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(54) **Tumble drier.**

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Description

The invention relates to a tumble drier according to the precharacterising part of claim 1.

In tumble driers it is important to be able to interrupt the drying process when the moisture content of the articles that have been washed (hereinafter referred to as "wash") has reached a desired value. If the drying is interrupted too early, the moisture content is too high with the ensuing obvious disadvantages. Interrupting the drying too late, entails an unnecessarily high energy consumption, and the too low moisture content of the wash imparts to it an increased tendency to crease and reduced ironability and an increased risk of shrinkage and of static electric charge of the wash.

The time it takes to reduce the moisture content to the desired value depends greatly on the quantity of wash in the drum, on the temperature of the injected air, on the moisture content at the beginning of the drying process, and on other factors. Simple timing programs, according to which the drying is interrupted after a predetermined adjustable time, therefore provide a wholly unsatisfactory control of the drying process.

From GB-A-1 261 361 it is previously known to arrange a temperature sensor which senses the temperature of the exhaust air from the washing drum. The drying is interrupted when this temperature has reached a predetermined value. However, also with this method the moisture content of the wash at the termination of the drying will vary greatly in dependence on, inter alia, the amount of wash in the drum. Further, the method entails the disadvantage that the drying is not interrupted until the temperature of the exhaust air from the drum has risen by a not-insignificant amount above the relatively constant temperature which prevails during the major part of the drying process. In certain types of tumble-driers, for, example condensation tumblers, which operate with high temperature of the exhaust air, this increase of temperature at the end of the drying process entails a considerable risk of damage to the wash, especially for certain synthetic materials.

Further, it is known to interrupt the drying process in dependence on the time rate of change of the temperature of the outlet air. Also this method has the disadvantages mentioned above.

A further prior art method comprises arranging electrodes in the drum for measuring the electrical resistance of the wash, which resistance is dependent on the moisture content. With the aid of this method, however, a reliable measurement of the moisture content cannot be attained down to the low moisture content which corresponds to dry wash. The last part of the drying process is therefore performed under control of a timer, and the

final moisture content of the wash will then vary with, inter alia, the amount of wash and the type of material of the wash.

From GB-A-990 711 a tumble drier is previously known, in which a moisture sensor is arranged to sense the moisture content of the exhaust air from the drum. Drying of the clothes is effected by passing heated air to a basket accommodating the clothes. This air is heated by a gas burner. This burner is controlled continuously between one first predetermined value and a second lower predetermined value whereby the control of the latter is brought about with the help of the moisture content sensor. Also this method has proved to yield unsatisfactory results, and it has proved that the moisture content of the wash upon interruption of the drying process will greatly depend on the amount of wash in the drum and the type of the wash.

The invention aims at developing a tumble drier of the above-mentioned kind, in which a desired moisture content of the wash can be obtained, automatically and with great accuracy, at the interruption of the drying process, and this highly independently of factors such as the quantity of wash, the type of wash and the initial moisture content of the wash.

To achieve this aim the invention suggests a tumble drier according to the introductory part of claim 1, which is characterized by the features of the characterizing part of claim 1.

Further developments of the invention are characterized by the features of the additional claims.

The invention offers special advantages in condensation tumble driers, which may be allowed to operate at a high temperature without the risk of damage to the wash.

According to a preferred embodiment of the invention, a temperature control system is adapted to control the temperature of the exhaust air of the drum so that this temperature during the latter part of the drying process is maintained at a constant value. Preferably, this control system is designed as an electronic control system to obtain the desired speed of action and hence accuracy of the temperature control. The accurately constant temperature of the exhaust air thus obtained during the latter part of the drying process results in the actual moisture content of the wash, at the termination of the drying process, corresponding with high accuracy to the desired moisture content.

By way of example, the invention will now be described in greater detail with reference to the accompanying drawings showing in

Figure 1 schematically a tumble drier according to the invention,
Figure 2 the control members of the tumble drier and the connection of these

- control members to the other components of the tumble drier, in the form of a flow chart the mode of operation of the microprocessor included in the control members of the tumble drier,
- Figure 3
- Figure 4 as a function of time, the temperature and moisture content of the exhaust air during a drying process.

Figure 1 schematically shows the design and functioning of a tumble drier according to the invention. It has a drum 1 for the wash to be dried. The drum can be rotated relatively slowly around an axis A-A. The two end walls of the drum have openings 20a, 20b for the inlet and outlet, respectively, of an air current for drying the wash. On either side of the drum there are end pieces 21a, 21b, to which a closed air channel 25 for circulation of the air current is connected. The end pieces are sealed against the end walls of the drum with the aid of sliding seals 22a, 22b. The air current is circulated by a fan 3. The fan may suitably be driven by the same drive motor 8 (Figure 2) that rotates the drum 1, and in the following this is assumed to be the case.

The air flowing out of the drum is passed to a condenser 4 for separation of water from the air. In the condenser the air is cooled, and part of the moisture content of the air is precipitated in the form of water, which is discharged. In tumble driers for use in households, the condenser is normally air-cooled with the aid of the surrounding air, but also other cooling methods, for example water cooling, may be used. After its exit from the condenser, the cooled and dehumidified air is led past an electric heating element 5, with the aid of which the flowing air is heated to the desired extent.

In the air channel section 25a, between the drum 1 and the condenser 4, a moisture content sensor 6 and a temperature sensor 7 are arranged. These two sensors sense the conditions in the air flowing out of the drum 1 and their modes of operation will be described in the following.

Figure 2 shows the configuration of the control system of the tumble drier. The functions of the control system are controlled by a microprocessor 9 with associated memory members (not shown) for storing the program and working data for the control. A control console 14 is connected to the microprocessor. The control console is provided with a starting button 141, which, when being depressed, delivers a starting signal ST to the microprocessor. This causes the microprocessor to start operating in accordance with a prestored program and to control the execution of the programmed drying process. With the aid of a selector switch 142 the value of a signal F can be set, which indicates the desired moisture content of the wash

at the termination of the drying process. The position A, B and C of the selector switch give values of the signal F which correspond to "extra dry" wash, "dry" wash and wash "ready for ironing and mangling". With the aid of a second selector switch 143, the desired drying temperature TO may be set. For example, the position D may correspond to a temperature of 50 °C and the position E to a temperature of 70 °C.

The tumble drier is connected to an alternating voltage source via a main switch 16. A voltage supply unit 15 delivers the necessary operating voltages to the control system of the tumble drier. The main alternating voltage is also supplied to the drive motor 8 of the tumble drier via a driver 11 and to the heating element 5 via a driver 13. These drivers may consist of relays or - preferably, - of suitable semiconductor members, such as transistors or thyristors. The drivers are controlled from the microprocessor 9 by digital control signals M and E supplied therefrom. When one of these signals assumes the value "1", the associated operating member (the motor 8 and the element 5, respectively) is switched on, and when the signal assumes the value "0", the associated operating member is switched off.

The moisture content sensor 6, arranged in the air current between the drum and the condenser, suitably is of the electronic variety, for example of the Shibaura Electronic Co. Ltd make, the type CHS-1. The sensor is connected to the microprocessor 9 via a measured value converter 61, which delivers to the processor a signal f which indicates the moisture content of the air current, i.e. its water content per unit of volume.

The temperature sensor 7 suitably consists of the thermistor. The sensor senses the temperature in the air current upon its exit from the drum. The sensor signal is transformed via a measured value converter 71 into a form suitable for the microprocessor. The signal T received by the processor is thus a measure of the temperature of the air current upon its exit from the drum.

Figure 3 shows in the form of a flow chart the mode of operation of the control system during a drying process. By pressing the starting button (block 101), the microprocessor is caused to start executing its stored-in program. First it is checked whether the door of the tumble drier is closed (block 102). If this is the case, the signal M (block 103) is set at the value "1". This causes the drive motor 8 to start rotating the drum 1 and the fan 3 and thus the air current to circulate. Thereafter (block 104), the variable E is set at "1", the heating element 5 thus being switched on.

Under rotation of the drum and circulation of the air current, a successive heating of the air, the tumble drier and the wash now takes place. Both

the moisture content sensed by the sensor 6 and the temperature sensed by the sensor 7 will increase successively during this stage. This is illustrated in Figure 4, which shows the sensed temperature T and sensed moisture content f as a function of the time t. The tumble drier is started at the time t₀, and during the first part of the process both sensed temperature and sensed moisture content increase continuously.

The microprocessor periodically senses (block 105) whether the moisture content f, which is sensed at that particular time, exceeds the stored value of the variable f_m. If this is the case, the sensed moisture content is stored as the new value of the variable f_m (block 106). This successive increase of the variable f_m will proceed until the condition in block 105 is no longer fulfilled. This occurs at the time t₁ in Figure 4. The variable f_m will then remain unchanged and indicate the highest moisture content sensed during the drying process.

During the first stage after start-up, the sensed moisture content may vary in an irregular manner. It may therefore be suitable not to start the sensing of the moisture content until a predetermined period of time, for example 5 minutes, has passed after start-up. The conditions have then had time to stabilize so that the sensed moisture content is continuously increasing.

The program has a loop for temperature control which consists of the blocks 107-110. In dependence on the temperature T₀ set on the control console, the microprocessor sets two temperature limits T₂ and T₁, which are, respectively, somewhat higher and somewhat lower than the temperature T₀. In block 107 it is checked whether the sensed temperature exceeds the value T₂. If this is the case, the signal E is set at the value "0" and the heating element 5 is switched off. If the sensed temperature does not exceed the value T₂, it is compared in block 108 with the value T₁. If the sensed temperature is lower than this value, the signal E is set at the value "1" (block 109), the program then returning via block 109 to block 105. If the sensed temperature is not lower than the value T₁, the program directly returns to block 105. With the aid of this electronic temperature control, the temperature of the exhaust air from the drum, once the temperature has reached its steady state, will be maintained very accurately at the set value T₀.

After the time interval t₁, the sensed moisture content f will begin to drop, as mentioned above. It is compared periodically in block 111 with the stored maximum value f_m. As long as the difference between these two values is lower than a predetermined value df, the drying process is continued in the manner described above. However,

when the sensed moisture content f has dropped so low that the mentioned difference reaches the value df, the program proceeds to block 112 (at t=t₂ in Fig. 4). In this block the signal E is set at the value "0", the heating element 5 thus being switched off. Then follows a cooling phase of the predetermined duration t_d. During this phase the wash cools under continued air circulation and rotation of the drum. When the time t_d has elapsed after switching off the heating, the condition stated in block 113 has been fulfilled, and the program proceeds to block 114, where, by setting the signal M at the value "0", the drive motor 8 is switched off and the drying process is terminated. The program is then terminated - block 115.

The value df is set by the microprocessor in accordance with the value F - set with the aid of the control console - of the desired final moisture content of the wash. The greater the set value of df, the lower will be the final moisture content of the wash.

The appearance of the curve which indicates the sensed moisture content as a function of the time will vary considerably in dependence on, for example, the quantity of wash, the initial moisture content of the wash, the type of wash and the selected working temperature. Thus, for example, an increase of the amount of wash will entail an increase of the moisture content sensed during the drying process. A decrease of the working temperature will entail an extension of the drying process. However, it has proved that, in a tumble drier according to the invention, the desired final moisture content of the wash will be reached with high accuracy independently of such variations.

The invention has been described above in connection with a condensation tumble drier, where - as mentioned in the introduction - it provides special advantages. However, the invention may also be used with other types of tumble driers, for example an exhaust air tumble drier, where no recirculation of the air current occurs.

The output signals from the sensors 6 and 7 will unavoidably contain a certain amount of noise, which may disturb the function of the control system. To reduce this noise, the sensor signals may suitably be filtered. A filtering may be carried out with the aid of hardware filters, for example built into the measured value converters 61 and 71, or by any conventional method for digital filtering in the processor or by a combination of these two methods.

A fast and accurate control of the working temperature is important for the good function of the described control system. In the embodiment described above, the microprocessor takes care of the temperature control, but, alternatively, a separate temperature regulator of analog or digital type

may be arranged to take care of the temperature control.

In the embodiment described above, the work of the tumble drier is controlled by a microprocessor programmed in a suitable way. Alternatively, however, the corresponding control functions may be obtained with the aid of a specially built analog or digital control system.

It has been described above how the temperature control is carried out with the aid of switching on and-off of the heating element 5. Alternatively, however, the temperature control may be carried out by continuously varying the heating power of the heating element, for example with the aid of phase angle control or controlled pulsing of the voltage supplied to the element.

In the embodiment described above, the tumble drier has one single heating element 5. Alternatively, it may be provided with two heating elements with different power ratings, the heating element with the higher rating being used at the higher of the two settable working temperatures and the heating element with the lower rating being used at the lower working temperature. In this way, a more accurate temperature control can be achieved.

According to the above description, the heating element 5 for heating the air current is switched off completely when the difference between maximum sensed moisture content and current moisture content of the exhaust air reaches a predetermined value (at $t = t_2$ in Fig. 4). Alternatively, the effect of the heating element may be reduced to a low value, at this time so that a slight heating of the air current takes place also during the cooling phase.

Claims

1. Tumble drier with a drum (1) for the goods to be dried, with members (3, 8) adapted to drive an air current through the drum, with members (5) for heating the air current prior to its entry into the drum, with control means (9) for controlling the drying process, and with a moisture-sensing member (6) adapted to sense the moisture content of the air current after its exit from the drum and to deliver to the control means a signal (f) representative of the moisture content, **characterized** in that the control means comprises a member adapted to store a quantity (fm) which corresponds to the highest moisture content sensed during the drying process, and that the control means are adapted to compare said quantity (fm) with the signal (f) from the moisture-sensing member and to reduce or interrupt the heating of the air current when the difference (fm-f) between said quantity and said signal reaches a pre-

determined value (df).

2. Tumble drier according to claim 1, **characterized** in that it comprises members (142) for manual setting of said predetermined value.
3. Tumble drier according to claim 1 or 2, **characterized** in that it comprises a condenser (4), that the air current after its exit from the drum is adapted to pass through the condenser for precipitation of water and thereafter to be returned to the drum again, and that the moisture-sensing member (6) is adapted to sense the moisture content of the air current prior to its entry into the condenser.
4. Tumble drier according to any of the preceding claims, **characterized** in that it comprises a temperature sensor (7) adapted to sense the temperature of the air current after its exit from the drum and to deliver a signal (T), representative of the sensed temperature, to temperature control means (9) which are adapted to control the heating members (5) of the air current in such a way that the air current is maintained at a predetermined temperature.
5. Tumble drier according to claim 4, **characterized** in that the signal (T) delivered by the temperature sensor is an electric signal and that the temperature control means (9) are of the electronic variety.
6. Tumble drier according to any of the preceding claims, **characterized** in that the air current adapted to be driven through the drum circulates in a closed system.

Patentansprüche

1. Trommeltrockner mit einer Trommel (1) für zu trocknende Gegenstände, mit Gliedern (3, 8) zum Treiben eines Luftstromes durch die Trommel, mit Gliedern (5) zum Aufheizen des Luftstromes, bevor dieser in die Trommel eintritt, mit Steuergliedern (9) zur Steuerung des Trocknungsprozesses und mit einem Feuchtigkeitsmeßglied (6) zur Messung des Feuchtigkeitsgehaltes des Luftstromes nach seinem Austritt aus der Trommel und zur Lieferung eines Signals (f) für den Feuchtigkeitsgehalt an die Steuervorrichtung, **dadurch gekennzeichnet**, daß die Steuervorrichtung ein Glied zur Speicherung einer Größe (fm) enthält, welche dem höchsten während des Trocknungsprozesses gemessenen Feuchtigkeitsgehalt entspricht, und daß die Steuervorrichtung in der Lage ist, die genannte Größe (fm) mit dem

Signal (f) vom Feuchtigkeitsmeßglied zu vergleichen und die Heizung des Luftstromes herabzusetzen oder zu unterbrechen, wenn die Differenz (fm-f) zwischen der genannten Größe und dem genannten Signal einen vorgegebenen Wert (df) erreicht.

2. Trommeltrockner nach Anspruch 1, **dadurch gekennzeichnet**, daß er mit Gliedern (142) für die manuelle Einstellung des genannten vorgegebenen Wertes ausgerüstet ist. 10
3. Trommeltrockner nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet**, daß er mit einem Kondensator (4) ausgerüstet ist, daß der Luftstrom nach seinem Austritt aus der Trommel zur Niederschlagung von Wasser durch den Kondensator leitbar und danach wieder zur Trommel zurückführbar ist und daß das Feuchtigkeitsmeßglied (6) imstande ist, den Feuchtigkeitsgehalt des Luftstromes vor dessen Eintritt in den Kondensator zu messen. 15 20
4. Trommeltrockner nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß er einen Temperatursensor (7) enthält, der imstande ist, die Temperatur des Luftstromes nach seinem Austritt aus der Trommel zu messen und ein die gemessene Temperatur repräsentierendes Signal (T) an eine Temperatursuervorrichtung (9) zu liefern, welche imstande ist, die Heizglieder (5) für den Luftstrom derart zu steuern, daß der Luftstrom eine vorgegebene Temperatur beibehält. 25 30 35
5. Trommeltrockner nach Anspruch 4, **dadurch gekennzeichnet**, daß das von dem Temperatursensor gelieferte Signal (T) ein elektrisches Signal ist und daß die Temperatursuervorrichtung (9) elektronischer Art ist. 40
6. Trommeltrockner nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß der durch die Trommel getriebene Luftstrom in einem geschlossenen System zirkuliert. 45

Revendications

1. Séchoir à tambour comprenant un tambour (1) pour les objets à sécher, des éléments (3, 8) destinés à faire passer un courant d'air dans le tambour, des éléments (5) destinés à chauffer le courant d'air avant son entrée dans le tambour, des moyens (9) de commande destinés à commander le processus de séchage et un élément (6) détecteur d'humidité destiné à détecter la teneur en humidité du courant d'air à 50 55

sa sortie du tambour et à envoyer aux moyens de commande un signal (f) représentatif de la teneur en humidité, caractérisé en ce que les moyens de commande comprennent un élément destiné à mémoriser une quantité (fm) qui correspond à la plus grande teneur en humidité détectée pendant le processus de séchage et en ce que les moyens de commande sont destinés à comparer cette quantité (fm) au signal (f) issu de l'élément détecteur d'humidité et à diminuer ou interrompre le chauffage du courant d'air lorsque la différence (fm - f) entre ladite quantité et ledit signal atteint une valeur (df) donnée à l'avance.

2. Séchoir à tambour selon la revendication 1, caractérisé en ce qu'il comprend des éléments (142) destinés à régler manuellement ladite valeur donnée à l'avance.
3. Séchoir à tambour selon la revendication 1 ou 2, caractérisé en ce qu'il comprend un condenseur (4), en ce que le courant d'air, à sa sortie du tambour, est destiné à passer dans le condenseur afin de précipiter de l'eau et ensuite à être retourné au tambour, et en ce que l'élément (6) détecteur d'humidité est destiné à détecter la teneur en humidité du courant d'air avant son entrée dans le condenseur.
4. Séchoir à tambour selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comprend un capteur (7) de température pour détecter la température du courant d'air à sa sortie du tambour et pour envoyer un signal (T), représentatif de la température détectée, à des moyens (9) de commande de température qui sont destinés à commander les éléments (5) chauffant du courant d'air de sorte que le courant d'air est maintenu à une température donnée à l'avance.
5. Séchoir à tambour selon la revendication 4, caractérisé en ce que le signal (T) fourni par le capteur de température est un signal électrique et en ce que les moyens (9) de commande de température sont de type électronique.
6. Séchoir à tambour selon l'une quelconque des revendications précédentes, caractérisé en ce que le courant d'air destiné à passer dans le tambour circule en système fermé.

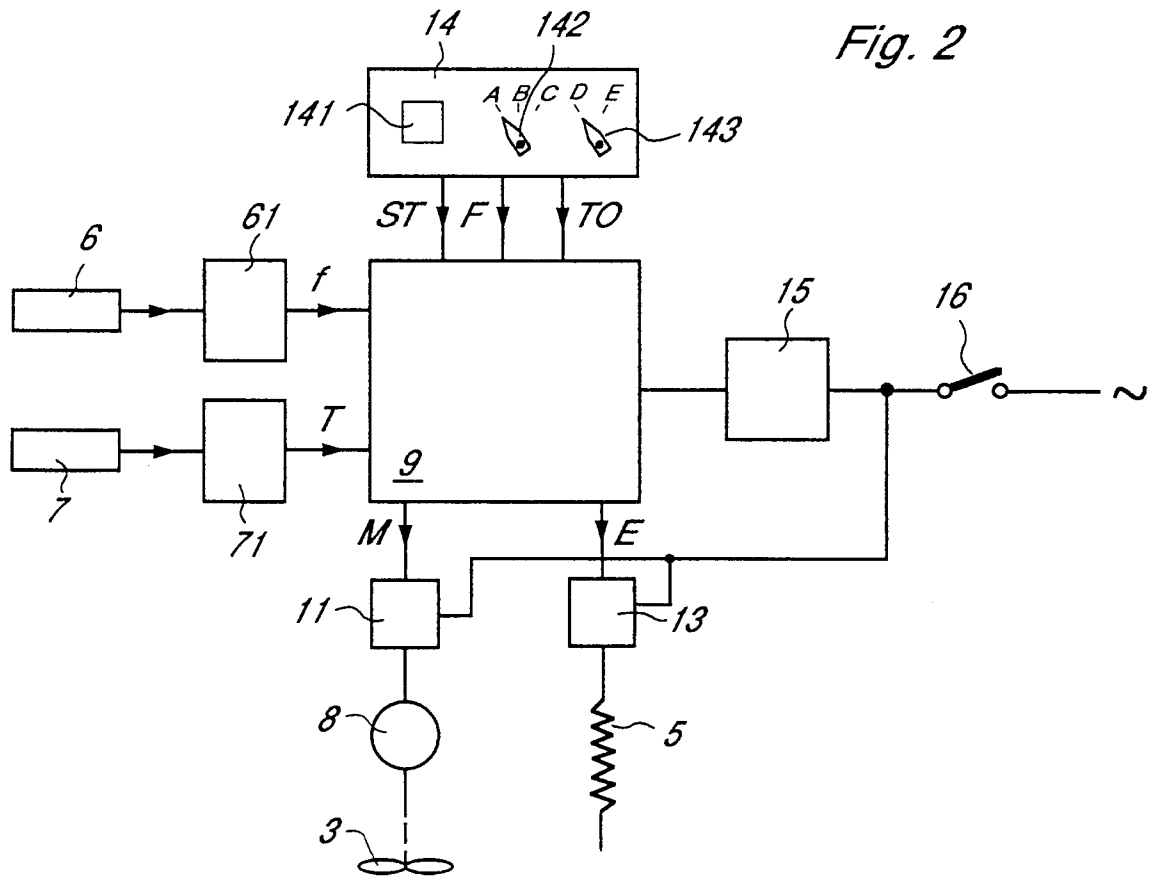
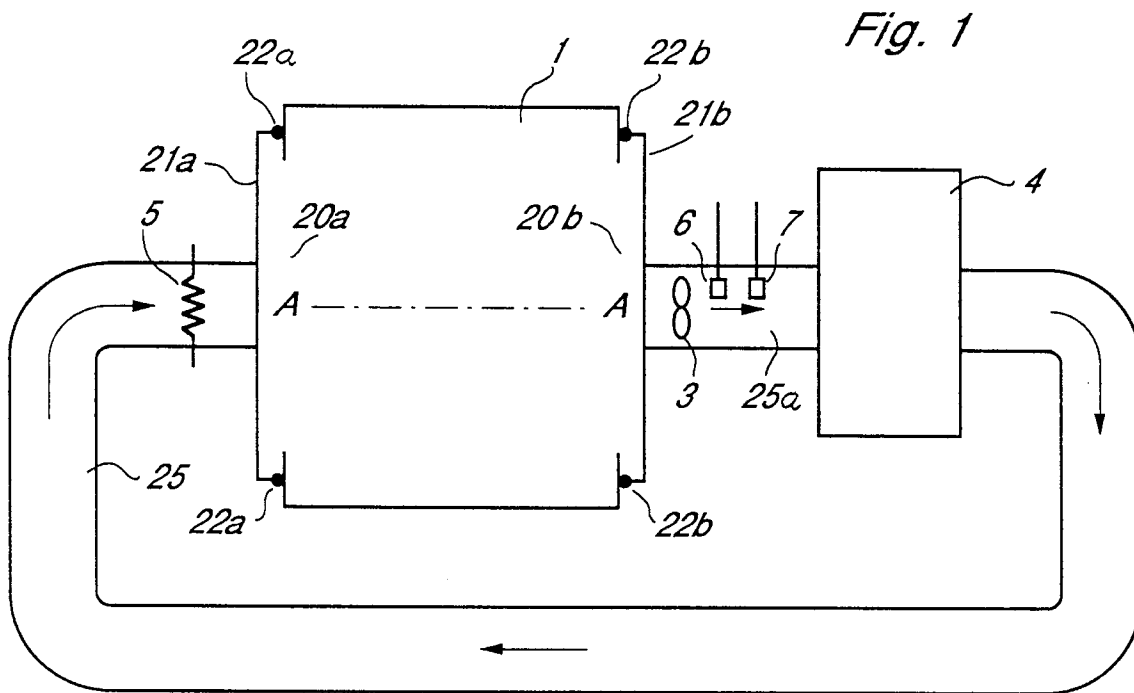


FIG. 3

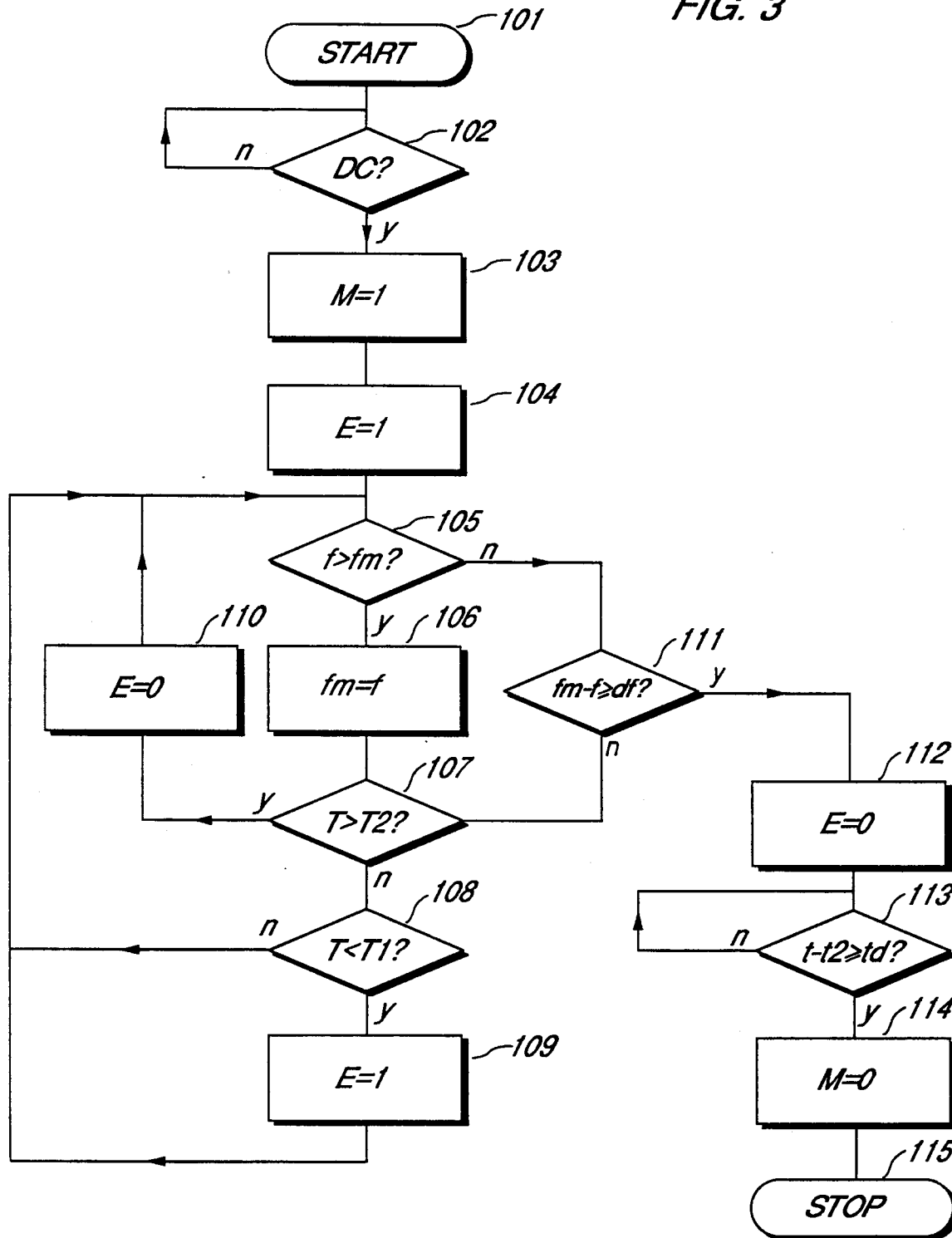


FIG. 4

