(12) UK Patent Application (19) GB (11) 2 174 261 A

(43) Application published 29 Oct 1986

(21) Application No 8604900

(22) Date of filing 27 Feb 1986

(30) Priority data
(31) 726708 (32) 24 Apr 1985 (33) US

(51) INT CL⁴
G01D 5/25

(52) Domestic classification (Edition H):
H3H 12E 13D 14A 14E 1A 1F 1G 1X 23F 6A 6B 6D 7B 7F 8B 9X E
G4A FL
U1S 1247 G4A H3H

(56) Documents cited
GB A 2153171 GB 1577823 GB 0993179
GB A 2015222 GB 1305941 GB 0002232

(58) Field of search
H3H
G4A
G1N
Selected US specifications from IPC sub-class G06F

(71) Applicant
Dresser Industries Inc. (USA–Delaware),
The Dresser Building, Elm & Akard Streets, P. O. Box 718, Dallas, Texas 75221, United States of America

(72) Inventor
Frederick R Johanson

(74) Agent and/or Address for Service
A A Thornton & Co,
Northumberland House, 303–306 High Holborn, London WC1V 7LE

(54) Data monitor

(57) A data monitor (10) (e.g. for an underground mining machine) receives signals from several transducers (12) on the machine to monitor operating functions of the machine. Values determined by the tranducers are displayed (34) for the operator and stored in both short term and long term memories for recall by maintenance personnel. A microprocessor (20) is arranged to cause the display device to display either any out-of-bounds value monitored for each channel function consecutively or every function value monitored for a particular selected channel. In addition, maintenance instructions are periodically displayed for necessary personnel to ensure that the maintenance is performed. The monitor may be programmed either at the machine or through a portable data transfer unit (48) which is programmed at a remote location and carried to the machine for access by the monitor to change its instruction memory data. Stored data in the short term and long term memory may be transferred to the portable data transfer unit (48) and the portable unit hand carried to a remote location for analysis of the stored data.

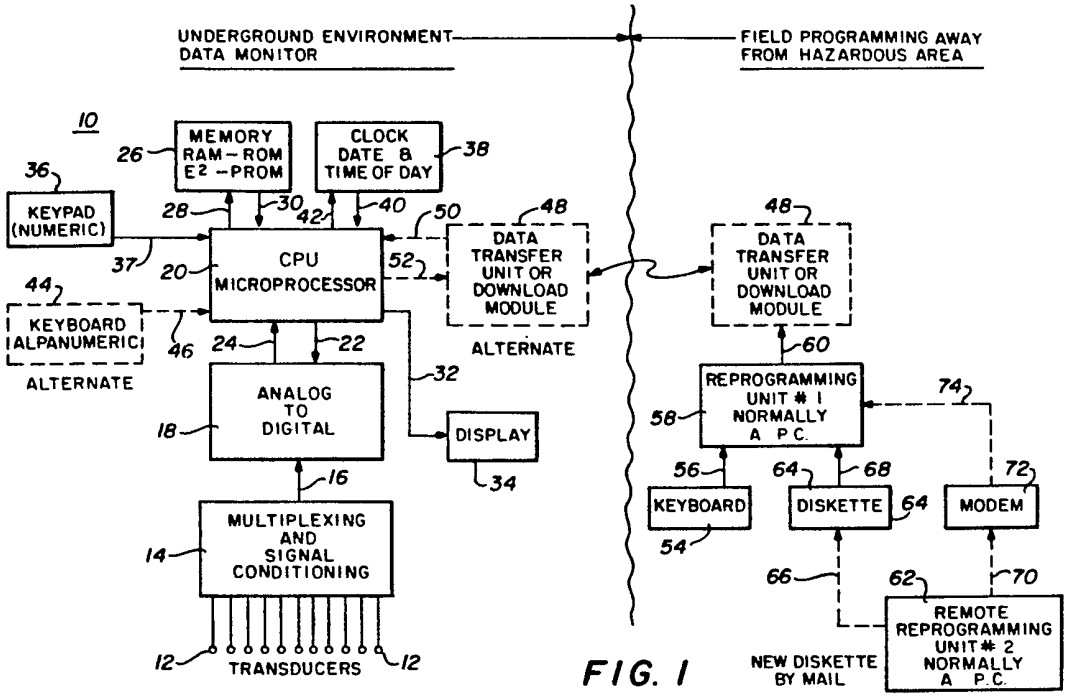


FIG. 1

GB 2 174 261 A

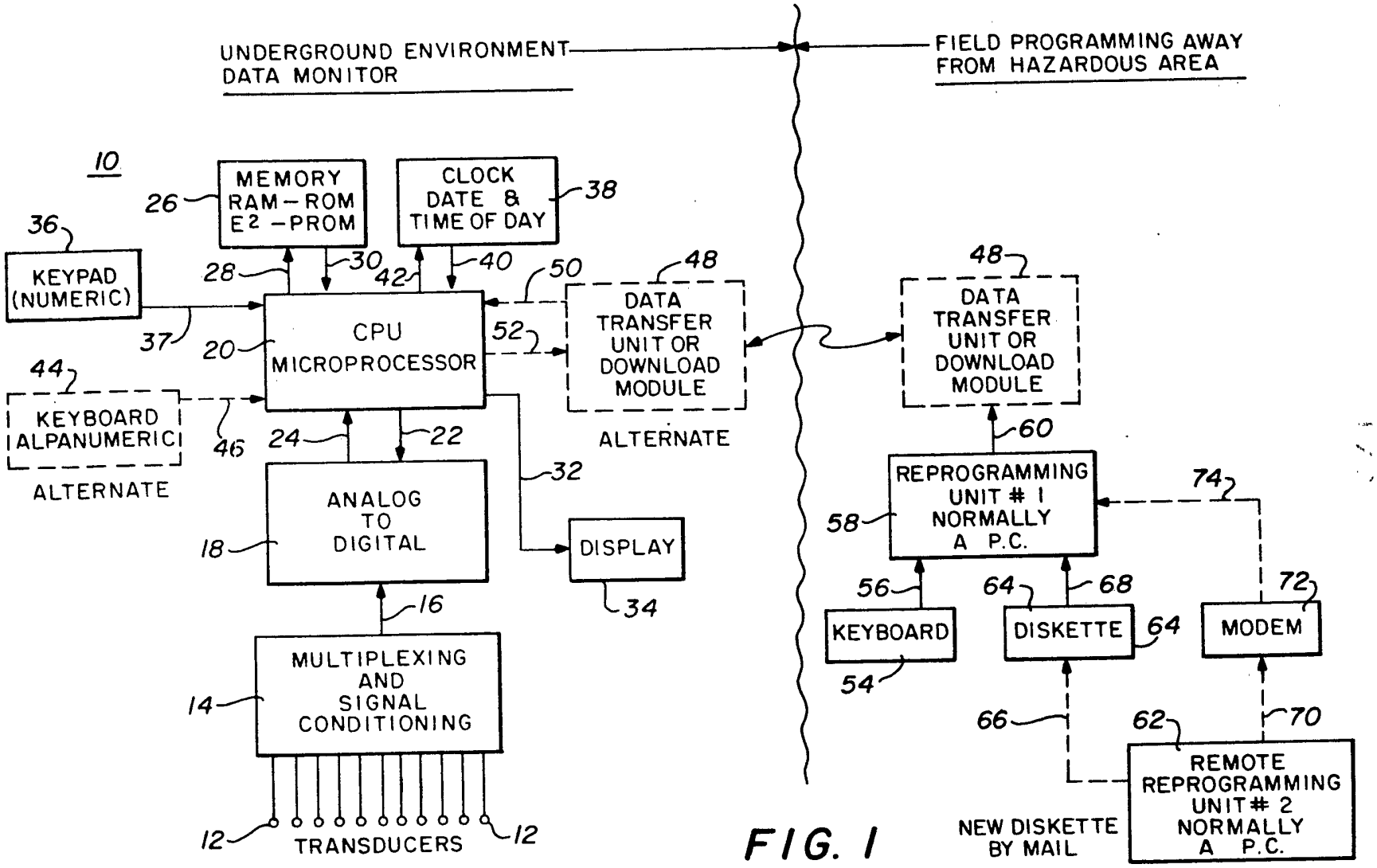

UNDERGROUND ENVIRONMENT DATA MONITOR
FIELD PROGRAMMING AWAY FROM HAZARDOUS AREA
10
MEMORY RAM-ROM E2-PROM
26
CLOCK DATE & TIME OF DAY
38
36
KEYPAD (NUMERIC)
37
28
30
42
40
50
48
CPU MICROPROCESSOR
20
52
DATA TRANSFER UNIT OR DOWNLOAD MODULE
ALTERNATE
44
KEYBOARD ALPANUMERIC
ALTERNATE
46
24
22
32
ANALOG TO DIGITAL
18
DISPLAY
34
16
MULTIPLEXING AND SIGNAL CONDITIONING
14
12
TRANSDUCERS
12
48
DATA TRANSFER UNIT OR DOWNLOAD MODULE
60
REPROGRAMMING UNIT # 1 NORMALLY A P.C.
58
74
56
KEYBOARD
54
64
68
DISKETTE
64
72
MODEM
66
62
70
REMOTE REPROGRAMMING UNIT # 2 NORMALLY A P.C.
NEW DISKETTE BY MAIL

FIG. 1

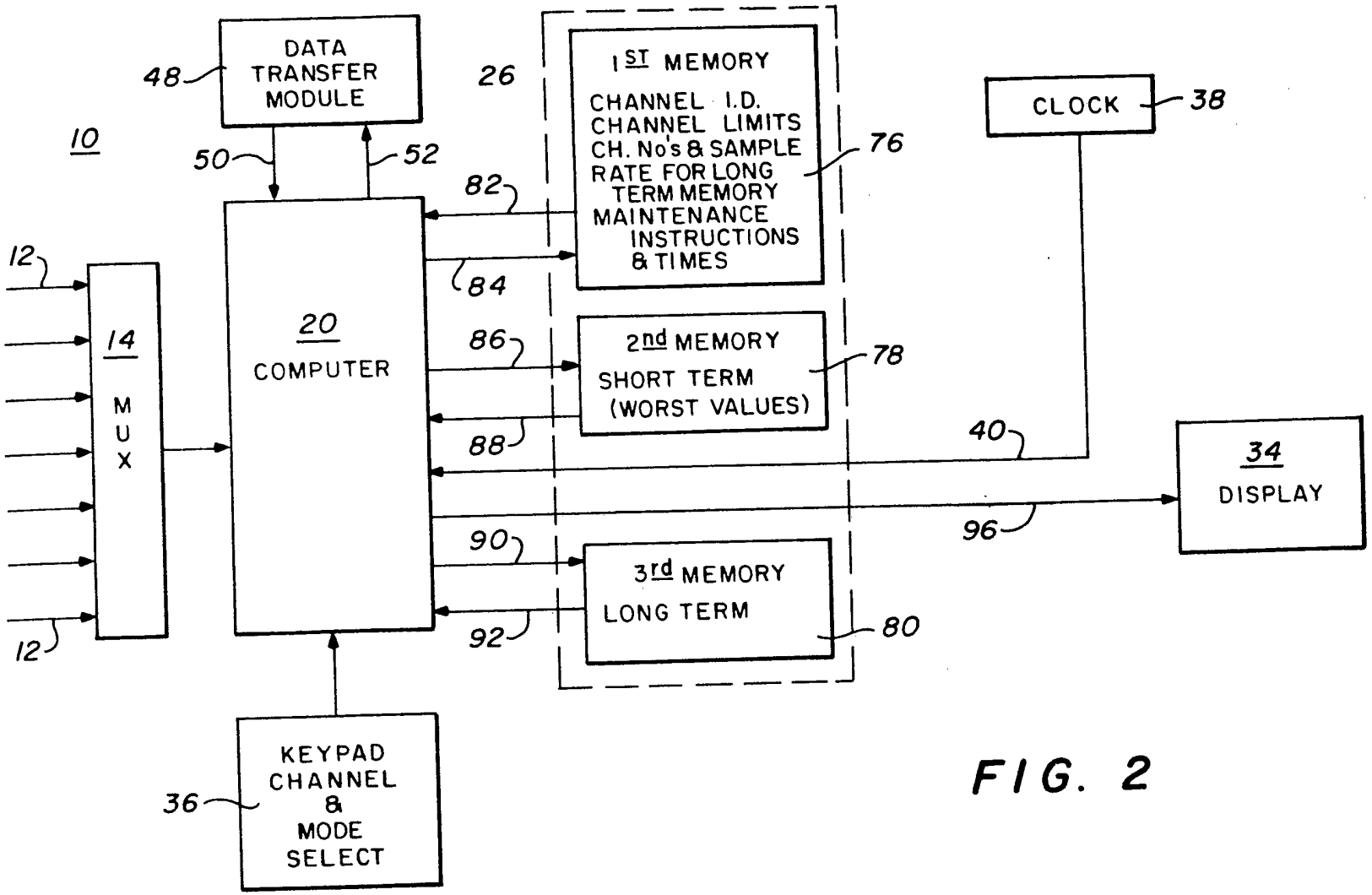

10
48
DATA TRANSFER MODULE
50
52
26
1ST MEMORY
CHANNEL I.D.
CHANNEL LIMITS
CH. No's & SAMPLE RATE FOR LONG TERM MEMORY
MAINTENANCE INSTRUCTIONS & TIMES
76
82
84
CLOCK
38
12
14
MUX
20
COMPUTER
86
2nd MEMORY
SHORT TERM
(WORST VALUES)
78
88
40
34
DISPLAY
96
90
3rd MEMORY
LONG TERM
80
92
12
KEYPAD CHANNEL & MODE SELECT
36

FIG. 2

SPECIFICATION

Data monitor

The present invention relates to a data monitor and in the preferred embodiment provides a data monitoring and display system that provides easily understood messages, conveys maintenance instructions, provides digital recording capabilities and can be reprogrammed either remotely or in the field.

Many machines, such as underground mining machines, are remotely controlled by an operator who is positioned up to 50 feet behind the machine. Due to the operating environment, the operator often cannot see how well the machine is performing or if trouble is developing in any of the operating components of the machine. For instance, a bearing may be heating or the temperature of a motor may be rising and the operator has no warning that a problem is beginning to occur. If a motor overheats and is damaged or if a bearing is damaged because of overheating or if other parts of the machine are damaged because of excessive pressure or lack of fluid or the like, serious down times of the machine occur with a concurrent loss of productivity. Further, many components of such machines, such as the electric motors which may be several hundred horse-power in size, are very expensive to replace. Also, at the end of the day, when maintenance personnel are inspecting the machine, there is no way to tell which components should be looked at closely because of a problem such as an overheat condition or the like that occurred that day.

Thus, the preferred embodiments of the present invention can monitor the critical operating functions on a machine and transmit or store data representing such functions for delivery to the operator during actual machine operation or to maintenance personnel after the normal working hours or at any other time maintenance or repair is being performed.

The operators and maintenance personnel for these machines are normally individuals with little electronic background and are not engineers. They will not have the time to spend many hours learning how to operate a complex data acquisition system. Thus, a simple information display is provided in the preferred embodiment. Because of the great complexity of the equipment and the multiplicity of maintenance actions required to ensure machine longivity, the preferred embodiment provides for periodic display of maintenance instructions.

In the preferred embodiment a system is provided which accepts data inputs from various transducers representing functions such as pressure, fluid flow, temperature, fluid level, and the like, for a plurality of channels, such as 40 channels and produces voltage outputs representing the instantaneous value of the function being monitored. Active channels, those that have sensors connected thereto, provide the system with a signal that recognizes them as active. Further, such data is checked against preset normal high and low value boundaries and an alarm is set for an out-of-bounds condition. Also, the maximum and minimum values attained by each channel are recorded for maintenance purposes. The system is able to operate in any one of several output modes.

One such mode provides such data to the operator on the machine during operation thereof not only for all channels in succession but also for any one particular channel that is selected by the operator.

In another mode, the stored data is able to be transmitted to a remote operator or remote mining station.

In still another mode, the data is able to be stored on the machine for later retrieval by maintenance personnel after working hours or at any other convenient time.

In yet another mode, a memory is provided in which maintenance instructions and times for performing such maintenance can be stored. A real time clock is provided so that when the time for the maintenance occurs, the stored maintenance instruction can be displayed as required.

In order to be able to use the data monitor on different machines, the number of channels, the channel data and identity and out-of-bound limits are easily reprogrammed in the preferred embodiments. The preferred embodiments incorporate the needed monitoring requirements and overcome the disadvantages of the prior art systems and use transducers placed at various points of interest on the machine which produce analog voltage signals that are coupled to the system. A central processing unit such as a microprocessor or computer controls the processing of data and the display of desired information to the operator or stores data which is available to maintenance personnel whenever required. In a first mode, the channels are reviewed consecutively in real time by a multiplexer and if any function on any channel being reviewed exceeds the predetermined limits established in the computer memory, the identity of that channel and the function exceeding the limits is identified and displayed for the operator. These displays for the operator need only last a few seconds, e.g. three seconds, for each channel since it is sufficent for the operator to notice that an out-of-bounds condition exists. A warning sound or light may also accompany the display.

If such condition does exist for any one particular channel, the operator may desire to select a second mode in which that channel function may be selected and displayed continuously whether in or out-of-bounds so that he can monitor the conditions on that particu-

lar channel as they are occurring in real time to see whether or not that function is becoming more abnormal.

In the preferred embodiment of the invention the operating condition for each channel is also stored in a short term memory and each time a particular channel value is monitored by the computer, if the operating condition value "worsens" with respect to an out-of-bounds limit, the new "worse" value replaces the earlier stored value whether in-bounds or out-of-bounds. However, if the condition betters and the abnormal value decreases, the new value does not replace the "worst" value that occurred which is already stored in memory. Thus, in a third mode the maintenance personnel or the operator can see only the "worst" condition that occurred on any channel during the period of operation of the machine and the date and time of day at which it occurred.

In a fourth operating mode, the "worst" condition data for each channel in the short term memory is checked against that particular channel out-of-bounds limits and these worst out-of-bound values and time of day when each occurred are displayed sequentially to the observer. Thus, a maintenance person will be informed of the value of only the worst out-of-bounds condition of any active channel and when it occurred.

Another portion of the memory of the preferred embodiment stores continuously all the data for certain selected channels as they are being monitored. If desired, all channels may be monitored and the data stored. This allows a long term storage record to be accumulated so that the system can be interrogated for these particular channels and the history for a given time period is presented to the maintenance personnel who then can determine if any symptoms indicate that problems are beginning to develop in the device being monitored. Thus, if monitoring of the bearing temperature over a specified operating cycle of the machine indicates that the temperatures are gradually increasing over a period of time, the maintenance personnel are warned of an approaching bearing failure.

The preferred embodiment incorporates a data monitor which is programmed to display various maintenance instructions during the normal maintenance interval such as during shift change and/or off shifts. A real time clock controls which maintenance instructions are to be presented at any particular time and the interval between display occurrences. For example, a particular maintenance instruction "grease motors" may be displayed, along with other instructions, between 3:30 and 4:30 in the afternoon and the display continually presented during the maintenance period between shifts until such time as a cancellation signal is entered. This particular maintenance instruction can be programmed to reoccur at any frequency desired such as once a week, once a month, after 20 operating shifts and the like.

A portable data transfer module is preferably also provided, and is programmable at a remote location from the machine to established channel identification, channel function, out-of-bounds function limits for each channel, maintenance instructions and sample rates for long term monitoring. The data transfer module, as programmed, may then be hand carried to a particular machine, attached to the monitor and interrogated by the computer which updates its memory banks with the data that is in the portable data transfer module. This allows the data monitor to be utilized on different machines but be programmed to check different functions with different high and low boundary limits.

Since a clock is available on the data monitor which generates signals representing time of day, the time of day is preferably automatically recorded with each channel function experiencing an increase in the worst condition, whether in or out of bounds. Thus, the time of day of the occurrence of the worst condition is also stored whereby a maintenance record of the machine may be established.

Thus, the preferred embodiments of the present invention provides a data having a data transfer module removably coupled to the computer and containing information and instructions from which said computer can selectively update its storage unit memory data as necessary thereby enabling said data monitor to be used on different machines.

Thus, one embodiment of the present invention relates to a data monitor for a machine having multiple channel functions to be monitored comprising a first instruction memory for storing data representing channel identification, channel function, out-of-bounds function limits sample rates and maintenance instructions; a second short term memory for storing data repesenting only the worst actual operating condition reached for each channel function, a third long term memory for storing data representing continual operating conditions for any channels programmed into said long term memory, a display, a real time clock for generating signals representing date and time of day, and computer means coupled to said display and said first and second memory either for displaying data representing the worst out-of-bounds condition for each channel consecutively and the date and time of occurrence of said condition or for displaying a selected channel to appraise the operator of the worst operating condition of said selected channel and the date and time of occurrence of said condition or displaying data stored in said third memory whenever desired whereby maintenance can be performed on said machine as required before actual problems occur.

Another embodiment of the present invention relates to a data monitor which includes a portable data transfer module programmable at a remote location from the machine to establish channel identification, channel function, out-of-bounds function limits for each channel, sampling rates and maintenance instructions, and means coupled to the computer for removably receiving said portable data transfer module whereby a first computer memory may be updated with said remotely programmed data and data in a second memory may be transferred to said data transfer module for analysis at a remote location from said machine.

Another preferred embodiment of the invention relates to a method of monitoring multiple channel functions of a machine comprising the steps of storing in a first memory data representing channel identification, channel function, out-of-bounds function limits, and maintenance instructions, storing in a second memory the worst actual operating conditions for each channel function, storing in a third memory data representing continual operating conditions for selected channel functions, providing a display, and coupling a computer means between said display and said first, second and third memories either for displaying data during actual operation of said machine to appraise the operator of either the worst actual operating conditions of a selected channel of said machine, or the worst out-of-bounds condition of all channels consecutively or displaying data stored in said second or third memories as desired whereby maintenance can be performed on said machine as required before actual problems occur or displaying specific maintenance instructions at a predetermined time.

Figure 1 is a basic block diagram of the system illustrating how the data transfer module may be programmed at a remote location and then hand carried to the machine as a plug-in unit for updating the information necessary in the memories for operation of a particular machine and to receive data stored in said memories for remote analysis; and

Figure 2 is a diagrammatic representation of the data monitor forming the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

A basic block diagram of the novel data monitor including the circuit for field programming a portable data transfer module is shown in Fig. 1. When the monitor unit 10 is installed on an operating machine, a plurality of channels, typically 40, may be monitored by transducers 12. It is to be understood that these transducers are of various types which can monitor pressure, fluid flow, temperature, fluid levels, and the like. Each of the transducers 12 produces an analog signal representing the instantaneous value of thenction which it is monitoring. Transducers are placed at various points of interest on the machine and the analog voltage signals which they produce are conducted to the system by conductors or cables. The cables connect to the system housing with a plug-in terminal (not shown).

Multiplexer 14 is used to select a particular channel and produce an output on line 16 which is coupled to the analog-to-digital unit 18 which converts the analog input to a twelve bit digital word. The central processing unit 20 (CPU), which may be a microprocessor, communicates to and from the A-to-D converter 18 through lines 22 and 24. The microprocessor 20 also communicates with memory 26 through lines 28 and 30. Memory 26 consists of RAM (random access memory), ROM (read only memory), and E^2PROM (electrically erasable programmable read only memory). The memory portion of the data monitor containing the E^2PROM memory units holds the variable portion of the computer program which may need to be updated or changed to allow modification of channel identification, channel scaling and limits, maintenance instructions, display time, frequency of maintenance instructions, designation of channels and sampling frequency for long term monitoring. This allows tailoring of the data monitor to a particular situation or type of equipment.

The various machine functions are monitored by transducers 12 which output to the multiplex unit 14. This in turn sequentially passes through A-to-D conversion unit 18 to computer 20.The computer 20 causes the received digital signals for each channel to be compared with the preset limits in memory 26 and if the value exceeds that already stored in a short term portion of memory 26, whether in or out-of-bounds, the new number replaces the old in the short term memory. When this occurs, the real time clock signal from clock 38 on line 40 is also paired and stored with the new number in the short term storage portion of memory 26. This allows tracking of worst values, whether in or out-of-bounds, with the time of day.

The computer 20 interrogates a first instruction portion of memory 26 to determine which channels are to be placed in the third or long term portion of memory 26 and to determine what sampling rate is to be used for those selected channels. The computer 20 will then place the monitored digital values, whether in or out-of-bounds, for the specified channels into the long term portion of memory 26 at the indicated sample rate.

The operator or observer will select the desired operating mode through the keypad 36. This information is outputted on line 37 to the computer 20. The computer will then connect the appropriate data source to the display 34.

In mode 1, the real time multiplexed values on line 16 will be compared to the channel

limits stored in the first portion of memory 26. If the limits are exceeded, the real time channel value, channel identification and time of day will be outputted to the display 34. Since the digital values are being multiplexed sequentially, the computer 20 will temporarily cause the multiplex unit 14 to cease scanning for three seconds while the abnormal value and channel identification is being indicated to the observer on display 34. At the end of this time, the multiplex unit 14 again commences scanning. The computer 20 will again output each and every channel 12 whose digital value has exceeded its channel limits stored in the first portion of memory 26.

If the observer selects mode 2 through the keypad 36, the computer 20 will lock on a specific channel number selected through keypad 36. The computer 20 will output whatever real time value is received from the multiplex unit 14 to display 34 whether in-bounds or out-of-bounds. Despite the single channel readout on display 34 in this case, the various other channel digital values are still being sequentially multiplexed into the computer 20 and checked against previous worst condition values stored in the short term portion of memory 26. If the old stored value is exceeded, the new value (increasingly abnormal) replaces the old value stored.

If the observer selects mode 3 and identifies a specific channel, the computer 20 will extract the worst case stored value for that channel (whether in or out-of-bounds) over a predetermined period of time from the short term memory 26 and the time when it occurred. Thus, this mode may also be used, for example, for maintenance purposes after normal shift hours to check the worst case condition for each channel that occurred during the previous shift or other predetermined periods of time.

If the observer chooses mode 4 through keypad 36, then the computer 20 interrogates the worst value for each channel as stored in the second or short term portion of memory 26. These are compared with the various channel limits stored in the first memory. If a particular stored value for a given channel exceeds the channel limits, then the computer will output that channel identification from the first memory, the digital value stored and time of day from the second memory onto display 34. If more than one channel is out-of-bounds, then each channel that is out-of-bounds will be displaced sequentially. This mode may be used, for example,, for maintenance purposes after normal shift hours to see which channels exceeded preset limits during the previous period of operation.

The computer 20 has been programmed to read out specific maintenance instructions stored in the first storage portion of memory 26. When the computer 20 senses through the real time clock 38 that the correct time for display has been reached, it will then display these instructions for the maintenance interval until such time as the observer enters a cancellation signal through keypad 36, indicating that he has completed his maintenance step. This is the maintenance instruction mode. No entry is made via the keypad 36 for this mode. The real time clock 38 and instructions in the first storage portion of memory 26 control this operation. It is changed only through reprogramming the first portion of memory 26 with the data transfer module 48 or the alternate keyboard 44 at the data monitor.

In a fifth mode, the data stored in the long term storage portion of memory is continually displayed for any given channel thereby allowing a review of the operation of the channel for an entire predetermined period. If an observer wishes, he may connect the data transfer module 48 to the data monitor 10. If he then enters an access number through keypad 36, the contents of the second or short term memory or the third or long term storage portion of memory 26 will be selectively transferred through the computer 20 via line 52 into the data transfer module 48 which would then be removed and taken to a remote viewing station where the data transfer module 48 contents would be outputted to a review unit, normally a personal computer. As stated previously, the long term storage includes all monitored information whether in or out-of-bounds. Data in the first storage portion of memory 26 determines which channels are to be placed in the third or long term portion of memory 26 and at what specific rate each selected channel is to be sampled. While the third portion of memory 26 has an approximate capacity of 128K bytes, excessively fast sampling will reduce the recording time unnecessarily, thus, the need for a variable sampling rate. This operation is automatic in that it is regulated by the first portion of memory 26. Changes in channel selections for recording are accomplished through reprogramming the first portion of memory 26 through either the alpha numeric keyboard 44 or data transfer unit 48.

The data stored in the second or third portion of memory 26 may be selectively outputted to either the display 34 or the data transfer module 48. This is accomplished by entering an access number through the keypad 36.

It will be understood that if the data monitor is to be made a universal unit which can be utilized on different types of equipment, that it will be necessary to alter the data stored in memory unit 26 to accommodate the different channels, different functions, different sampling rates, and different limits that may be established for a different machine. To that end, an alpha-numeric keyboard 44 is coupled to CPU 20 through line 46 which enables one

who is skilled in programming to make changes in the memory 26 by entering data through keyboard 44 thereby reprogramming memory 26. It is also understood that the operators of these machines are not usually technical people who can do the programming themselves to bring about the necessary changes in memory to accommodate different machines. Therefore, it is necessary to provide a means for reprogramming the unit not only at the machine itself but through a remote unit so that if the operator is incapable of doing so, the unit may be simply reprogrammed by plugging in a preprogrammed unit which the CPU 20 can interrogate and the data stored therein used to update the data stored in its memory 26 and thus allow the data monitor 10 to operate on any particular machine.

Thus, for those operators who do not know how to reprogram a unit, a portable data transfer module or unit 48 may be removably coupled to CPU 20 through lines 50 and 52. The CPU 20 can then interrogate the data transfer unit 48 on line 52 and receive on line 50 therefrom the information stored therein which will be used to modify the program stored in memory 26 of the data monitor 10. Once the data has been transferred from unit 48 to memory 26, the data transfer unit 46 can be unplugged from the CPU and returned to a remote location for reprogramming for a different unit.

As shown in Fig. 1, the remote programming of data transfer unit 48 takes place at a location remote from the data monitor unit 10. Thus, an alphanumeric keyboard 54 produces an output on line 56 which is coupled to a reprogramming unit 58. The reprogramming unit 58 is normally a personal computer and produces outputs on line 60 which are coupled to the portable data transfer unit 48 so that it can be reprogrammed by an expert at some remote location so that the data transfer unit 48 can then be hand carried to the location of a data monitor unit 10, plugged in, interrogated by CPU 20 and its data transferred to the memory 26 of the data monitor 10.

Further, the data transfer unit 48 may be reprogrammed in other ways. For instance a second remote programming unit, which also may be a personal computer 62 could be used to program a diskette 64 which may be hand carried or mailed to the station where personal computer 58 is located and is plugged into personal computer 58 as represented by line 66. The diskette 64 then transfers the data stored on it through line 68 to personal computer 58 which then transfers the data to the data transfer unit 48 through line 60.

In addition, the second remote reprogramming unit 62 could also transmit programming signals over a telephone line 70 through modem 72 and lines 74 to the personal computer 58 where that data would be transferred through line 60 to data transfer unit 48.

Thus, it can be seen that there are several ways that the data transfer unit 48 can be reprogrammed but the important feature is that it is reprogrammed at a remote unit for hand carry to the particular machine on which a data monitor 10 is mounted so that the unit 48 can be plugged into that particular data monitor 10 and interrogated by CPU 20 and the new data utilized to update the information stored in memory 26 so that channel identification, channel scaling and limits, maintenance instructions, display time and frequency of maintenance instructions and designation of channels and sampling frequency for long term monitoring can be stored.

A detailed diagrammatic representation of data monitor 10 is disclosed in Fig. 2. In this Figure, like numerals represent like components in Fig. 1. As can be seen again in Fig. 2, transducers 12 are connected to a multiplexer 14 which produces an output on line 16 that is coupled to computer 20. It is assumed in this case that the analog-to-digital converter 18 shown in Fig. 1 is an integral part of the computer 20 shown in Fig. 2.

Assume that memory 26 has stored therein a first instruction memory 76 for storing data representing channel identification, channel limits, channel numbers and sample rate for the long term memory, maintenance instructions and times for maintenance. Further, assume that a second memory 78 contains memory elements for short term storage of data representing worst case function values of each channel while a third memory unit 80 contains memory elements for long term storage of data representing all monitored function values for each predetermined channel during a predetermined operating period.

If the operator selects a first operating mode through keypad 36, all of the channels 12 are reviewed consecutively in real time by multiplexer 14 and if any function on any channel being reviewed exceeds the predetermined limits established in the memory 76, the identity of that channel, and the value of the function exceeding the limits is identified and displayed for the operator. These displays last only three seconds for each channel. It is sufficient for the operator to notice on display 34 that an out-of-bounds condition exists. A warning sound or light may accompany the display on display 34.

If such condition does exist for any one particular channel 12, the operator may want to select a second mode through keypad 36 in which that channel function may be selected and displayed continuously on monitor 34 so that the operator can view the monitored conditions of that particular channel as they are occurring in real time to see whether or not that function is becoming more abnormal.

It will be understood that whether the system is working in the first or second mode, the monitored value representing the operating condition for each channel is also stored in short term memory 78 and each time a particular channel 12 is monitored, if the operating condition value "worsens" toward an out-of-bounds limit, the new value replaces the earlier stored value in short term memory 78. However, if the condition betters and the abnormal value decreases, the new value does not replace the "worst" value that previously occurred which is already stored in memory 78. Thus, the maintenance personnel or the operator can see the "worst" condition that occurred during the period of operation of the machine for each channel. This is the third mode which can be selected, for instance, by the maintenance personnel through keypad 36 at the end of the operating shift or at any other particular predetermined period of time.

The operator can also select a fourth mode in which all channels are consecutively monitored and the worst out-of-bounds condition for each channel consecutively displayed. This mode assists maintenance personnel in quickly reviewing which of the channels operated with an out-of-bounds condition and the value thereof.

Another portion 80 of the memory stores continuously all of the data for certain selected channels as they are being monitored. This allows a long term storage record to be accumulated so that at the end of the day after normal working hours (or during longer periods of time), the system can be interrogated in a fifth mode for these particular channels and the history for that entire day (or time period) for the selected channels is presented to the maintenance personnel who then can determine if any symptoms are beginning to develop indicating potential problems with the device being monitored. Thus, if monitoring of the bearing temperature over a specified operating cycle of the machine indicates that the temperatures are gradually increasing over a period of time, the maintenance personnel are warned of an approaching bearing failure.

The novel data monitor 10 is programmed to automatically display various maintenance instructions during the normal maintenance interval during shift change and/or off shifts. A real time clock 38 and a portion of the instruction memory control which maintenance instructions are to be presented on display 34 at any particular time as well as the interval between display occurrences. For example, a particular maintenance instruction, "grease motors", may be displayed along with other instructions between 3:30 and 4:30 in the afternoon and the display continually presented during the maintenance period between shifts until such time as a cancellation signal is entered through keypad channel 36. This particular maintenance instruction can be programmed to reoccur at any frequency desired such as once a week, once a month, after 20 operating shifts and the like.

In the past, when a machine malfunctions, operating parameters are often measured by recording the particular phenomena on a strip chart recorder. This presents difficulty in an underground environment because of the presence of methane gas and the requirements for the system to be intrinsically safe or explosion proof. Data monitor 10 allows the storage of data in memory without obtaining a separate and time consuming additional approval for use of a strip chart recorder in the methane environment by the use of data transfer module 48 which is coupled to computer 20 through lines 50 and 52. At the request of the operator, the computer 20 can interrogate the data in memories 78 and 80 and transfer that information on line 52 to the data transfer module 48. Data transfer module 48 can then be taken to a remote location where that data can be plotted with strip chart recorders or other devices for analysis and review.

As stated earlier, the data unit 10 also allows for reprogramming in the field through the use of data transfer module 48. Thus, data transfer module 48 may have stored in it, at a remote location from the data module 10, any changes in program information that would be needed by data monitor 10. Thus, channel identification, channel units, alarm or out of bound limits, channel scaling or sensitivity, maintenance instructions and the frequency and time-of-day that the maintenance instructions are displayed can be changed or reprogrammed. Additionally, the channels and sampling rate for the long term memory 80 can also be designated remotely. These provisions allow easy customizing of the system for a particular installation or situation and allow the same system designed to be used on several different types of equipment.

Data monitor 10 is equipped with a 128K memory to permit storage of the various operating parameters of the machine on which it is installed. The system is configured such that any one or more of the channels can be placed in long term memory 80. Since the rate of change of the data obviously varies with different phenomena, the sampling rate of the various channels is made a programmable variable. While auger gear cases do not change temperature rapidly and thus does not require frequent monitoring, the current being drawn by electric motors certainly does change rapidly and must be monitored frequently. Having the sampling rate programmable allows the accumulation of the maximum amount of usable data in a given size memory. All of the data is acquired, stored and correlated with the time-of-day and date so that upon retrieval, time/amplitude relationships are able to be re-established. Further, to

eliminate the recording of information when the machine is idle, the system is configured to indicate on the time base when the machine is powered down.

Thus, with the display of information such as gear box temperatures, hydraulic pressures and flow measurements, motor currents, line voltage, motor torques, conveyor operating time, hydraulic oil levels, and the like, it is possible for unusual operating conditions to be detected and corrected before they become sufficiently serious to cause machine damage, down time and expense. It is also possible to determine good operating practice and to train operators in the correct operation of the machine by presenting these various parameters in the form of an alphanumeric display consisting, for example, of two lines of 24 characters each mounted in front of the operator.

Thus, in the first mode, the computer 20 scans all of the channels of input 12. If a channel 12 is operating outside its predetermined limits, the computer 20 will output, through the alphanumeric display 34 in real time, the channel description, channel number, and parameter value of the event. The display 34 will flash for three seconds and scanning will resume.

In the second mode, the operator will key in the desired channel through keypad 36. Computer 20 will then display in real time the monitored values for the selected channel through the alphanumeric display 34 and include the channel description, and parameter value.

In the third mode, the operator keys in a specific channel of interest through keypad 36. Short term memory 78 stores every worst case for all channels. The system will display all the worst values and the time of day they occurred for the channel selected whether in-bounds or out-of-bounds.

As stated, the computer 20 will store in memory portion 78 the worst condition value occurring over a predetermined period of time such as "since system restart" for each channel along with the time of day that this value occurred. Mode four may be selected to review this memory and display in brief for each channel consecutively only the worst case parameter that has exceeded an out-of-bounds condition as defined by instruction memory 76 for each channel it being remembered that only any new "worst" case data replaces the old "worst" case data.

The maintenance instruction mode occurs automatically. No entry is made via keypad 36 for this operation. The real time clock 38 and the instructions in memory portion 76 control this operation.

The data acquisition operation is intended primarily for use by maintenance personnel. Through the use of a data transfer module 48 which is a plug-in accessory, it is possible to program the memory 26 to record any one or more of the channels as desired. The rate at which the data is recorded or the sampling rate is also programmed. Data is then committed to the long term memory 80 in monitor 10 until such time as the appropriate areas of memory bank 26 are full. At this time, the oldest data is replaced with new. Memory capacity is such that it is possible to record the temperature of three individual gear cases on a five minute interval for approximately three months. This recording does not interfere with the operator's use of the first four modes of operation. At a later date, the data transfer module 48 is plugged into the computer 20 and the contents of memory units 78 and 80 are transferred to module 48 so that the information becomes available for observation at a remote location through the use of a cathode ray tube, strip chart recorder or any other method of data reduction. This data could, however, be selected through keypad 36 and displayed on the monitor 34.

Thus, there has been disclosed a novel data monitor whose programming can be changed by a remotely programmed data transfer module which is plugged into the unit and the data in memory changed accordingly. The novel monitor also interrogates all channels indicated and displays a message for each channel whose output exceeds a preset value. This enables the operator to detect unusual operating conditions and correct them before they become sufficiently serious to cause machine damage, down time and expense.

The novel monitor also allows individual channel information to be displayed on demand thus allowing the operator to monitor a particular channel which may be appearing to be having problems.

The novel unit also allows maintenance personnel to interrogate each channel whose function has exceeded a preset value and observe the highest value for that channel and the time of day that it was achieved.

It also allows maintenance personnel to recall all stored values in memory for predetermined channels so that an archive of operating parameters is established for each such channel for maintenance purposes.

In addition, the novel unit instructs the operator when a particular maintenance function should be performed and the time that it is to be performed.

The novel system also allows all functions stored in the instruction memory to be changed through a data transfer module which is programmed remotely from the unit and also allows the data transfer module to interrogate the memory of the data monitor so that the information can be taken to a remote location and analyzed.

While the invention has been described in connection with a preferred embodiment, it is not intended to limit the scope of the invention to the particular form set forth, but, on

the contrary, it is intended to cover such alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

CLAIMS

1. A data monitor for a machine having multiple channel functions to be monitored comprising:

a. means for generating signals representing the real time operating value of each of said functions,

b. an instruction memory for storing data representing channel identification, channel function and out-of-bounds function limits,

c. a visual monitor, and

d. a computer coupled to said signal generating means, said memory and said monitor for causing said monitor to selectively display either only any out-of-bounds value monitored for each channel function consecutively or every function value monitored for a particular selected channel.

2. A monitor as in Claim 1 further including:

a. a second memory coupled to said computer and storing only the worst case value of each function monitored whether in or out-of-bounds, and

b. means coupled to said computer for selectively causing said monitor to display either the worst out-of-bounds value stored in said second memory for each channel function consecutively or displaying the worst value stored in said second memory for any selected channel whether in or out-of-bounds.

3. A monitor as in Claim 2 further including:

a. data representing a particular sampling rate for predetermined channels stored in said instruction memory,

b. a third memory coupled to said computer and said instruction memory for storing every monitored value for each predetermined channel over a predetermined period of time at said particular sampling rate, and

c. means coupled to said computer for causing said monitor to display every monitored value stored in said third memory for any said predetermined channel function.

4. A monitor as in Claim 3 further including:

a. a clock coupled to said computer for providing data and time of day signals,

b. said computer causing said date and time of day signals to be stored in said second memory for each worst case value being stored whether in or out-of-bounds, and

c. said computer causing said date and time of day signals to be stored in said third memory whereby a performance record of said machine may be established.

5. A monitor as in Claim 4 further including:

a. said instruction memory including maintenance instructions and time of performance of said functions,

b. said computer comparing said time of performance of said maintenance instructions with said real time clock signals and producing a signal when a comparison is found, and

c. said monitor displaying said maintenance instructions when said computer finds a comparison and generates said comparison signal.

6. A monitor as in Claim 5 further including:

a. a portable data transfer module programmable at a remote location from said machine to establish channel identification, channel function, out-of-bounds function limits for each channel and maintenance instructions, and predetermined channels whose monitored functions are to be stored in said third memory and the particular sampling rate for said channels, and

b. means coupled to said computer for removably receiving said portable data transfer module whereby said instruction memory in said monitor may be updated with said remotely programmed data and said second and third memory data may be transferred from said monitor to said data transfer module for analysis at a remote location from said machine.

7. A monitor as in Claim 2 wherein said second memory is a short term memory which replaces stored data representing the worst case value for a particular channel only when the succeeding monitored data value represents a condition worse than that data already stored for that channel whether in or out-of-bounds.

8. A monitor as in Claim 3 wherein said third memory is a long term storage memory of all function values monitored for each channel whereby an operating record of said machine is maintained for maintenance purposes.

9. A method of monitoring functions on multiple data channels of a field operating machine comprising the steps of:

a. generating signals representing the real time operating value of each of said functions,

b. storing in memory instruction data representing channel identification, channel function, and out-of-bounds function limits,

c. providing a visual monitor, and

d. coupling a computer to said signal generating means, said memory and said monitor for causing said monitor to selectively display either only any out-of-bounds value monitored for each channel function consecutively or every function value monitored for a particular selected channel.

10. A method as in Claim 9 further including the steps of:

a. coupling a second memory to said computer and storing only the worst case value of each function monitored whether in or out-of-bounds, and

b. utilizing said computer to selectively

cause said monitor to display either the worst out-of-bounds value stored in said second memory for each channel function consecutively or displaying the worst value stored in said second memory for any selected channel whether in or out-of-bounds.

11. A method as in Claim 10 further including the steps of:

a. storing data in said instruction memory representing a particular sampling rate for predetermined channels,

b. coupling a third memory to said computer and said instruction memory for storing every monitored value for each predetermined channel over a predetermined period of time at said particular sampling rate, and

c. utilizing said computer to cause said monitor to display every monitored value stored in said third memory for any said predetermined channel function.

12. A method as in Claim 11 further including the steps of:

a. providing a clock coupled to said computer for generating date and time of day signals,

b. causing said computer to store said date and time of day signals in said second memory for each worst case value being stored whether in or out-of-bounds, and

c. causing said computer to store said date and time of day signals in said third memory whereby a maintenance record of said machine may be established.

13. A method as in Claim 12 further including the steps of:

a. including in said instruction memory maintenance instructions and time of performance of said functions,

b. utilizing said computer to compare said time of performance of said maintenance instructions with said real time clock signals and producing a signal when a comparison is found, and

c. displaying said maintenance instructions when said computer finds a comparison and generates said comparison signal.

14. A method as in Claim 13 further including the steps of:

a. providing a portable data transfer module programmable at a remote location from said machine to establish channel identification, channel function, out-of-bounds function limits for each channel, maintenance instructions, and predetermined channels whose monitored functions are to be stored in said third memory and the particular sampling rate for said channels, and

b. removably coupling said portable data transfer module to said computer whereby said instruction memory in said monitor may be updated with said remotely programmed data and said second and third memory data may be transferred from said monitor to said data transfer module for analysis at a remote location from said machine.

15. A method as in Claim 10 further including the step of forming said second memory as a short term memory which replaces stored data representing the worst case value for a particular channel only when the succeeding monitored data value represents a condition worse than that data already stored for that channel whether in or out-of-bounds.

16. A method as in Claim 11 further including the step of forming said third memory as a long term storage memory of all function values monitored for each channel whereby an operating record of said machine is maintained for maintenance purposes.

17. A data monitor substantially as hereinbefore described with reference to the accompanying drawings.

18. A monitoring method, substantially as hereinbefore described with reference to the accompanying drawings.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1986, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.