Abstract: Apparatus and methods to assist monitoring of the energy consumed in regulating the temperature of an enclosed space such as the interior (2) of a building (4) for example. A processor (10, 10) is configured to receive signals representing temperature measurement data. The data comprises a first set of data relating to the temperature outside the enclosed space over a period of time, and a second set of data relating to the temperature at a location inside the enclosed space over the same period of time. The processor (10, 10) is arranged to generate display data signals with reference to the first and second sets of data which are transmissible to a display device (12, 12) to cause it to show an indication related to the heat energy loss or gain of the enclosed space over the time period.
Title: Apparatus and Methods for Monitoring Energy Consumption

Field of the invention

The present invention relates to apparatus and methods to assist monitoring of the energy consumed in regulating the temperature of an enclosed space, such as the interior of a building for example.

Background to the invention

Various appliances, structures and buildings define an enclosed space and include a system for managing the temperature of that space, whether by heating, cooling or a combination of both. A user is usually provided with a means by which to specify the required temperature for the enclosed space. Such control may be based on a repeating schedule which allows different temperatures to be specified at different times. The schedule may repeat daily, or over a number of days, for example.

In addition to specifying the required temperature pattern, it would be beneficial for a user to be able to understand the historical effect of his choices on the energy consumed by the heating/cooling system in attempting to achieve the specified temperatures. Ideally, a user would be provided with a direct measure of the actual amount of energy consumed, for example based on fuel supply meter readings. However, such information may not be readily available or obtainable from the meters.

Summary of the invention

The present invention provides apparatus for monitoring the energy consumed in regulating the temperature within an enclosed space, comprising a processor configured:

- to receive signals representing temperature measurement data, wherein the data comprises a first set of data relating to the temperature outside an enclosed space over a period of time and a second set of data relating to the temperature at a location
inside the enclosed space over the period of time, and to output display data signals; and
to generate display data signals with reference to the first and second sets of data, which display data signals are transmissible to a display device to cause the display device to show an indication related to the heat energy loss or gain of the enclosed space over the time period.

In this way, an indication of the heat energy transfer to or from the space can be given to a user without needing to directly measure the actual fuel or energy consumption.

The rate of heat loss from (or heat gain by) the enclosed space is primarily related to the difference between the internal temperature and the external temperature (amongst other factors). Therefore, the amount of heat loss (or gain) by the space over a given period is related to the differences between the first and second sets of data. The processor is therefore able to derive an indication of the energy loss or gain and send this to the display device. This measure of energy transfer enables a user to make more informed selections of temperature schedules so as to lower or otherwise change energy consumption in the future.

In a preferred embodiment, the processor is configured:
to calculate an energy transfer measure related to the total heat energy loss or gain of the enclosed space over the time period with reference to the first and second sets of data; and
to generate display data signals which cause the display device to show an indication of the magnitude of the calculated energy transfer measure over the time period.

This indication may be quantitative, in the form of a relative or absolute numerical indication of the magnitude of an energy transfer measure. It may be expressed in terms of "degree days" or "degree hours" calculated by multiplying the number of degrees difference between the internal and external temperatures by the duration of that difference, and summing these amounts over the time period of interest. Alternatively, it may be expressed in qualitative terms, for example in words and/or by selection of a corresponding symbolic or colour indication.
Instead of, or in addition to an indication of a calculated estimate, the processor may be configured:

to generate display data signals which cause the display device to show two graphs plotted over the period of time corresponding to data from the first and second sets of historical temperature measurement data, respectively, on the same axes; and
to cause the display device to visually distinguish an area bounded by the two graphs from the remainder of the graph area to provide a user with an indication related to the heat energy loss or gain of the enclosed space over the time period.

The amount of heat energy transfer to or from an enclosed space over a given period is related to the area between a curve representing its internal temperature and another curve representing its external temperature over the same period. Accordingly, apparatus according to this embodiment enables a user to visualise the amount of heat energy transfer and how the rate of energy transfer varied over the time period under consideration. This in turn provides a guide as to the rate of energy consumption involved in regulating the temperature of the enclosed space. If the internal temperature were to be maintained by heating or cooling, the rate of energy consumption to achieve this would be proportional to the rate of energy loss or gain of the enclosed space.

Thus, in a graph plotted with temperature on the y-axis against time on the x-axis, the area bounded or delimited above and below by internal and external temperature plots provides a measure of the energy consumed over the time period. This region may be visually distinguished from the remainder of the graph area for example by being filled with a different colour, or left blank whilst the background is shaded a different colour.

A user may be able to interact with apparatus embodying the present invention, for example to select a sub-period from a currently displayed time period. The processor may then be configured to cause the display to show an indication of the heat energy loss or gain over the selected sub-period.
The areas of two or more different predetermined sub-periods may be calculated automatically by the processor and corresponding indications given to the user. These indications may be in the form of qualitative measures, such as different visual distinctions. Alternatively, a quantitative measure may be calculated based on the difference between the sizes of two areas.

The processor may be configured to visually distinguish a first area bounded by the two graphs over a first sub-period from a second area bounded by the two graphs over a second, separate sub-period, wherein the first and second sub-periods are of equal duration and the first area is greater than the second area. In this way, variations in the rate of energy loss or gain can be highlighted for the user.

The apparatus preferably includes a user input arrangement, which enables a user to define a period of time over which data is to be displayed, and/or to select one or more sub-periods from a displayed time period.

Furthermore, the processor may be configured to generate display data signals with reference to the first and second sets of data which cause the display device to show an indication related to the heat energy loss or gain of the enclosed space over said time period, and a further indication related to the heat energy loss or gain of the enclosed space over a further, separate time period. This allows the user to make a comparison between the measures of energy transfer over two separate time periods. For example, energy loss or gain over one day may be compared with another day. The data relating to the two separate time periods may be overlaid on the same pair of graph axes for ease of comparison.

On the basis that the efficiency of the heating and/or cooling system and the thermal conductivity of the enclosure around the enclosed space remain substantially constant, valuable information can be gained regarding relative rates of heat loss or gain by comparing this data over two different periods.

The display device may be portable so that it can be carried by a user independently of the processor. A wireless communication link may be provided between the
display device and the processor. Alternatively, the display device and processor may be housed in a common portable unit. A portable unit may be provided with a corresponding docking station to allow data to be downloaded to and/or from the portable unit to the docking station.

Apparatus in accordance with the present invention may form part of a heating and/or cooling system.

The present invention further provides a method of monitoring the energy consumed in regulating the temperature of an enclosed space, comprising the steps of:

receiving signals in a processor representing temperature measurement data, wherein the data comprises a first set of data relating to the temperature outside an enclosed space over a period of time and a second set of data relating to the temperature at a location inside the enclosed space over the period of time, and to output display data signals;

generating display data signals using the processor with reference to the first and second sets of data; and

transmitting the display data signals to a display device which cause the display device to show an indication related to the heat energy loss or gain of the enclosed space over the time period.

**Brief description of the drawings**

Embodiments of the invention will now be described by way of example and with reference to the accompanying schematic drawings wherein:

Figure 1 is a block diagram of an apparatus embodying the present invention;

Figure 2 is a block diagram of an apparatus according to a further embodiment of the invention; and

Figure 3 is an example of a display provided on the display devices of Figures 1 and 2.
Detailed description of the drawings

The block diagram of Figure 1 represents an apparatus embodying the present invention for monitoring the energy consumed in regulating the temperature of a building. An internal space 2 is enclosed by the structure 4 of the building.

An external temperature sensor 6 is mounted outside the building, whilst an internal temperature sensor 8 is provided within the building structure. Both temperature sensors are communicatively coupled to a processor 10 of the monitoring apparatus. The processor is in turn communicatively coupled to a display device 12. The display device has a screen 14 and an array of user input keys 16.

The processor may take the form of a single microprocessor with memory included. Alternatively, it may be implemented in the form of two or more separate components or modules which together perform the processor functions described herein.

The temperature sensors 6, 8 generate output signals responsive to the temperature of their immediate environments. These signals are fed to processor 10. Data correlating these temperature measurements with time is stored in memory within the processor. This data is then available for the processor to retrieve and process to generate display data signals with reference to the temperature measurement data which causes the display device to show an indication of the heat energy loss or gain over a given time period.

The display device is arranged to enable a user to control the apparatus to select data ranges of interest for assessment. Screen 14 may be in the form of a touch-sensitive screen to assist interaction between the user and the displayed data or other data stored in the processor 10.

Although the temperature sensor, processor and display device are shown in the embodiment of Figure 1 as being connected together via wires 18, 20 and 22, it will be appreciated that one or more of these links may be effected wirelessly.
device 14 may be portable for convenience. In some instances it may be deployed at a
location remote from the building. For example it may be configured to receive
display data signals from the processor via the internet.

An implementation of a further apparatus embodying the invention is shown in Figure
2. The temperature sensors 6', 8', processor 10' and display device 12' correspond to
those shown in Figure 1, except that these components are communicatively coupled
together wirelessly, with processor 10' being sited at a location remote from the
building 4. Processor 10' may for example be a remote server handling temperature
data relating to one or a plurality of enclosed spaces such as buildings. Temperature
readings from internal sensor 8' are transmitted to processor 10' via the internet.
Temperature data is sent separately to the processor 10' from an external temperature
sensor 6'. Again, this data may be sent via the internet.

The temperature sensors 6, 6' may be dedicated to the apparatus associated with a
particular building. Alternatively, they may be independent sources of temperature
data. For example, it may be a temperature sensor controlled by a weather
information service and temperature data provided by that service is received by the
respective processor 10, 10'.

Display device 12, 12' may be dedicated to the function of displaying an indication
related to the heat energy loss or gain of the associated enclosed space. Alternatively,
it may be a general purpose device such as a personal computer or a general purpose
display. In further embodiments, the display device is a computer communicatively
coupled to the internet, receiving display data signals from processor 10, 10' via the
internet.

An example of a display generated on display device 12, 12' by the respective
processor is shown in Figure 3. Temperature is plotted against time. An upper curve
30 represents the internal temperature over the time period, whilst lower curve 32
relates to the measured external temperature over the time period. As discussed
above, the area 34 between these two curves is related to the amount of heat energy
lost from the building over the time period. This area is highlighted by shading in
Figure 3. The vertical distance between the two curves gives an indication of the rate of heat loss from the building and so the changing profile of area 34 over the time period also indicates to the user changes in this rate.

As well as this graphical indication of the energy consumption, a calculated energy transfer measure (36) related to the total heat energy loss or gain of the enclosed space over the displayed time period is also included in the display depicted in Figure 3.

In Figure 3, temperature is plotted on the y-axis against time on the x-axis. It will be appreciated that the temperature data may be represented in various other formats or co-ordinate systems. For example, the temperature may be plotted along the x-axis with time along the y-axis, or a polar co-ordinate system may be employed.

In one mode of operation, real time temperature data may be displayed, with the right-hand vertical edge of the graph corresponding to the current time. Alternatively, historical data only may be used to generate the display.

The apparatus enables a user to select one or more time periods of interest for comparison in the display. For example, data corresponding to two or more equivalent periods may be presented in the manner shown in Figure 3 (for example two different days). The user may then compare indications of the heat energy losses on those two days by comparing the relative sizes of the areas between the respective internal and external temperature curves. This enables a user to understand the historical effect of differing temperature profiles (internal and external) on the relative amounts of energy required to maintain chosen temperatures.

Embodiments of the invention described with reference to the drawings may comprise computer apparatus and processes performed in computer apparatus. Furthermore, the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object code, a code intermediate between source and object code in a partially compiled form, or in any other form suitable for use in the
implementation of the processes according to the invention. The carrier may be any entity or device capable of carrying the program.

For example, the carrier may comprise a storage medium, such as ROM for example, a CD-ROM or a semiconductor ROM, or a magnetic recording medium, for example a floppy disc or hard disc. Furthermore, the carrier may be a transmissible carrier such as an electrical or optical signal which may be conveyed via electrical or optical cable or by radio or other means.

When the program is embodied in a signal which may be conveyed directly by a cable or device or means, the carrier may be constituted by such cable or other device or means.

Alternatively, the carrier may be an integrated circuit in which the program is embedded, the integrated circuit being adapted for performing, or for use in the performance of the relevant processes.
Claims

1. Apparatus for monitoring the energy consumed in regulating the temperature within an enclosed space, comprising a processor configured:
   to receive signals representing temperature measurement data, wherein the data comprises a first set of data relating to the temperature outside an enclosed space over a period of time and a second set of data relating to the temperature at a location inside the enclosed space over the period of time; and
   to generate display data signals with reference to the first and second sets of data, which display data signals are transmissible to a display device to cause the display device to show an indication related to the heat energy loss or gain of the enclosed space over the time period.

2. Apparatus of claim 1, wherein the processor is configured:
   to calculate an energy transfer measure related to the total heat energy loss or gain of the enclosed space over the time period with reference to the first and second sets of data; and
   to generate display data signals to cause a display device to show an indication of the magnitude of the calculated energy transfer measure.

3. Apparatus of claim 2, wherein the indication is a numerical indication.

4. Apparatus of any preceding claim, wherein the processor is configured:
   to generate display data signals to cause a display device to show two graphs plotted over the period of time corresponding to data from the first and second sets of historical temperature measurement data, respectively, on the same axes; and
   to cause a display device to visually distinguish an area bounded by the two graphs from the remainder of the graph area to provide a user with an indication related to the heat energy loss or gain of the enclosed space over the time period.

5. Apparatus of claim 4, wherein the processor is configured to cause a display device to visually distinguish a first area bounded by the two graphs over a first sub-period from a second area bounded by the two graphs over a second, separate sub-period, wherein the first and second sub-periods are of equal duration and the first area is greater than the second area.
6. Apparatus of any preceding claim, including a user input arrangement, which enables a user to define said period of time.

7. Apparatus of any preceding claim, wherein the processor is configured to generate display data signals with reference to the first and second sets of data to cause a display device to show an indication related to the heat energy loss or gain of the enclosed space over said time period, and a further indication related to the heat energy loss or gain of the enclosed space over a further, separate time period.

8. Apparatus of any preceding claim including a display device communicatively coupled to the processor for receiving the display data signals from the processor.

9. Apparatus of claim 8, wherein at least the display device is portable.

10. A heating and/or cooling system for an enclosed space including apparatus of any preceding claim.

11. A method of monitoring the energy consumed in regulating the temperature of an enclosed space, comprising the steps of:

   receiving signals in a processor representing temperature measurement data, wherein the data comprises a first set of data relating to the temperature outside an enclosed space over a period of time and a second set of data relating to the temperature at a location inside the enclosed space over the period of time, and to output display data signals;

   generating display data signals using the processor with reference to the first and second sets of data; and

   transmitting the display data signals to a display device which cause the display device to show an indication related to the heat energy loss or gain of the enclosed space over the time period.

12. A computer program comprising program instructions for causing a computer to perform the method of claim 11.
13. A computer program of claim 12 on a carrier, embodied in a record medium, stored in a
computer memory, embodied in a read-only memory, or carried on an electrical carrier signal.

14. Apparatus for monitoring the energy consumed in regulating the temperature within an
enclosed space substantially as described herein with reference to the accompanying drawings.

15. A method of monitoring the energy consumed in regulating the temperature within an
enclosed space substantially as described herein with reference to the accompanying drawings.

16. A computer program comprising instructions for causing a computer to perform a
method of monitoring the energy consumed in regulating the temperature within an enclosed
space substantially as described herein with reference to the accompanying drawings.
Temperature Scale

°C

00:00  06:00  noon  18:00  00:00

0  10  15  20

30  32  34

19.6 degree hours

Time Scale

Fig. 3
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01K17/00

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

Date of the actual completion of the international search

18 November 2011

Date of mailing of the international search report

25/11/2011

Authorized officer

Bagnera, Carl o
**DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>US 2010/211222 A1 (GHOSN MICHEL [US]) 19 August 2010 (2010-08-19) abstract figures 1, 2, 4, 5, 9, 13,16, 21 paragraphs [0006], [0022], [0023], [0051], [0052], [0054], [0059], [0060], [0062], [0067], [0069], [0082] claims 1,2</td>
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