location. The signal scanning unit 18 analyzes the status of the signal 14 to detect if there is any disruption of the signal 14. In case of a signal 14 disruption, the signal scanning unit 18 sends the information to a control station 19. The control station 19 subsequently process the signal 14 information using suitable processing algorithms to identify the location of deformation on the fluid pipe wall 11 inducing a leak of fluid from the fluid pipe 10.

The signal transmission cable 13 can be made from metallic/non-metallic wires or optical fibers adapted to transmit at least one of an electrical and optical signal 14. The signal transmission cable 13 can be for instance a copper cable, which changes the signal transmission properties under a mechanical stress caused by the deformation of the fluid pipe wall 11. For instance, the mechanical influence creates a cable 13 rupture causing a discontinuity in signal transmission, tampers the transparency of the optical cable, changes resistance of the electrical cable, or changes polarization of the light/signal. The signal transmission cable 13 herein can have a thickness of approximately 0.2- 1.4 micrometers, as an example.

Here, the signal 14 transmitted through the signal transmission cable 13 is generated at a low current signal source 16. The signal source 16 is connected to the signal transmission cable 13 through at least one connector 17 provided on the fluid pipe wall 11. The connector 17 also connects the signal transmission cable to the signal coding unit 18 to transmit the signal 14 from the cable 13. The connector 17 can be made of a corrosion resistant material such as plastic, ceramic or the like.

The cable 13 should be positioned at a specific distance from the fluid pipe wall 11 to reduce the effect of the ambient temperature or pressure changes on the cable 13. Also the signal transmission cable 13 is arranged on the fluid pipe 10 with cable spacing 23 such that the cable 13 has sensitivity for a secure detection of a predefined leak size. The cable spacing 23 herein refers to the distance between the adjacent convolutions of the cable 13. The distance between adjacent convolutions can range for example from approximately 5cm to 20 cm. The adjacent convolutions of the cable 13 are spaced apart to form a space into which the leakage fluid can readily penetrate, thereby causing a change in cable 13 characteristics.

The method herein does not have any limitations regarding the leak size as the protective coating may be damaged even though there is no leakage from the pipe. Thus the minimum detectable leak size can also be determined by protective coating 15 durability.

The signal transmission cable 13 has a significant impact on detection and locating of damages on subsurface applications where the accessibility to the pipelines is restricted. The signal transmission cable 13 embedded on the protective coating 15 as a part of the pipe wall 11 prevents the influence of any corrosive elements or surrounding environment on the cable 13. The cable 13 can be installed above, below or along the side of the pipeline depending upon the nature and surface of contact prone to damages.

The pipe 10 carries a fluid, which may be a liquid such as gasoline or the like or a gas, such as natural gas, synthetic gas, methane, butane, propane or the like. The embodiment can also be employed to detect damages in storage containers, tanks, the pipes for transporting ink from an ink tank to a printer head in a printer, fuel equipments, and the like.

FIG 2 illustrates a cross-sectional view of a portion of the fluid pipe 10 shown in FIG. 1. The fluid pipe 10 is shown as including a protective coating 15 on the surface of a pipe wall 11 and a signal transmission cable 13 modeled as a threaded formation adjacent to the surface of the fluid pipe wall 11. Also, a connector 17 is shown coupled to the pipe wall 11, typically implanted in the protective coating 15.

The protective coating 14 also includes a sub layer 24 as a part of the protective coating 15 between the cable 13 and the pipe wall 11. The sub layer 24 serves as a substrate for the cable 13 and for connector 17 mounting. The sub layer 24 ensures a tight coupling between cable 13 and pipe wall 11 and protective coating 15 prevents the cable 13 from elongation. During the occurrence of a leak, the cable 13 ruptures instead of elongation and can easily detect interruption of transmitted signal 14.

The signal transmission cable 13 is arranged on an area of the fluid pipe 10 to be monitored for fluid leakage. The cable 13 is installed in the body of a hardenable material here shown as a protective coating 15 layer which can protect the cable 13 from considerable mechanical, chemical and other influences.

The signal transmission cable 13 arrangement pattern helps to detect a damage of the protective coating 15, even if there is no leakage of fluid or pipe wall 11 destruction. This allows prediction of electrochemical corrosion caused by protective coating deterioration. An appropriate selection of cable spacing 24 for arranging the cable 13 allows setting the signal transmission cable 13 sensitivity for a secure detection of a pre-defined leak size. The linear dimensions of the leak zone depend on leak dimensions, pipeline pressure and protective coating 15 material properties. Also, more than one signal transmission cable 13 can be coupled to the fluid pipe 10 for more precise detection of leak or other deformation.

FIG 3 illustrates a schematic view of an arrangement of a pipeline monitoring network 20 wherein the invention is applied. The arrangement herein enables to monitor the overall pipeline by monitoring the pipeline in the sections. Here the pipeline is divided into a group of fluid pipes forming a cluster 21 of pipes preferably connected to a single pipeline. Referring to FIG. 3, the pipeline monitoring network 20 is assembled in a hierarchical manner, where the network 20 includes separated pieces each responsible for a single fluid pipe 10 status.

The pipeline is divided into fluid pipe clusters 21 in order to minimize the use of additional equipments such as connectors, wiring etc. Each cluster 21 consists of a plurality of fluid pipes 10 where the size of one fluid pipe 10 equals approximately 10m to 50m. Here the pipe cluster 21 length is about 1km. The clusters 21 in turn are splitted into a smaller set consisting of about 5-10 fluid pipes 10.

Each set is connected to the cluster 21 through an encryptor 25. Each cluster 21 is further connected to a signal scanning unit 18 through a controller 22 associated with the cluster 21. Thus the signal 14 from the signal transmission cable 13 is transmitted through connectors 17 to the signal scanning unit 18, which analyzes the signal 14 and generates a report containing information of all the fluid pipes 10 in the selected cluster 21. All the information concerning the pipeline status is collected from the concerned signal scanning unit 18 and is processed at the control station 19. As each cluster 21 sends separate signals 14 to the scanning unit 18, it is easy to detect the cluster 21 in which the damage is occurred.

The control station 19 is used for coordinating the signal scanning units 18. The signal scanning units 18 can be placed at definite locations to minimize system cost and maintenance. The control station 19 then determines the location of the leak by knowing which signal scanning unit 18 detected the discrepancy and the prominence of the leak.

FIG 4 shows a schematic view of a fluid pipe having a signal transmission cable arranged in an alternative manner, according to an embodiment herein. As shown in FIG. 4, a plurality of signal transmission cables 13 can be arranged parallel to the axis 12 of the fluid pipe 10 with a pre-determined cable spacing 23. The cables 13 can be passed longitudinally along the pipe wall 11, above the pipe wall 11 or below the pipe wall 11 and then the pipe 11 is provided with a protective coating 15 to enclose the cables 13 between the pipe wall 11 and the protective coating 15. When cable 13 is arranged substantially along the length of the pipe 10, the fixing may be carried out using an appropriate adhesive, for example an adhesive tape. The protective coating 15 when dried seals the cable 13 to the pipe surface to prevent the ingress of moisture or dirt.

The cables 13 can also be introduced into the protective coating 15 by resorting using a pushing or a pulling technique. The arrangement enables exact location of the leak at a relatively high speed. Here, one or more damaged cables 13 can be replaced with one or more fresh cables 13 while the pipe 10 of FIG. 4 remains embedded in the ground in a subsurface application.

FIG 5 shows a schematic view of a fluid pipe having a signal transmission cable arranged in another alternative mode, according to an embodiment herein. The signal transmission cables 13 as shown in the figure is arranged such that the plurality of signal transmission cables 13 circumferentially encloses the fluid pipe wall 11. The signal transmission cables 13 are arranged on the fluid pipe 10 with a cable spacing 23 selected to detect a predefined leak size.

The signal detection cables 13 are in intimate contact with the fluid pipe 10 so that even a small leak will reach the cable 13 and effects its operation. This procedure will immediately isolate the damaged section of the pipe 10 and prevent uncontrolled leakage of the fluid into the environment.

Here, the signal transmission cables 13 can also be interconnected so as to effectively form a single cable 13.

The location of the damage along the fluid pipe 10 is instantly displayed on a control station 19. The control station 19 connected to the signal scanning unit 18 includes additional equipment for further analyzing the signal 14 status to determine the proximity of the signal 14 using the amplitude of the signal 14 and the transmission characteristics of the pipe 10 to determine the location of the deformation. A service crew can be immediately dispatched to the exact location of the fault to make necessary repairs.

FIG 6 illustrates a fluid pipe 10 having a pair of signal transmission cables 13, according to an embodiment herein. As shown in FIG. 6, a pair of signal transmission cables 13 is arranged along the pipeline such that the cables 13 are spiraling in opposite rotational direction along the axis 12 of the pipeline. The signal transmission cables 13 are separated with a cable spacing 23 with reference to a predetermined distance from each other along the entire length of the fluid pipe 10. The distance between the cables 13 is chosen such that at least one cable 13 is able to detect a deformation on the pipe wall 11 leading to a leak of the fluid.

By knowing which cable 13 detected the leak and the prominence of the leak the control station 19 is able to determine the location of the deformation. The distance between the cables 13 determines the reliability of the system and the minimum size of the leak which is able to detect. The cables 13 can also be associated to different sections of the pipe 10.

The signal scanning unit 18 is capable of making very accurate measurements so that any small difference in signal transmission properties of the cable 13 along the pipeline can be precisely indicated. These units 18 communicate with a control station 19 that is used as an interface between the fluid pipe 10 and the pipeline monitoring personnel.

The embodiment herein makes it possible to place two different spiral cables 13 with an axial and circumferential orientation to provide a grid like structure. The orientation of the cables in grid like structure provides a good coverage on the fluid pipe. The density of the coverage can be increased by having a narrower spiral by using a plurality of cables in the axial and the circumferential direction.

FIG 7 illustrates another alternative arrangement of signal transmission cables, according to an embodiment herein. The plurality of signal transmission cables 13 is arranged circumferentially and longitudinally on a single pipe 10 as shown in the figure. The arrangement forms a grid like structure enclosing the fluid pipe wall 11. As the cables 13 are in intimate contact with the pipe wall 11, a smallest deformation may also break the cable and effects its operation. A disruption of these signal transmission cables 13 indicates the exact location of the damage on the pipe 10.

The grid like structure provides for rapid and exact location of the damage which in turn reduces response time and any potential excavation expenses in order to find and locate the deformation. Also it continuously monitors all points along the pipe at all times providing complete pipe 10 integrity.

FIG 8 shows an exemplary illustration of a fluid pipe 10 with a pipe wall 11 deformation, according to an embodiment herein. The signal transmission cable 13 is secured to the fluid pipe wall 11 using a mechanical coupling means and is enclosed using a protective coating 15 in an air-tight manner. The cable 13 is arranged for the transmission of any form of control or data signal for instance, electrical or optical. Both the mechanical coupling of cable 13 to the fluid pipe wall 11 and properties of the cable 13 are such that a deformation of the cable 13 would rather effect, for instance, break the cable 13 than slackening it from the pipe wall 11.

A change in mechanical properties associated with the fluid pipe 10 can cause a deformation on the pipe wall 11, such as a fissure 26 as shown in FIG. 8. The formation of the fissure 26 causes a rupturing of the cable 13 at the site of deformation. The rupture of the cable 13 in turn leads to a discontinuity in the transmission of signals 14 indicating a defect on the structural integrity of the pipe wall 11 to the signal scanning unit 18.

In addition to this, the disruption of the cable 13 can also be caused by a deterioration of the protective coating 15 on the fluid pipe 10. As the cable 13 is tightly connected to the protective coating 15, any damage of the protective coating 15 will also lead to a breakage of the cable 13 causing interruption of signal transmission.

The embodiment herein provides a novel and improved combination of a fluid pipe and one or more separate signal transmission cables for a single pipe. This enables more accurate localization of the damaged zone on the fluid pipe wall. There is no need in complete reconstruction of the pipeline monitoring network after complete overhaul. Also, it is possible to replace the plastic coating with signal transmission cable by heat-shrinkage insulation with embedded wires. Here, curled cables should be used instead of ordinary straight ones in order to compensate insulation elongation during winding procedure and its subsequent shrinkage after thermal treatment.

The embodiment herein improve the safety of infrastructure and for personal as any leaks will be detected quickly thus reducing risk to operations personnel. The signals used for the detecting damages are extremely low power because it is much easier to detect presence of signal than a predefined signal intensity level. Also it is incapable of igniting flammable gases making it suitable for use in hazardous zones. In case of flammable gases ignition hazard,optical signal can be optionally applied to eliminate any possibility of spark. Also, it enhances system reliability through reduced downtime as the signal transmission cable is a sensing cable with a longer life. Furthermore, the system can be automated to lower operating cost with less risk of human error and can be interfaced with other control systems using standard protocols.

The implementation of the embodiment herein can be realized by modeling the fluid pipe-cable combination prior or subsequent to burying of the pipe below the ground level or in the pipe wall or any other hard to-reach locations. Further, embedding the cables within the protective coating helps to shield confined cables from undesired mechanical and/or other influences on the fluid pipe. Additional sensors can also be used to monitor the structural integrity of the pipeline and providing an alert indicating any undesirable movement in the pipeline that could potentially lead to mechanical failure.

The fluid pipe herein has a simple construction requiring only a signal transmission cable and a protection coating to adhere the different parts together. The signal transmission cable in accordance with the embodiment is inexpensive to manufacture and is easy to install and remove. Moreover, it is possible to easily replace existing methods with those of the present invention with a minimal expenditure of cost, effort, and time.

List of Reference Signs

10. Fluid pipe
11. Pipe wall
12. Axis
13. Signal transmission cable
14. Signal
15. Protective coating
16. Signal source
17. Connector
18. Signal scanning unit
19. Control station
20. Pipeline monitoring network
21. Cluster
22. Controller
23. Cable spacing
24. Sub layer
25. Encryptor
26. Fissure

Patent claims

1. A fluid pipe (10) comprising:
- a fluid pipe wall (11) enclosing a passage for a fluid; and
- a signal transmission cable (13) mechanically coupled to the fluid pipe wall (11) such that a deformation of the fluid pipe wall (11) leads to a disruption of a transmission of a signal (14) through the signal transmission cable (13).

2. The fluid pipe (10) according to claim 1, wherein the signal transmission cable (13) is mechanically coupled continuously along a substantial length of signal transmission cable (13).

3. The fluid pipe (10) according to claim 1 or 2, wherein the disruption of the signal transmission is an interruption of a signal (14) transmitted by the signal transmission cable (13).

4. The fluid pipe (10) according to claim 3, wherein a rupture of the signal transmission cable (13) caused by the deformation of the fluid pipe wall (11) leads to the interruption of the signal (14).

5. The fluid pipe according to any of the claims 1 to 4, wherein the signal transmission cable (13) changes the signal transmission properties under a mechanical stress caused by the deformation of the fluid pipe wall (11).

6. The fluid pipe (10) according to any of the claims 1 to 5, wherein the deformation of the fluid pipe wall (11) is a fissure (26).

7. The fluid pipe (10) according to any of the claims 1 to 6, wherein the signal transmission cable (13) is arranged parallel to an axis (12) of the fluid pipe (10).

8. The fluid pipe (10) according to any of the claims 1 to 7, wherein the signal transmission cable (13) is arranged such that the signal transmission cable (13) circumferentially encloses the fluid pipe wall (11).

9. The fluid pipe (10) according to any of the claims 1 to 8, wherein the signal transmission cable (13) is arranged spirally around the axis (12) of the fluid pipe (10).

10. The fluid pipe (10) according to any of the claims 1 to 9, wherein the signal transmission cable (13) is arranged on the fluid pipe wall (11) with a cable spacing (23) selected to detect a predefined leak size.

11. The fluid pipe (10) according to any of the claims 1 to 10, wherein the signal transmission cable (13) is embedded in a protective coating (15) of the fluid pipe wall (11).

12. The fluid pipe (10) according to claim 11, wherein the deformation of the fluid pipe wall (11) is a deterioration of the protective coating (15).

13. The fluid pipe according to any of the claims 1 to 12, wherein the signal transmission cable (13) is adapted to transmit at least one of an electrical and optical signal (14).

14. The fluid pipe (10) according to any of the claims 1 to 13, further comprising at least one connector (17) adapted to connect a signal source (16) to the signal transmission cable (13).

15. The fluid pipe (10) according to any of the claims 1 to 14, wherein the fluid pipe (10) includes a plurality of the signal transmission cables (13) to locate the deformation on the fluid pipe (10) by identifying the cable (13) from which the signal (14) is disrupted.

16. A method for detecting a deformation on a fluid pipe (10) according to one of the claims 1 to 15, the method comprising steps of:
- transmitting a signal (14) through the signal transmission cable (13); and
- analyzing the signal (14) transmitted by the signal transmission cable (13) to detect a disruption of the signal (14).

17. The method according to claim 16, wherein a signal scanning unit (18) is used to analyze the signal (14) received from the signal transmission cable (13).

18. The method according to claims 16 or 17, wherein a status of the signal (14) from the signal scanning unit (18) is collected and processed at a control station (19) distant from fluid pipe (10).

19. The method according to any of the claims 16 to 18, wherein a plurality of the signal transmission cables (13) is coupled to the fluid pipe (10) to locate the deformation on the fluid pipe (10) by identifying the cable (13) from which the signal (14) is disrupted.

FIG 1

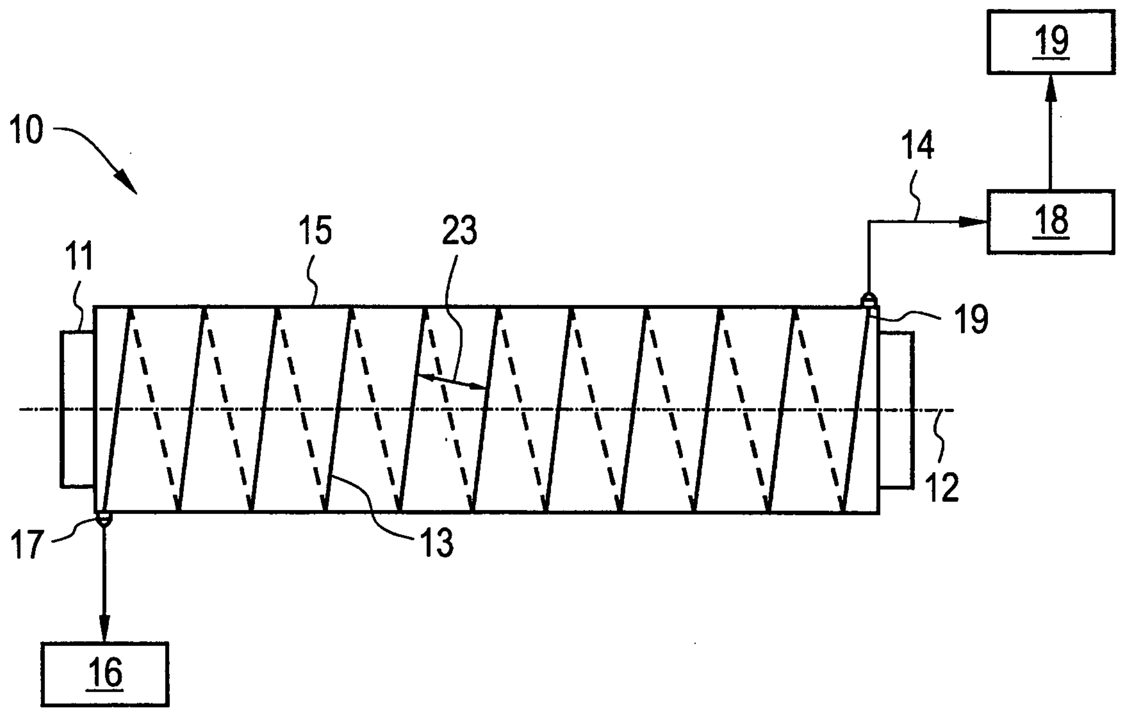


FIG 2

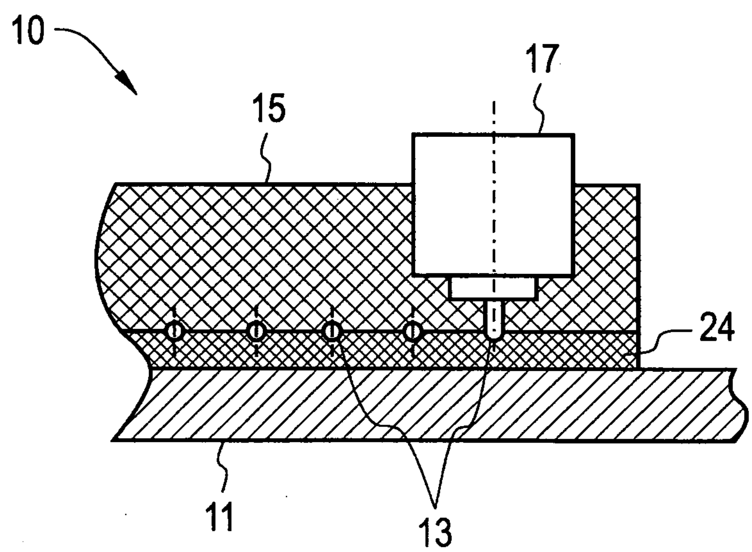


FIG 3

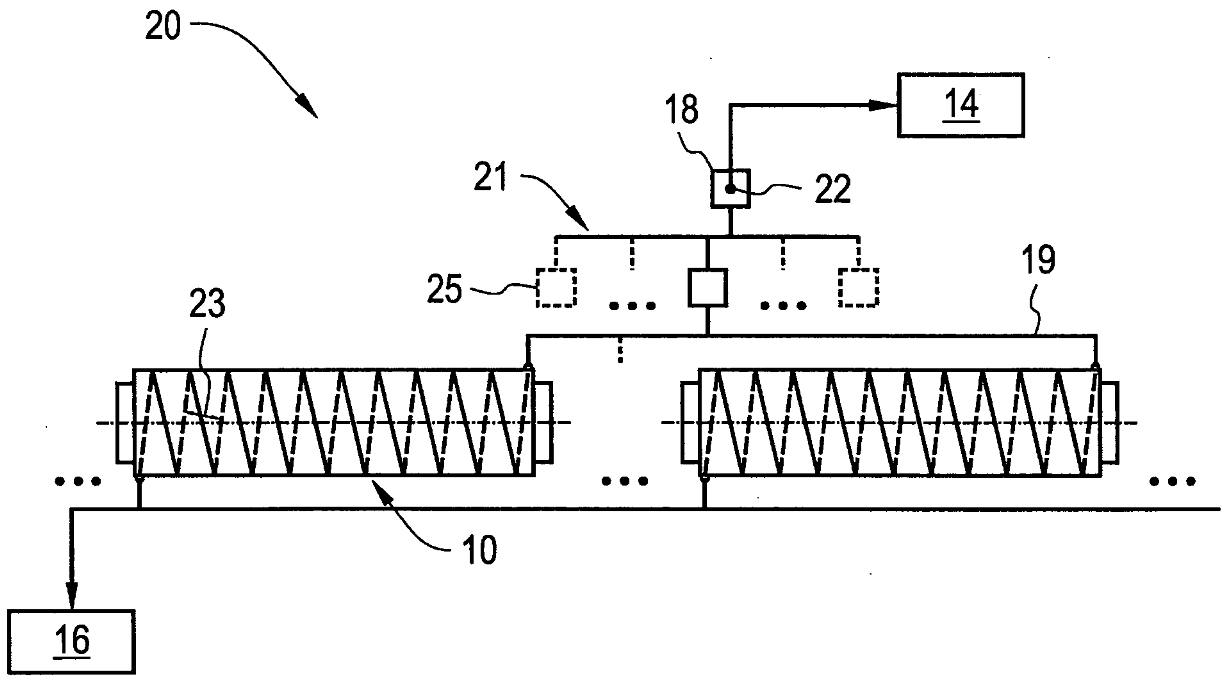


FIG 4

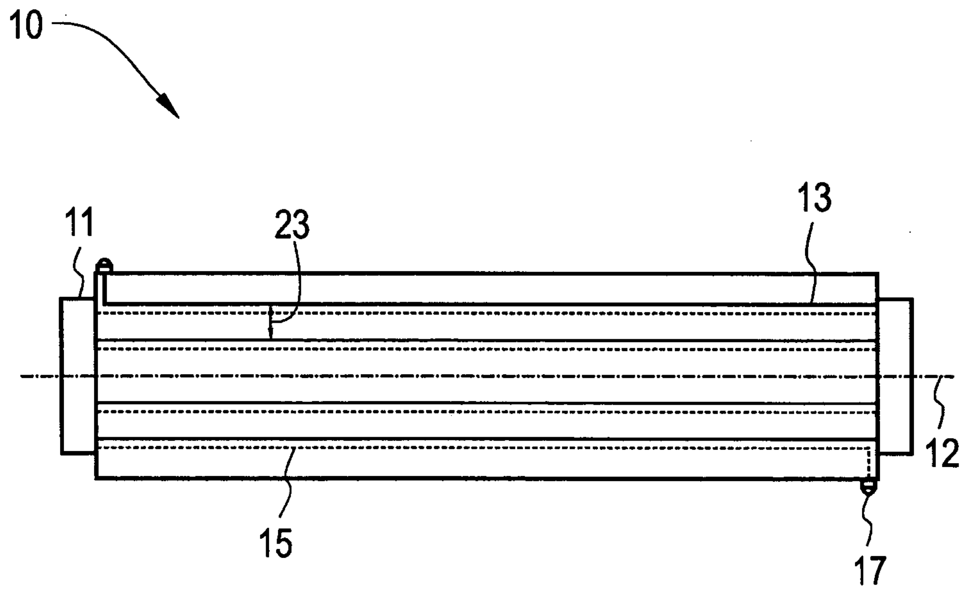


FIG 5

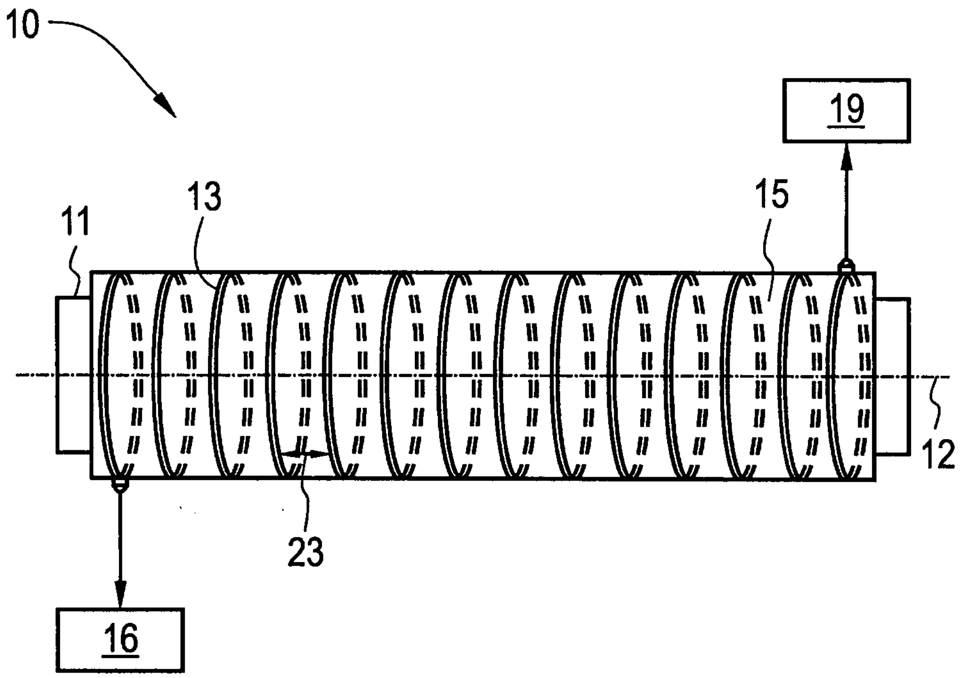


FIG 6

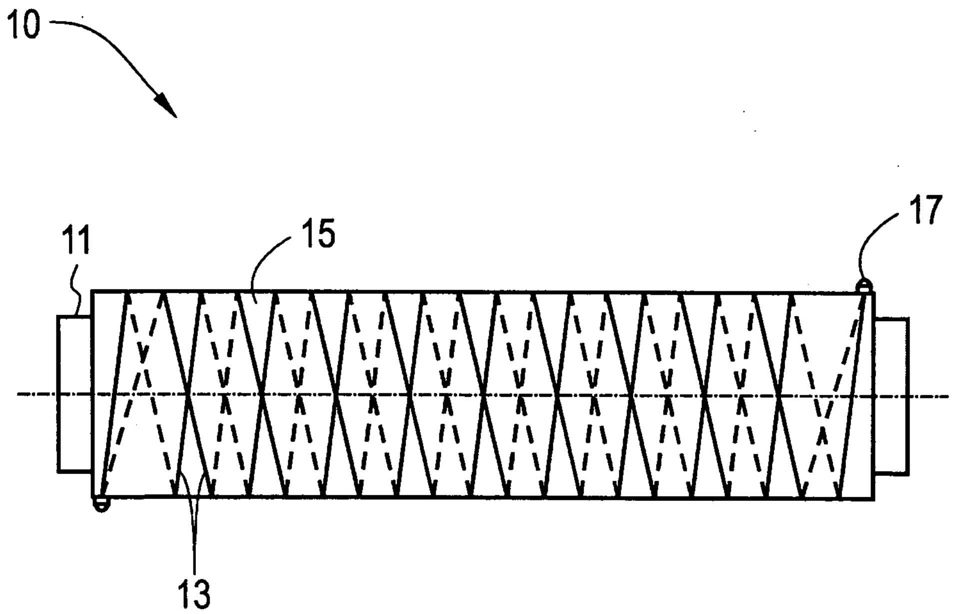


FIG 7

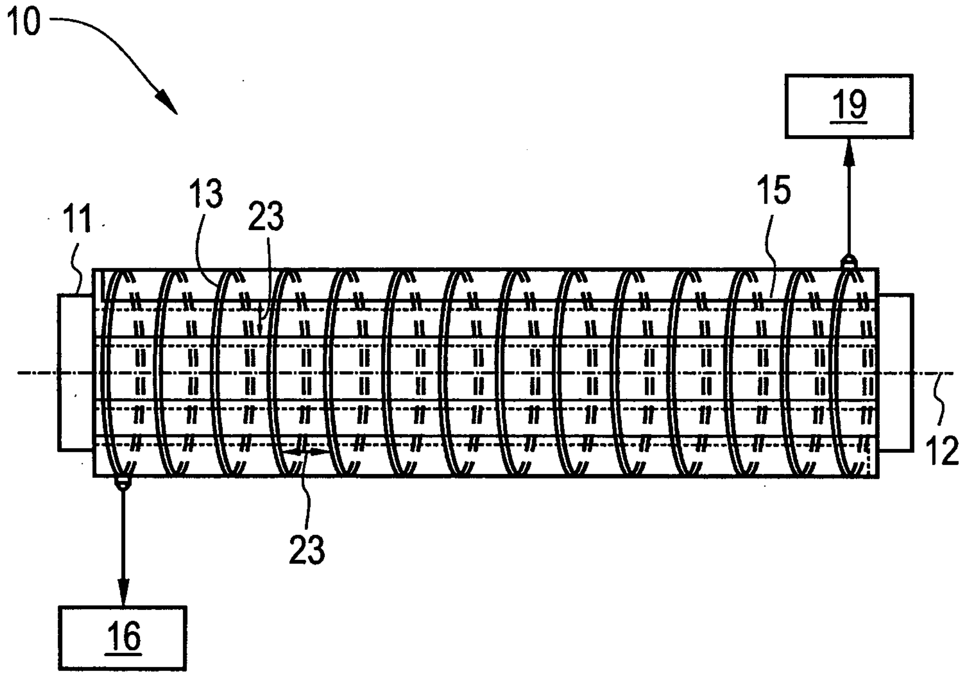
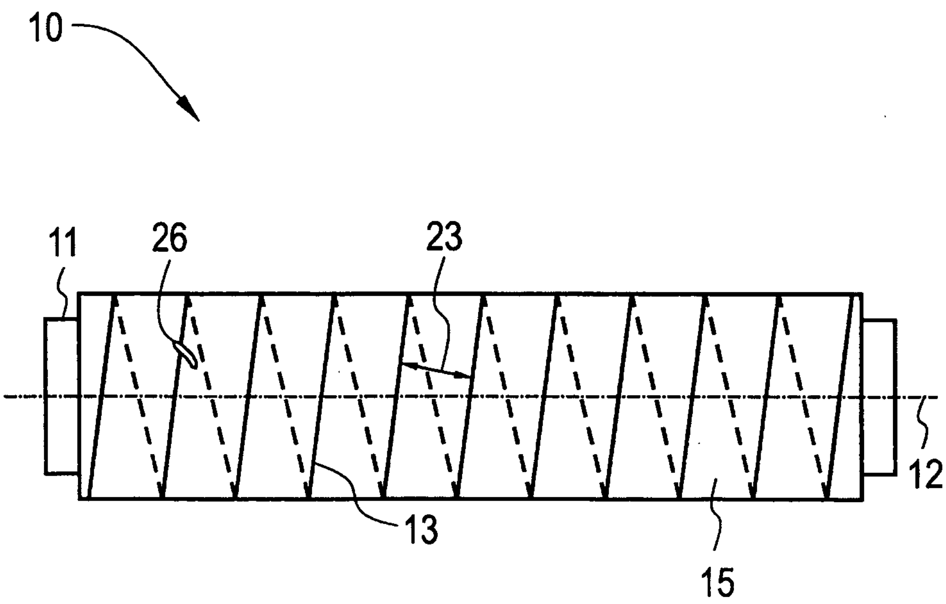


FIG 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/RU2009/000550

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01M3/04 G01M5/00 F17D5/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01M F17D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/087720 A1 (UNIV REGINA [CA]; HARA ELMER H [CA]) 9 August 2007 (2007-08-09) page 9, line 4 - page 15, line 13; figures 1-8	1-6,8-19
X	WO 2005/114226 A1 (PURE TECHNOLOGIES LTD [CA]; PAULSON PETER O [CA]) 1 December 2005 (2005-12-01) page 9, line 30 - page 18, line 22; figures 1,2	1,2,5-7, 11-19
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2010	06/07/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gruss, Christian

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 635 034 A1 (INSENSYS LTD [GB] SCHLUMBERGER HOLDINGS [VG]) 15 March 2006 (2006-03-15) paragraph [0051] - paragraph [0092]; figures 2-10	1,2,5-7, 13-19
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X	EP 0 323 019 A1 (BRITISH PETROLEUM CO PLC [GB]) 5 July 1989 (1989-07-05) column 4, line 12 - line 42; figure 1	1-7, 13-19

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International application No
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