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Description

This invention relates to tumble dryers and has particular but not exclusive reference to tumble dryers for domestic use.

There are many known systems for controlling automatically the drying cycle of a tumble dryer. In some systems, the "dryness" of articles undergoing tumble drying is sensed by measuring the electrical resistance of the articles in the drum of the dryer. However, it is difficult to measure the resistance sufficiently accurately as it increases towards the value indicating that the articles are dry. It is also found that there are other factors than the dampness of the articles that affect their electrical resistance particularly around the "dry" condition of the articles and the variation produced by these factors is sufficient to make effective sensing impossible. The systems, therefore, are designed to sense a particular "damp-dry" condition of the articles after which the drying time is extended by an amount determined by the user and which is assumed to bring the articles to a "dry" condition. As the added time depends upon many factors, it is very likely to be incorrect.

Other systems make use of the observation that the temperature of air leaving the drum — exhaust air — rises as articles in the drum dry out. Knowledge of factors including air flow through the drum and heat input enable the system to assume that when a particular exhaust air temperature is reached, the articles in the drum have reached the "dry" condition. Variable factors, for example, ambient air temperature affect the exhaust air temperature but the effect of these variables can be allowed for by the system. One system of this general type is described in DE—A—2941166. In this system, use is made of the fact that, as a drying cycle progresses, exhaust air temperature shows an initial rapid increase followed by a steady condition and then rises again: by monitoring the exhaust temperature at regular intervals, the systems detects when a predetermined temperature increase above the "steady condition" has been achieved and terminates the drying cycle. Systems of this general type are effective when required to sense the "dry" condition but considerably less effective when required to detect the "damp-dry" condition suitable for ironing because the difference between the exhaust air temperature when the articles contain about 25% by weight of moisture and that when the articles contain say 10% by weight of moisture, is small, although the different moisture contents are important. In addition, other variable factors not catered for by the system can affect the exhaust air temperature by that difference or more.

A combination of the two systems just described has also been proposed but even this does not produce fully acceptable results.

Other systems dependent upon monitoring exhaust air temperature have also been proposed but all suffer from the disadvantage that they are not able to sense sufficiently accurately the "damp-dry" condition mentioned above.

It is an object of the present invention to provide a control system for a tumble dryer that is able to sense to an acceptable degree of accuracy the "damp dry" condition of articles during a tumble drying operation and able to sense to the same degree of accuracy the "dry" condition.

According to the present invention, a tumble dryer includes a control means for controlling the drying cycle, which comprises a temperature sensor responsive to the temperature of air exhausted from the drum of the dryer and means for monitoring, at specified times during the drying cycle, changes in said temperature and translating said changes into an output to control the duration of the drying cycle, characterized in that the monitoring means is operable to monitor exhaust air temperature changes during at least an initial part of the drying cycle and, from said changes, to predetermine the duration of the drying cycle and to terminate operation of the dryer when the predetermined time has elapsed.

The control means may further include means for assessing the rate of flow of air through the drum and for modifying the effect of the monitored exhaust air temperatures to take account of the assessed air flow rate.

The means for assessing the rate of air flow may include an arrangement for measuring the increase in temperature of air emerging from the air heater of the dryer. Conveniently, such an arrangement includes a temperature sensor responsive to the temperature of air entering the air heater and another temperature sensor responsive to the temperature of air leaving the air heater.

Heat is also imparted to air before it enters the air heater, for example, the air may pass over hot components. In many cases, air is drawn over the motor driving the drum before entering the air heater. Means may be provided for taking into account such extra heat when the control system translates exhaust air temperatures.

Furthermore, changes in ambient air temperature may increase or decrease the temperature of air leaving the heater and the drum, and a sensor may be provided for detecting such ambient air changes. The output of the sensor is fed into the control means where the effect of the changes on other variables is accommodated.

Variations in other factors affecting the exhaust air temperature may be taken into account to modify or adjust the effect of exhaust air temperature readings. For example, the control means may include means responsive to the existence of changes in exhaust air temperature which, in the said initial part of the drying cycle, depart from a pre-set pattern, said responsive means being operable to adjust the predetermined duration of the drying cycle.

In addition, the control means may provide a visual indication of the time that must elapse before the articles reach the predetermined condition of dryness. To this end, the control means may include an indicator connected to receive an output of the monitoring means for indicating the said predetermined duration of the drying cycle, the arrangement including means for setting the indicator.

In one embodiment, a visual indication is given of the longest time that must elapse to reach a predetermined degree of dryness, the time being maintained but the heat input being corrected either by decreasing the time for which heat is supplied or by decreasing the rating of the heater in terms of kilowatts of heat input, as determined by the subsequent monitored conditions, should correction be necessary. For example, the control means may be adapted to set the indicator to show a predetermined cycle time duration based on a first monitored exhaust air temperature during the initial part of the drying cycle and to predetermine in accordance with a subsequently monitored exhaust air temperature at which point in that cycle time duration air heating shall be terminated. Alternatively, the control means may be adapted to set the indicator to show a predetermined cycle time duration based on monitored exhaust air temperatures during the initial part of the drying cycle and to determine, in accordance with monitored rate of increase of exhaust air temperature, at which point in that cycle time duration air heating shall be terminated.

In another embodiment, the control means is adapted to set the indicator to show a cycle time duration translated from a first monitored exhaust air temperature and to reset the indicator in accordance with a subsequently assessed exhaust air temperature during the said initial part of the drying cycle.

By way of example only, embodiments of the invention will now be described with reference to the accompanying drawings of which:

Fig. 1 is a block schematic of a control system embodying the invention,

Figs. 2—6 are explanatory graphs, and

Figs. 7A, B, C and 8 are explanatory flow diagrams.

The tumble dryer to which the control system is fitted may be of any conventional form. A typical example of dryer to which the system may be fitted is found in GB—A—1,226,951.

Fig. 1 shows in block schematic form the features of a control system embodying the invention.

A microprocessor has a plurality of inputs applied to it via an input interface 2, the outputs of the microprocessor being applied via an output interface 3.

Fig. 1 shows a variety of inputs of which some are user-controlled and others are not. A user-operated control (not shown) inputs to the input interface 2 over leads 4, 5, 6 to indicate the material of which articles to be tumbled are made, for example Fig. 1 shows a control operable to select cotton or nylon or acrylic materials, the control could equally well be adapted to select cotton, acrylic or mixed materials.

Temperature sensors (not shown) are positioned so as to be exposed to air leaving the drum of the dryer (exhaust air), to ambient air, to air inside the machine before such air passes over the air heater of the dryer, and to air that has been heated by the air heater but has not yet entered the drum. The exhaust air sensor inputs over lead 7, the ambient air sensor inputs over lead 8, the sensor exposed to unheated air inside the machine inputs over lead 9 whilst the remaining sensor inputs over lead 9*a*. Such sensors may be thermistors or thermocouples providing a voltage input to the interface 2 indicating the sensed value of exhaust air temperature and ambient air temperature.

Input 10 is connected to a voltage sensitive device that detects variations in the voltage of the mains supply to the tumbler dryer.

A further input 11 indicates the electrical load of the air heater of the tumble dryer and is normally set during factory testing of the machine. The heater rating may also be variable by the user on operation of the control indicating the type of material of which articles to be tumbled are made.

Input 12 is connected to a control set by the user at the commencement of a drying cycle and determines the stage to which the cycle is to be taken to ensure articles reach a required state of dryness. The control may be a multi-position knob settable to different positions indicating, for example "Dry", "Iron Dry", "Damp 1", "Damp 2 ...", "Extra Dry". "Iron Dry" indicates a condition suitable for ironing, whilst "Damp 1", "Damp 2 ..." are differing degrees of dampness of the articles. "Extra Dry" provides a drying cycle of somewhat greater duration than "Dry" and is suitable for articles with seams or otherwise of uneven thickness and require an extra long cycle to ensure that such thick parts reach the dry condition.

Controlled by the microprocessor output via output interface 3 are a digital display 13, a motor (not shown) driving the drum of the dryer and an impeller (not shown) pumping air through the drum, and an air heater (not shown) of the dryer that heats air prior to its entry into the drum.

As is described in the Specification referred to above, air passing over the air heater of the dryer has been drawn into the casing of the appliance and over the motor driving the drum.

The following factors determine the drying cycle required by a particular load of articles to be tumble dried:

1. The type of material from which the articles are made.
2. The total amount of water in the load.
3. The weight of the load.
4. The rate of flow of air through the drum of the dryer.
5. The total heat input.
6. The basic efficiency of the dryer.
7. The ambient temperature.
8. The humidity of the ambient air.

9. The temperature of the articles when they are loaded into the drum.

Of these factors, the first is programmed into the microprocessor by the user and results in an input on one of input leads 4, 5 or 6.

Factor 2 is the most important single one of the factors which determine the time that a wet load takes to dry in a particular design of dryer where efficiency and the heat input remain constant. The weight of clothes involved — factor 3 — is relatively unimportant in determining the time for a particular total weight of water to be evaporated, but it does affect the shape of the temperature/time curve. These factors are determined by the microprocessor in accordance with information received and following procedures to be described below.

The rate of flow of air through the drum — factor 4 — has little effect on total drying time but is important because it influences the shape of the exhaust air temperature/time relationship which is referred to below. Air flow is difficult to sense directly but a sufficiently accurate assessment is obtainable indirectly from observations of the increase in temperature of air flowing over the air heater. Such increase is determined by sensing the temperature of air entering, and that of air leaving, the air heater.

The value of factor 5 is determined by ambient air temperature, the extent to which air picks up heat before entering the air heater, for example from the motor and the heat imparted to the air by the air heater.

There are basically two different sets of conditions to be considered in connection with heat pick-up. The dryer may be totally at ambient air temperature, or it, or parts of it, may be at a temperature other than that of ambient air. In the latter two cases, the exhaust air temperature will be initially modified by this factor and allowance will have to be made for this, and the consequences of the differing initial temperature conditions of the dryer are discussed later.

The heater input depends upon the electrical resistance of the heater and the supply voltage. Resistance could be measured during a final factory test and the control system calibrated to respond to the time/temperature curve given by a specific heater resistance by means of an adjustable potentiometer and subsequently regarded as pre-set. In Fig. 1, the setting of the potentiometer forms input 11.

Alternatively, the resistance of the heater could be sensed at the commencement of a drying cycle and the value indicated over input 11.

Changes in supply voltage are sensed and indicated over input 10.

The basic efficiency of the dryer — factor 6 — can be determined during the course of development and can, thereafter, be regarded as constant.

In practice, the humidity of ambient air can be ignored as it has very little significant effect on the drying cycle within the range associated with normal dryer use.

The temperature of the articles loaded into the drum of the dryer will be determined to a very large extent by the temperature of water used for a final rinse during a washing process to which the articles are subjected before they are to be tumble dried in the case in which the user takes the articles directly from the washing machine and loads them into the tumble dryer.

If there is a delay between extracting the articles from the washing machine and loading them into the tumble dryer, the temperature of the articles may vary from that of ambient air to the rinse water temperature.

The way in which such conditions are dealt with is described below.

In order to explain the evaluation of factor 2, it is now proposed to detail the basic drying cycle of the tumble dryer.

Fig. 2 shows the way in which exhaust air temperature increases with time in the case in which the dryer is empty. Air incoming to the drum from the air heater merely heats up the drum and adjacent components of the dryer and consequently the exhaust air temperature shows an initial rapid increase followed by a steady condition.

Fig. 3 shows the relationship with time of changes in the exhaust air temperature for several different loads of articles made of cotton.

Of the curves shown in Fig. 3, that numbered 14 shows the relationship for a 4 kg (dry weight) load of cotton articles with, initially, a 100% (by weight) water content. Curves 15, 16 and 17 show respectively the relationship for a 4 kg (dry weight) load of cotton articles with, initially, a 50% (by weight) water content, a 2 kg (dry weight) load of cotton articles with, initially, a 100% (by weight) water content, and, a 2 kg (by weight) load of cotton articles with, initially, a 50% (by weight) water content.

The relationships are of the same general pattern. There is an initial fairly rapid increase in the temperature of the exhaust air — time period A — after which that temperature stabilises at an intermediate plateau temperature during which evaporation from articles in the drum takes place at a steady state. When the bulk of the water in the articles has been driven off, the exhaust air temperature starts to rise again and, when the articles are completely dry, stablises once again.

From Fig. 3, it can be seen that, for the same dry weight of articles, the rate of increase in exhaust air temperature during time period A varies primarily with the amount of water in the load. Thus, in general, a large rate of increase in exhaust air temperature is an indication of a small weight of water requiring a shorter time to dry the load, the converse also being true.

However, it will be seen that although curve 16 rises initially at a larger rate of increase than curve 15, both having the same 2 kg content of water to be evaporated, in fact a slightly longer, nor shorter, drying time is required for the smaller dry weight of articles. This is because the smaller weight of articles makes less efficient use of the hot air passing through the drum of the dryer, and consequently the drop in temperature from the temperature at which the air enters the drum is less and the plateau temperature is slightly higher.

Thus, other factors, for example voltage, heater loading, air flow, type of material and ambient temperature, being equal, a) the larger the rate of increase in exhaust air temperature during the initial period the shorter the drying time, and b) the higher the plateau temperature for a particular rate of increase in exhaust air temperature the longer the drying time. If the temperature is ultimately going to be slightly higher during the plateau period other factors, such as those mentioned above and also the amount of water in the articles, being constant, the initial rate of increase will be greater. This initial larger rate of increase would cause the microprocessor to miscalculate the time required to evaporate the water contained in the articles, as the microcompressor would assume less water in the load than was actually the case unless some compensations were made. This compensation can be made by the microprocessor when it sees what the plateau temperature is. The microprocessor will endeavour to anticipate the plateau temperature from the initial shape of the temperature/time curve, an early large rate of increase in exhaust air temperature followed by a more rapid decline in the rate of increase will indicate a lower plateau temperature than the same early rate of increase followed by a less rapid decline in the rate of increase. The more time and temperature reference positions that are taken and the longer they continue to be taken, the more accurate the assessment will be. For any particular initial rate of increase in exhaust air temperature, time will have to subsequently be detracted by the control from the time first calculated to switch off the heater, should the plasteau temperature be less than the assumed temperature programmed into the microprocessor for any given heat input, air throughput, ambient temperature and so on.

This is illustrated in Fig. 3, the "dry" condition for each load being indicated by the points X on the curves. Point X on curve 16 occurs later in the drying cycle than does point X on curve 15.

Generally similar curves apply to other different materials. Fig. 4 shows the exhaust air temperature/time relationship for 2 kg (dry) weight with 100% (by weight) initial water content of articles made of nylon — curve 21, and of acrylic fibers — curve 22. In each case, the points X on the curves indicate the dry condition and it will be noted that the time to reach that condition is different for the different materials.

Thus, it will be appreciated that, in general, the less weight of water initially present in the articles, the greater is the initial rate of increase in exhaust air temperature and the smaller the weight of articles the higher is the exhaust air temperature that is reached after the initial heat up over time period A, additionally.

The relationship between exhaust air temperature and time over the initial part of a drying cycle will depend upon the dryer temperature at the commencement of the cycle, all other variables being the same.

Fig. 5 illustrates the dependence. If the dryer is "hot" at the commencement of a drying cycle, the exhaust air temperature will start from a higher value but will in due course, rise to the said final temperature as if the starting temperature was that of ambient air.

In Fig. 5, curve 23 relates exhaust air temperature and time for the case in which the starting exhaust air temperature is 30°C. Curve 23 can be compared with curve 24 which relates exhaust air temperature and time for the case in which the starting exhaust air temperature is 10°C. The curve 23 condition must be recognised by the microprocessor so that the latter can apply a correction to the sensing base from which the microprocessor calculates the heating time and the overall cycle duration of the dryer which may take the form of a decreasing deduction from the sensed value of the exhaust air temperature as indicated by curve 25, the deduction being the curve 23 value minus the curve 24 value.

A somewhat similar situation arises in the case of articles to be dried and which are loaded into the dryer when their temperature is below that of ambient air and of the dryer. In this case, the first effect on exhaust air temperature is to depress it below ambient. After a while, the exhaust air temperature will increase and will eventually reach the same final temperature referred to above. This is illustrated in Fig. 6 whose curve 26 relates exhaust air temperature and time for the case in which articles at a temperature of 5°C are loaded into the dryer. For comparison purposes, curve 27 relates exhaust air temperature and time for the case in which the articles are at a temperature of 10°C when loaded into the drum.

The correct time to reach dryness must be based on the curve from the point at which the exhaust temperature has risen to the ambient value, thereafter the curve will be identical with that of articles loaded whilst at ambient temperature. Thus, the microprocessor must respond to the drop in sensed exhaust air temperature and make the appropriate correction.

The microprocessor is programmed to scan or otherwise monitor the rate of increase in exhaust air temperature at specified intervals of time during the initial heat up period — time period A.

The microprocessor is also programmed with a series of cycle durations corresponding with a variety of different exhaust air temperatures and times of occurrence of such temperatures. These cycle durations will be not only those required to bring the articles to a "dry" condition but will also include cycle durations to reach various conditions of damp dry.

The exhaust air temperature is checked at specified intervals of 0.5 sec for the first 5 sec after the start of a drying cycle. Thus, at the end of the first 5 sec of the drying cycle, the microprocessor will deduce from the averaged or aggregated exhaust temperature readings that the cycle duration is, say 2 hours. That duration is displayed in a mode characterizing an unconfirmed time because the time is likely to be an approximation only, because at the commencement of a cycle, the exhaust air temperature/time curves, as can be seen from Fig. 3, are very close together. However, as more readings become available greater certainty is possible and after about 60 seconds a reasonably accurate cycle duration is available. The displayed time includes "cold" run of 10 min.

Typically, checking continues every 0.5 sec for a further period of 10 sec (15 sec runs time). At the end of that further period, the microprocessor determines and stores the average value of the temperatures at each 0.5 sec interval, or aggregates those temperatures. The microprocessor will then up-date the first assessed cycle duration time and display, in the unconfirmed mode, the up-dated time including the 10 min "cold" run.

Monitoring of exhaust air temperature is then continued for a further 45 sec (60 sec run time) during which time the temperature is checked every 0.5 sec to give, at the end of the 60 sec run time, an averaged value or an aggregated value which is related to the averaged or aggregated value obtained at the end of the 15 sec period to enable the microprocessor to make a final estimate of the cycle duration time (T) which will include a 10 minute period of "cold" run after the air heater has been de-energised.

In practice, the initial duration deduced would be programmed to be the longest that would be required, to be corrected at a later stage. The correction made might be of the order of a 5 minute reduction in the time during which the heater is energized, but no reduction will be made in the total time to run of the dryer.

Monitoring of exhaust air temperature may cease after a predetermined time programmed into the microprocessor or it may continue as will be described below.

The deduced cycle time is also displayed on the display 13 — preferably a digital display showing minutes only or hours and minutes.

Thus, in the example just described, the display would be energised after 5 sec to show 2:00 hours. To indicate to a user that the displayed time may be an unconfirmed time only, an additional symbol is energized, for example the colon separating the hours and minutes in the display is caused to flash — this is referred to as the "unconformed mode".

As monitoring of the exhaust temperature continues, the deduced duration may change and this can be indicated to the user as such changes take place, i.e. by a constantly changing display or by one single change at the end of the 60 sec period. The colons would cease flashing at the end of that period — the display then being in the confirmed mode.

Once the cycle duration has stabilised, its value is stored to allow the microprocessor to produce, at the approximate time, outputs to terminate the drying cycle. Two outputs are normally required because the air heater is de-energised before the drying cycle ends, the remainder of the cycle being simply the conventional "cool-down" period during which cool air is circulated through the drum to cool articles therein.

It is, of course, possible to so program the microprocessor that monitoring of exhaust air temperature continues after the 60 sec period referred to above. This continued monitoring enables a more accurate deduction to be made of the cycle duration. Thus, at the end of, say, 5 min from start a very accurate duration time is available. The displayed time is not changed and the more accurate duration is used to cause de-energisation of the heater earlier or later within the cycle time, the "cool-down" period being lengthened or shortened as a result and the total duration of the cycle remains unchanged.

Operation of the "materials" control inputting over leads 4, 5 and 6 sets the microprocessor to approximate cycle duration times appropriate to the selected material. If "acrylic" is selected, the microprocessor may also be programmed to reduce the heater to a half-heat condition at an appropriate point in the cycle. This will reduce the possibility of overheating articles made from that material.

Changes in ambient temperature and any other changes, for example supply voltage, may be caused to adjust the effect of exhaust air temperature readings either before such readings are inputted to the microprocessor or within the latter. Inputs 9, 9*a*, 10 and 11 may operate in a similar fashion.

Adjustment of input 12 makes an appropriate adjustment to the time within a cycle that the air heater is energised, the microprocessor having been programmed to terminate energisation in accordance with the adjustment of the input 12 and the state of dryness indicated thereby.

To use a tumble dryer incorporating the features described above, a user first loads the machine with articles to be tumble dried and then sets the control in accordance with the nature of the material from which the articles are made. Control 12 is then set in accordance with the state of dryness required. Once the door giving access to the drum is closed, the machine may be energised and may commence the tumble dry cycle.

By observation of the display 13, the user will, after 60 sec running time or when the colons are "steady", be able to read the exact time that must elapse before the cycle finishes.

It will, of course, be understood that the machine may incorporate some only of the features mentioned above. For example, only exhaust air temperature may be monitored, fixed values being assumed for ambient air temperature, inlet air temperature supply voltage and element loading. In addition, it may be possible to distinguish between acrylic and other materials only.

As an alternative to relating the increase in exhaust air temperature to ambient or to a given datum, it could be related to the temperature of air entering the drum after passing over the heater.

Figs. 7A, B, C and 8 are flow diagrams showing in more detail the procedure described above. The convention adopted employs blocks with round ends to designate inputs to and outputs from the microprocessor, rectangular blocks to designate non-decision operations which are carried out and diamond-shaped blocks to represent interrogations.

Step 1 in the diagram of Fig. 7 is normally affected during factory testing of the dryer but steps 2 and 3 are carried out by the user as explained above.

Rectangular blocks carrying the text "adjust sensing base" indicate that a sensed variation from standard of the parameter is used to adjust the value to be used in step 11.

Fig. 8 is an alternative to the automatic de-energisation of the air heater at time T-10 min, it is possible to employ a microprocessor programmed to terminate air heating when the rise in exhaust air temperature exceeds a predetermined value and to monitor exhaust air temperature throughout the drying cycle or at least for that part thereof during which the air heater is energised.

For example, monitoring of exhaust air temperature is continued after the 5 min period mentioned above, checks on the temperature occurring ever 5 sec. By averaging exhaust air temperatures over a selected period, a temperature trend can be established and when this indicates an increase of a preselected value, the air heater is de-energised. Tumbling then continues under "cool" incoming air conditions until time T is reached when the drum motor is switched off.

Such a technique is the subject of the flow diagram of Fig. 8.

It will, of course, be understood that the tumble dryer may be embodied as a combined washing machine and tumble dryer.

Claims

1. A tumble dryer including a control means for controlling the drying cycle of the dryer, the control means comprising a temperature sensor responsive to the temperature of air exhausted from the drum of the dryer and means (1, 7) for monitoring, at specified times during the drying cycle, changes in said temperature and translating said changes into an output to control the duration of the drying cycle, characterised in that the monitoring means (1, 7) is operable to monitor exhaust air temperature changes during at least an initial part (A, Fig. 3) of the drying cycle and, from said changes, to predetermine the duration (T_1) of the drying cycle (step 23, Fig. 7C) and to terminate operation of the dryer when the predetermined time has elapsed (step 27, Fig. 7C).

2. A tumble dryer as claimed in claim 1 in which the control means also includes means (9, 9*a* for assessing the rate of flow of air through the drum and for modifying the effect of monitored exhaust air temperature to take account of the assessed air flow rate.

3. A tumble dryer as claimed in claim 2 in which the means for assessing the rate of air flow includes an arrangement (9, 9*a*) for measuring the increase in temperature of air emerging from the air heater.

4. A tumble dryer as claimed in claim 1, 2 or 3 in which the control means further includes a temperature sensor (8) exposed to ambient air temperature and means for modifying the effect of monitored exhaust air temperature to take account of changes in ambient air temperature.

5. A tumble dryer as claimed in any one of claims 1—4, in which the control means includes means responsive to the existence of changes in exhaust air temperature which, in the said initial part of the drying cycle, depart from a pre-set pattern (curve 23, Fig. 5 and curve 26, Fig. 6); said responsive means being operable to adjust the predetermined duration of the drying cycle.

6. A tumble dryer as claimed in any one of claims 1—5 in which the control means includes an indicator (13) connected to receive an output of the monitoring means (1) for indicating the said predetermined duration of the drying cycle, and including means for setting the indicator.

7. A tumble dryer as claimed in claim 6 in which the control means is adapted to set the indicator to show a cycle time duration translated from a first monitored exhaust air temperature (step 20, Fig. 7B) and to reset the indicator in accordance with a subsequently assessed exhaust air temperature during the said initial part of the drying cycle (steps 22, 24 Fig. 7C).

8. A tumble dryer as claimed in claim 6 or claim 7, in which the control means is adapted to set the indicator to show a predetermined cycle time duration based on a first monitored exhaust air temperature during the initial part of the drying cycle (step 2, Fig. 7B) and to predetermine in accordance with subsequently monitored predetermined exhaust air temperature at what point in that cycle time duration air heating shall be terminated (step 25, Fig. 7C).

9. A tumble dryer as claimed in claim 6 or claim 7, in which the control means is adapted to set the indicator to show a predetermined cycle duration based on monitored exhaust air temperatures during the initial part of the drying cycle (step 20, Fig. 7B) and to determine, in accordance with monitored rate of increase of exhaust air temperature at what point in that cycle time duration air heating shall be terminated (step 26, Fig. 8).

Patentansprüche

1. Ein Trommeltrockner mit einer Steuereinrichtung für die Steuerung des Trocknungszyklus des Trockners, welche Steuereinrichtung einen Temperatursensor umfaßt, ansprechend auf die

Temperatur von Abluft aus der Trommel des Trockners und einer Einrichtung (1, 7) für die Überwachung zu spezifizierten Zeiten während des Trocknungszyklus von Änderungen in der genannten Temperatur und die Umsetzung der genannten Änderungen in einen Ausgang zum Steuern der Dauer des Trocknungszyklus, dadurch gekennzeichnet, daß die Überwachungseinrichtung (1, 7) betätigbar ist zum Überwachen von Ablufttemperaturanderungen während zumindest des anfänglichen Teils (A, Fig. 3) des Trocknungszyklus und, aus den genannten Änderungen, die Dauer (T_1) des Trocknungszyklus (Schritt 23, Fig. 7C) zu bestimmen und den Betrieb des Trockners zu beenden, wenn die vorbestimmte Zeit verstrichen ist (Schritt 27, Fig. 7C).

2. Ein Trommeltrockner nach Anspruch 1, bei dem die Steuereinrichtung ferner eine Einrichtung (9, 9*a*) umfaßt für die Abschätzung der Luftdurchströmungsrate durch die Trommel und für die Modifizierung des Effekts der überwachten Ablufttemperatur zur Berücksichtigung der abgeschätzten Luftströmungsrate.

3. Ein Trommeltrockner nach Anspruch 2, bei dem die Einrichtung für die Abschätzung der Luftströmungsrate eine Anordnung (9, 9*a*) umfaßt für die Messung der Temperaturzunahme von aus dem Lufterhitzer austretender Luft.

4. Ein Trommeltrockner nach Anspruch 1, 2 oder 3, bei dem die Steuereinrichtung ferner einen Temperatursensor (8) umfaßt, der der Umgebungslufttemperatur ausgesetzt ist, und eine Einrichtung für die Modifikation des Effektes der überwachten Ablufttemperatur zur Berücksichtigung von Änderungen der Umgebungslufttemperatur.

5. Ein Trommeltrockner nach einem der Ansprüche 1 bis 4, bei dem die Steuereinrichtung eine Einrichtung umfaßt, ansprechend auf das Vorliegen von Änderungen in der Ablufttemperatur die, in den genannten Anfangsteil des Trocknungszyklus, von einem voreingestellten Muster (Kurve 23, Fig. 5 und Kurve 26, Fig. 6) abweicht, welche Einrichtung betätigbar ist zum Einstellen der vorbestimmten Dauer des Trocknungszyklus.

6. Ein Trommeltrockner nach einem der Ansprüche 1 bis 5, bei dem die Steuereinrichtung einen Indikator (13) umfaßt, angeschlossen zum Empfang eines Ausgangs der Überwachungseinrichtung (1) für die Anzeige der genannten vorbestimmten Dauer des Trocknungszyklus, einschließlich einer Einrichtung für das Setzen des Indikators.

7. Ein Trommeltrockner nach Anspruch 6, bei dem die Steuereinrichtung ausgebildet ist zum Setzen des Indikators zum Anzeigen einer Zykluszeitdauer, umgesetzt von einer ersten überwachten Ablufttemperatur (Schritt 20, Fig. 7B) und zum Rücksetzen des Indikators in Übereinstimmung mit einer nachfolgend zugeordneten Ablufttemperatur während des genannten Anfangsteils des Trocknungszyklus (Schritte 22, 24, Fig. 7C).

8. Ein Trommeltrockner nach Anspruch 6 oder 7, bei dem die Steuereinrichtung ausgebildet ist zum Setzen des Indikators zum Anzeigen einer vorbestimmten Zykluszeitdauer, basierend auf einer ersten überwachten Ablufttemperatur während des Anfangsteils des Trocknungszyklus (Schritt 20, Fig. 7B) und zum Vorbestimmen, in Übereinstimmung mit einer nachfolgend überwachten vorbestimmten Ablufttemperatur, an welchem Punkt in dieser Zykluszeitdauer die Lufthitzung beendet werden soll (Schritt 25, Fig. 7C).

9. Ein Trommeltrockner nach Anspruch 6 oder 7, bei dem die Steuereinrichtung ausgebildet ist zum Setzen des Indikators zum Anzeigen einer vorbestimmten Zykluszeitdauer, basierend aus überwachten Ablufttemperaturen während des Anfangsteils des Trocknungszyklus (Schritt 20, Fig. 7B) und zum Bestimmen, in Übereinstimmung mit der überwachten Rate der Zunahme der Ablufttemperatur, an welchem Punkt in dieser Zykluszeitdauer die Lufterhitzung beendet werden soll (Schritt 26, Fig. 8).

Revendications

1. Sécheur à agitation comportant un dispositif de commande servant à commander le cycle de séchage du sécheur, le dispositif de commande comprenant un capteur de température réagissant à la température de l'air déchargé du tambour du sécheur et un moyen (1, 7) pour contrôler, à des instants spécifiés pendant le cycle de séchage, des variations de ladite température et pour convertir lesdites variations en un signal de sortie servant à commander la durée du cycle de séchage, caractérisé en ce que le moyen de contrôle (1, 7) peut agir pour contrôler des variations de la température de l'air sortant pendant au moins une partie initiale (A, figure 3) du cycle de séchage et pour prédéterminer, à partir desdites variations, la durée (T_1) du cycle de séchage (étape 23, figure 7c), et pour faire cesser le fonctionnement du sécheur quand le temps prédéterminé s'est écoulé (étape 27, figure 7C).

2. Un sécheur à agitation tel que revendiqué dans la revendication 1, dans lequel le dispositif de commande comprend également un moyen (9, 9a) pour déterminer le débit d'écoulement de l'air au travers du tambour et pour modifier l'effet de la température d'air sortant contrôlée afin de tenir compte du débit d'écoulement d'air ainsi déterminé.

3. Un sécheur à agitation tel que revendique dans la revendication 2, dans lequel le moyen de détermination du débit d'écoulement d'air comprend un agencement (9, 9a) pour mesurer l'augmentation de la température de l'air sortant du réchauffeur d'air.

4. Un sécheur à agitation tel que revendiqué dans la revendication 1, 2 ou 3, dans lequel le dispositif de commande comprend en outre un capteur de température (8) exposé à la température de l'air ambiant et un moyen pour modifier l'effet de la température d'air sortant contrôlée pour tenir compte de variations de la température d'air ambiant.

5. Un sécheur à agitation tel que revendiqué dans une quelconque des revendications 1 à 4,

dans lequel le dispositif de commande un moyen réagissant à l'existence de variations dans la température d'air sortant qui, dans ladite partie initiale du cycle de séchage, s'écarte d'une relation prédéterminée (courbe 23, figure 5 et courbe 26, figure 6); ledit moyen de réaction pouvant opérer pour régler la durée prédéterminée du cycle de séchage.

6. Un sécheur à agitation tel que revendiqué dans une quelconque des revendications 1 à 5, dans lequel le dispositif de commande comporte un indicateur (13) connecté de manière à recevoir un signal de sortie du moyen de contrôle (1) pour indiquer ladite durée prédéterminée du cycle de séchage, et comportant un moyen de réglage de l'indicateur.

7. Un sécheur à agitation tel que revendiqué dans la revendication 6, dans lequel le dispositif de commande est adapté pour régler l'indicateur de façon à indiquer une durée temporelle de cycle établie à partir d'une première température d'air sortant contrôlée (étape 20, figure 7B) et à ramener l'indicateur dans la condition initiale en concordance avec une température d'air sortant déterminée ultérieurement pendant ladite partie initiale du cycle de séchage (étapes 22, 24, figure 7C).

8. Un sécheur à agitation tel que revendiqué dans la revendication 6 ou la revendication 7, dans lequel le dispositif de commande est adapté pour régler l'indicateur de manière à indiquer une durée temporelle de cycle prédéterminée, basée sur une première température d'air sortant contrôlée pendant la partie initiale du cycle de séchage (étape 20, figure 7b) et pour prédéterminer, en concordance avec une température d'air sortant prédéterminée et contrôlée ultérieurement, à quel moment de cette durée temporelle de cycle le chauffage de l'air doit être terminé (étape 25, figure 7C).

9. Un sécheur à agitation tel que revendiqué dans la revendication 6 ou la revendication 7, dans lequel le dispositif de commande est adapté pour régler l'indicateur de façon à indiquer une durée temporelle de cycle prédéterminée basée sur des températures d'air sortant contrôlées pendant la partie initiale du cycle de séchage (étape 20, figure 7B) et pour déterminer, en concordance avec l'allure d'augmentation contrôlée de la température d'air sortant, à quel moment de cette durée temporelle de cycle le chauffage de l'air doit être terminé (étape 26, figure 8).

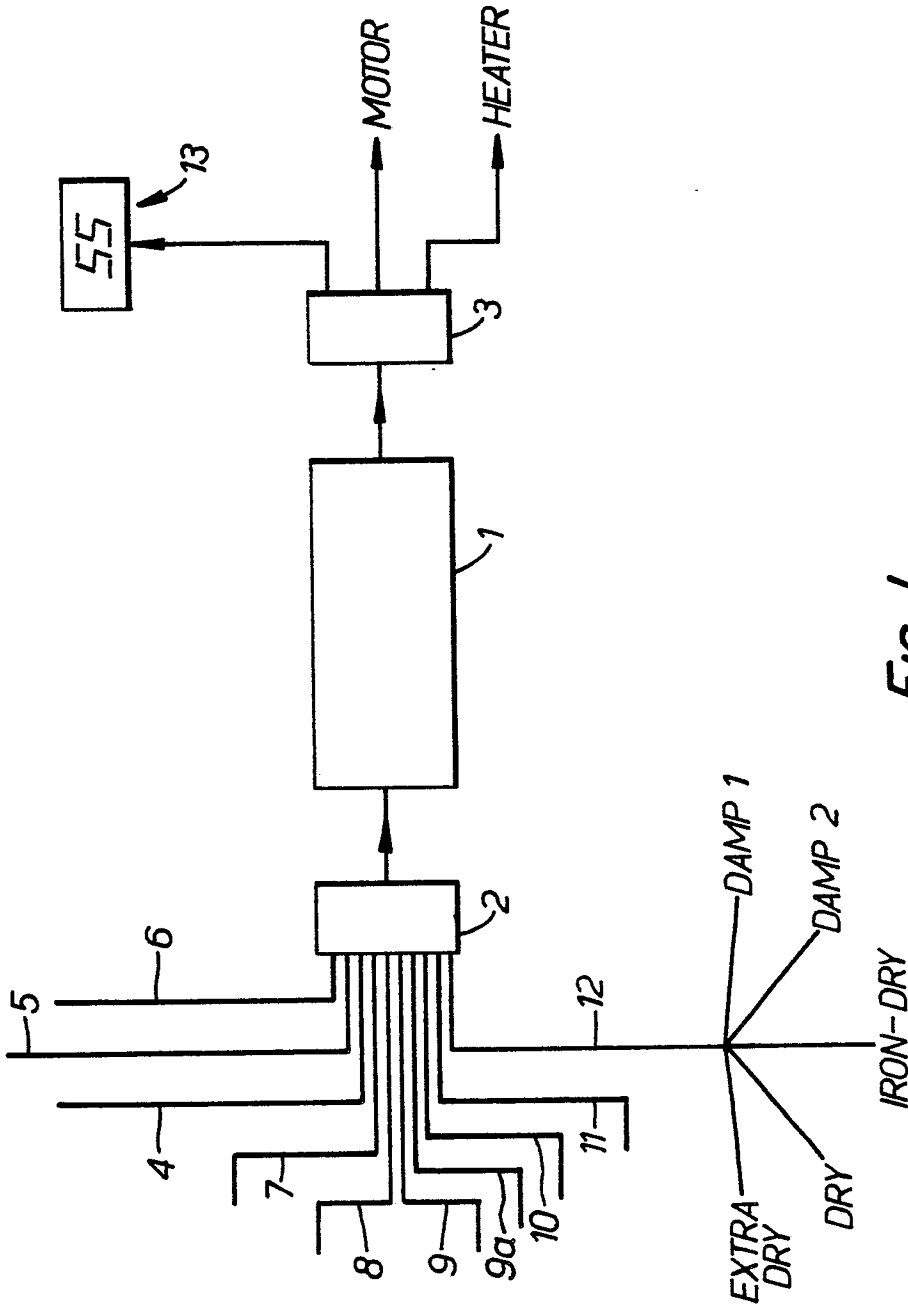
MOTOR
HEATER
55
13
3
1
2
5
6
4
7
8
9
9a
10
11
12
DAMP 1
DAMP 2
IRON-DRY
DRY
EXTRA DRY

FIG. 1.

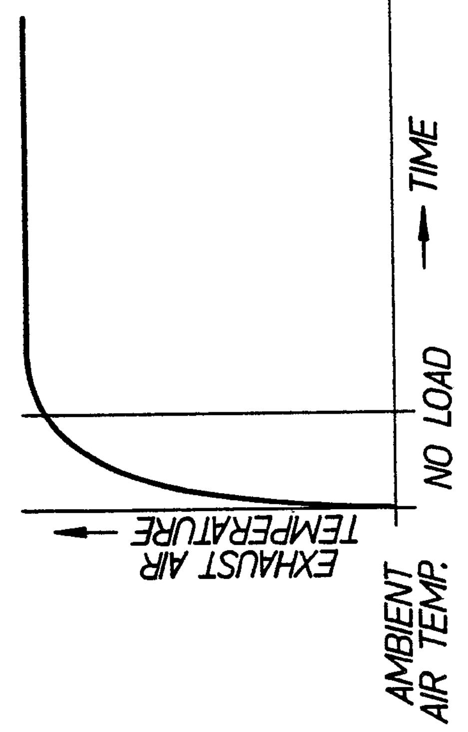
EXHAUST AIR TEMPERATURE
TIME
NO LOAD
AMBIENT AIR TEMP.

FIG. 2.

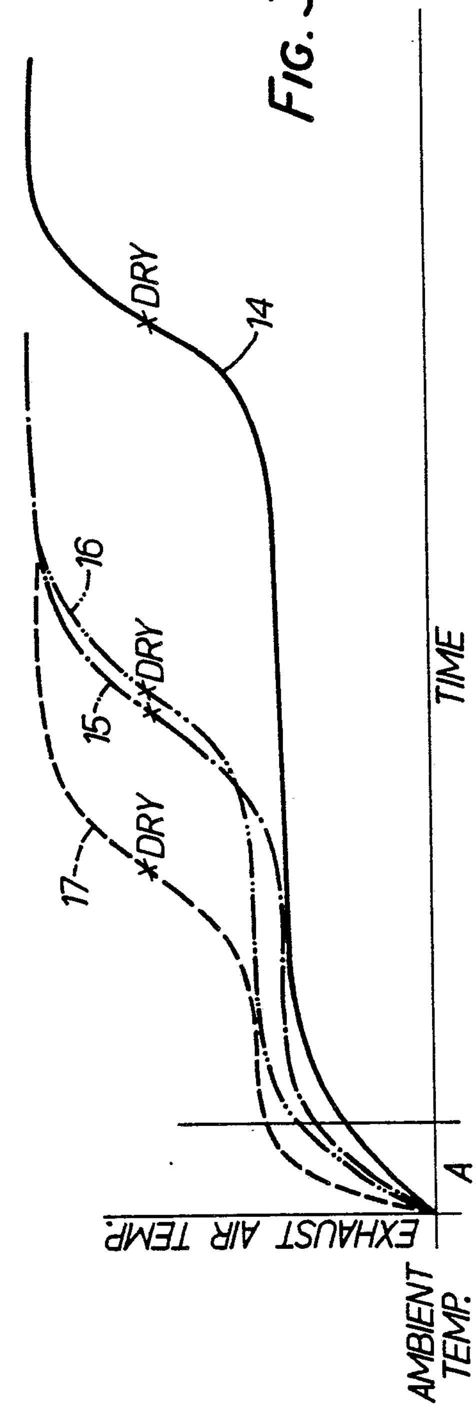
14
DRY
16
DRY
15
DRY
17
TIME
A
EXHAUST AIR TEMP.
AMBIENT TEMP.

FIG. 3.

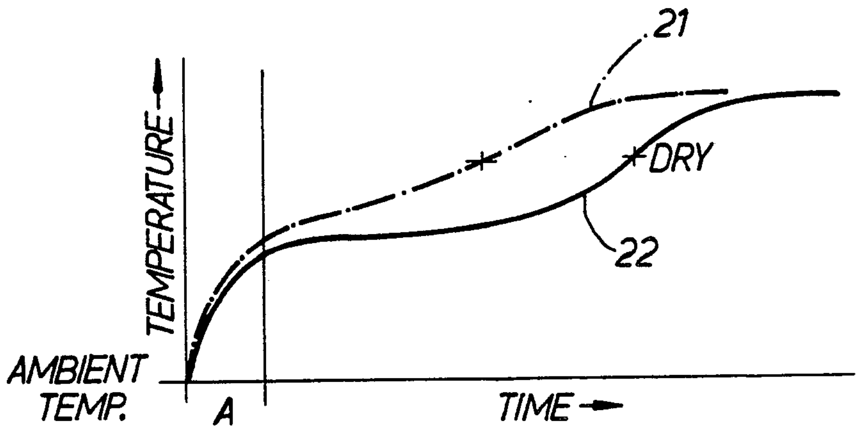
21
TEMPERATURE
DRY
22
AMBIENT
TEMP.
A
TIME

FIG. 4.

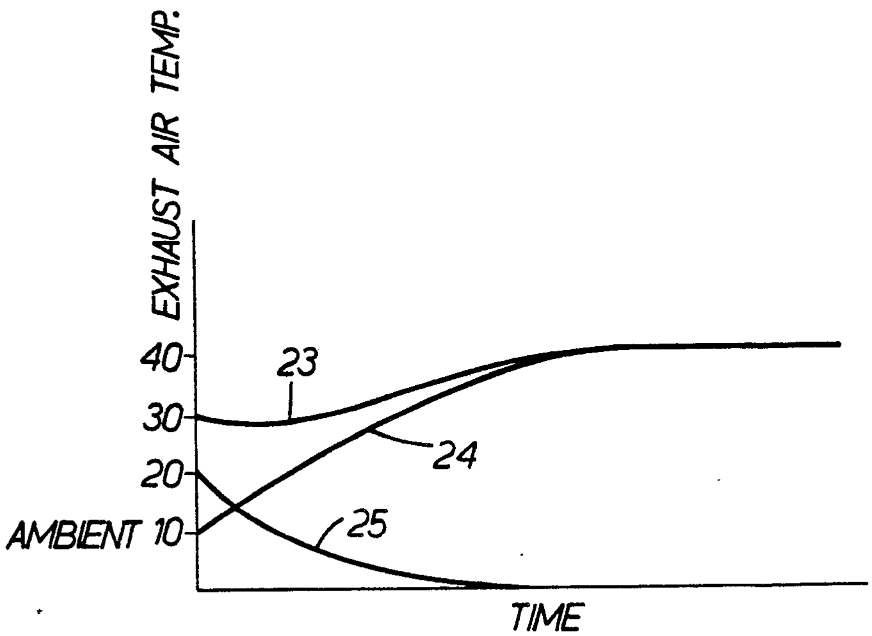
EXHAUST AIR TEMP.
40
30
20
AMBIENT 10
23
24
25
TIME

FIG. 5.

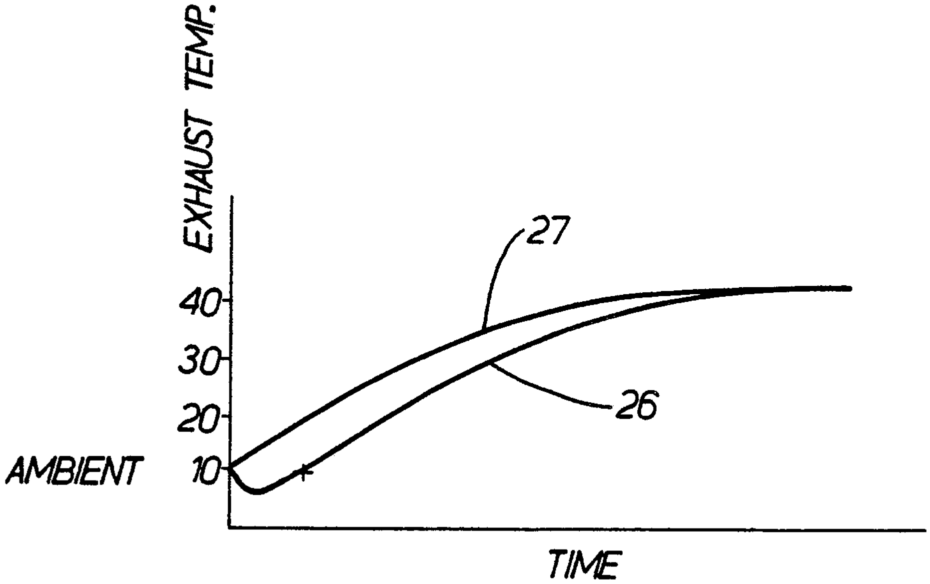

FIG. 6.

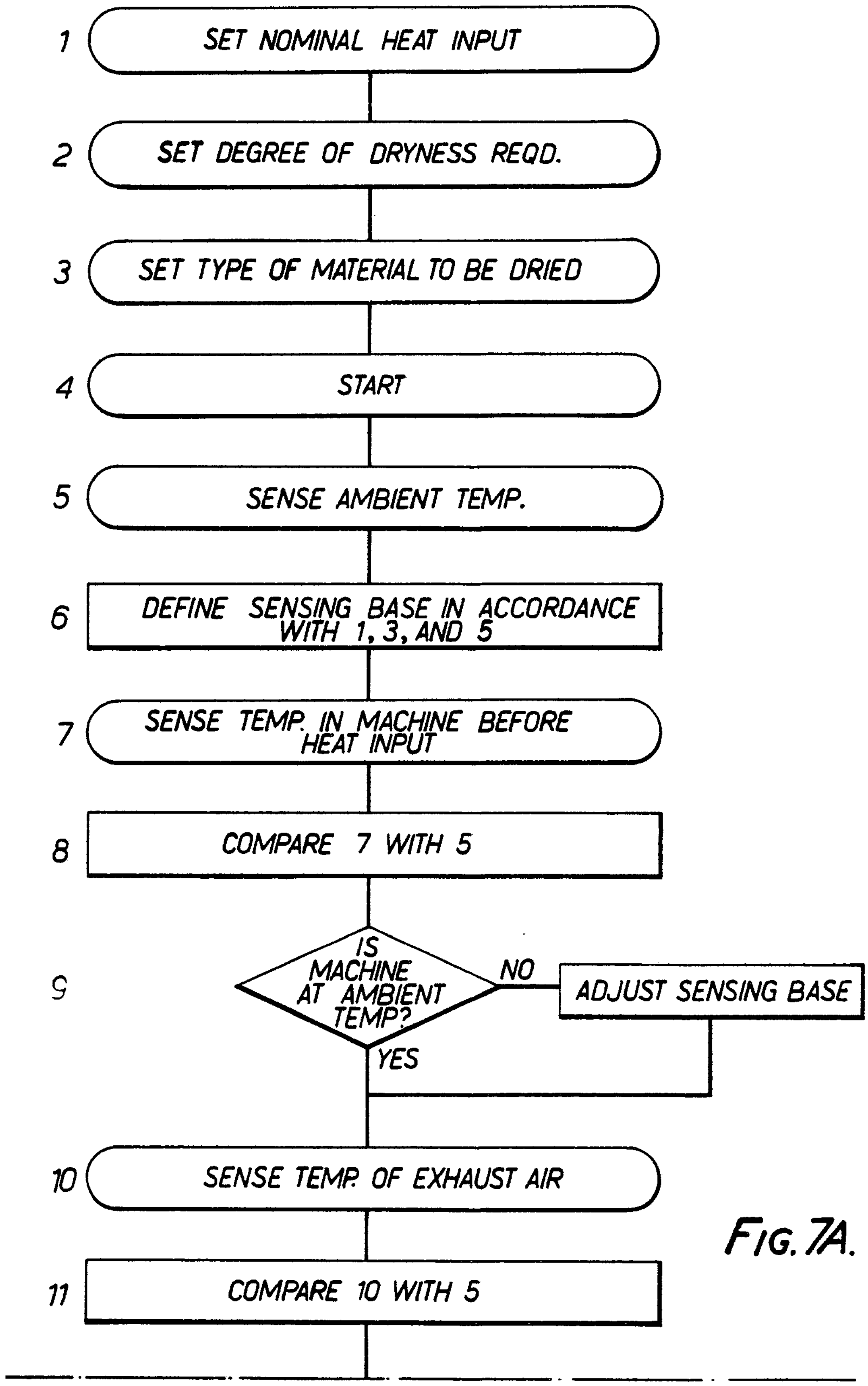
1 SET NOMINAL HEAT INPUT
2 SET DEGREE OF DRYNESS REQD.
3 SET TYPE OF MATERIAL TO BE DRIED
4 START
5 SENSE AMBIENT TEMP.
6 DEFINE SENSING BASE IN ACCORDANCE WITH 1, 3, AND 5
7 SENSE TEMP. IN MACHINE BEFORE HEAT INPUT
8 COMPARE 7 WITH 5
9 IS MACHINE AT AMBIENT TEMP?
NO
ADJUST SENSING BASE
YES
10 SENSE TEMP. OF EXHAUST AIR
11 COMPARE 10 WITH 5

FIG. 7A.

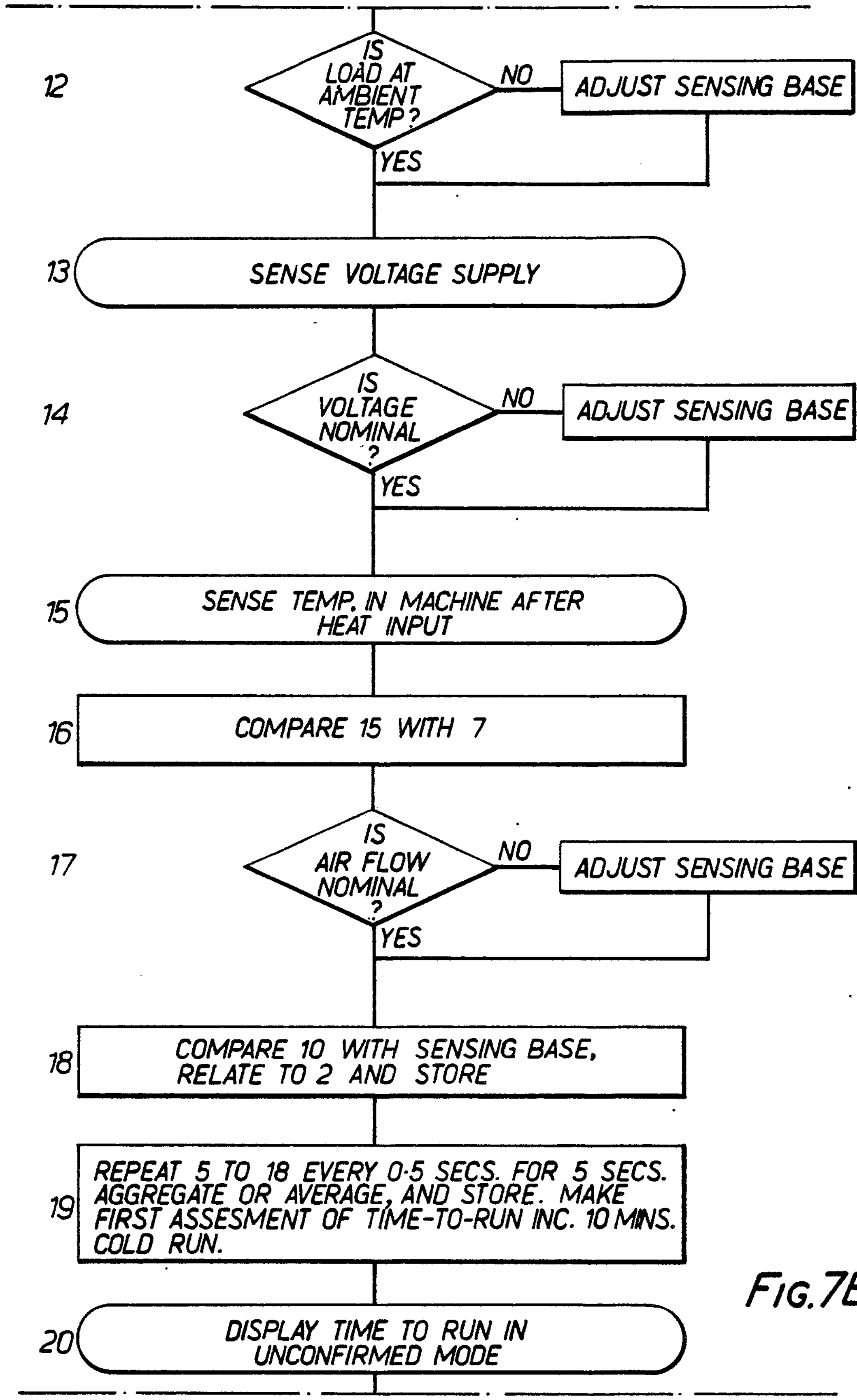
12
IS LOAD AT AMBIENT TEMP ?
NO
ADJUST SENSING BASE
YES
13
SENSE VOLTAGE SUPPLY
14
IS VOLTAGE NOMINAL ?
NO
ADJUST SENSING BASE
YES
15
SENSE TEMP. IN MACHINE AFTER HEAT INPUT
16
COMPARE 15 WITH 7
17
IS AIR FLOW NOMINAL ?
NO
ADJUST SENSING BASE
YES
18
COMPARE 10 WITH SENSING BASE, RELATE TO 2 AND STORE
19
REPEAT 5 TO 18 EVERY 0·5 SECS. FOR 5 SECS. AGGREGATE OR AVERAGE, AND STORE. MAKE FIRST ASSESMENT OF TIME-TO-RUN INC. 10 MINS. COLD RUN.
20
DISPLAY TIME TO RUN IN UNCONFIRMED MODE

FIG.7B.

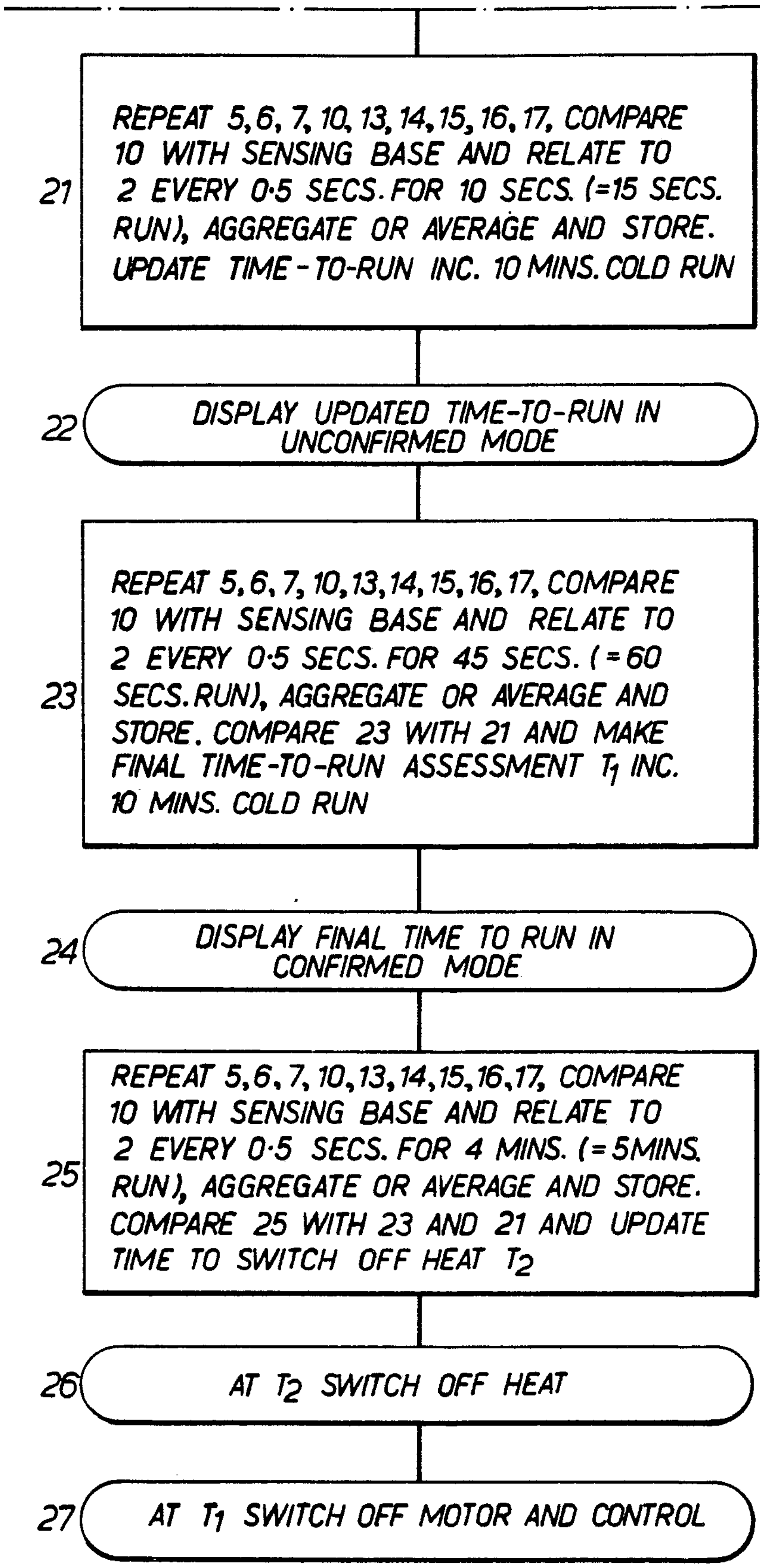
21
REPEAT 5, 6, 7, 10, 13, 14, 15, 16, 17, COMPARE 10 WITH SENSING BASE AND RELATE TO 2 EVERY 0·5 SECS. FOR 10 SECS. (=15 SECS. RUN), AGGREGATE OR AVERAGE AND STORE. UPDATE TIME-TO-RUN INC. 10 MINS. COLD RUN
22
DISPLAY UPDATED TIME-TO-RUN IN UNCONFIRMED MODE
23
REPEAT 5, 6, 7, 10, 13, 14, 15, 16, 17, COMPARE 10 WITH SENSING BASE AND RELATE TO 2 EVERY 0·5 SECS. FOR 45 SECS. (=60 SECS. RUN), AGGREGATE OR AVERAGE AND STORE. COMPARE 23 WITH 21 AND MAKE FINAL TIME-TO-RUN ASSESSMENT T1 INC. 10 MINS. COLD RUN
24
DISPLAY FINAL TIME TO RUN IN CONFIRMED MODE
25
REPEAT 5, 6, 7, 10, 13, 14, 15, 16, 17, COMPARE 10 WITH SENSING BASE AND RELATE TO 2 EVERY 0·5 SECS. FOR 4 MINS. (=5MINS. RUN), AGGREGATE OR AVERAGE AND STORE. COMPARE 25 WITH 23 AND 21 AND UPDATE TIME TO SWITCH OFF HEAT T2
26
AT T2 SWITCH OFF HEAT
27
AT T1 SWITCH OFF MOTOR AND CONTROL

FIG. 7C.

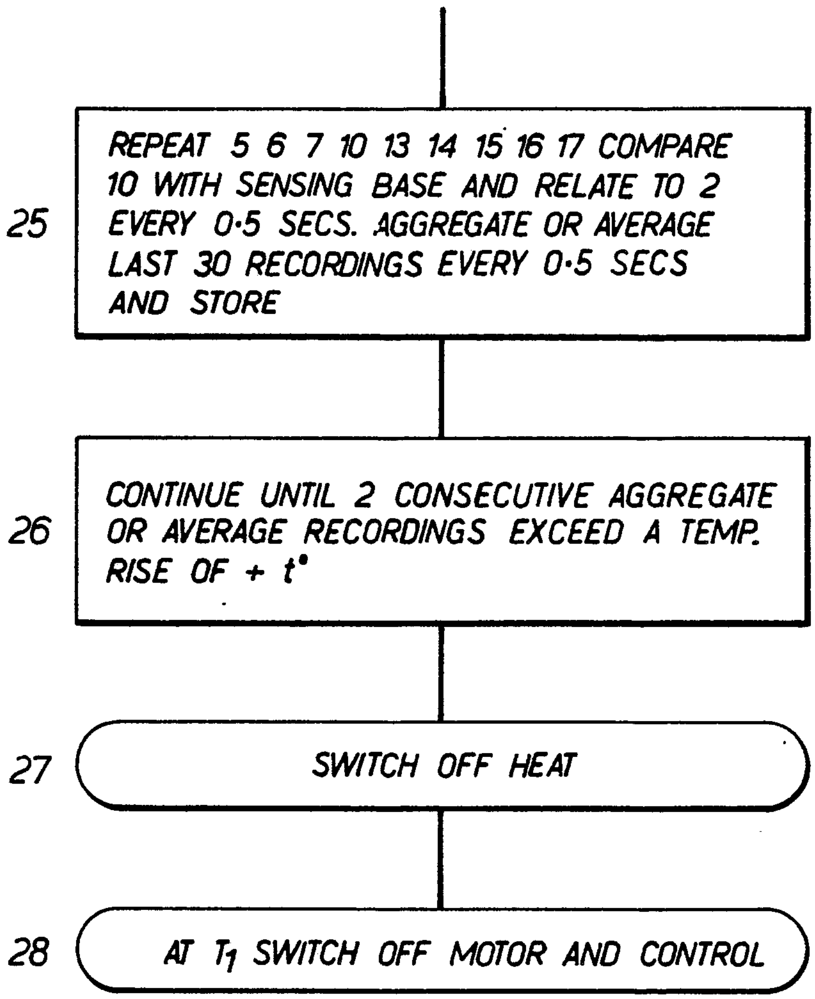
25
REPEAT 5 6 7 10 13 14 15 16 17 COMPARE 10 WITH SENSING BASE AND RELATE TO 2 EVERY 0·5 SECS. AGGREGATE OR AVERAGE LAST 30 RECORDINGS EVERY 0·5 SECS AND STORE
26
CONTINUE UNTIL 2 CONSECUTIVE AGGREGATE OR AVERAGE RECORDINGS EXCEED A TEMP. RISE OF + t°
27
SWITCH OFF HEAT
28
AT T1 SWITCH OFF MOTOR AND CONTROL

FIG. 8.