

## MONITORING SYSTEM WITH POWER SUPPLY BUILT THEREIN

## BACKGROUND OF THE INVENTION

## Field of the Invention:

The present invention relates to a monitoring system for maintaining and inspecting valves such as a pressure reducing valve, a safety valve, an automatic control valve, a directional control check valve, attached to various pipe arrangements, traps such as a steam trap and a gas trap, or various facilities installed in various factories. The present invention relates particularly to a monitoring system with a built-in power supply, which is capable of reducing expenses used to install the monitoring system and obtaining a stable output result of monitoring.

## Description of the Related Art:

Plant facilities such as various rotating machines and driving machines, and valves for controlling the flows of various fluids have been mounted in large numbers on production sites in various factories. These facilities and valves have been constantly or periodically inspected and monitored for their operating conditions according to the degree of their importance in order to obtain the maximum volume of production with the minimum energy of consumption and maintain the maximum quality of production.

As the conventional monitoring system, one has

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generally been used which senses physical quantities such as temperatures, pressure, and vibrations to be monitored, compares each sensed value with a predetermined reference value, and observes a change in each sensed value with time, thereby making a decision or determination as to whether an object to be monitored normally operates or is brought into a possibility that the object will lead to a failure in near future.

In the conventional monitoring system, a commercial source used through a general electrical wire or line, a photocell, that is, a solar battery, or a thermal power-generating element or device, etc. have been used as driving sources for a sensor unit, an arithmetic display unit, etc.

The monitoring system using the commercial source of the conventional driving sources is accompanied by a problem in that the electrical wire is made long in distance and becomes complex, thereby increasing its cost, a problem in that the photocell cannot obtain a sufficient electromotive force at night or indoors and the electromotive force is reduced with smudges of the surface of a light-receiving panel, or a problem in that the thermal power-generating device cannot obtain a stable electromotive force at all times.

It is therefore an object of the present invention to provide an advanced monitoring system capable of providing less installation expenses and obtaining a

stable output result of monitoring for a predetermined period to thereby make it possible to reliably confirm operating conditions of various facilities and valves.

#### SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a monitoring system, comprising a sensor unit for sensing one or plural of physical quantities such as temperatures, pressure, and vibrations, which are objects to be monitored, an arithmetic display unit for making a decision or determination, based on the value sensed by the sensor unit, as to whether an object to be monitored normally operates or is brought into a possibility that the object will lead to a failure in near future, and a driving power supply incorporated in at least one of the sensor unit, the arithmetic display unit and a coupling portion for coupling the sensor unit and the arithmetic display unit to each other by wire or radio. Thus, a power supply is incorporated into a point where an electrical wire is maximized in length and becomes complex, to thereby omit the electrical wire, and a power supply is built in a point where a stablest drive source is required, whereby installation expenses can be reduced and a predetermined stable result of monitoring can be obtained.

The above, other objects and features of the invention will hereinafter be described in detail by the

following embodiments with reference to the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a block diagram showing a first embodiment of a monitoring system with a built-in power supply, according to the present invention;

Fig. 2 is a block diagram illustrating a second embodiment of a monitoring system with a built-in power supply, according to the present invention;

Fig. 3 is a block diagram depicting an embodiment of a steam trap-oriented monitoring system with a built-in power supply, according to the present invention;

Fig. 4 is an enlarged cross-sectional view of a sensor employed in the steam trap-oriented monitoring system shown in Fig. 3; and

Fig. 5 is a cross-sectional view showing a modification of the sensor shown in Fig. 4.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

Fig. 1 shows a monitoring system wherein a sensor unit 2 is directly attached to a valve, a trap 1 or the like to be monitored, monitoring information is collected by a remote portable data logger 3, and the detailed analysis, arithmetic operation and display or storage or the like of data are performed by a computer 4.

A method of mounting the sensor unit 2 to the trap 1 is capable of joining both to each other with a fastener such as screws or the like or detachably mounting them to each other through a joint. When the sensor unit 2 cannot be directly mounted to an object to be monitored, the sensor unit 2 may be placed in the vicinity of the object through a transfer member corresponding to a physical quantity as an object. Alternatively, the sensor unit 2 may of course be incorporated and placed inside the object 1 to be monitored such as the valve, trap or the like.

The sensor unit 2 shown in Fig. 1 comprises sensors 5 and 6 capable of detecting physical quantities such as pressure, temperatures, vibrations, etc., a CPU 7 for computing values detected by the sensors 5 and 6 and comparing them with a reference value, a display 8 for displaying the result of computation by the CPU 7, a

communication module 9 for sending the result of computation by the CPU 7 to the portable data logger 3, and a lithium battery 10 used as a source or power supply for driving the entire sensor unit 2.

The sensor unit 2 is capable of displaying the result of computation by the CPU 7, based on the values detected by the sensors 5 and 6 and confirming the state of operation of the object 1 to be monitored on the spot. Further, the sensor unit 2 is capable of sending the result of computation to the remote portable data logger 3 through the communication module 9. When it is not necessary to cause the sensor unit 2 to display the state of operation thereof, the sensor unit 2 is also allowed to have the function of communicating with the data logger 3. Although not illustrated in the drawing, a limiter for sending a signal when the upper limits or lower limits of the values detected by the sensors 5 and 6 exceed a predetermined set value, is incorporated into the sensor unit 2. Similarly, a storage unit such as a RAM, a ROM or the like is provided within the sensor unit 2 to store therein an ID number as an identification code for the valve or the trap 1 to be monitored.

The present embodiment shows an example in which information can be bidirectionally transferred between the sensor unit 2 and the portable data logger 3 by radio. Radio communications include optical communications using infrared rays or the like, ultrasonic communications or

communications using commonly-used radio waves. Instead of radio communications of information as done in the illustrated embodiment, known wire communication may be employed.

The portable data logger 3 comprises a module 11 which communicates with the sensor unit 2, a CPU 12, a memory 13, a display 14, a module 15 which communicates with the computer 4, and a lithium battery 16 used as a source or power supply for driving these. The portable data logger 3 may be so arranged as to collect data obtained by monitoring a plurality of valves and traps 1 at any remote location, then, provide arithmetic operations on the collected data and display the result of the arithmetic operations. Alternatively, the portable data logger 3 sends the data to the computer 4 to allow various detailed analyses and arithmetic operations thereof, etc. When it is unnecessary to cause the data logger 3 to display the state of operation, the data logger 3 is allowed to have the function of communicating with the computer 4 and the computer 4 may display the state of operation.

Physical quantities such as temperatures, vibrations, conductance, etc. which indicate state quantities of the valves and the traps 1 to be monitored, are detected by the sensors 5 and 6 and sent to the portable data logger 3 through the communication module 9 together with the ID numbers corresponding to the identification codes of each individual valves or steam traps, which have been stored in the storage unit, where monitoring data indicative of the states of operations of the objects to be monitored such as the large number of

valves and traps or the like are collected, followed by transmission to the computer 4, where their analyses and arithmetic operations are performed in further details. As a result, monitoring to be effected on the objects to be monitored is executed at all times or with the frequency corresponding to the degree of importance of the objects to be monitored. In the present embodiment, the communication module 9 of the sensor unit 2 and the communication module 11 of the portable data logger 3 constitute a coupling portion.

In order to reduce the consumption of power by the sensor unit 2 and increase the life of the built-in battery, an analog circuit system lying within the sensor unit 2 is normally kept deactivated and the communication module 9 is kept in a received waiting state. Further, the analog circuit system lying within the sensor unit 2 is kept in communication upon only reception of a command from the portable data logger 3. Under such a condition, the values detected by the sensors 5 and 6 can be displayed or transmitted.

Another method of reducing the consumption of power by the sensor unit 2 is as follows: An unillustrated timer lying within the CPU 7 is utilized and only the timer is normally driven. Only when the timer passes beyond a set time, the sensor unit 2 is energized to perform sensing, and the result of sensing is stored in a memory or it is sent to the data logger 3 at the time of

the sensing, whereby the power consumption can be reduced.

A so-called primary battery such as an alkaline battery, a mercury battery or a lithium battery is suitable for a source or power supply. Described specifically, a lithium battery such as a thionyl chloride lithium battery may desirably be used. Assuming that when the present thionyl chloride lithium battery is used, the power per day, which is consumed or used up by each of the sensor unit, the arithmetic display unit and the coupling portion, for example, is about 250 mW, the battery is able to continue using without its replacement for about seven years.

A battery may be utilized in combination with a solar battery, a thermal power-generating element or device or the like as the power supply at a point having a possibility of smudges being less outdoors or a point where a predetermined quantity of heat is steadily generated.

A second embodiment is illustrated in Fig. 2. In Fig. 2, a monitoring system comprises a sensor unit 2 similar to that employed in the embodiment shown in Fig. 1, a repeater 20 for communications, a data logger 21 for receiving a signal sent from the repeater 20, and a computer 4.

A communication module 22 and a source or power supply 23 are incorporated into the repeater 20. A primary battery such as a lithium battery or the like or

a combination of a solar battery or a thermal power-generating device and a battery may be used as the power supply 23.

The data logger 21 comprises a communication module 25, a CPU 26, a module 27 which communicates with the computer 4, and a general commercial source 28. In the present embodiment, a communication module 9 of the sensor unit 2, the communication module 22 of the repeater 20, and the communication module 25 of the data logger 21 constitute a coupling portion.

A physical quantity of an object 1 to be monitored, which has been detected by the sensor unit 2, is transmitted and received by the data logger 21 through the repeater 20, followed by transmission to the computer 4 through a commonly-used wire connection or infrared interface. These information transfers are not necessarily limited to one direction. The signal can be bidirectionally transferred among them. In the present embodiment, the placement of the repeater 20 in a predetermined point makes it possible to take a system for fixedly placing the data logger 21 in a predetermined position.

While the present embodiment shows an example in which the power supplies for the sensor unit 2 and the portable data logger 3 are used as the built-in batteries, the built-in battery may be used only for the sensor unit 2 or the built-in battery may be used only for the

portable data logger 3. The portable data logger 3 is normally carried by maintenance and inspection personnel upon working. Since the portable data logger 3 can be charged before its carrying, a rechargeable battery may be used in place of the built-in battery.

A monitoring system in which a steam trap 1 is intended for an object to be monitored, is next shown in Figs. 3 and 4.

Referring to Fig. 3, the steam trap 1 is mounted between steam piping 30 on the inlet side and drain piping 31 on the outlet side with flanges 32 and 33 interposed therebetween. The steam trap 1 allows only steam introduced from the steam piping 30 and a drain in a mixed fluid, of a drain obtained as condensed water of steam to flow downward toward the drain piping 31. Where only the drain flows downward within the steam trap 1 and the steam originally prohibited from flowing downward flows downward, the values of vibrations developed when their fluids flow downward, differ from each other and the values of temperatures on the external surface of the steam trap are also different from each other. The monitoring system performs sensing on the values of these vibrations and temperatures through the use of a sensor 17 and monitors whether the steam trap 1 is properly operated.

In the present embodiment, the sensor 17 and a transmitter 18 are separated from each other and only the

sensor 17 is directly attached to the steam trap 1 used as the object to be monitored. Further, the transmitter 18 is mounted on the steam piping 30 on the inlet side through a heat insulator 34 such as glass wool. Incidentally, the sensor 17 and the transmitter 18 employed in the present embodiment constitute the sensor unit 2 shown in Fig. 1. The sensor 17 and the transmitter 18 are electrically connected to each other by a cable 35. As is shown by a cross-sectional view in Fig. 4, the sensor 17 is attached and fixed to a nut 36 for assembling the steam trap 1. A nut holder 38 is placed over the nut 36 with a spacer 37 interposed therebetween and coupled to a sensor body 39 by screws, whereby the sensor 17 is fixedly mounted on the nut 36 of the steam trap 1. The spacer 37 and the nut holder 38 form a mounting fixed portion 24.

The sensor body 39 is made up of stainless steel and shaped in the form of a hollow cylinder. The sensor body 39 has a plurality of radiating fins 47 at its upper portion and is connected to the transmitter 18 shown in Fig. 3 through a cap 48 and the cable 35. A vibration transfer bar 40 with a piezoelectric element 41 attached to an upper end of the sensor body 39 is placed within the sensor body 39 while being held by a holding member 42, and a thermocouple 43 is placed at a lower end of the sensor body 39. The vibration transfer bar 40 is shaped in the form of a taper so that the diameter thereof

increases from bottom to top. When a lower end of the vibration transfer bar 40 makes contact with an upper end of a bolt 44 paired with the nut 36, vibrations produced in the steam trap 1 are transferred to the piezoelectric element 41 through the bolt 44. The holding member 42 is made of a heat resistant resin and prevents heat generated in the steam trap 1 from being transferred to the piezoelectric element 41. On the other hand, the piezoelectric element 41 is composed of lead niobate or lithium niobate high in heat resistance. A coil spring 45 is placed within the holding member 42 so as to urge the holding member 42 downward. A cord 46 is mounted to an upper portion of the piezoelectric element 41 and passes in the cable 35 so as to be connected to the transmitter 18 shown in Fig. 3.

The thermocouple 43 is also connected to the transmitter 18 through a cord 49. One, which has heretofore been used so as to be capable of measuring a high temperature of the external surface of the steam trap 1, is used as the thermocouple 43.

The monitoring system for the steam trap 1, which is shown in Figs. 3 and 4, detects vibrations produced in the steam trap 1 through the use of the piezoelectric element 41 and detects each temperature of the external surface of the steam trap 1 by the thermocouple 43, and transfers it to the transmitter 18 through the cable 35. The detected signal is sent from the transmitter 18 to

the portable data logger 3 shown in Fig. 1, whereby the determination or decision as to whether the steam trap 1 normally operates or fails to operate in the normal manner, is made as described above.

Next, one shown in Fig. 5 is a sensor 19 wherein the mounting fixed portion 24 of the sensor 17 shown in Fig. 4 is partly modified so as to be set as a mounting fixed portion 29. The mounting fixed portion 29 is formed at a lower end of a sensor body 50 by a female screw portion 52 and a bolt 51 paired with a nut 36, and the sensor body 50 is threadedly inserted into an upper portion of the bolt 51, whereby the sensor body 50 is fixed and attached to the steam trap 1.

According to the present invention as described above, a monitoring system can be provided wherein owing to the incorporation of a power supply in at least one of a sensor unit, an arithmetic display unit and a coupling portion, a power supply is incorporated into a point where an electrical wire is maximized in length or becomes complex, to thereby omit wiring, and a power supply is built in a point where a stablest drive source is required, to thereby make it possible to reduce its installation expenses and obtain a predetermined stable result of monitoring.

While the present invention has been described with reference to the illustrative embodiments, this description is not intended to be construed in a limiting

sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to those skilled in the art on reference to this description. For example, whilst in Fig. 3, the power supply is contained within the transmitter 18 housing, the power supply may be provided in the sensor 17 housing (with an electrical wire connection being provided between the two in either case) or separate power supplies may be provided within the sensor 17 and transmitter 18. Furthermore, the sensor 17 and transmitter 18, where independently powered, may communicate by wireless means. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

THIS SHEET HAS BEEN  
REPLACED

WHAT IS CLAIMED IS:

1. A monitoring system, comprising:

a sensor unit for sensing one or plural of physical quantities including temperatures, pressure, vibrations, sound, conductance, concentrations, or pH, which are objects to be monitored;

an arithmetic display unit for determining or deciding, based on each value sensed by said sensor unit, whether an object to be monitored normally operates or is brought into a possibility that said object will lead to a failure in near future; and

a driving power supply incorporated in at least one of said sensor unit, said arithmetic display unit and a coupling portion for coupling said sensor unit and said arithmetic display unit to each other by wire or radio.

2. The monitoring system according to claim 1, further including a wire or wireless communication module for transmitting and receiving a signal to and from said sensor unit and said arithmetic display unit.

3. The monitoring system according to claim 1, wherein said sensor unit is directly attached to the corresponding object to be monitored.

4. The monitoring system according to claim 1, wherein said sensor unit is mounted in the vicinity of said object to be monitored.

5. The monitoring system according to claim 1, wherein said object to be monitored is a valve or a steam



trap or the like whose inside allows a fluid to pass therethrough, and said sensor unit is mounted directly to or in the vicinity of said corresponding object to be monitored.

6. The monitoring system according to claim 1, wherein said sensor unit is provided with a limiter for sending a signal when the upper or lower limit of the value detected by said sensor unit exceeds a predetermined set value.

7. The monitoring system according to claim 1, wherein said sensor unit is directly attached to a fastener such as a bolt or a nut or the like attached to said object to be monitored.

8. The monitoring system according to claim 1, wherein sensors and a communication module of said sensor unit are provided in divided form, and said sensors are directly attached to said object to be monitored, whereas said communication module is mounted away from said sensors in the vicinity of said object.

9. Monitoring apparatus comprising:

at least one sensor arranged to sense at least one physical quantity of an object to be monitored;

a processor spaced from the or each sensor in a separate housing and arranged to be responsive to the or each sensor to determine a possible failure state of the object; and

a power supply incorporated in at least one of said sensor unit and said processor.

