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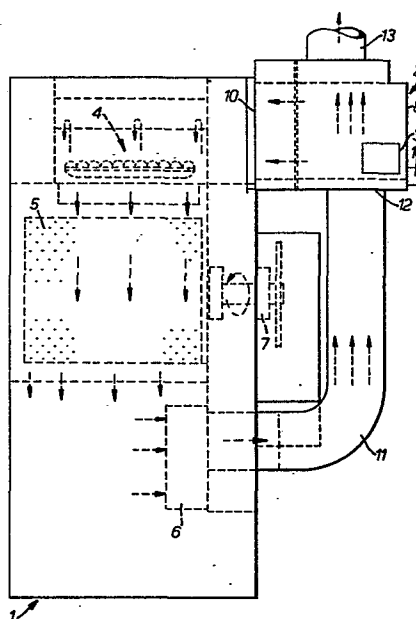
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Tumble drying machines.

In a tumble dryer machine, a motor 7 which drives the drum 5 and circulating fan 6 continues to operate at the end of a drying cycle, but with the air heater 4 cut-out, until the exhaust air temperature sensed at 16 reduces to a predetermined level. The time during which the heater 4 is in operation can thus be reduced. A heat exchanger 2 serves to preheat the incoming air with the exhaust air.



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Tumble Drying Machines

This invention relates to tumble drying machines and to a method of operating such machines.

In known tumble drying machines used in the laundry industry, and as installed in launderettes, ambient air is drawn by a fan into the machine, raised in temperature, passed through a rotatable drum and discharged to waste. The heat energy which has to be applied is in excess of the true work requirement because some of the heat energy of the drying air is used in heating the machine parts, such as the rotatable drying drum and the machine housing. In existing machines the energy used to heat the machine parts remains as residual heat after the drying operation has been completed. With present day high energy costs, the residual heat is an expensive waste and in launderettes could make machines considerably less profitable.

It has been proposed to overcome the problem of residual heat in coin-operated machines by providing an "over-run" period in which the primary heat source is inoperative and in which the drum and the air circulation fan remain operative, the air thus removing the residual heat. However, in such machines the mechanism which provides the over-run is coupled to the coin-feed mechanism so that the period of over-run is constant for each cycle of operation irrespective of the period actually required

to remove the residual heat. Thus, the period of the total drying cycle, including the over-run, could be greater than that required for optimum machine performance. This results in poor machine utilisation and poorer monetary return per hour than desirable.

The present invention aims to overcome the above-mentioned problem and provides a tumble dryer machine having a rotatable drum, a fan for circulating air from an inlet through the drum to an outlet, a primary heat source for heating the air, motor means for operating said fan and said drum, and control means including temperature-sensitive means which is operative to operate said motor means and prevent operation of said heat source at the end of a drying cycle and to stop said motor means when the temperature sensed by the temperature sensitive means is reduced to a predetermined value.

The temperature-sensitive means preferably senses the temperature of the air at the outlet. Preferably, it comprises a single pole changeover thermo-disc type switch connected in an electrical circuit incorporating said motor means. The switch breaks the circuit below the predetermined temperature and makes the circuit above the temperature.

The invention also provides a method of controlling the cycle of a tumble dryer comprising a fan, a drum and a primary heat source, said method comprising operating said fan, drum and heat source simultaneously, switching off said heat source whilst still operating said fan and drum, sensing the temperature of the air exiting from said drum and switching off said fan and drum when said sensed temperature reaches a predetermined value.

Thus, the duration of the over-run part of the cycle, when the heat source is inoperative, is dependent upon the temperature of the exhaust air, which is itself dependent upon the residual heat of the machine.

In order to further increase the efficiency of the machine according to the invention it is preferred to use a heat exchanger through separate channels of which inlet and outlet air respectively pass, the outlet air
5 serving to warm the inlet air during operation of the machine.

A tumble dryer machine in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

10 Figure 1 is a schematic side view of the machine illustrating the major components of the machine and the direction of air flow,

Figure 2 is an exploded rear view of a heat exchanger and control device of the machine, and

15 Figure 3 is a diagram of a control circuit of the control device.

The tumble dryer machine comprises a housing 1 attached to the rear of which is the heat exchanger 2 and control device 3 and within which are located, in the
20 direction of air flow, a primary heat source 4, a rotatable perforated drum 5 and a fan 6. The drum 5 and the fan 6 are operated by a motor 7.

In use, ambient air is drawn through inlet 8 of the heat exchanger 2, along parallel inlet tubes 9
25 formed in the heat exchanger, through an opening 10 and over the heat source 4. From there the air passes through the perforated drum 5, where the air becomes moist, past the fan 6 and through a heat-resistant, flexible hose 11 to an opening 12 at the bottom of the heat exchanger.
30 The air passes through parallel outlet tubes (not shown) of the heat exchanger to a heat-resistant, flexible exhaust hose 13 and from there to atmosphere. The heat exchanger is so arranged that substantially all of the inlet air passes therethrough.

35 The inlet and exhaust tubes of the heat exchanger

are arranged alternately and are preferably rectangular in cross section, having smooth uninterrupted surfaces, without ripples, indentations or projections such as rivets, to reduce the risk of blockage by lint and fluff.

5 The construction of the heat exchanger is best shown in Figure 2. Each hose 11,13 is attached to a full-width cover plate 14 which is secured to the top or bottom of the heat exchanger by two quick-release clips 15. The plates 14 allow quick and easy access to
10 the heat exchange tubes for cleaning.

 The heat exchanger works as follows. The hot, humid air enters the exchanger at opening 12, passes through the exchanger and exits to atmosphere. In passing through the exchanger this exhaust air gives up
15 part of its heat to the fresh air entering the tumble drying machine. This heat gain to the fresh air entering the machine causes it to increase in temperature prior to it reaching the primary heating source 4; thus this fresh air is pre-heated. The primary heating source can
20 be either a gas fired natural draught burner bar or bars, or a hot water or steam heating coil, or an electrical heating element. Whatever form the primary heating source of the machine takes, because of the fresh air being pre-heated through the heat exchange battery and thus being at
25 a temperature significantly above ambient, it will require significantly less energy to raise it to the set temperature, than would be the case with fresh air entering at ambient temperature. It should be noted that there is no mixing of fresh air and exhaust air. No exhaust air is
30 allowed to re-enter the machine and each type of air follows separate, sealed paths and no inter-mixing takes place.

 The tumble drying machines in which air entry to the drying drum is allowed on both sides of a common up-standing formation of drum case and in which the primary
35 heat source is on one side only of this up-stand may have

a blanking plate fitted to close off the air way from the side without heat source.

The blanking or baffle plate (not shown) results in increased velocity over the heat source and at the air port left open, which in turn provides a significant improvement in uniformity of temperature throughout the bulk of the air entering the drum 5. This improved uniformity in temperature provides increase of drying work per unit of entering air. Conversely, this improvement of "work per unit of air" allows equal drying at reduced bulk of entering air. This reduction of total entering air quantity results in a corresponding reduction in the energy needed to raise the air temperature to the set point of the tumble drying machine's control thermostat.

The baffle plate is an addition to improve machine performance and results in energy saving.

The control device is provided to control the operation cycle of the machine and the control circuit is illustrated in Figure 3. The circuit illustrated is for a coin-operated machine, but could be adapted for other machines.

The control device comprises a temperature sensitive device 16 which is preferably a single pole changeover thermo-disc switch. The switch is connected in the electrical circuit by live line part 17. Another live line part 17A, having common commencement point as line 17, is taken through a clock switch 18, operated by a coin feed mechanism (not shown) and connected to a terminal 19 and to the operating coil of a two pole changeover relay 22 of which ultimately all terminals are used. The operating coil of relay 22 has a connection to neutral. A centre changeover contact terminal 20 of relay 22 is connected through a door-operated switch 23 to the motor 7. A connecting line is provided from the door switch 23 to the other centre changeover terminal 24 of relay 22.

With the relay in the energised condition centre change-over contact 24 is made to fixed contact 25, which in turn is connected through normally closed thermo switches 27-28-29 to gas valve 30. The motor 7 and the gas valve 30 have
5 connections to neutral.

Operation of the control device will now be described. An inserted coin operates the clock switch 18 to energise the relay 22, so that when the door is closed and thus door switch 23 is made the motor 7 operates and
10 the gas valve 30 is opened to provide the heat source 4. Thus initially the machine works with the fan, drum and heat source all operating via electrical motive force provided on path from line 17A. At this stage the thermo disc switch 16 is in the cold condition and therefore
15 open, effectively breaking the circuit along the alternative path line 17.

After a considerable period of time, when a predetermined temperature in the exhaust air has been reached and maintained, which is so arranged as to be about
20 80% of the time through the drying cycle, the switch 16 closes, but because relay 22 is still in the energised condition the circuit along line 17 is broken at relay terminal 21. Thus, at the time of changeover of switch 16 from "cold" to "hot" condition i.e. from "broken" to
25 "made" circuit condition, the operation of the machine is in no way affected.

After a predetermined time, determined by the number of coins fed into the slot, the clock switch 18 opens and this de-energises the relay 22. Since switch 16
30 is closed, the motor 7 still operates, fed along line 17, through switch 16 to terminals 20;21 of relay 22, which is in the de-energised condition, and through door switch 23. Changeover terminal 24 breaks the contact with terminal 25 and contacts the terminal 26 and thus the gas valve
35 or other heat source control 30 is closed to cut off heat

source 4.

Further operation is an over-run with fan and drum operating until the exhaust air temperature drops to and remains below a predetermined value, at which the residual heat is substantially dissipated, and the switch 16 changes to the "cold" condition, which opens the contacts to cut off the motor.

Because of the preheating of the incoming air through the heat exchanger 2 and because of the improved air mixing and because drying will be completed during the over-run period, it is possible, and to achieve maximum economy it is necessary, to reduce the cycle time available through the coin mechanism, as compared to the existing machine cycle time. On a 30lb. load, 30" drum standard tumble drying machine, the coin cycle time is reduced to 4/5ths. The over-run time, available only after the second or third coin cycle, is approximately three minutes. It will be seen that single coin feeding a tumble drying machine fitted with the control device will not affect the overall drying cycle time, because no over-run can occur until the switch 16 has changed to the "hot" condition and that changeover, in practise, does not occur until the bulk of the drying work has been done. The saving of 1/5th of the machine time available through the coin clock is compensated for by the three minutes of over-run available on the last coin only. Thus, the overall drying time remains substantially unchanged, when compared to that for a standard tumble drying machine without press-dry cycle.

Shown in broken line in Figure 3 are meters 31, 32 which allow monitoring of the time the tumble dryer is actually in work, fed by the electrical circuit through the coin operating mechanism, and separately the time the drum and fan have worked through the thermo disc switch 16 on over-run. Another meter 33 is provided to record the length of time the heat source has been in action.

The results from these three recording meters allows complete analysis and record of the energy consumption of the machine. The machine coin take can also be recorded to allow accurate calculation of machine
5 utilisation factors.

The thermostat 27 is preferably of rod-type design and is preferably positioned directly in the exhaust air path after the exhaust air has left the fan 6, but before it enters the heat exchanger. If the air
10 temperature reaches a predetermined high value, the thermostat 27 operates to interrupt electric supply to both switches 28 and 29, close the gas valve 30 and shut off heat source 4. Control and limit thermostats on standard tumble drying machines are very slow in action
15 and have very high differential characteristics. These two weaknesses individually or in combination, allow excessive temperature over-run when the machines work on light work loads, or when the work load is an easy-dry material, such as nylon. Light, easy-dry materials such
20 as nylon, are sensitive to excessive heat and can be burned or scorched in tumble drying machines with excessive temperature over-run.

The additional rod type high temperature limit thermostat 27 reduces the risk of burning the work load.
25 Also, because it is positioned in an easily accessible position and because the thermostat design allows adjustment of the "set point", this limit thermostat can be checked for operation and function in a very short time and with great ease. Because checking of this control
30 is so simple and can be carried out without special equipment, in a very short time, it is practical and possible to make this checking operation part of the recommended routine preventive maintenance applied to tumble drying machines.

35 The addition of the thermostat 27, makes the tumble

drying machines less of a fire risk generally, and less likely to destroy or damage some work loads.

Although described as incorporated in a tumble dryer machine, it will be appreciated that the control
5 device and heat exchanger could be provided as a unit for attachment to existing machines.

CLAIMS

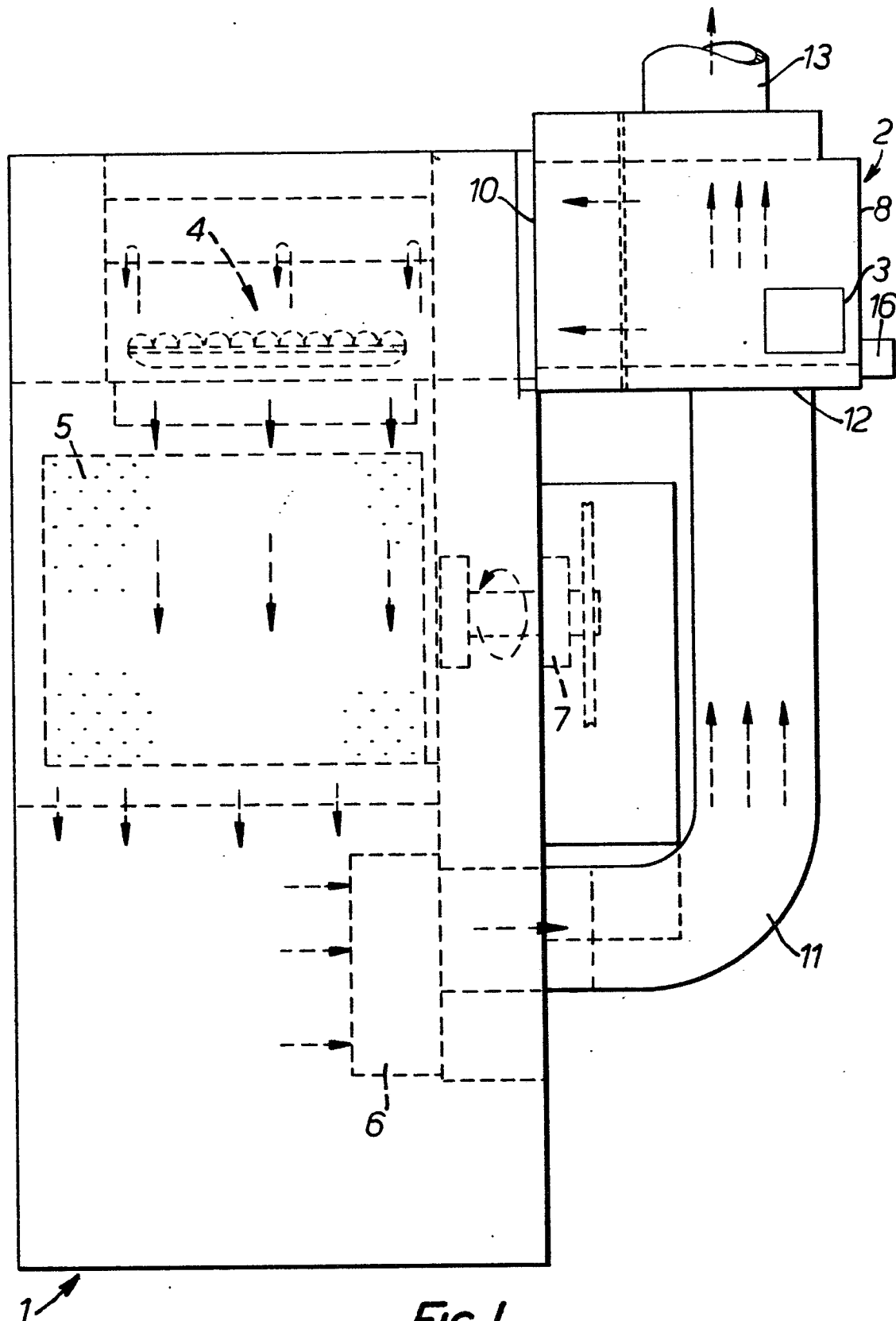
1. A tumble dryer machine having a rotatable drum, a fan for circulating air from an inlet through the drum to an outlet, a primary heat source for heating the air, motor means for operating said fan and said drum and control means including temperature sensitive means which is operative to continue operation of said motor means (but prevent operation of said heat source) beyond a period in which both the motor means and heat source have been in operation, said temperature sensitive means being further operative subsequently to stop the motor means in response to the temperature which it senses reducing to a predetermined value.
2. A machine as claimed in claim 1, in which the temperature sensitive means senses the temperature of the air at the outlet.
3. A machine as claimed in claim 1 or 2, including timing means arranged for said period of operation of the motor means and heat source to comprise a predetermined duration.
4. A machine as claimed in any preceding claim, further comprising a high temperature limit switch positioned in the exhaust air path and arranged to terminate operation of the heat source in response to the temperature which it senses reading a limit value.
5. A machine as claimed in any preceding claim, further comprising a meter for recording the total time during which the machine is set for normal operation of both the motor means and heat source.

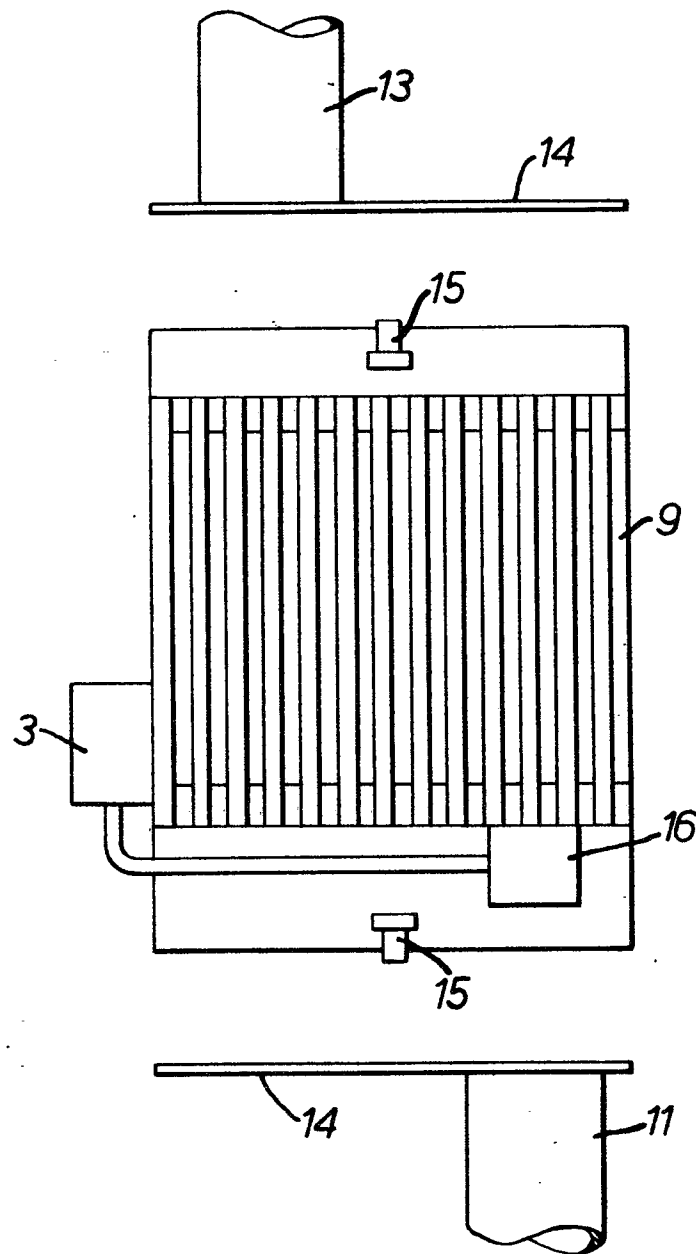
6. A machine as claimed in any preceding claim, further comprising a meter for recording the total time during which the machine is set for over-run operation of the motor means without the heat source.

7. A machine as claimed in any preceding claim, further comprising a meter for recording the total time during which the heat source is actually in operation.

8. A machine as claimed in any preceding claim, further comprising a heat exchanger through which the exhaust air passes to effect preheating of the incoming air, without intermixing of the exhaust and incoming air.

9. A method of controlling the cycle of a tumble dryer comprising a fan, a drum and a primary heat source, said method comprising operating said fan, drum and heat source simultaneously, switching off said heat source whilst still operating said fan and drum, sensing the temperature of the air exiting from said drum and switching off said fan and drum when said sensed temperature reaches a predetermined value.



*FIG. 2.*

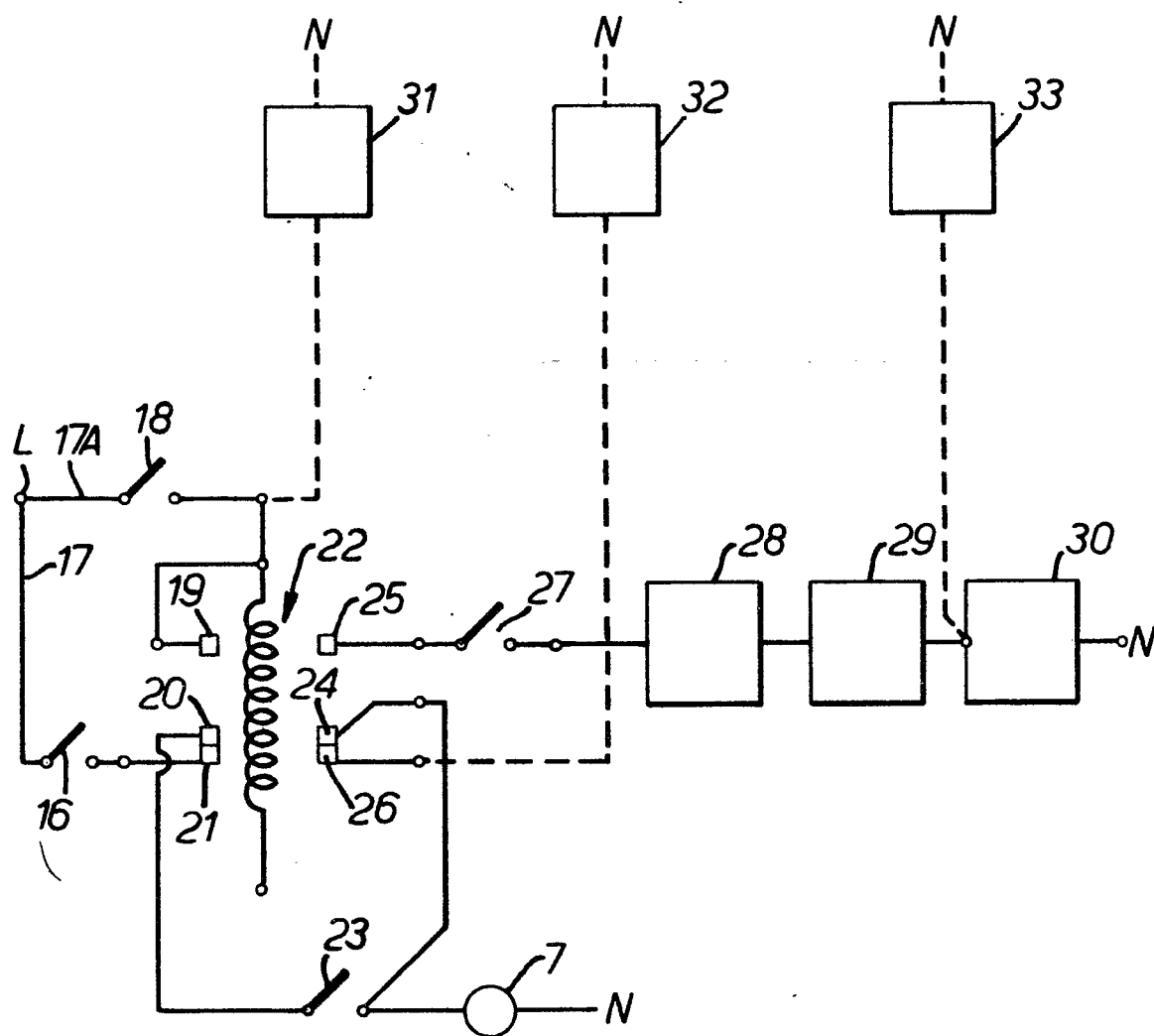


FIG. 3.