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(54) A tumble dryer

(57) A tumble dryer having an electric heating element 10 switched between first and second states in a regular repetitive cycle. In the preferred embodiment the heating element 10 is switched either fully on or fully off by a relay 24 according to a pulse width modulation control by a microprocessor 21. Advantageously, the effective heater output is continuously variable to any desired level.

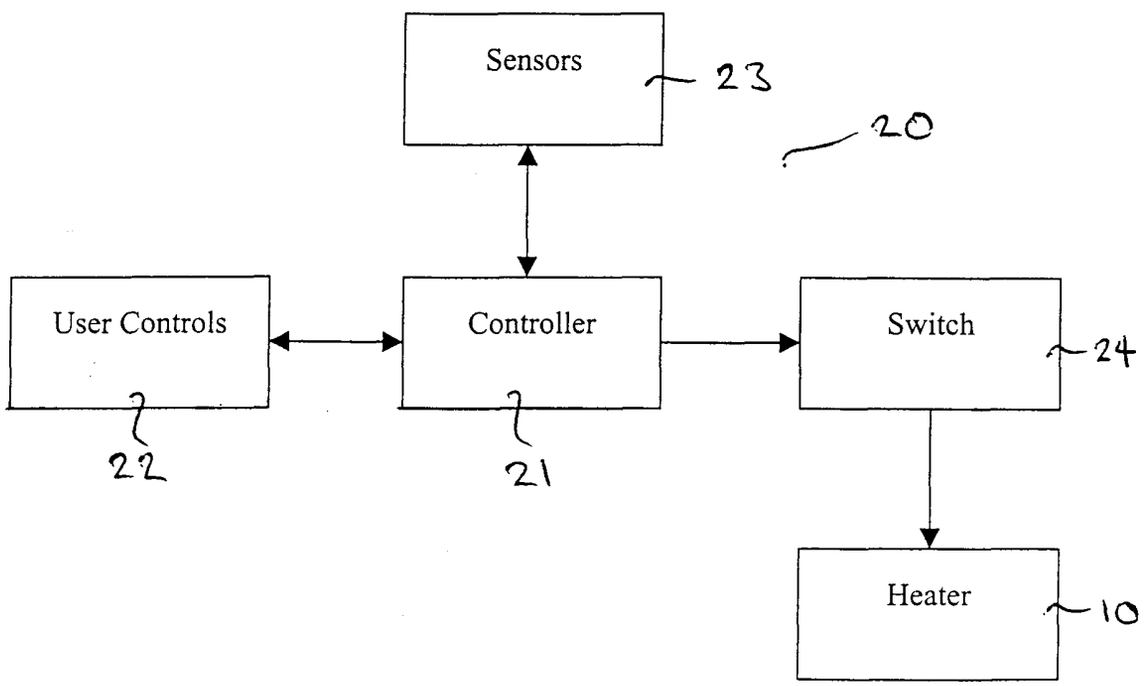

Fig. 2

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Description

[0001] The present invention relates in general to the field of tumble dryers and more particularly to a method and apparatus for heating air in a tumble dryer.

[0002] A tumble dryer includes a heater for heating a flow of air used to dry a load, such as laundry. Most commonly, the heater has a fixed capacity and may be switched on or off by a controller. Typically the heater is switched on at the start of the drying cycle and the chosen level of heat is then maintained throughout the cycle. However, as clothes become dry and the level of moisture within the load reduces the latent heat of vaporisation reduces and the temperature rises. For safety reasons, such as to prevent overheating, a thermostat is usually provided to switch the heater off when a predetermined temperature is reached. However, the thermostatic control is relatively expensive and suffers poor reliability.

[0003] EP-A2-0863244 discloses a tumble dryer with a heater comprising two elements which operate at two different heat output levels namely full heat or half heat by selectively switching on one or both of the two heating elements. However, such an arrangement requires additional control elements including a heat selection switch which adds to the cost and complexity of the control arrangement. Further, it is complicated and expensive to split the heater into many stages of heat output. Therefore, in practice this form of staged heater is restricted to having at most 2 or 3 discrete settings.

[0004] It is desired to vary the heat output of the heater based, for example, on the size and nature of the load and ideally it is desired to vary the heat output at selected stages of a drying cycle, in order to improve energy efficiency, reduce drying time and minimise creasing. Further, it is desired to provide a continuously variable heat output, such that the heat output may exactly match the needs of the load.

[0005] An aim of the present invention is to provide a tumble dryer and a method and apparatus for heating air in a tumble dryer addressing at least some of the problems discussed above. It is an aim of at least the preferred embodiments of the invention to provide a tumble dryer that is cost efficient and energy efficient.

[0006] According to the present invention there is provided a method of heating air in a tumble dryer, comprising the step of controlling a heater to switch between a first state and a second state in a regular repetitive cycle.

[0007] Also according to the present invention there is provided an apparatus for heating air in a tumble dryer, comprising heat output means and means for controlling the heat output means to switch between a first state and a second state in a regular repetitive cycle.

[0008] Further, according to the present invention there is provided a tumble dryer comprising a heater for heating a flow of air, and a controller for controlling the heater to switch between a first state and a second state in a regular repetitive cycle.

[0009] Preferably, in the first state the heater operates in a high power mode, and ideally is switched full on. Preferably, full operative current is supplied to the heater in the first state. Preferably, in the second state the heater operates in a low power mode, and ideally the heater is switched off in the second state. Conveniently, the flow of current to the heater is interrupted in the second state.

[0010] Preferably, the heater is controlled using pulse width modulation. Any suitable form of pulse width modulation may be employed. Preferably the heater is switched to the first state for a first predetermined time period and then to the second state for a second predetermined time period in a regular repetitive cycle. The ratio of the first state (on) to the second state (off) is used to adjust the effective heat output. Advantageously, pulse width modulation control provides a continuously variable effective heat output, giving potentially an infinite number of heat output levels.

[0011] Preferably, the controller comprises a control logic unit and switch means for controlling the heater. The control logic unit may take any suitable form, preferably including a solid state control circuit and ideally a microcontroller. The switch may take any suitable form including, for example, a relay. Preferably the switch is a solid state switching device such as a power transistor, a thyristor or a triac. Advantageously, the controller requires a minimum of components thereby reducing manufacturing costs. Further, only one switching arrangement is required again reducing costs and improving reliability. The preferred control arrangement is simple, reliable and cost effective.

[0012] In a first embodiment the duration and ratio of the first and second time periods is determined at the point of manufacture or installation of the tumble dryer. However, in another embodiment the duration and/or ratio is variable and is adjustable by the controller during use.

[0013] Preferably the method of heating air in a tumble dryer comprises the steps of controlling the heater with pulse width modulation to provide a high heat output at the beginning of a drying cycle, and selectively adjusting the heat output during the cycle. Preferably, the heat output is adjusted at predetermined stages of the drying cycle. Suitably, the stages are determined in response to conditions of a load being dryed. Preferably, the condition of the load is determined by any suitable form of sensor including, for example, air temperature sensors, load temperature sensors, load weight sensors, or moisture content sensors.

[0014] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic representation of a tumble

dryer; and

Figure 2 is a schematic representation of a control circuit for a tumble dryer.

[0015] The preferred embodiment of the present invention will be described with particular reference to a tumble dryer for laundry. Figure 1 shows the basic components for a tumble dryer including a housing 1, a rotatable drum 2 powered by a motor 3, and a fan 4 providing a flow of air through the drum 2. These and other components of a tumble dryer will be familiar to the skilled person and need not be described in detail here.

[0016] The tumble dryer 1 further comprises a heater 10 for heating air flowing through the drum 2, and a controller 20 for controlling the operation of the tumble dryer including operation of the heater 10.

[0017] The heater 10 may take any suitable form but is conveniently an electrical resistance heater having an output of the order of 2kW to 3.5kW. Conveniently, a single element heater is employed.

[0018] In the preferred embodiment the controller 20 stores and operates at least one control program for controlling a drying cycle and ideally selects and executes one program amongst a plurality of stored programs depending, for example, on user input signals and/or a determination of the nature and type of load. However, any suitable control arrangement may be employed.

[0019] Referring now to Figure 2, the controller 20 comprises a microprocessor unit 21 coupled to a user control panel 22, a set of laundry and machine operation sensors 23 and a power switch 24. The switch 24 determines current flow through the heater 10. Suitably the switch 24 is a relay. In other preferred embodiments the switch 24 is a solid state switching device such as a thyristor or a triac. However, any suitable switching arrangement may be employed. For example, in a gas-powered embodiment the switch 24 controls the flow of gas to a burner (heater) 10.

[0020] In the preferred embodiment the controller 20 selects one of a predetermined plurality of heat settings. Conveniently, the controller selects one of at least three heat settings including full heat, half heat and no heat. However, any suitable number of heat settings may be provided, and advantageously a large number of discrete heat settings are available.

[0021] In use, when the controller 20 determines that heating is required at the full heat setting, the heater 10 is switched on via the switch 24. Full operating current is passed through the switch to the heater 10.

[0022] When the controller 20 determines that heating is required at the no heat setting, for example to provide a cool tumble operation, the heater 10 is switched off. Ideally, the supply of current to the heater is completely interrupted using the switch 24.

[0023] When the controller 20 determines that heating is required at an intermediate heat setting, such as a half heat setting, the controller 20 enters a pulsed heating mode. Here, the controller 20 signals the switch 24 to turn on the heater 10 with the full operating current for a first predetermined time period ideally of the order of 10 to 20 seconds. At the end of the first predetermined time period the microprocessor 21 signals the relay 24 to interrupt current flow to the heater 10. The heater 10 remains switched off for a second predetermined time period again ideally of the order of 10 to 20 seconds. At the end of the second time period the cycle is repeated.

[0024] Advantageously, by repeatedly cycling the heater 10 between these first and second states the effective heat output is reduced to approximately one half. However, energy efficiency is maximised because the heater operates at full operating current for the period that it is turned on.

[0025] In the first preferred embodiment the available heat settings are predetermined such that, in use, the controller selects amongst a discrete set of predetermined heat output levels. In another preferred embodiment the controller 20 controls the heater using continuously variable pulse width modulation. The controller 20 determines the first and second time periods and selects an appropriate mark-space ratio for cycling the heater on and off, thereby adjusting the effective heat output of the heater 10. Advantageously, the effective heat output may be adaptively selected during a drying program performed by the microprocessor and/or according to a determination of load conditions obtained, for example, using the sensors 23. Further, the use of expensive temperature controlling components such as a thermostat is avoided. The preferred embodiments of the present invention increase energy efficiency and reliability whilst minimising component costs.

[0026] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0027] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0028] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0029] The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel

one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A method of heating air in a tumble dryer, comprising the step of controlling a heater (10) to switch between a first state and a second state in a regular repetitive cycle.

2. A method as claimed in claim 1, wherein in the first state the heater (10) operates in a high power mode, and in the second state the heater operates in a low power mode.

3. A method as claimed in claim 1 or 2, wherein in the first state a full operative current is supplied to the heater (10), and in the second state the flow of current to the heater (10) is interrupted.

4. A method as claimed in any of claims 1 to 3, wherein the heater is controlled (21) using pulse width modulation.

5. A method as claimed in any of claims 1 to 4, wherein the heater (10) is switched to the first state for a first predetermined time period and then switched to the second state for a second predetermined time period in a regular repetitive cycle.

6. A method as claimed in any of claims 1 to 5, wherein the heater is controlled such that the ratio of the time spent in the first state with respect to the time spent in the second state is used to adjust the effective overall heat output of the heater (10).

7. A method as claimed in any of claims 1 to 6, further comprising the step of selectively adjusting the ratio between time spent in the first state and time spent in the second state within each regular repetitive cycle, such that the effective heat output of the heater (10) is adjusted.

8. A method as claimed in any of claims 1 to 7, including the step of selecting between a full heat output setting wherein the heater is switched on continuously, and a reduced heat output setting wherein the heater is controlled with pulsed width modulation to provide a reduced effective heat output.

9. A method as claimed in claim 8, wherein the selecting step is applied at predetermined stages of a drying cycle.

10. A method as claimed in claim 9, further comprising the step of sensing (23) at least one condition of a load being dryed, and thereby determining the stages of the drying cycle.

11. A method as claimed in claim 10, wherein the condition is selected to be at least one amongst a group comprising air temperature, load temperature, load weight, and moisture content.

12. An apparatus for heating air in a tumble dryer, comprising: a heater (10); and control means (20) for controlling the heater to switch between a first state and a second state in a regular repetitive cycle.

13. An apparatus as claimed in claim 12, wherein the control means (20) comprises control logic means (21) and switch means (24) for determining current flow to the heater (10), the switch means (24) being responsive to the control logic means (21).

14. An apparatus as claimed in claim 13, wherein the switch means (24) is arranged to supply full operative current to the heater when in the first state, and to substantially interrupt the flow of current to the heater (10) when in the second state.

15. An apparatus as claimed in any of claims 12 to 14, wherein the control logic means (21) applies pulse width modulation to switch between the first state and the second state in a regular repetitive cycle, thereby adjusting the effective heat output of the heater (10).

16. An apparatus as claimed in claim 15, wherein the control logic means (21) applies the first state for a first predetermined time period and the second state for a second predetermined time period in a regular repetitive cycle, such that the ratio of the time spent in the first state to the time spent in the second state defines the effective heat output of the heater (10).

17. An apparatus as claimed in any of claims 12 to 16, wherein the heater (10) comprises an electrical resistance heating element.

18. A tumble dryer comprising an apparatus as claimed in any of claims 12 to 17.

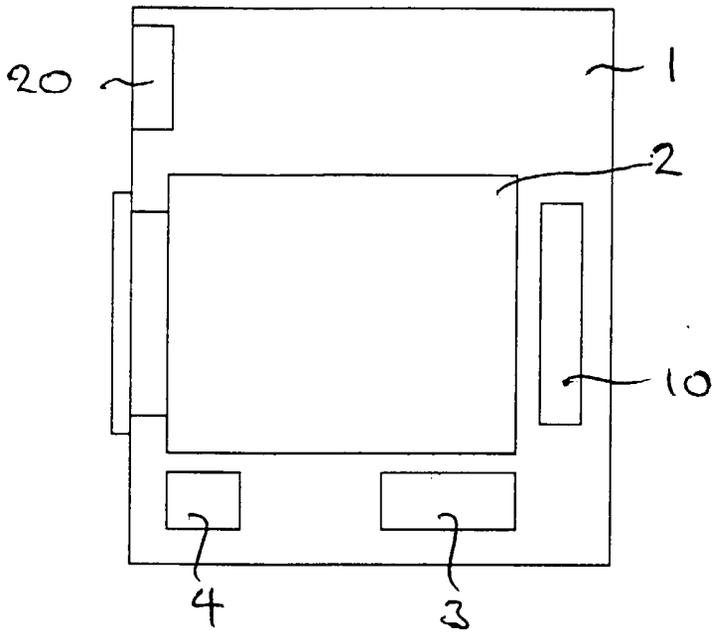
20
1
2
10
4
3

Fig. 1

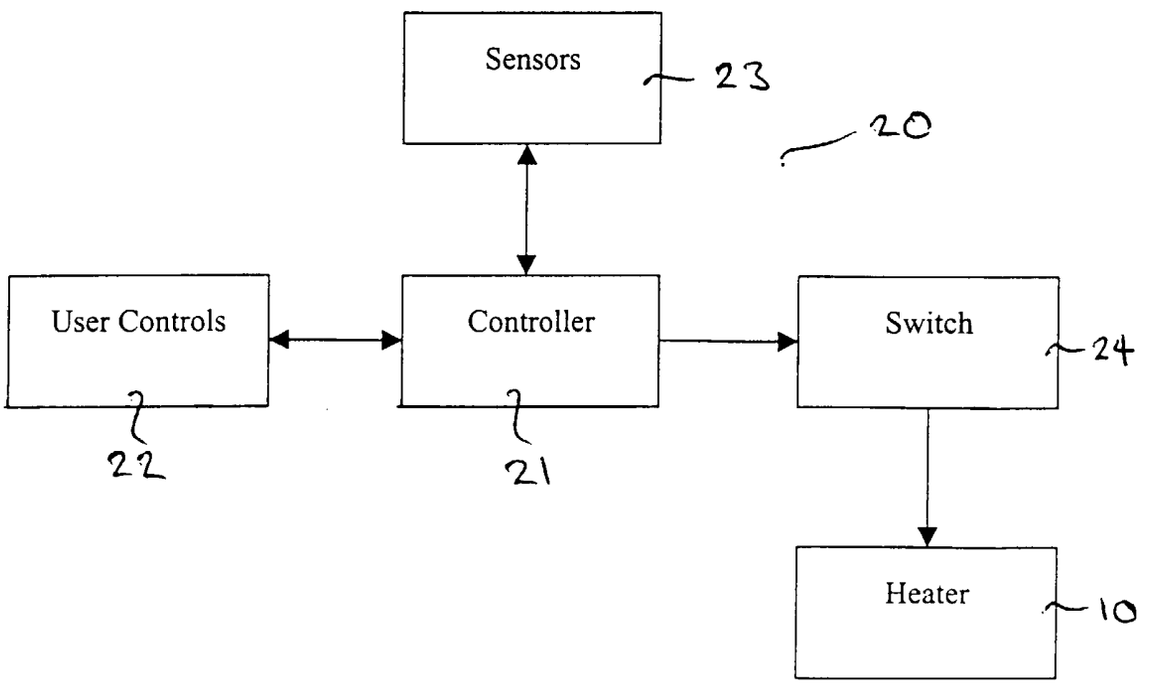
Sensors
23
20
User Controls
Controller
Switch
24
22
21
Heater
10

Fig. 2