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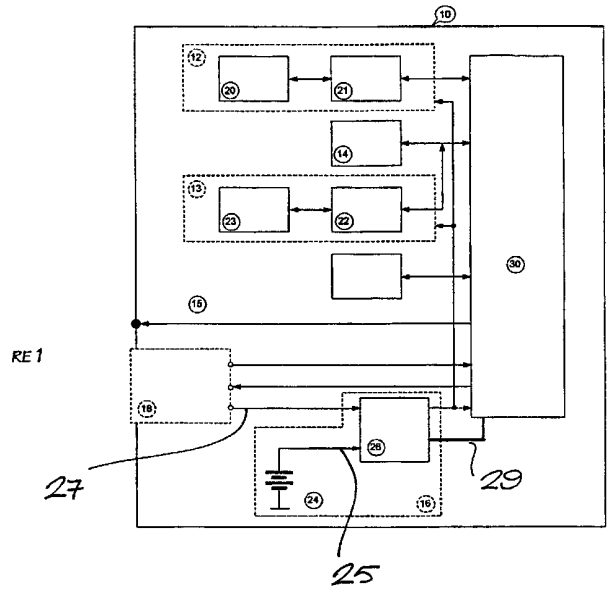

(57) Abstract: This invention relates to data recording apparatus that includes a self-contained monitor (10) adapted for attachment to a machine to monitor one or more parameters of operation of the machine. The monitor includes a transducer (12) adapted to sense changes in state of one or more of the monitored parameters of machine operation and to convert the sensed change in parameter state to recordable machine parameter data, a data store (14) adapted to receive and store the data and a power supply (16) adapted to provide operating power to the transducer and data store. The data recording apparatus includes a data communication device externally of the monitor, which data communication device is adapted to supply the monitor with power to enable data communication between the monitor and the external data communication device.

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Machine Monitor

Background to the invention

This invention relates to data recording apparatus.

The invention finds particular application in monitoring the operation of a machine in order to produce an operation history for the machine and it will be described with reference to such an application. It will be appreciated, however, that this is merely exemplary and it is not intended to limit the invention to such an application.

Data recording apparatus, such as machine monitors, are known. Conventionally, such monitors include a structural enclosure that can be attached to the machine to be monitored and a power supply to provide electrical power to the monitor. The monitor typically includes one or more transducers or sensors adapted to sense one or more parameters of machine operation and to convert the sensed parameter to recordable data - normally digital data. This data, together with time data, is stored in memory as the operation history of the machine, as monitored. Finally, a data communication mechanism is used to communicate with an external data processing device, normally to transfer the stored operation history of the machine to the data processor.

Machine monitors such as this are used to monitor the use of various pieces of machinery and equipment such as vehicles, general machinery such as drilling equipment, air-conditioner units, generators and compressors, and access control devices including doors, gates and turnstiles. The apparatus involved ranges from simple hour meters, which merely record the total operating time of a particular piece of machinery, to more complex devices capable of storing and analysing detailed information pertaining to the use of the machinery.

The monitors currently in use are generally powered by an internal power supply which is used not only to power the transducers, data conversion and memory components of the monitor, but also

the components used for the communication of stored information to the external data processing device. If an electrical battery is used as the power supply, battery life is dictated largely by the extent of communication initiated from within the monitor, normally the number of data transfers between the monitor and the external data processing device. As a result, the battery may need to be replaced frequently. Monitors of this kind are often used in situations where a completely self contained monitor is required. It will be appreciated that, in these cases, the entire monitor would have to be replaced.

Summary of the invention

The data recording apparatus of this invention includes a self-contained monitor adapted for attachment to a machine thereby to monitor one or more parameters of operation of the machine, the monitor including a transducer adapted to sense changes in state of one or more of the monitored parameters of machine operation and to convert the sensed change in parameter state to recordable machine parameter data, a data store adapted to receive and store the data and a power supply adapted to provide operating power to the transducer and data store, the data recording apparatus including a data communication device externally of the monitor, which data communication device is adapted to supply the monitor with power to enable data communication between the monitor and the external data communication device.

Unless the context clearly indicates otherwise, the term "machine" is intended, in this specification, to refer to any type of machine or item of equipment.

In addition, the term "self-contained monitor" refers to a monitor that is effectively sealed against the environment in which it operates and which is substantially tamper-proof.

The term "tamper-proof" refers not only to a monitor which is resistant to tampering, but also to a monitor that, when tampered with, indicates that it has been tampered with or is either partially or completely destroyed during the process of tampering.

By providing power to the monitor from the external data communication device during the communication of data, the power drain on the power supply internal to the monitor is minimised, thereby prolonging the useful life of the power supply.

Since the monitor used in the data recording apparatus of the invention is normally a sealed monitor, any extension of the useful power supply life means that the useful life of the monitor is extended by the same amount. In a permanently sealed monitor, once the power supply has been exhausted, the entire monitor will have to be replaced. In a monitor that is not permanently sealed, only the power supply will need replacement.

The power supply includes a power source such as an electric battery and a power control device adapted to discontinue the supply of power from the power source at least to data communication devices internal to the monitor when power is received from the external data communication device.

In one form of the invention, the power supply is adapted to discontinue the supply of power from the power source to the entire monitor when power is received from the external data communication device.

In the preferred embodiment of the invention, the monitor includes an internal clock that is adapted to add time data to the machine parameter data recorded in the data store.

In this manner, it becomes possible to construct a history of the use of the machine to which the monitor is attached.

The transducer in the monitor may be constituted by any one or more of a number of different transducers or sensors, depending on the monitor application. Suitable sensors include but are not limited to, vibration sensors, magnetic reed switches, tilt switches, magnetic sensors or optical sensors.

The external data communication device may be constituted by any one of a number of

communications devices. To this end, the data communications devices internal to the monitor may be constituted by any one or more of a number of external data communications interfaces compatible with the external communication device concerned.

The external data communication device can be adapted to provide power to the monitor in a number of ways.

Where a cable link to the monitor is acceptable and it is not necessary for the monitor to be completely self-contained, power can be supplied by means of the cable link.

In cases where it is necessary for the data recording apparatus to be completely self-contained and radio frequency communication is used, the radio frequency carrier signal transmitted by the external communication device may provide the power supply and data transfer mechanisms simultaneously.

Additional features may be added to the monitor to enhance its performance. These features include the addition of a network interface, a counter input and equipment for measuring and recording the changes in ambient temperature in the operating environment of the monitor.

Brief description of the drawings

In the drawings:

Figure 1 is a block diagram illustrating a machine monitor forming part of the data recording apparatus of the invention; and

Figures 2, 3 and 4 are block diagrams illustrating different external data communications interfaces, each of which is intended, interchangeably, to form part of the monitor of Figure 1 to enable communication with an external data communication device forming part of the data recording apparatus of the invention.

Description of embodiments of the invention

The data recording apparatus of the invention consists, essentially, of a combination of the machine monitor 10 illustrated in Figure 1 with an external data communications device (not shown).

The monitor 10 includes a sensor interface 12, a microprocessor 30, a memory device 14, a clock circuit 13, an external communications interface 18 and a power supply 16.

The sensor interface 12 is adapted to sense one or more parameters of machine operation and to convert the sensed parameter to recordable, digital data that is stored in memory 14, together with time data, as the operation history of the machine to which the monitor 10 is attached.

The external communications interface 18 is used to communicate with an external data communication device, normally to transfer the stored operation history of the machine to an external data processing device.

The machine monitor 10 is housed within a structural enclosure that can be attached to the machine to be monitored and it monitors one or more parameters of machine operation.

The structural strength of the monitor enclosure will be determined by the conditions within which the monitor 10 is required to operate. Monitors of this type are conventionally used in industrial locations and for this reason the monitor enclosure will be fairly robust and able to withstand the stress normally anticipated in such an environment. A housing of impact resistant plastics will normally be sufficient.

In addition, the housing will normally be sealed and substantially tamper resistant or tamper indicating.

In use, the monitor 10, using an appropriate sensor interface 12, is attached to a machine about which certain operational data is required. The sensors in the sensor interface 12 sense certain

activities undertaken by the machine and the microprocessor 30 records the date and time that the activity was undertaken.

Once transferred from the monitor 10 using the appropriate external data communication device, the data may be transferred to a computer for in-depth analysis of the machine operating history, including, for instance start and stop periods and duration of each period. In addition, the monitor 10 can be used to determine a number of operational details in respect of an item of equipment. For instance, the monitor 10 can be used to determine:

whether or not the equipment is being fully utilised;

if the equipment is optimally utilised and, if so, when such optimal use occurs;

whether unauthorised use of the equipment is taking place and, if so, when such unauthorised use occurs;

if and when the equipment is undergoing unscheduled downtime; or

the optimal scheduling of service intervals.

The monitor 10 is also ideally suited to determine the exact operating time of hired equipment for billing purposes.

The sensor interface 12 includes at least one transducer or sensor 20 that is adapted to sense an operating parameter of the machine and to produce electrical signals corresponding to changes in the monitored parameter. Within the sensor interface 12, a signal processor 21 receives and processes the sensor signals, converting the signals to digital form.

Preferably only certain, predetermined changes in state of the monitored parameter are viewed as recordable events. This can be done, for instance, by the selection of the appropriate sensor, the adjustment of the sensor sensitivity or programming of the signal processor 21 to exclude unwanted signals.

The type of transducer 20 used in the monitor 10 will depend on the machine parameter to be monitored. Examples of some sensor arrangements will be given below.

A simple vibration sensor may be employed as the transducer 20 merely to sense when the piece of machinery being monitored is operating. In a slightly more complex variation of this transducer arrangement, the vibration sensor could be adapted to sense when the machine is operating in one of a number of predetermined operational modes, provided each mode of operation has a characteristic, detectable vibration profile. The transducer output will then be indicative of the mode of operation of the machine.

The information required for analysis will determine the complexity of the transducer 20 and the content of the transducer output. To this end, the transducer 20 could be a complex sensor or combination of sensors adapted to produce information rich data, thereby enabling the production of a detailed machine operation history. For example, where the sensed parameter is machine vibration sensed by a vibration sensor, the signal processor 21 can be adapted to produce complex vibration profile data which permits the recordal and output of a detailed machine operation history for subsequent analysis. Operating parameters which can be monitored include machine speed, machine load and various other data pertaining to the machine operation. For example, the monitor 10 can then be used to monitor and record the cumulative time of machine operation in various load categories, such as cumulative time of operation at more than 100 percent-rated load.

A magnetic sensor arrangement can be employed to measure liquid flow rates. An example of such a sensor arrangement would be a magnetically monitored rotary flow meter that rotates at a speed equivalent to water flow through the meter.

Another example of a sensor arrangement would be the use of multiple tilt switches on rotating drums. Such an arrangement could be used to provide information pertaining to drum rotation, such as the direction and duration of drum rotation.

Magnetic reed switches may be employed as sensors to sense when a magnetic field is activated or interrupted, such as in the opening or closing of warehouse or container doors. The use of a multiplicity of switches, strategically placed, can ensure that attempts at tampering with the operation of the magnetic reed switches are detected and recorded.

An optical sensor may provide a signal each time a light source is activated or interrupted. For example, such a sensor arrangement, combined with a suitable shaft encoder, may be used to measure shaft rotation and speed.

The digital signals output by the signal processor 21 are fed to a microprocessor 30 for processing and then to a data store or memory 14 in the form of a nonvolatile memory device such as an EEPROM.

The monitor 10 includes a clock circuit 13 that feeds time data pertaining to recordable events to the microprocessor 30 and memory 14. The clock circuit 13 includes a real-time clock 22 and an oscillator 23, which, in combination, permit the recordal of data pertaining to the duration, time and date of a particular event.

A status indicator 15 constituted by one or more light emitting diodes (LEDs) or the like, is used to communicate visually with users of the monitor 10. In its simplest form, the status indicator 15 provides visual confirmation that the monitor 10 is functioning correctly by flashing briefly each time an event is recorded. Also when the internal battery level falls below its low battery threshold and replacement of the battery or the entire monitor 10 is required, the status indicator 15 can be made to flash periodically to indicate this condition. In this manner, a number of monitor operating conditions can be communicated visually.

Data stored in memory 14 is communicated by way of the microprocessor 30, the external communications interface 18 and an external data communication device (not shown) to an external data processing device (not shown). In most situations, the external data processing device will be constituted by a computer that is connected to the monitor 10, in which case the data will be communicated automatically. Alternatively, the data can be transferred to the data processing device by means of an intervening data communication device, such as a portable data logging or collecting device.

The power supply 16 includes an internal power source, constituted by a battery 24, and a power control 26. The monitor is normally powered by electrical power from the battery 24 that is

supplied to the power supply 16 on a primary power line 25.

However, when the external communications interface 18 is used to communicate with the monitor 10, the external communication device provides power for the complete monitor 10, including the external communications interface 18, the sensor interface 12, the memory 14, the clock circuit 13 and the microprocessor 30.

In operation, the external communication device will initiate data communications with the monitor 10 in a master/slave fashion, with the monitor 10 serving as the slave device. The external communication device then supplies the power requirements of the monitor 10. During communication, the supply of power from the battery 24 to the monitor 10 is discontinued to assist in prolonging battery life.

In initiating communications, the external communication device supplies power to the power supply 16 by way of an external power line 27. The power control 26 is adapted to compare the voltage on the primary power line 25 with that of the external power line 27. When the voltage of the external power line 27 exceeds that of the primary power line 25, the power control 26 switches to the external power supplied on the external power line 27. In addition, the power control 26 transmits a control signal to the microprocessor on a control line 29.

The microprocessor 30 monitors the power control on the control line 29 to ensure that the voltage on the external power line 27 reaches and maintains a predetermined threshold, whereupon the microprocessor 30 prepares the monitor 10 for data transfer between the monitor 10 and the external communication device. As soon as the voltage of the external power line 27 drops below the threshold (normally at the end of a communication session), the power control 26 switches back to the primary power line 25 for the resumption of the supply of battery power to the monitor 10 and of the normal monitoring functions of the monitor 10.

The nature and type of the external communications interface 18 will vary depending on the nature and type of the external data communication device used.

For this reason, the external communications interface 18 can consist of any one of a number of interface options, three of which (118, 218 and 318) are illustrated in Figures 2, 3 and 4 respectively. Using one of these interface options, the format of the data communicated by way of the external communications interface 18 is presented to the external data communication device in compatible format.

The external communications interface 118 illustrated in Figure 2 is configured to comply with the industry standard RS232 interface. In this case, the data presented by the microprocessor 30, is converted to RS232 format by the external communications interface 118 for communication with RS232 compatible external data communication devices. The RS232 communications interface is suitable for use in single unit, point to point cable installations or in benign factory environments where cable links between a plurality of monitors 10 and an external data communication device is acceptable. The external data communication device may take the form of a dedicated unit manufactured specifically for this function. Alternatively, a portable computer with an RS232 interface may be used.

In the case of the external communications interface 218 illustrated in Figure 3, the data presented by the microprocessor 30 is converted to the RS485 industry standard for communication within a multiple unit network cable installation. The RS485 external communications interface 218 can be used for factory environments where a number of monitors 10 are networked together to a computer using a 4-wire interconnection cable. In this case the computer fulfils the functions of the external data communication device.

The external communications interfaces 118, 218 described above both require cabled or wired, with permanently wired or plug-in connections between the monitors 10 and the external data communication device and power source. It is possible, however, to configure the external communications interface 18 for wireless communication.

Figure 4 illustrates such a wireless external communications interface 318 in which the data presented by the microprocessor 30 is converted to a radio frequency (RF) communications format for communication by way of an antenna 310.

The RF external communications interface 318 is suitable for use in situations where a plurality of monitors 10 are installed in single unit, wireless configuration. Since the connection to the external

data communication device is contact free, such an RF interface (318) is ideally suited to harsh or intrinsically safe environments where stringent safety standards, such as spark free communications interfaces, must be employed.

The external data communication device preferred for use with the RF external communications interface 318 is preferably a dedicated, purpose-built RF data logging device. In this way, matching, proprietary RF communications formats can be used in the external communications interface 318 and the RF data logging device.

In order to collect and transfer the stored operation history of a monitored machine to an external data processing device, the RF data logging device is brought into close proximity with the monitor 10 and actuated. The RF signal output by the RF data logging device is converted in the RF communications interface 318. The voltage of the resultant power input is sufficiently high for the power control 26 to switch to the external power line 27.

In this way, electrical power is supplied by the RF data logging device during the process of data communication between the RF data logging device and the monitor 10

As soon as the RF data logging unit is deactivated or removed from the proximity of the monitor 10, the voltage on the external power line 27 drops below the set threshold. This results in the power control 26 switching back automatically to the primary power line 25 for the resumption of the supply of battery power to the monitor 10.

In wired or cabled applications where wired or cabled external communications interfaces (118 and 218) are acceptable, the external data communication device provides power to the monitor 10 for the duration of the data communication session. In these situations, a dedicated power line will be included in the connection cable.

The ability to derive the monitor power supply from the external data communication device via the external communications interface 18 ensures that the power drain from the battery 24 is minimised, thus extending the operating life of the battery 24 and therefore of the monitor 10.

Claims

1. Data recording apparatus including a self-contained monitor adapted for attachment to a machine thereby to monitor one or more parameters of operation of the machine, the monitor including a transducer adapted to sense changes in state of one or more of the monitored parameters of machine operation and to convert the sensed change in parameter state to recordable machine parameter data, a data store adapted to receive and store the data and a power supply adapted to provide operating power to the transducer and data store, the data recording apparatus including a data communication device externally of the monitor, which data communication device is adapted to supply the monitor with power to enable data communication between the monitor and the external data communication device.

2. Data recording apparatus according to claim 1 in which the power supply includes a power source such as an electric battery and a power control device adapted to discontinue the supply of power from the power source at least to data communication devices internal to the monitor when power is received from the external data communication device.

3. Data recording apparatus according to either one of claims 1 or 2 in which the power supply is adapted to discontinue the supply of power from the power source to the entire monitor when power is received from the external data communication device.

4. Data recording apparatus according to any one of claims 1 to 3 in which the monitor includes an internal clock that is adapted to add time data to the machine parameter data recorded in the data store.

5. Data recording apparatus according to any one of the preceding claims in which the transducer in the monitor may be constituted by any one or more of a number of different transducers or sensors, depending on the monitor application.

6. Data recording apparatus according to claim 5 in which the sensors include, vibration

sensors, magnetic reed switches, tilt switches, magnetic sensors or optical sensors.

7. Data recording apparatus according to any one of the preceding claims in which the external data communication device may be constituted by any one of a number of communications devices.

8. Data recording apparatus according to any one of the preceding claims in which the data communications devices internal to the monitor may be constituted by any one or more of a number of external data communications interfaces compatible with the external communication device concerned.

9. Data recording apparatus according to any one of the preceding claims in which the external data communication device can be adapted to provide power to the monitor in a number of ways.

10. Data recording apparatus according to claim 9 in which power is supplied by means of a cable link.

11. Data recording apparatus according to claim 9 in which power is supplied by a radio frequency carrier signal transmitted by the external communication device.

12. Data recording apparatus according to claim 11 in which the radio frequency carrier signal transmitted by the external communication device provides the data transfer mechanism.

13. Data recording apparatus according to any one of the preceding claims in which the monitor used in the data recording apparatus of the invention is a sealed monitor.

14. Data recording apparatus according to any one of the preceding claims in which additional features are added to the monitor to enhance its performance.

15. Data recording apparatus according to claim 14 in which the additional features include the addition of a network interface, a counter input and equipment for measuring and recording

the changes in ambient temperature in the operating environment of the monitor.

16. Data recording apparatus substantially as described in this specification with reference to the accompanying drawings.

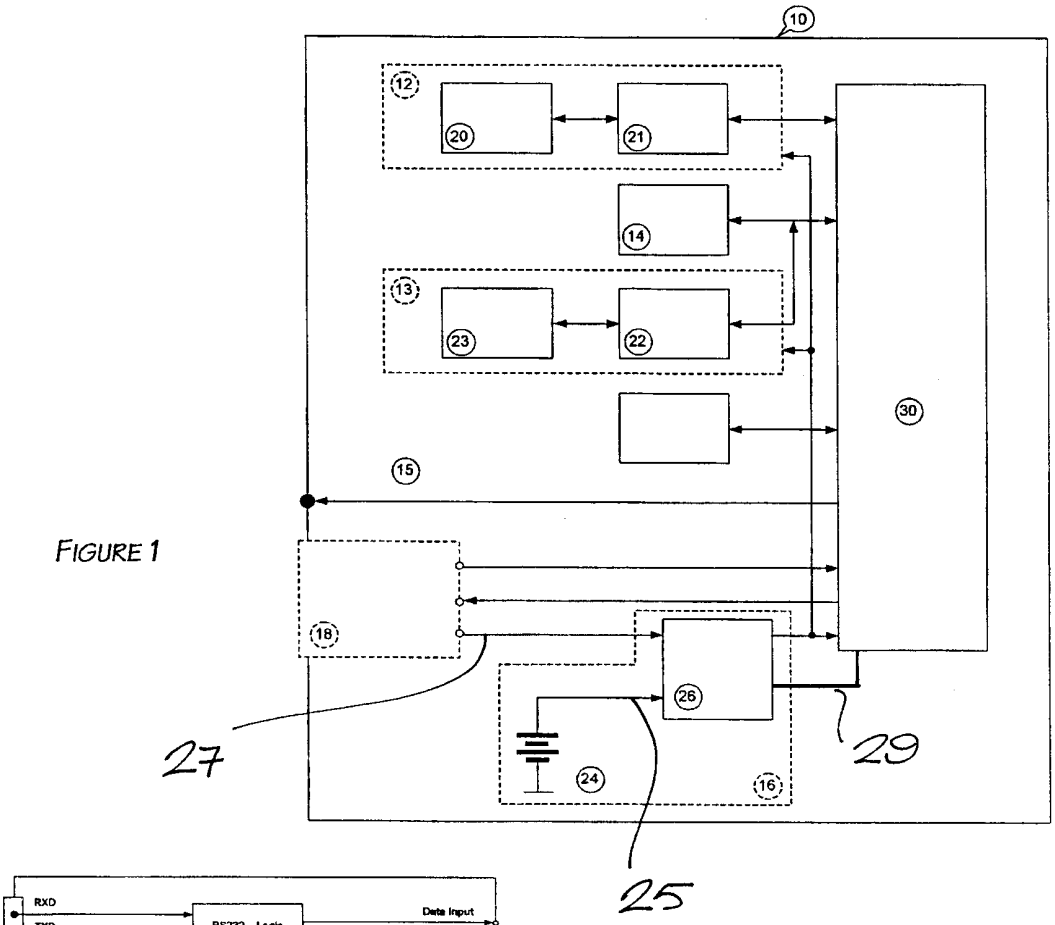

FIGURE 1

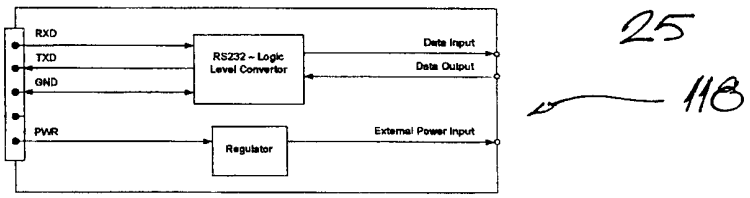

FIGURE 2

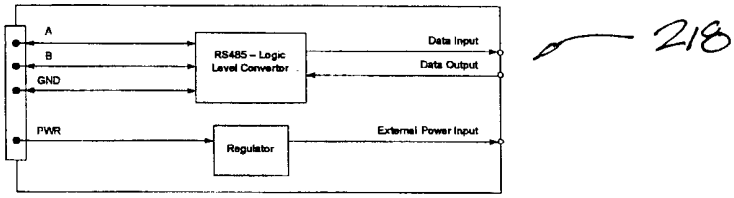

FIGURE 3

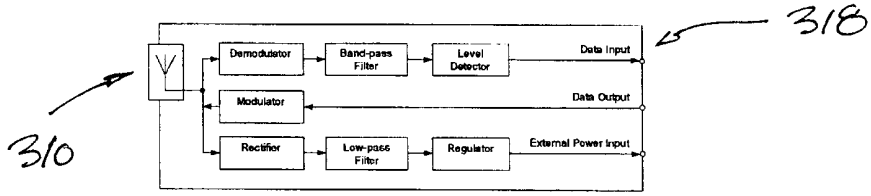

FIGURE 4