

- [54] **CONDITION MONITORING APPARATUS**
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| 3,553,441 | 1/1971 | Launder | 235/92 TC |
| 3,551,672 | 12/1970 | Homer..... | 340/237 S |

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[58] **Field of Search**..... 340/237 S, 221; 235/92 EV,
235/92 PC, 92 TC, 92 C

[56] **References Cited**

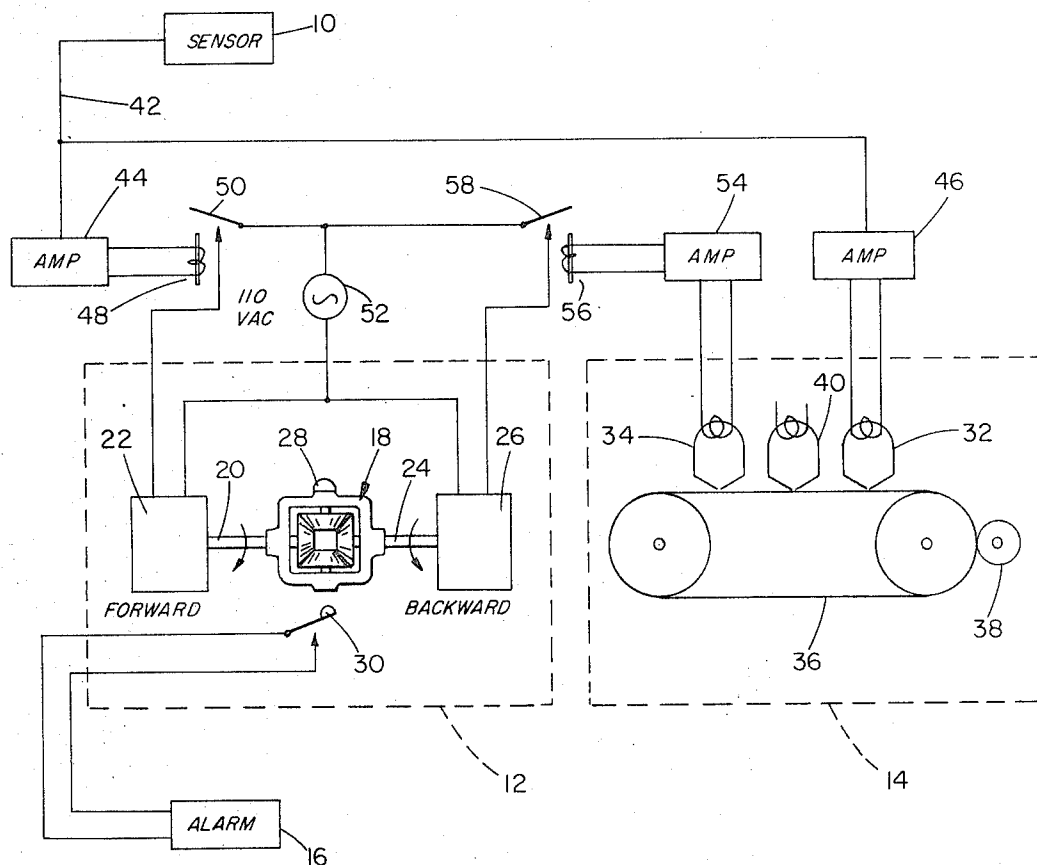
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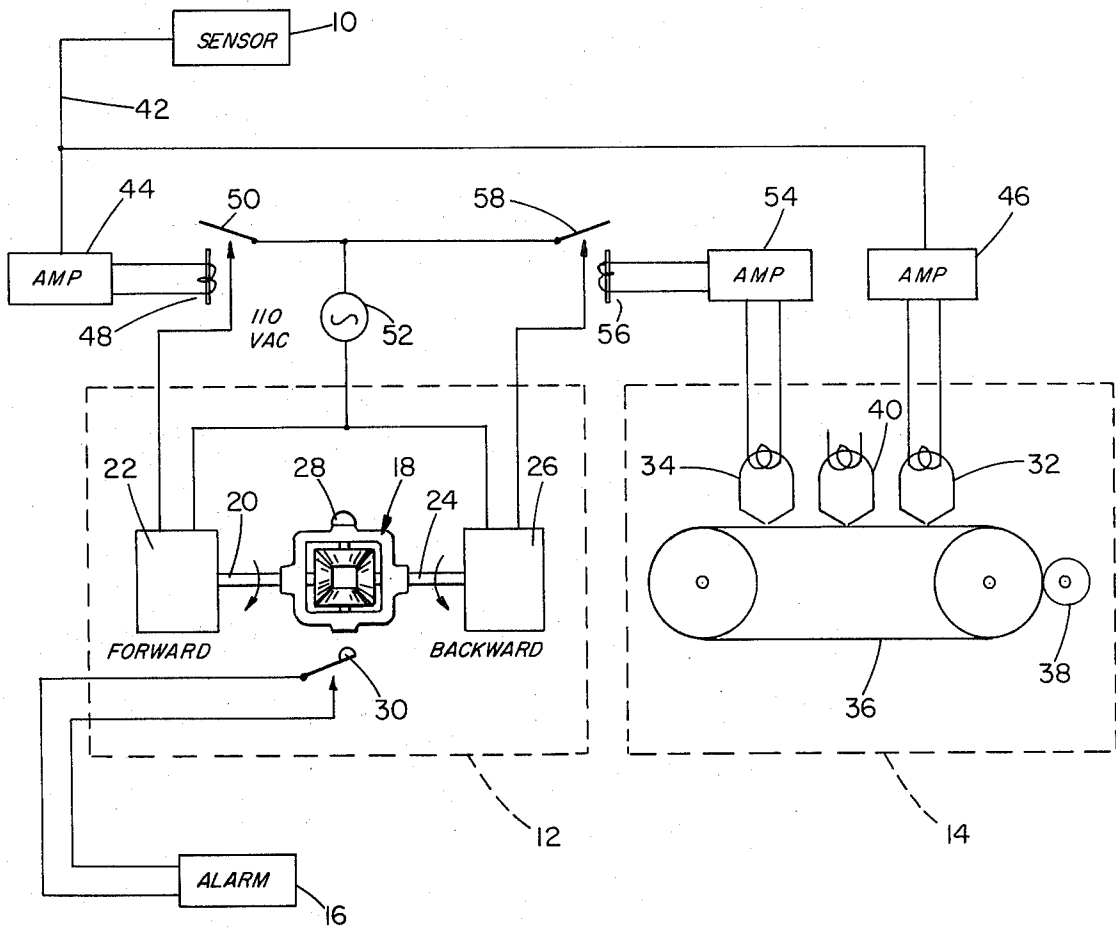
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|-----------|---------|--------------------|-----------|
| 3.112.067 | 11/1963 | Ernest et al. | 235/92 EV |
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[57] ABSTRACT

A system for indicating how many minutes of excess smoke emission have occurred during a predetermined time interval, e.g., an hour, includes an accumulator for storing the time duration value of the excess smoke signal. The excess smoke signal is applied to a delay means and the output of the delay means is applied to decrease the time duration value of the signal stored therein.

4 Claims, 1 Drawing Figure





CONDITION MONITORING APPARATUS

SUMMARY OF INVENTION

This invention relates to apparatus for measuring time and more particularly to apparatus for measuring the accumulated amount of time for which a detected condition is present during every time interval of a predetermined length.

It is often desired to measure the accumulated amount of time for which a detected condition exists in comparison with a larger period of time over which the accumulation is made. An example is the operation of large furnaces for which it can be useful and important to know how many minutes of smoke emission have occurred during a particular interval of time. Devices presently exist that are capable of measuring such accumulated time separately for successive intervals. However, these devices are not suitable when it is desired to measure the accumulated time over every possible interval of a given length. The need for such a measurement arises, for example, from smoke-emission regulations that prohibit more than a certain number of minutes of emission during any one-hour interval. Existing devices are not capable of measuring the total emission time for every one-hour interval since they accumulate emission time only for successive intervals at the end of which the accumulated time is always reset to zero. With such a device that resets every hour on the hour, for example, it is not possible to determine how much emission occurs during any of the overlapping one-hour intervals, such as from a quarter past the hour to a quarter past the next hour.

Accordingly, an object of this invention is to provide a novel and improved condition detection system.

Another object of the invention is to provide apparatus for measuring the accumulated time for which a detected condition exists during every possible interval of a specified length.

Still another object of the invention is to provide apparatus for making and indicating such measurement continuously so that at every point in time there may be indicated the accumulated time for which the detected condition has existed during the interval ending at that point in time.

Still another and more specific object of the invention is to provide an apparatus for continuously measuring, indicating, and recording the total accumulated time of pollution emission, such as smoke from a furnace stack, during the immediately previous time interval of specified length, and for producing a warning signal or alarm whenever that accumulated time exceeds a specified threshold during any such interval.

In accordance with the principles of the invention there is provided a condition monitoring system that includes a time duration value accumulator that can be both increased and decreased, condition responsive means connected to the accumulator to modify the value of the accumulation in one direction while the condition of interest is present, and a delay device connected to the accumulator to modify the value of the accumulation in the opposite direction. The length of the delay provided by the delay device is equal to the length of the time interval over which presence of the condition of interest is to be accumulated. There is also provided an output from the accumulator representing the value of the accumulation for activating display, re-

cording, alarm, or other output devices. The condition signal may take a variety of forms for example, AC or DC or pulses. A number of devices can be used for the accumulator including but not limited to bi-directional timers, digital counters, electronic integrator circuits and their equivalents. In a particular embodiment of the invention described in greater detail hereinafter, a differential gear assembly connected to two electric motors that are equal in speed but opposite in direction is utilized as an accumulator. The position of the differential gear registers the amount of time currently accumulated. A smoke detector is used to close a circuit whenever excess smoke is present, thereby providing power for one of the motors. The differential gear then progresses in the forward direction. Whenever the smoke detector activates the forward motor it also places a signal on a magnetic tape moving at constant speed. When this signal passes under a read head after a delay equal to the time interval over which the smoke-emission time is to be accumulated, a relay is closed to provide power for the other motor in the accumulator. In this manner every positive contribution to the accumulated time remains in effect only for a length of time equal to the interval over which the accumulation is to be made, after which it is immediately subtracted from the accumulation. A switch located in the path of the differential gear is used to indicate when the total accumulated time has exceeded predetermined threshold and to activate appropriate warning circuits.

Other objects, features, and advantages of the invention will be seen as the following description of an embodiment thereof progresses in conjunction with the accompanying drawing which is an illustration partially in schematic form and partially in block diagrammatic form of that embodiment.

DESCRIPTION OF PARTICULAR EMBODIMENT

The timing apparatus shown in the drawing includes a sensor 10, an accumulator 12, a delay device 14, and an alarm circuit 16. The accumulator 12 includes a differential gear assembly 18 having one shaft 20 connected to a forward motor 22 and another shaft 24 connected to a backward motor 26 whose speed is the same as that of the forward motor 22 but whose rotational direction is opposite. The differential gear assembly 18 includes a differential gear 28 which progresses in one direction when only the forward motor 22 is operating, in the opposite direction when only the backward motor 26 is operating, and otherwise in neither direction. The position of the differential gear 28 in its progression represents the value of the accumulation. There is also included in the path of the differential gear 28 a threshold switch 30 which closes the alarm circuit 16 when the differential gear 28 reaches that point (e.g., corresponding to two minutes) in its path.

The delay device 14 includes a magnetic write head 32, a magnetic read head 34, and an endless loop of magnetic tape 36 which is driven by a motor 38 at a constant speed appropriate for causing a point on the tape 36 to pass from the write head 32 to the read head 34 in a predetermined length of time. There is also included an erase head 40 located between the read head 34 and the write head 32 in the path of the tape 36.

The sensor 10 provides an output signal on line 42 which is connected to the input of an amplifier 44 and

to the input of a preamplifier 46. The output of the amplifier 44 is connected to a relay 48 whose normally-open switch contacts 50 connect the forward motor 18 to a 110-volt a.c. power source 52 in response to a relay energizing output from amplifier 44. The output of the preamplifier 46 is connected to the write head 32. The read head 34 is connected to the input of amplifier 54 whose output is connected to a relay 54 which closes normally open switch contacts 58 to connect the backward motor 26 to the power source 50.

In operation, the sensor 10 provides a signal on the line 42 whenever the detected condition is present. The signal on the line 42 causes the relay 48 to close contacts 50 thereby activating the forward motor 22 and causing the differential gear 28 to progress in the forward direction. The signal on the line 42 is also recorded by the write head 32 on the magnetic tape 36. After a delay of predetermined length, one hour in this embodiment, the recorded signal is detected by the read head 34 causing the relay 56 to close contacts 58 thereby activating the backward motor 26 and causing the differential gear 28 to progress in the backward direction. The erase head 40 continuously erases the signal on the tape 36 after it has been detected by the read head 34 thereby permitting the same tape 36 to be used repeatedly. Thus, every interval of smoke as sensed by detector 10 that is added to the value of the accumulation is subtracted (cancelled) from the value of the accumulation after the delay interval (one hour). Whenever the value of the accumulation as represented by the position of the differential gear 28 exceeds a predetermined level, the differential gear 28 closes the threshold switch 30 which activates the alarm circuit 16.

Thus it will be seen that the invention provides simple and inexpensive means for measuring accumulated time for a detected condition including but not limited to detection of smoke emission from a furnace stack, over every time interval of a given length, for continuously indicating and recording this measurement, and for signalling when the measurement exceeds a given value. The apparatus of the invention easily accommodates a wide range of different detectable conditions and a wide range of accumulation intervals and alarm levels. The principles of the invention can be realized with a variety of different sensors, accumulators, delays, or equivalent devices. While a particular embodiment of the invention has been shown and described, various modifications therein will be obvious to those having ordinary skill in the art and therefore it is not intended that the invention be limited to the described embodiment or to details thereof and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. Apparatus for providing a warning indication whenever the accumulated time that a contaminant is present in a fluid stream exceeds a predetermined frac-

tion of a predetermined length of time,

comprising a contamination sensor for monitoring said fluid stream and providing a continuous contaminant condition signal whenever said contaminant is present,

means responsive to said contaminant condition signal for providing a continuous delay signal corresponding to but offset in time from said contaminant signal by said predetermined length of time, a differential gear assembly responsive to said condition and delay signals,

said differential gear assembly having a first gear, a second gear, an output gear in continuous meshing engagement with said first and second gears, first and second input shafts connected to said first and second gears, respectively, a first motor connected to said first shaft for driving said first shaft in rotation in one direction, and a second motor connected to said second shaft for driving said second shaft in rotation in the opposite direction,

means responsive to said contaminant condition signal for continually energizing said first motor to continuously drive said first gear whenever said contaminant condition signal is present in a first direction to move said output gear in a direction indicating an increased time duration value,

means responsive to said delay signal for continually energizing said second motor to continuously drive said second gear whenever said delay signal is present to move said output gear in the direction opposite said increased time duration value indicating direction, and

means responsive to the position of said output gear of said differential gear assembly for providing a warning indication whenever the position of said output gear relative to said first and second gears indicates that the contaminant as sensed by said sensor has been present in said fluid stream for an accumulated time greater than said predetermined fraction of said predetermined length of time.

2. Apparatus as claimed in claim 1 wherein said delay signal providing means includes means for recording said condition signal, and means for reproducing said recorded signal said predetermined length of time after it was recorded.

3. Apparatus as claimed in claim 1 wherein said delay signal providing means includes a magnetic storage member, means to move said magnetic storage member, a write head, a read head so positioned relative to said write head that the length of time needed for a point on said magnetic storage member to pass from said write head to said read head is equal to said predetermined length of time.

4. Apparatus as claimed in claim 1 wherein said contamination sensor is an excess smoke detector.

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