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(54) **DETERMINATION OF PIPE BLOCKAGES THROUGH THE MONITORING OF AMBIENT ACOUSTICS**

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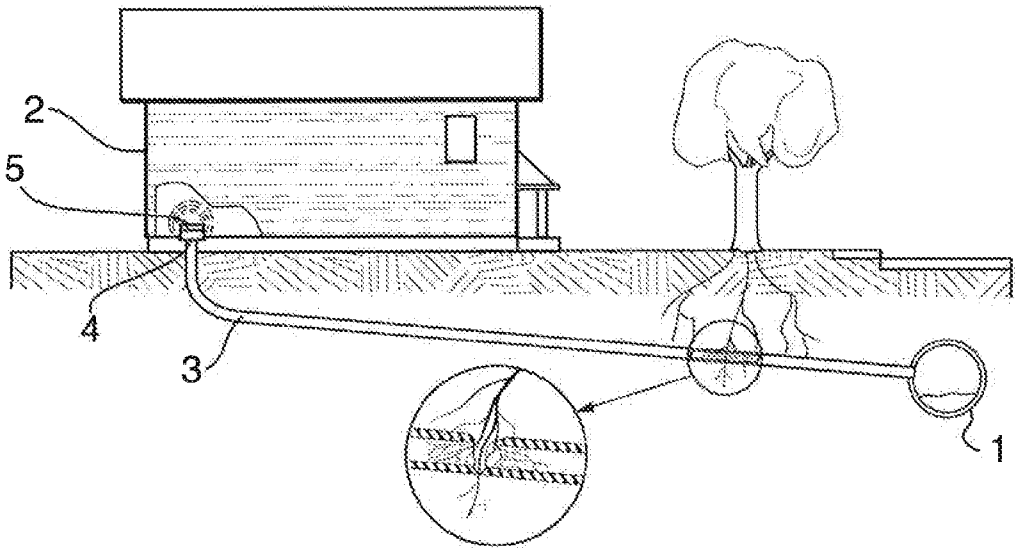
(57) **ABSTRACT**

A device is provided for detecting blockages in a pipe connecting a sewer to a structure. The device includes an acoustic energy sensor, a transmitter for transmitting a signal from the sensor, and a receiver for receiving the signal transmitted from the sensor and indicating to a user the strength of the signal.



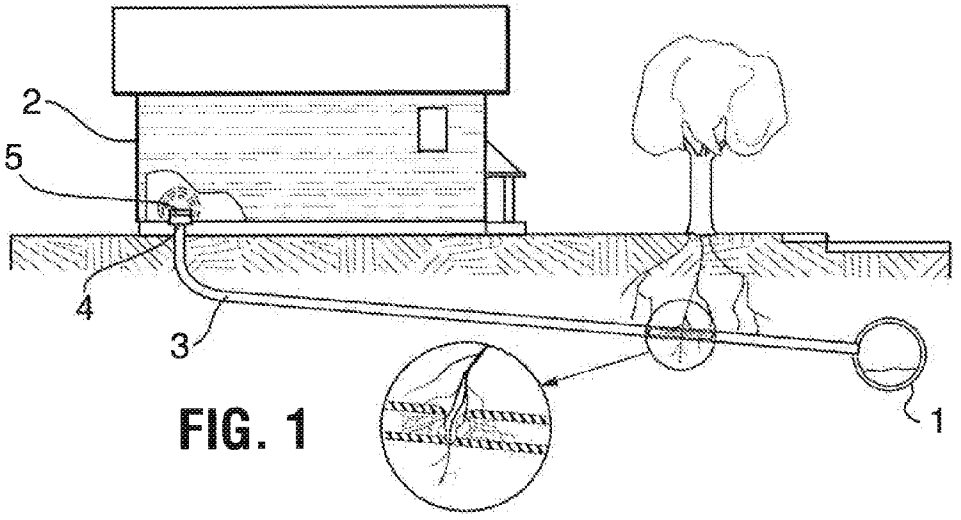


FIG. 1

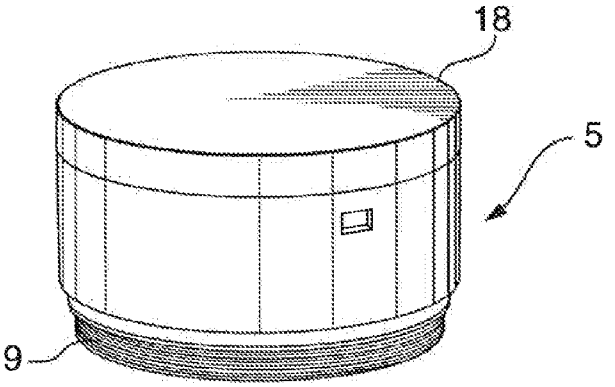


FIG. 2

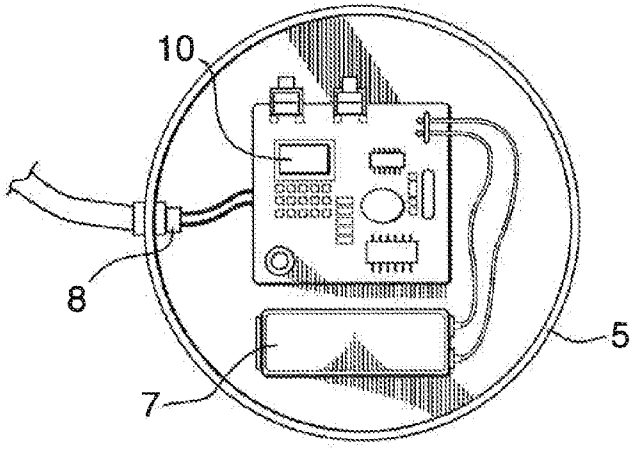


FIG. 3

FIG. 4

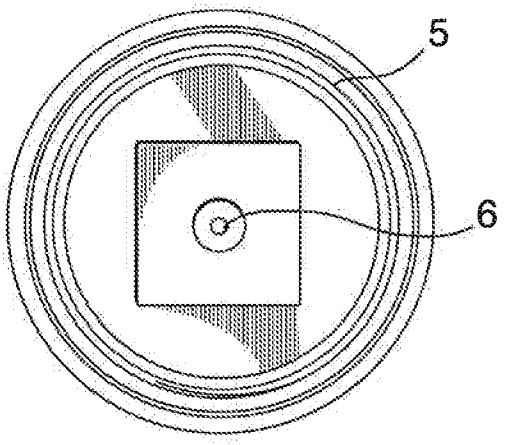
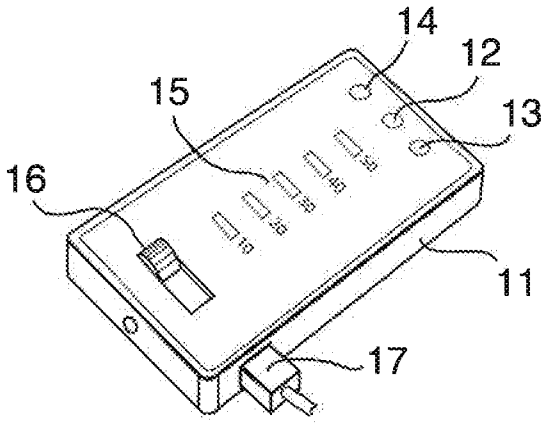


FIG. 5



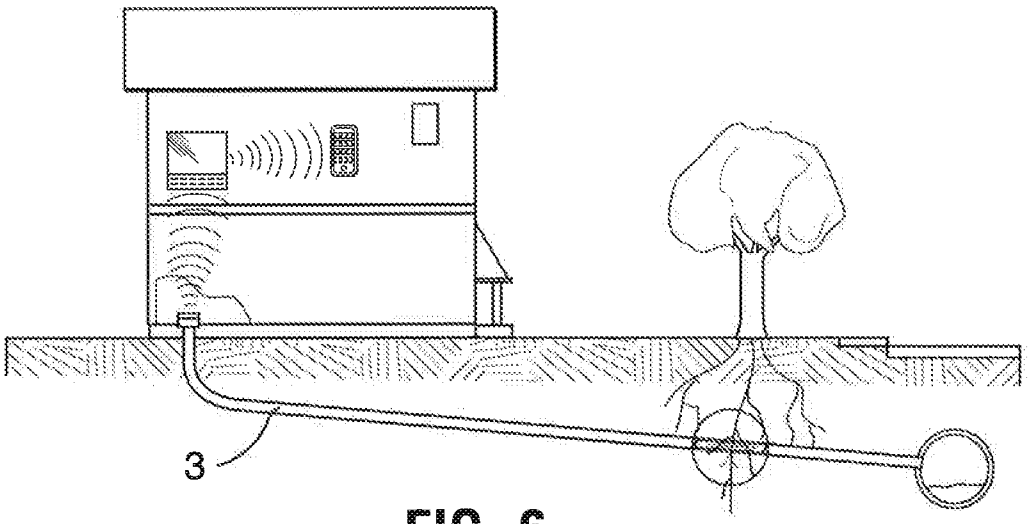


FIG. 6

DETERMINATION OF PIPE BLOCKAGES THROUGH THE MONITORING OF AMBIENT ACOUSTICS

BACKGROUND

[0001] The present invention relates to the field of alarms and warning devices. In particular, the present invention provides a device that provides a warning when sewer pipes are blocked or significantly restricted.

[0002] Typically, the plumbing fixtures within residences are connected with municipal sewer systems, in particular sanitary sewers, by a sewer pipe extending from the residence to the sewer line. Such a pipe can, however, become clogged, by debris, tree roots or by other means. Accordingly, an access point is provided in the residence, comprising a pipe extending upwardly from the sewer connecting line, and capped with a removable cap, so that equipment to unblock or clean out the line can be fed into the line from a convenient location in the residence.

[0003] However, even if sewer lines and connections are regularly inspected, it is very often the case that the first indication of a blocked connection is a backed up toilet, or a sink that will not drain. This can lead to damage in a home, and to expensive, urgent repairs.

SUMMARY

[0004] The Applicant has observed, however, that the sewer line into which household waste water drains virtually always has a flow of water in it, and that the sound of this flow can be detected at the clean out location in a home, if the cap to the clean out access pipe is removed. The present invention, then, provides a device that constantly "listens" to the flow in the municipal sewer, and provides an alarm indication when the sound of the flow drops a statistically significant amount.

[0005] In a broad aspect, then, the present invention relates to:

[0006] (1) A device to detect blockages in a pipe connecting a sewer to a structure, comprising an acoustic energy sensor, means for transmitting a signal from said sensor, and means for receiving said signal transmitted from said sensor and indicating to a user the strength of said signal.

[0007] (2) A device to detect blockages in a pipe connecting a sewer to a structure according to (1), wherein said sensor is a microphone.

[0008] (3) A device to detect blockages in a pipe connecting a sewer to a structure according to (2), further comprising a clean out cap in which said microphone is mounted.

[0009] (4) A device to detect blockages in a pipe connecting a sewer to a structure according to (3), wherein said means for transmitting a signal from said sensor is a transmitter mounted on said clean out cap.

[0010] (5) A device to detect blockages in a pipe connecting a sewer to a structure, wherein said microphone is mounted on the inside of said cap, which is the surface of said cap facing into said connecting pipe, and the transmitter is mounted on the outside of said cap, which is the surface opposite the inside.

[0011] (6) A device to detect blockages in a pipe connecting a sewer to a structure according to (5), wherein said transmitter transmits signal to said means for receiving said signal.

[0012] (7) A device to detect blockages in a pipe connecting a sewer to a structure according to (6), wherein said means for receiving said signal is provided with output means to display the level of signal received, whereby a blockage in said connecting pipe will result in a low or absent signal, and will show an alarm condition.

[0013] (8) A device to detect blockages in a pipe connecting a sewer to a structure according to (7), wherein said transmitter and receiver are each provided with electrical power.

[0014] (9) A device to detect blockages in a pipe connecting a sewer to a structure according to (7), wherein said receiver sends a signal to, or is integrated into a computer, and said computer is programmed to send a signal to a smartphone or other computer by email, text or the like to indicate the level of signal received, and/or the presence of an alarm condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In drawings that illustrate the present invention by way of example:

[0016] FIG. **1** is a schematic of a residential sewer connection;

[0017] FIG. **2** is a top perspective view of an alarm device according to one embodiment of the present invention;

[0018] FIG. **3** is a top view of the device shown in FIG. **2** with the cover removed;

[0019] FIG. **4** is an underside view of the device shown in FIG. **2**;

[0020] FIG. **5** is a perspective view of a receiver according to the present invention; and

[0021] FIG. **6** is a schematic view of transmission of an alarm.

DETAILED DESCRIPTION

[0022] Referring to the drawings, it will be observed that municipal sewer line **1** is connected to a house **2** by means of a residential connecting line **3**. Access to the connecting line **3** is by a clean out pipe **4** in the house **2**. The clean out pipe **4** is provided with a screw-on cap **5**, to prevent liquids or gasses in the connection line **3** from escaping into the house. It will be understood, moreover, that the connecting line is a hollow pipe, and that sound will travel in it. Accordingly, the device of the present invention comprises a microphone **6** mounted in cap **5** (see FIG. **4**). Microphone **6** is connected to a power supply, such as a battery pack **7** or a low voltage power line **8**. Battery pack **7** may be rechargeable, and mounted in the cap **5**. The microphone **6** is mounted on the inside surface of the cap, and the associated parts, i.e., battery pack and the like, on the outer surface. The cap is dimensioned to fit any commercially available, or previously available clean-out pipes. The cap may, for instance, have threads **9** on its outer surface, so that it may be screwed into a pipe having a threaded bore. Alternatively, the cap may fit over the pipe, rather than into it, and be provided with a depending skirt with a threaded interior surface, to screw onto a pipe bearing a threaded exterior surface. Moreover, any other conventional mean to mount a cap to a pipe may be employed, as will be obvious to one skilled in the art. In this regard, then, although only one form and size of cap has been shown, it will be understood that the present invention can take the form of, or be integrated into, any cap currently or previously in use. It is only required that the cap have an interior surface or portion on which a micro-

phone **6** may be mounted or positioned. Microphone **6** is also connected to an RF or wifi transmitter **10** that transmits a signal to a receiver **11** (see FIG. **5**) that may be positioned elsewhere in the house or may connect to an external system. Under normal circumstances a signal indicating that the microphone is detecting a normal sound level is transmitted to the receiver, and the receiver is provided with an indicator, such as a green light **12** to show this. The receiver is also provided with an alarm indicator, which can be a red light, an audible alarm or the like. A "warning" light, e.g. a yellow light **14** may also be provided. The receiver is programmed to trigger the alarm when the sound level detected by the microphone falls below the predetermined level. This would indicate a blockage in the connecting line **3** preventing sound from traveling from the municipal sewer line to the microphone in the clean out cap **5**. Preferably, an LED read-out **15** is also provided, to show sound levels in the line **3**. An on-off switch **16** is positioned on the receiver. Receiver **11** is connected by a low voltage line **17** to a source of power, or may be battery powered.

[0023] As can be seen from FIGS. **3** and **4**, the microphone **6** is mounted inside the clean out cap, and the transmitter **10** may be mounted on the outside of the cap **5**, but inside cover **18**, preferably. Preferably, all parts associated with the device are waterproof, or are coated or otherwise protected from water damage.

[0024] In a preferred embodiment, the alarm device of the present invention is capable of transmitting signals to permit remote monitoring of a sewer line or other piping system. In such an embodiment, the monitoring and alarm signals may be sent, for instance, by RF signal to the computer **19** of a user and then, from the computer, via email or text, to a phone **20**. A signal may also be sent to an alarm system, or to a utility or municipality via RF, wifi, LAN, telephone lines, cable, VHF, email, text or other established means. This is shown schematically in FIG. **6**.

[0025] Accordingly, it will be understood that in a preferred embodiment, the alarm of the present invention also includes a smartphone application, so that an internet capable phone of a user upon which the application has been loaded can be used to monitor the signal being received by a computer. Moreover, the receiver or the cap may be provided with a wireless internet access device upon which the application has been loaded, whereby it is only necessary to provide an internet connected computer with a wireless router to establish a network to which the wireless internet access device in the cap or receiver may connect. If the wireless internet access device is located in or at the cap, the receiver **11** may be eliminated entirely, and the condition of the drain line monitored over the internet or by smartphone application only.

[0026] It will be understood that in using the device of the present invention that the normal sound level in a sewer will vary from one location to another, and to some extent from one time to another during the day. Therefore, after the device of the present invention is installed by replacement of the existing clean-out cap with a cap according to the present invention, it is necessary to calibrate the device of the present invention to the location. To do this, the cap is installed after the drain line has been cleaned out, or inspected to ensure it is clean, and then the sound levels in the sewer are monitored for a predetermined period of time, as will be explained below.

[0027] The device of the present invention is designed to be used in a variety of different geographical locations that exhibit different sewage flow characteristics and trends. For instance, if the device of the present invention were to be installed in a residence in a high density urban neighborhood, it would be expected that local sanitary sewer that the drain of the residence is connected to would also connect to a large number of other residences and businesses. Moreover, in a high density urban environment, it may be expected at the sewage system has a pattern of usage with more usage throughout the night by shift workers and by businesses such as bars and restaurants that may be open late.

[0028] Conversely, in a low density suburban neighborhood, the pattern of use of the sanitary sewer system may show very low values during the night, and peak values at other times during the day that are different from urban use peaks, due, for instance, to commuting times factoring into a determination of peak usage time. Moreover, the lack or absence of all-night or late night businesses in a suburban setting may contribute to low usage through the night.

[0029] Accordingly, in a preferred embodiment, the processor of the present invention is provided with software to calibrate the device, in place. This is known as a "learning cycle". In this regard, the device is provided with means, such as a designated push-button (although other means, such as remote activation are possible) to initiate a learning cycle. A learning cycle may be seven days long, but other learning cycle durations are possible, as would be obvious to one skilled in the art. A seven day cycle is considered appropriate because it will account for usage throughout a full week.

[0030] During the Learning Cycle LAeq values will be recorded for each one hour period of a 24 hour day. (i.e. LAeq for midnight to 1 am, LAeq for 1 am to 2 am, etc.). A Learning Cycle of 7 days length will create a 'Weekday Benchmark' and a 'Weekend Benchmark'. Weekday Benchmark will be the average LAeq for each one hour period over the 5 weekdays. Weekend Benchmark will be the average for each one hour period for Saturday and Sunday. Benchmarks are stored in non-volatile memory located either in the cap, or on a computer that communicates with the cap, which doesn't erase with loss of power.

[0031] Leq is the preferred method to describe Sound Levels that vary over time, resulting in a single decibel value which takes into account the total Sound Energy over the period of time of interest.

[0032] Leq—equivalent continuous noise level:

[0033] Noise levels often fluctuate over a wide range with time. For example in the middle of the night the level might go down as low as 30 dB(A) with occasional peaks to 70 dB(A) or more. Later comes the dawn chorus followed by the general noises of the day before relative quiet returns in the late evening. Even within a given hour, flushing toilets and drainage from showers and sinks will create peaks in the sound level.

[0034] This is where the Leq noise or equivalent continuous noise level meter comes in. The device must therefore faithfully follow all the fluctuations, store them in its memory and at the end of the measurement period (e.g. one hour) calculate an 'average energy' or Leq value. This is not a simple arithmetic average because the measurements are in decibels which are Logarithmic vales. So device converts the dB values to 'real numbers', adds them all up then divides by the number of samples and finally converts this equivalent level back to decibels—dBs.

[0035] LAeq—It is common practice to measure noise levels using the A-weighting setting built into all sound level

meters, in which case the term is properly known as LAeq and the results should say so—for example LAeq=73 dB or Leq=73 dBA.

[0036] The sound level meter used in the device of the present invention preferably samples and 'captures' the noise levels 16 times a second which means over an hour it makes 16×60×60=57600 calculations. This will provide a fairly accurate average reading.

[0037] Each hourly LAeq value (measured in dBA) will be subtracted from the corresponding Weekday or Weekend Benchmark value to calculate a Blockage Indicator ("BI") in dBA. If the actual LAeq is greater than the corresponding benchmark value the BI will be considered to be 0. This will be done since louder noise signals (e.g. due to increased water flow or other noise disturbances) are not relevant in monitoring for blockages. For example,

[0038] i. From 01:00-02:00, actual LAeq is 52 dBA and the corresponding benchmark for this period is 48 dBA. Then BI for the period will be considered as 0 (ie. no degradation in sound level).

[0039] ii. From 11:00-12:00, actual LAeq is 62 dBA and the corresponding benchmark for this period is 68 dBA. Then BI for the period will be considered as 5 (ie. 5 dBA below the corresponding benchmark).

[0040] Preferably, at the end of each 24 hour period, the daily average sound level vs benchmark ("DailyBI") is calculated as the average of the 24 BI values for the period. DailyBI values for each day will form the basis of alarms and warnings and should be stored, for instance for a month, and recalculated regularly.

[0041] Warning and alarms will be triggered based on two conditions. First, DailyBI (ie. a sustained decrease in sound compared to the benchmarks), where if DailyBI<AA (e.g. AA=6 dBA) for a predetermined period of N days the system will provide a warning or if DailyBI<BB (e.g. BB=12 dBA) the system will sound an alarm. Alternatively, a significant rate of decrease in DailyBI, where if DailyBI is decreasing at a rate >=x dBA per day over a 7 day period, then the system will provide a warning, where x is large enough to show a trend, or if DailyBI is decreasing at a rate >=y dBA per day over a 7 day period, then the system will sound an alarm, where y is large enough to show a trend, and greater than x.

[0042] Three embodiments of the device of the present invention are considered to be commercially viable and useful, as follows:

[0043] 1. Consumer model providing LED warning/alarm lights and an audible alarm. In such a mode, the device would not be connected through the internet to the alarm, but rather directly thereto, by either a wired or wireless connection.

[0044] 2. Internet enabled model that displays the current BI value and transmits warnings by text/email/voice mail. For display purposes the BI may be converted to a percentage of the alarm value BB above. This model would connect via wifi to a computer or other transmission device capable of sending a message to a smartphone or other computer that is provided with an appropriate application.

[0045] 3. Commercial model that provides monitoring by constantly transmitting the current BI value in addition to transmission of warnings and alarms. For display purposes the BI may be converted to a percentage of the alarm value BB above. This Commercial model would be similar to the internet enabled model, and is configurable so that transmissions may be sent for instance by email or text to a monitoring company or municipality from multiple devices with unique registrations or identifiers to enable constant monitoring of multiple sites.

[0046] While a particular embodiment of the device for determining pipe blockages through the monitoring of ambient acoustics has been described herein, it will be appreciated by those skilled in the art that changes and modifications may be made thereto without departing from the invention in its broader aspects and as set forth in the following claims.

1. A device to detect blockages in a pipe connecting a sewer to a structure, comprising: an acoustic energy sensor; means for transmitting a signal from said sensor; and means for receiving said signal transmitted from said sensor and indicating to a user the strength of said signal.

2. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **1**, wherein said sensor is a microphone.

3. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **2**, further comprising a clean out cap in which said microphone is mounted.

4. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **3**, wherein said means for transmitting a signal from said sensor is a transmitter mounted on said clean out cap.

5. A device to detect blockages in a pipe connecting a sewer to a structure, comprising: said microphone is mounted on the inside of said cap, which is the surface of said cap facing into said connecting pipe; and the transmitter is mounted on the outside of said cap, which is the surface opposite the inside.

6. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **5**, wherein said transmitter transmits signal to said means for receiving said signal.

7. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **6**, wherein said means for receiving said signal is provided with output means to display the level of signal received, whereby a blockage in said connecting pipe will result in a low or absent signal, and will show an alarm condition.

8. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **7**, wherein said transmitter and receiver are each provided with electrical power.

9. A device to detect blockages in a pipe connecting a sewer to a structure according to claim **7**, wherein said receiver sends a signal to, or is integrated into a computer, and said computer is programmed to send a signal to a smartphone or other computer by email, text or the like to indicate the level of signal received, and/or the presence of an alarm condition.

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