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(54) PLUMBING SUPPLY MONITORING, MODELING AND SIZING SYSTEM AND METHOD

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(52) **U.S. Cl.** **702/56**; 702/54
(58) **Field of Search** 73/1.48, 1.82; 702/33, 39, 45, 48, 50, 54, 56, 179, 182, 183

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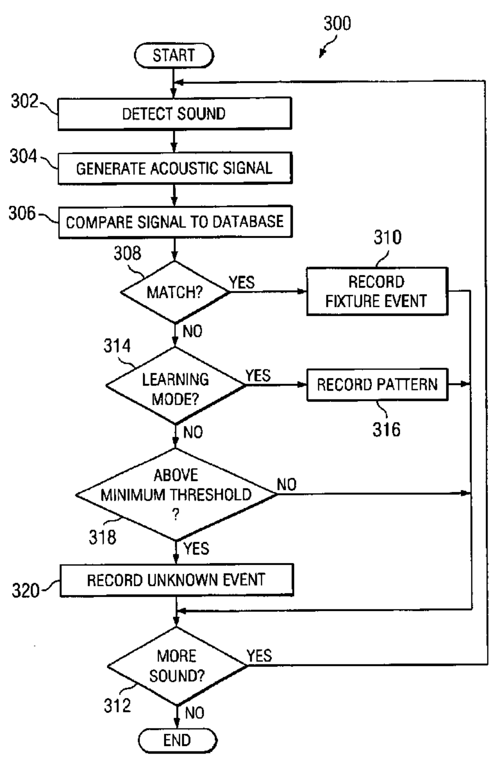
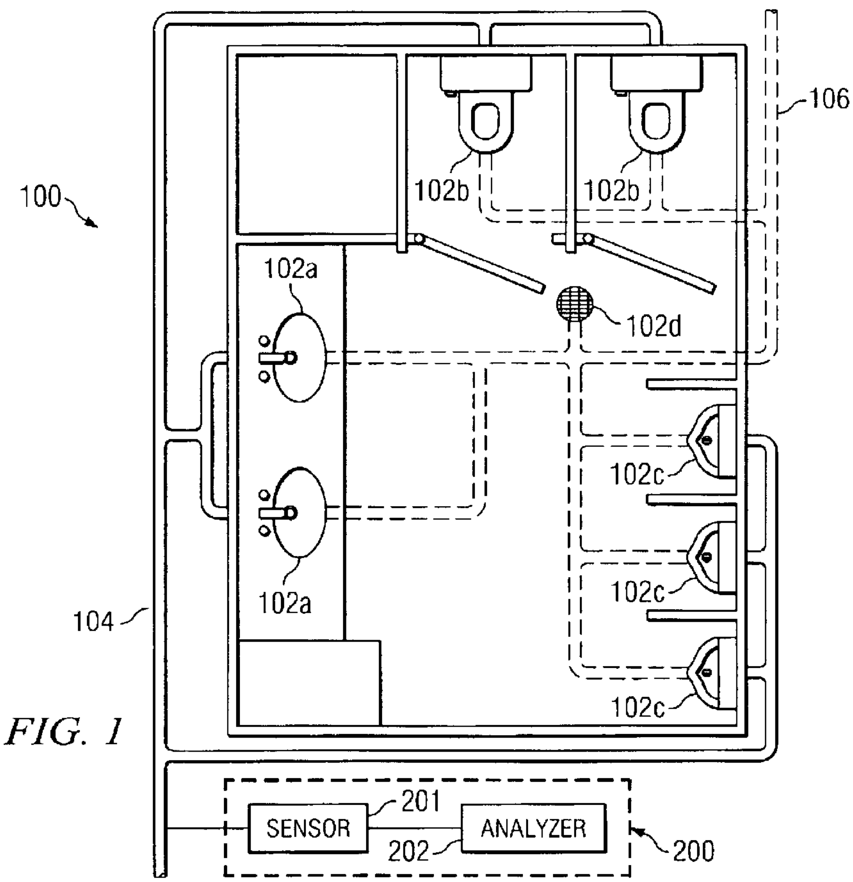
(57) **ABSTRACT**

A system for monitoring a plumbing system having a plurality of fixtures includes a sensor vibrationally coupled to the plumbing system and a processor. The sensor detects a vibration produced by the plumbing system, and generates a signal representative of the vibration. The processor receives the signal, compares the signal to a signal database that associates each of a plurality of stored signals with operation of one or more of the fixtures, and determines that the associated fixture or group of fixtures has been operated based on the comparison. The processor also stores a record of the operation of the associated fixture or group of fixtures.

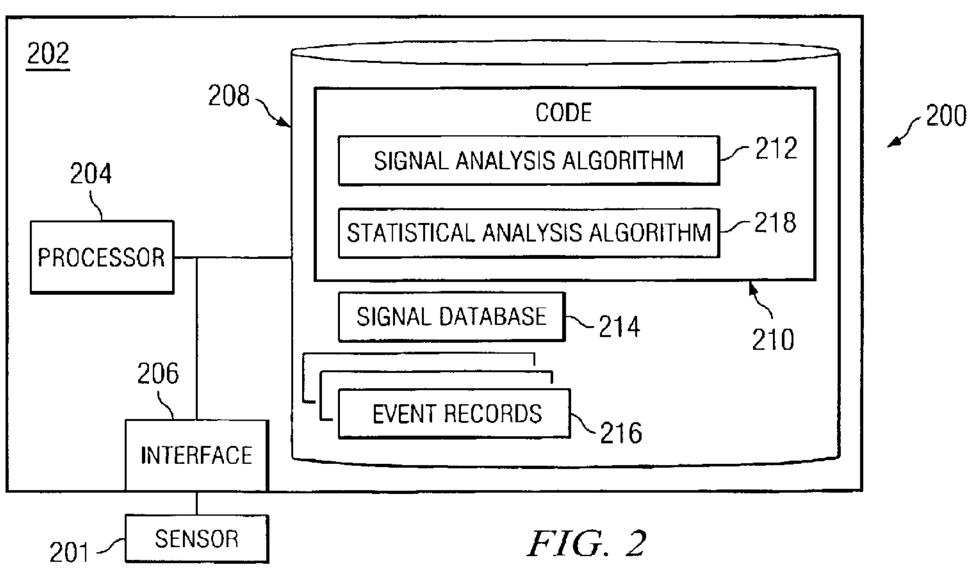
17 Claims, 2 Drawing Sheets





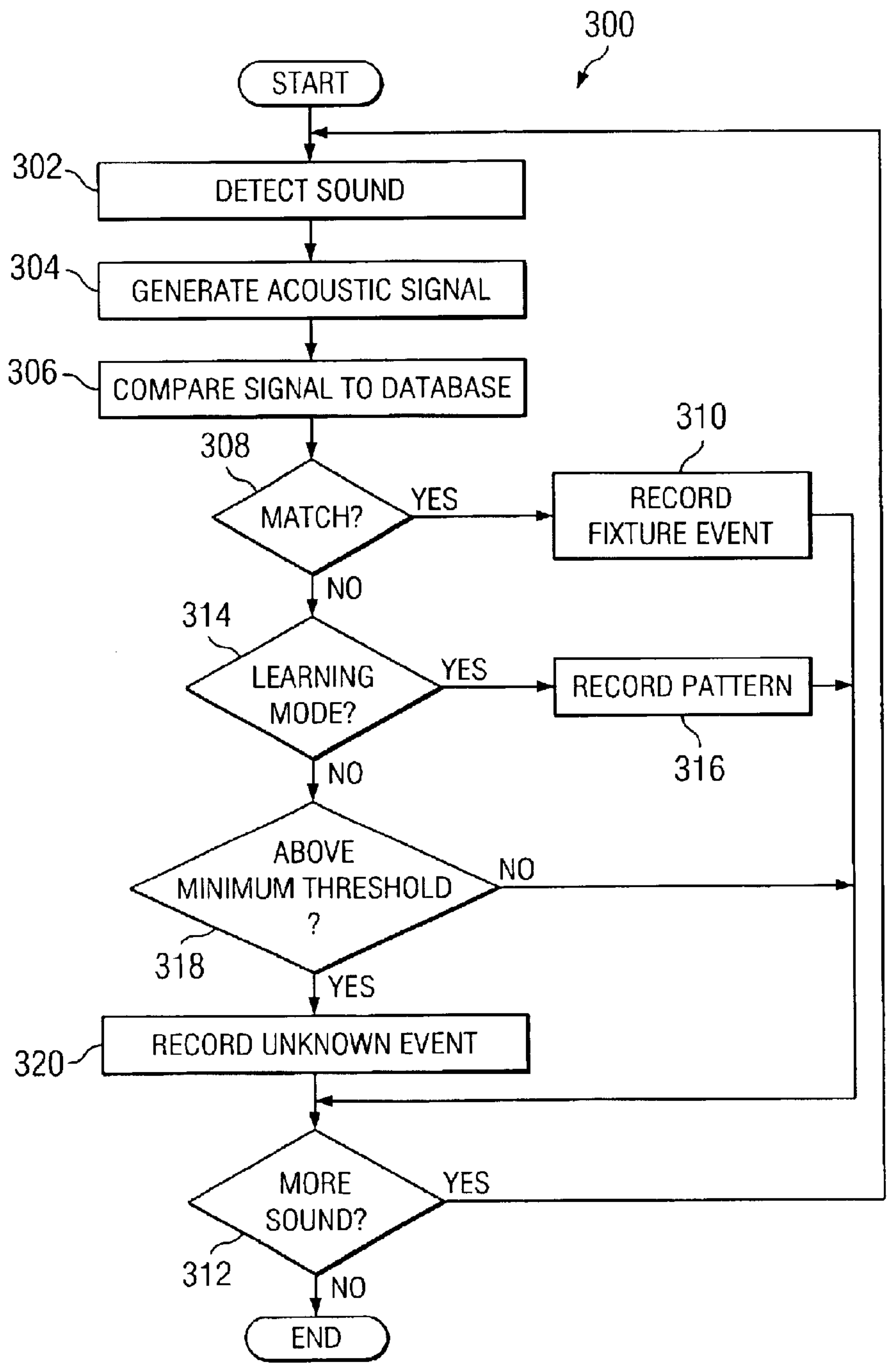
100
106
102b
102b
102a
102d
102a
102c
102c
102c
104
201
SENSOR
ANALYZER
202
200

FIG. 1



202
208
CODE
SIGNAL ANALYSIS ALGORITHM
212
STATISTICAL ANALYSIS ALGORITHM
218
200
204
PROCESSOR
SIGNAL DATABASE
214
210
206
EVENT RECORDS
216
INTERFACE
SENSOR
201

FIG. 2


300
START
302
DETECT SOUND
304
GENERATE ACOUSTIC SIGNAL
306
COMPARE SIGNAL TO DATABASE
308
MATCH?
YES
310
RECORD
FIXTURE EVENT
NO
314
LEARNING
MODE?
YES
RECORD PATTERN
316
NO
ABOVE
MINIMUM THRESHOLD
?
NO
318
YES
320
RECORD UNKNOWN EVENT
MORE
SOUND?
YES
312
NO
END
FIG. 3

PLUMBING SUPPLY MONITORING, MODELING AND SIZING SYSTEM AND METHOD

RELATED APPLICATIONS

This application claims the priority benefit of U.S. Provisional Application Ser. No. 60/369,356 filed Apr. 1, 2002.

TECHNICAL FIELD OF THE INVENTION

This invention relates in general to the field of plumbing systems and, more particularly, to a plumbing supply monitoring, modeling and sizing system and method.

BACKGROUND OF THE INVENTION

Having an accurate determination of the amount of fixture usage in a plumbing system may be useful for a variety of reasons. The level of usage may help to predict the amount of associated resources, such as water supply or paper products, used in conjunction with the fixtures. It may also be used to assess the amount of wear on components of a plumbing system and to determine when components need to be replaced. Such information may also be used to redesign or improve the plumbing system in order for the system to function more effectively. For these reasons and many others, it is useful to have a method for determining the amount of plumbing fixture usage.

One method for monitoring restroom plumbing fixture use may include a camera mounted in the restroom. However, this has obvious social drawbacks. A person could monitor facility use, but in additional to social drawbacks, the person could not monitor continuously for 24 hours per day. Sensors (magnetic relay or optical relay) could be mounted in some fashion at each fixture, but this would require extensive wiring that is difficult to perform and/or install in existing facilities.

Flow meters could be installed in the supply lines for each of the fixture groups (water closet, urinal, lavatory), but this may be a prohibitively expensive and difficult option. Access to the piping supply risers is typically very limited, the cost per fixture group would be significant, and such metering would require shutdown of the facility for installation and removal of the flow meters.

SUMMARY OF THE INVENTION

The present invention provides a method and system for monitoring a plumbing system using a monitoring system vibrationally coupled to the plumbing system. Particular embodiments of the present invention provide a passive, non-invasive, opaque-to-facility-users, portable, and low-cost system and method for monitoring, modeling and sizing plumbing systems. Such embodiments present considerable advantages over existing techniques for monitoring plumbing systems.

In a particular embodiment, a system for monitoring a plumbing system having a plurality of fixtures includes a sensor vibrationally coupled to the plumbing system and a processor. The sensor detects a vibration produced by the plumbing system, and generates a signal representative of the vibration. The processor receives the signal, compares the signal to a signal database that associates each of a plurality of stored signals with operation of one or more of the fixtures, and determines that the associated fixture or group of fixtures has been operated based on the comparison. The processor also stores a record of the operation of the associated fixture or group of fixtures.

In another embodiment, a method for monitoring a plumbing system having a plurality of fixtures includes detecting, by a sensor, a vibration produced by a plumbing system, and generating, by the sensor, a signal representative of the vibration. The method further includes comparing, by a processor, the signal to a signal database that associates each of a plurality of stored signals with operation of one or more of the fixtures. The method also includes determining that the associated fixture or group of fixtures has been operated based on the comparison, and storing a record of the operation of the associated fixture or group of fixtures.

Important technical advantages of certain embodiments of the present invention include a non-invasive method for monitoring a plumbing system. Certain embodiments of the monitoring system may couple to accessible locations of a plumbing system, such as supply lines, valves, and fittings. This permits the use of the system without requiring complicated installation procedures. Particular embodiments may be compact and portable as well, further increasing their versatility.

Other important technical advantages include the use of "off the shelf" components in a monitoring system. Particular embodiments use conventional technology, such as microphones, personal computers, and existing voice recognition software, which is adapted for use in conjunction with a plumbing system. This permits production of monitoring systems without requiring specialized components that may be expensive and difficult to install.

Still other important technical advantages of certain embodiments of the present invention include concealability. Particular embodiments may be placed in areas inaccessible by users of fixtures of the monitored plumbing system. This prevents unnecessary social embarrassment that may be associated with being monitored, and it also protects the monitoring equipment from vandalism.

Although certain technical advantages have been enumerated here, particular embodiments of the present invention may include some, none, or all of the enumerated technical advantages. Other technical be readily apparent to those skilled in the FIGURES, descriptions, and claims

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and its advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. **1** shows a monitoring system, according to a particular embodiment of the present invention, coupled to a plumbing system;

FIG. **2** illustrates a particular embodiment of the monitoring system of FIG. **1**; and

FIG. **3** is a flow chart showing an example of a method of operation for the monitoring system of FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a plumbing system **100** that provides water services to a plurality of fixtures **102** (referring generally to fixtures **102***a*, **102***b*, **102***c*, and **102***d*). Supply lines **104** provide water or other fluid to fixtures **102**, while drain lines **106** remove waste water or fluid from fixtures **102**. Monitoring system **200** is vibrationally coupled to plumbing system **100**. In general, monitoring system **200** detects vibrations produced by the operation of one or more fixtures **102** and determines that the detected vibration corresponds to the operation of the one or more fixtures **102** that generated the vibration.

Fixtures **102** represent any components of plumbing system **100** that use water from plumbing system **100** or provide waste water to plumbing system **100** for disposal. In the depicted embodiment, fixtures **102** include lavatories **102***a*, water closets **102***b*, urinals **102***c*, and a floor drain **102***d*. Those components, however, are only examples, and plumbing system **100** may include other fixtures **102**, including faucets, drains, showers, baths, or other suitable devices. Fixtures **102** may be operated by users in any manner suitable to the type of fixture **102**, such as opening a flush valve or lavatory valve.

Supply lines **104** and drain lines **106** represent any suitable collection of pipes, valves, fittings, junctions, gaskets, sealers, or other components for carrying water to fixtures **102** or draining water away from fixtures **102**. Pipes used in plumbing system **100** may be made from metal, plastic, or other suitable materials. Plumbing system **100** may also include filtration devices, purifiers, disposals, or other devices coupled to supply lines **104** and drain lines **106**. Various components of plumbing system **100** may operate at any suitable water pressure.

Monitoring system **200** monitors vibration produced in plumbing system **100** by the operation of fixtures **102**. The vibrations sensed by monitoring system **200** are routinely generated due to turbulence in a fluid as it flows through valves, fittings and other turbulence-inducing objects, usually in association with a piping or plumbing system. One application of this process may be used to monitor plumbing fixtures used in restroom facilities. However, other plumbing uses may also be monitored with the scope of the invention. Although monitoring system **200** is shown as being coupled to a particular location in plumbing system **100**, monitoring system **200** may be coupled to plumbing system **100** at any suitable location on supply lines **104**, drains lines **106**, fixtures **102**, or any other area that permits detection of vibrations produced by fixtures **102**. For reasons stated earlier, it is generally desirable to conceal monitoring system **100** from users of fixtures **102** to prevent embarrassment and to protect monitoring system **200** from vandalism.

In the depicted embodiment, monitoring system **200** includes a sensor **201** and an analyzer **202**. Sensor **201** is any suitable component that detects any manner of vibration in plumbing system **100** and generates a signal that represents the detected vibration. Examples of sensors **201** include microphones, accelerometers, transducers, pressure sensors, laser devices, or other suitable components for detecting vibration. The type of sensor **201** may be selected based on cost, sensitivity, accuracy, or any other suitable design consideration. Sensor **201** may be coupled to plumbing system **100**, either proximal to an element of system **100** or placed some distance away, either in sufficient proximity to detect vibrations or coupled to system **100** by a vibrational connection suitable for carrying vibrations to sensor **201**, such as a stethoscope.

Analyzer **202** analyzes the signals produced by sensors **201** in order to learn characteristic vibrational patterns produced by fixtures **102** in operation ("vibrational signatures") and to compare received signals to previously stored vibrational signatures to determine when a particular fixture **102** or group of fixtures **102** is operating. Analyzer **202** is coupled to sensor **201** using any suitable wireline or wireless connection for communicating signals generated by sensor **201** to analyzer **202**. Analyzer **202** may perform any suitable conversion or processing, such as converting analog output from sensor **201** to digital form, in order to perform this analysis. In a particular embodiment, analyzer **202** uses voice recognition software to learn the vibrational signatures of fixtures **102** and to identify the vibrational signatures when they are detected later.

Monitoring system **200** has two modes of operation: a learning mode and a recognition mode. In learning mode, monitoring system **200** is coupled to plumbing system **100** and monitors vibrations produced by the plumbing system **100**. Using pattern recognition techniques, monitoring system **100** identifies particular vibrational patterns that are distinctive and stores those patterns in memory. Over time, monitoring system **100** builds a database of signals associated with the vibrational signatures of fixtures **102**. These signatures can then be associated with physical devices by input from a user. For example, the user may operate a fixture **102**, check to see which vibrational signature is recognized, and program monitoring system **200** to associate the vibrational signature with the physical device.

Once monitoring system **100** has adequately learned the vibrational signatures of fixtures **102**, monitoring system **100** may begin to operate in recognition mode. In recognition mode, monitoring system **100** monitors for signals matching any stored signals, and when a matching signal is detected, monitoring system **100** records a fixture-operation event. The record of the fixture-operation event may include a date, time, and an identifier for the particular fixture **102** or group of fixtures **102** operated. As more records are stored, the usage patterns of fixtures **102** may be statistically analyzed. In conjunction with other information, such as the amount of water used by particular fixtures **102** and the overall design of plumbing system **100**, the records may be used to determine total water usage over a certain time period, maximum water usage, average water usage, instantaneous flow velocities at a particular point in plumbing system **100**, or a wide array of other useful pieces of information.

Although monitoring system **100** has been depicted with a single sensor **201** and analyzer **202**, monitoring system **100** may include multiple sensors **201** and/or analyzers **202**, operating independently or under common control. In addition, a single sensor **201** may be used to monitor a single plumbing activity or event, or a single sensor **201** may be used to monitor multiple plumbing components and events. Sensors **201** may be distributed among multiple locations in plumbing system **100** to monitor different components or to provide redundancy to verify the accuracy of detected events. When multiple sensors **201** are coupled to a single analyzer **202**, a mixing device may be used to process the signals received from each sensor **201** separately.

Some advantages of this invention over other methods that might be used for similar purposes may include cost, ease of installation, opacity to facility users, and portability. In one embodiment, the described monitoring system **200** presents advantages over existing methods because it can be passive—requiring no moving parts typical of in-line flow meters; it can be non-invasive requiring neither intrusion into the privacy of a restroom like an on-site monitor nor insertion into the piping system like a flow meter; it can be opaque to users—facility users need not see or hear system **200** when it is in operation like an observation camera or an on-site observer; it can be portable—system **200** may be transported by one person unlike data loggers or video cameras and recorders; and it can be low cost—the initial costs and operating costs may be much lower for system **200** than video monitoring systems, flow metering systems or on-site observers.

The data on plumbing fixture use may be used to reevaluate piping system design criteria and possibly influence restroom design. In certain embodiments of monitoring system **200**, continuous monitoring is also possible for water use or conservation studies. Furthermore, certain embodiments of the described monitoring system **200** may solve many problems associated with existing methods. In a non-limiting list of examples of such embodiments, certain embodiments may require less maintenance than flow metering systems; they may be installed and removed without a large amount of ancillary damage to a building; they may be used so as not to intrude on the privacy of restroom users; they may be durable, small and easily carried from one project to another; and they may have lower initial installation and maintenance costs as compared to existing systems.

The described techniques are not limited in application to plumbing systems. In principle, they may be adapted to any mechanical system that involves vibrational signatures for the operation of a particular component or group of components of the system. In one non-limiting example, monitoring system **200** may be adapted to monitor an automobile engine to detect problems that are associated with a particular vibration. In another example, monitoring system **200** could monitor a construction site for characteristic vibrations, such as firing an air gun, to monitor various stages of the construction process. Manufacture of certain articles or materials may be monitored for characteristic vibrations produced at various stages in the formation process, such as the vibrations produced by concrete in different stages of hardening. Thus, the described monitoring system **200** may be adaptable to a wide array of other mechanical systems.

FIG. **2** shows a particular embodiment of monitoring system **200**. In the depicted embodiment, analyzer **202** includes a processor **204**, an interface **206**, and a memory **208**. Processor **204** represents any suitable hardware and/or software for processing information and performing any suitable task of analyzer **202**. Processor **204** may include microprocessors, micro-controllers, digital signal processors (DSPs), or any other suitable component or components. Interface **206** represents any port or connection, whether real or virtual, that enables analyzer **202** to communicate with components of monitoring system **200**. In particular, interface **206** allows analyzer **202** to receive signals from sensor **201**, performing any suitable signal conversion, mixing, or other processing to convert received signals into a form suitable for use by analyzer **202**. Memory **208** represents any suitable form of information storage, whether volatile or non-volatile, and memory **208** may include magnetic media, optical media, removable media, local components, remote components, or any other information storage accessible by processor **204**. Memory **208** stores code **210** executed by processor **204** to perform various tasks of analyzer **202**, as described in greater detail below.

In a learning mode of operation, analyzer **202** uses a signal analysis algorithm **212** within code **210** operable to detect characteristic patterns in vibrations detected by sensor **201**. Examples of signal analysis algorithms **212** include commercially available voice recognition software, such as VoicePlus from HK Software, or custom software programs. Recognizable patterns are stored in a signal database **214** for later comparison in recognition mode. Analyzer **202** may also be programmed to associate recognizable signals with particular fixtures **102** or groups of fixtures **102**.

Once a reasonably complete signal database **214** has been assembled, analyzer **202** may operate in recognition mode. In recognition mode, analyzer **202** uses signal analysis algorithm **212** to compare a received signal to signals stored in database **214** and based on the comparison, analyzer **202** identifies any stored signal that matches the received signal. If a match is detected, analyzer **202** determines that the associated fixture **102** or group of fixtures **102** has been operated, and stores a record **216**, which may include the date and time of the fixture-operation event. Analyzer **202** may store records **216** in any suitable format and may include any suitable information. For example, analyzer **202** may store events in a Microsoft Word document, using a macro to automatically include a date- and timestamp in record **216**.

Analyzer **202** uses statistical analysis algorithm **218** to analyze records **216** for the purpose of extrapolating useful information from them. Statistical analysis algorithm **218** may be any suitable well-known statistical analysis routine or yet-to-be-developed routine. Analyzer **202** may take into account any additional information, such as known properties of fixtures **102** or configuration of plumbing system **100**, to present the resulting information in a useful form. For example, analyzing patterns in the use of fixtures **102** may be used to extrapolate quantities such as total water use, average water use, and maximum water use. This information may in turn be used to assist in modeling, sizing, or modifying plumbing system **100**.

FIG. **3** is a flow chart showing one example of a method of operation for monitoring system **200**. Sensor **201** detects a vibration produced by plumbing system **100** at step **302**, and generates a signal representative of the vibration at step **304**. Analyzer **202** compares this signal to signal database **214** at step **306**. Based on the comparison, analyzer **202** determines whether the signal matches a stored signal in database **214** at step **308**.

If the signal matches a stored signal, monitoring system **200** records the event at step **310**. How the event is recorded may depend on the mode in which monitoring system **200** is operating. If monitoring system **200** is operating in learning mode, monitoring system **200** may store the pattern of the signal in database **214** as part of the process of learning the vibrational signatures of various fixtures **102**. If monitoring system **200** is operating in recognition mode, then system **200** may store a record that specifies useful information about the event, such as which fixture **102** operated and the time of operation (such as date, time, or duration).

If the signal received from sensor **201** does not match a stored signal in database **214**, then the response of analyzer **202** depends on whether system **200** is in learning mode or recognition mode, as shown by decision step **314**. If system **200** is in learning mode, analyzer **202** may record the pattern of the signal in order to more fully develop its catalog of known vibrational patterns. On the other hand, if system **200** is in recognition mode and comes across an unrecognized signal, it may determine whether the signal is significant according to a significance threshold, which is a predetermined set of criteria, such as minimum volume or minimum duration, that may be used to determine whether an unknown signal represents a significant event in plumbing system **100**. If the signal is determined to be significant, analyzer **202** may record the event as an event of unknown type, including any suitable time information such as date, time, or duration. In addition, analyzer **202** may store a pattern for the signal to assist in future learning.

Once the event has been classified as recognizable or not and any suitable record has been made, system **200** determines whether sensor **201** is continuing to receive vibrations. If sensor **201** is continuing to receive vibrations, the method repeats from step **302**. Otherwise, the method is at an end.

Although the present invention has been described in detail, various changes and modifications may be suggested to one skilled in the art. It is intended that the present invention encompass such changes and modifications as falling within the scope of the appended claims.

What is claimed is:

1. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

a microphone vibrationally coupled proximal to a supply line of the plumbing system, the microphone operable to:

detect a vibration produced by the plumbing system; and

generate a signal representative of the vibration; and

a processor operable to:

receive the signal;

compare the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determine that the associated one or more fixtures have been operated based on the comparison; and

store a record of the operation of the associated one or more fixtures.

2. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

a sensor vibrationally coupled to the plumbing system, the sensor operable to:

detect a vibration produced by the plumbing system; and

generate a signal representative of the vibration; and

a processor operable to:

receive the signal;

compare the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determine that the associated one or more fixtures have been operated based on the comparison; and

store a record of the operation of the associated one or more fixtures, wherein the record comprises an identifier for the associated one or more fixtures, a time of operation, and a date of operation.

3. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

a sensor vibrationally coupled to the plumbing system, the sensor operable to:

detect a vibration produced by the plumbing system; and

generate a signal representative of the vibration; and

a processor operable to:

receive the signal;

compare the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determine that the associated one or more fixtures have been operated based on the comparison;

store a record of the operation of the associated one or more fixtures; and

analyze a collection of stored records to determine usage patterns for the plumbing system.

4. The system of claim **3**, wherein the analysis is used to calculate a quantity selected from the group consisting of: a total water usage over a predetermined time period, a maximum water usage, an average water usage, and a flow velocity at a certain point in the plumbing system.

5. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

a sensor vibrationally coupled to the plumbing system, the sensor operable to:

detect a vibration produced by the plumbing system; and

generate a signal representative of the vibration;

a processor operable to:

receive the signal;

compare the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determine that the associated one or more fixtures have been operated based on the comparison; and

store a record of the operation of the associated one or more fixtures; and

wherein the processor uses voice recognition software to assemble the signal database and further uses the voice recognition software to compare the signal to the signal database.

6. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

a plurality of sensors, each sensor vibrationally coupled to a different location in the plumbing system, each sensor operable to:

detect a vibration produced by the plumbing system; and

generate a signal representative of the vibration;

a processor operable to:

receive the signal;

compare the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determine that the associated one or more fixtures have been operated based store a record of the operation of the associated one or more fixtures; and

the processor is further operable to perform the steps of receiving and comparing for signals received from any of the sensors.

7. A method for monitoring a plumbing system having a plurality of fixtures, comprising:

detecting, by a microphone coupled proximal to a supply line of a plumbing system, a vibration produced by the plumbing system;

generating by the sensor, a signal representative of the vibration;

comparing, by a processor, the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison; and

storing a record of the operation of the associated one or more fixtures.

8. A method for monitoring a plumbing system having a plurality of fixtures, comprising:

detecting, by a sensor, a vibration produced by a plumbing system;

generating, by the sensor, a signal representative of the vibration;

comparing, by a processor, the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison; and storing a record of the operation of the associated one or more fixtures, wherein the record comprises an identifier for the associated one or more fixtures, a time of operation, and a date of operation.

9. A method for monitoring a plumbing system having a plurality of fixtures, comprising:

detecting, by a sensor, a vibration produced by a plumbing system;

generating, by the sensor, a signal representative of the vibration;

comparing, by a processor, the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison;

storing a record of the operation of the associated one or more fixtures; and

analyzing a collection of stored records to determine usage patterns for the plumbing system.

10. The method of claim **9**, wherein the analysis is used to calculate a quantity selected from the group consisting of: a total water usage over a predetermined time period, a maximum water usage, an average water usage, and a flow velocity at a certain point in the plumbing system.

11. A method for monitoring a plumbing system having a plurality of fixtures, comprising:

detecting, by a sensor, a vibration produced by a plumbing system;

generating, by the sensor, a signal representative of the vibration;

comparing, by a processor, the signal to a signal database using voice recognition software, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison;

storing a record of the operation of the associated one or more fixtures; and

assembling the signal database using voice recognition software.

12. A method for monitoring a plumbing system having a plurality of fixtures, comprising:

detecting by a sensor, a vibration produced by a plumbing system;

generating, by the sensor, a signal representative of the vibration;

comparing by a processor, the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison;

storing a record of the operation of the associated one or more fixtures;

wherein the sensor is one of a plurality of sensors, wherein each sensor is coupled to a different location in the plumbing system; and

wherein the steps of receiving, comparing, determining, and storing are performed for signals received from any of the sensors.

13. A method for monitoring the operation of fixtures of a mechanical system, comprising:

providing a microphone vibrationally coupled to the mechanical system;

detecting, by the microphone, a vibration produced by the mechanical system;

generating, by the microphone, a signal representative of the vibration;

comparing the signal to a signal database using voice recognition software, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison;

storing a record of the operation of the associated one or more fixtures; and

assembling the signal database using voice recognition software.

14. A method for monitoring the operation of fixtures of a mechanical system, comprising:

providing a sensor vibrationally coupled to a mechanical system selected from a group consisting of: a plumbing system, an automobile engine, a building under construction, and a system for depositing concrete;

detecting, by the sensor, a vibration produced by the mechanical system;

generating, by the sensor, a signal representative of the vibration;

comparing the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

determining that the associated one or more fixtures have been operated based on the comparison; and

storing a record of the operation of the associated one or more fixtures.

15. The method of claim **14**, wherein the steps of comparing, determining and storing are performed by a personal computer.

16. A system for monitoring a plumbing system having a plurality of fixtures, comprising:

means for detecting a vibration produced by a plumbing system;

means for generating a signal representative of the vibration;

means for comparing the signal to a signal database, the signal database associating each of a plurality of stored signals with operation of one or more of the fixtures;

means for determining that the associated one or more fixtures have been operated based on the comparison; and

means for storing a record of the operation of the associated one or more fixtures.

17. The system of claim **16**, further comprising means for analyzing a collection of stored records to determine usage patterns for the plumbing system.

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