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(54) Improvements in refrigerators, in particular domestic refrigerators.

(57) A resonant element, in the form of a frost detector (20) and associated with the evaporator (7), is activated for a short time interval if an environmental probe (22) measures a temperature equal to or less than a given value T1 which causes compressor (6) cut-out. If the resonant element (20) does not resonate because of the frost deposits formed on it, the evaporator (7) undergoes defrosting, for example by means of defrosting resistance elements (19). A different probe (21) disposed on the evaporator (7) measures the temperature of this latter. At a temperature such as to ensure that defrosting has taken place, this different probe (21) causes restarting of the compressor (6) and cuts-out the defrosting resistance elements (19), if provided.

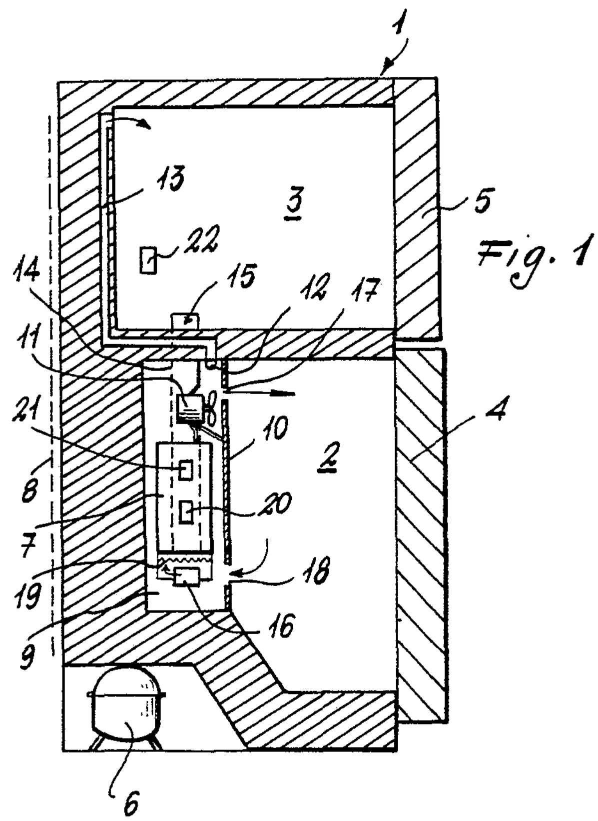

Fig. 1

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Improvements in refrigerators, in particular domestic refrigerators.

This invention relates to improvements in refrigerators, in particular domestic refrigerators, comprising:

a) at least one refrigerated compartment,

b) a refrigeration circuit with an evaporator, a condensor and a compressor,

c) means for controlling the compartment temperature, and

d) a piezoelectric frost detector associated with the evaporator.

For controlling the defrosting of the evaporator, piezoelectric frost detectors have already been proposed disposed in contact with the evaporator and connected to an oscillating circuit, the output of which is connected to an oscillation detector circuit. The resonance frequency and the impedance characteristic of the piezoelectric detector are modified by the frost which deposits on it. Any cessation or variation in the oscillation consequent on such deposits determines a signal which is used for stopping the compressor and for powering a defrosting resistance element. The defrosting restores the resonance conditions of the element in question, so that the consequent different signal reactivates the compressor and cuts-out the defrosting resistance element. In this known method, the piezoelectric element or rather the oscillating circuit into which it is connected is always powered. This fact leads to certain not indifferent drawbacks: there is no guarantee that the evaporator is completely defrosted, because the piezoelectric element only detects its own defrosting; the piezoelectric element is insensitive to a very soft frost, so that is continues to remain under resonant conditions and does not cause defrosting even when this is necessary to prevent excessive and wasteful energy consumption; and as a result of incomplete defros ting, there is continuous cutting-out and cutting-in of the compressor with negative consequences both on energy consumption and on the operation of the refrigeration circuit.

The object of the present invention is to improve refrigerators of the aforesaid type so that the said drawbacks are obviated.

According to the invention the improvements are characterised in that the means for controlling the compartment temperature determine the activation of the piezoelectric frost detector for a certain time interval at a preset temperature value corresponding to an adequate refrigeration of the compartment, and in that if during said activation the piezoelectric detector detects the need for defrosting the evaporator, the compressor is stopped temporarily until a defrosting probe associated with the evaporator measures another preset temperature value which denotes that defrosting has taken place.

The aforesaid inventive concept can be implemented in various ways according to the means used for defrosting the evaporator. If defrosting takes place naturally, i.e. by the effect of the heat of the environment in which the refrigerator is located, the compartment temperature control means for example in the form of a mechanical or electronic thermostat determine compressor cut-out and activation of the piezoelectric detector in known manner. If this latter detects the need for evaporator defrosting, the compressor is not returned to the control of said thermostat until the defrosting probe attains a preset temperature value which denotes that defrosting has taken place.

If the defrosting is of forced type by means of defrosting resistance elements, the compartment temperature control means determine compressor cut-out and activation of the piezoelectric detector. If this latter detects the need for evaporator defrosting, the defrosting resistance elements are activated and the compressor is not returned to the control of the said thermostat, and said resistance elements are not deactivated until the defrosting probe attains a preset temperature value which denotes that defrosting has taken place.

If defrosting is of forced type by means of at least one solenoid valve which reverses the cycle of the refrigeration circuit so that the functions of the evaporator and condenser are changed-over, the compartment temperature control means, for example a thermostat, determine compressor cut-out and activation of the piezoelectric detector. If this latter detects the need for evaporator deforsting, the said solenoid valve is energised and changes-over the functions of the evaporator and condenser, and then starts the compressor until the defrosting probe attains a preset temperature value which denotes that deforsting has taken place.

According to the invention, the piezoelectric detector is not continuously energised, and by choosing an adequate temperature (for example +5°C) for restoring normal operating conditions, effective evaporator defrosting is guaranteed to have taken place.

Under certain conditions, defrosting may be necessary when for compartment cooling reasons the compressor is in operation. To take account of this, according to the invention timing means, for example, electro-mechanical or electronic time counters or microprocessors, determine energisation cycles of the frost piezoelectric detector alternating with rest cycles.

Embodiments of the invention will now be described in more detail, by way of example, with reference to the accompanying drawing, in which:

Figure 1 is a diagrammatic vertical sectional view of a refrigerator according to the invention;

Figure 2 is a simplified control circuit diagram for the refrigerator using a microprocessor;

Figure 3 is a flow diagram which illustrates the operation of the circuit of Figure 2 and can be implemented by circuits incorporating discrete electronic components, mechanical components or mixed components as illustrated in Figures 4, 5 or 6;

Figure 4 is a schematic illustration of a circuit with discrete components and comprising defrosting resistance elements;

Figure 5 is a schematic illustration of a circuit comprising a solenoid valve for changing-over the functions of the evaporator and condenser; and

Figure 6 is a schematic illustration of a natural defrosting circuit.

In the figures, the reference numeral 1 indicates overall a refrigerator with two superposed preservation compartments 2, 3, which operate at different temperatures and are closed by respective doors 4, 5. The refrigerator incorporates a conventional refrigeration circuit comprising a compressor 6, a finned evaporator 7 and a condenser 8.

In this example, the evaporator 7 is disposed in a chamber 9 located on the rear of the colder compartment 2 and separated therefrom by a wall 10. The compartments 2, 3 are cooled by air streams provided by a fan 11. One of these streams enters (at 12) a duct 13 which opens into the upper part of the hotter compartment 3, and leaves this through a further duct 14 which commences (at 15) in the lower part of said compartment and opens (at 16) into the chamber 9 below the evaporator 7. The other stream is fed to the compartment 2 through upper apertures 17 in the wall 10 and returns to the chamber 9, below the evaporator 7, through lower apertures 18 therein. With the evaporator there are associated defrosting resistance elements 19, a piezoelectric detector 20 inserted into a seat provided in the evaporator finning, and a defrosting probe 21 (for example a resistor of negative temperature coefficient) also fixed to the finning in conventional manner.

A second temperature probe 22, for example constituted by a resistor of negative temperature coefficient, is present in the compartment 3.

In known manner, the piezoelectric element 20 comprises a casing 23, the upper part 24 of which is able to oscillate. This wall is rigid with an electrode 25 applied to one face of a piezoelectric crystal 26. Another electrode 27 is applied to the opposite face of the crystal 26. The two conductors 28 and 29 connected to the electrodes are connected to an oscillating circuit 30 which is connected to an oscillation detector circuit 31. The two circuits 30 and 31 are conventional. The output A of the detector circuit is associated with a microprocessor 32, if appropriate by way of a conventional interface.

The defrosting probe 21 is connected to said microprocessor by way of an interface 33. The temperature probe 22 is also connected to the microprocessor 32 by way of an interface 34. The two interfaces can be constituted by converter circuits which emit a frequency which is a function of the resistance of the corresponding resistor 21, 22 and thus of the temperature measured by these latter.

The compressor 6, the fan 11 and the defrosting resistance elements 19 are connected to the microprocessor by way of conventional interfaces 35, 36 and 37.

The operation is described hereinafter with reference to the flow diagram of Figure 3.

It will be assumed that the compressor 6 and fan 11 are operating, as indicated by the block A. The microprocessor 32 reads the current temperature TR in the compartment by means of the probe 22. This is indicated by the block B. At each interrupt, a counter inside the processor 32 is incremented by one (block C). If (block D) the current temperature TR measured by the probe 22 is less than or equal to a temperature T1 - (temperature at which the compressor is to be cut out), the circuits 30 and 31 and thus the piezoelectric detector 20 are activated, and this activation (block E) remains for a certain time (block F), for example 30 seconds, to enable any oscillation of the piezoelectric detector 20 to settle. If this latter begins to resonate (conditional block G), the result (conditional block H) is the stoppage of the compressor 6 and fan 11 and the de-energisation of the piezoelectric element 20 (block I). It should be noted at this point that if the piezoelectric detector 20 has begun to resonate, this means that there is no need to defrost the evaporator 7. It should also be noted that as the current temperature TR in the compartment 3 is less than or equal to the temperature T1 (selectable by the user), there is no need for the refrigeration circuit to provide further cold.

The block I leads to the block L which corresponds to the reading of the current temperature TR. If (block M) the temperature TR measured in the compartment 3 is greater than the temperature T2, which exceeds T1 for example by 1° or 2°, this means that the compartment 3 requires further cold in order to reduce its own temperature. In this case, both the compressor 6 and the fan 11 are started. If the temperature TR is less than or equal to T2, the process returns to the block L, with repetition of the reading of TR and comparison of TR with T2. Returning to block D, if TR is greater than T1 the process passes to the conditional block N. Here a check is made to see if the counter t has reached the value RR. If the counter has not reached the value RR, which means that a given time has not passed, then the process returns to the block B. If t is equal to RR, the process passes to the block O where a flag is introduced. It then passes to the already described blocks E and F, and if the conditional block G is affirmative (i.e. if the detector 20 is resonating or nearly so, and therefore defrosting is not necessary), the process passes to the block H where a check is made to see whether the flag has been introduced or not. If the flag has been introduced, the counter is zeroed (t = 0), the flag is removed and the piezoelectric detector 20 is de-energised (block P). The process then returns to reading the current temperature TR.

If, however, the activation of the piezoelectric detector 20, which as stated can be obtained either on a time basis (block N) or by temperature comparison (block D), does not cause it to oscillate - (block G), the compressor 6 and fan 11 are stopped and the piezoelectric detector 20 is de-energised (block Q). The defrosting resistors 19 are cut-in (block R) and the temperature of the evaporator 7 is read by the probe 21 (block S). If - (conditional block T) the temperature Y read by the probe 21 is equal to or greater than +5°C (temperature by which the vaporator 7 is certain to have undergone defrosting), the heating resistors 19 are disconnected (blocks T, U) and the compressor 6 and fan 11 are restarted (block A). If instead the temperature Y read by 21 is less than +5°C, the temperature measured by the probe 21 is again read and is compared with the reference temperature (+5°C).

As stated heretofore, the flow diagram can also be implemented using discrete electronic or electromechanical components or a combination of these components. Figure 4 shows a block diagram of a possible embodiment comprising discrete components which overall corresponds to this flow diagram.

The reference numeral 50 indicates a thermostat which measures the temperature of the preservation compartment 3 (Figure 1). If the compartment has been sufficiently cooled (for example to the temperature T1 or lower), the compressor 6 of the refrigeration circuit is stopped and an automatically zeroed timer or timing circuit 51 is started, so that, for the set time, it feeds a circuit 54 analogous to the circuit 30, 31 of Figure 2. The piezoelectric frost detector 53 corresponding to the detector 20 of Figure 2 is therefore activated for this time.

If insufficient frost has formed on the sensor 53, it resonates or oscillates adequately and nothing happens, otherwise, i.e. in the absence of resonance, the defrosting resistance elements 19 are activated and the thermostat 50 deactivated. After completion of the time set on the timer 51, this latter is zeroed and stops. However, the thermostat 50 remains cut out and the resis tance elements 19 are powered until the thermostat 21 reaches its operating temperature (Y) (for example +5°C), which ensures that the evaporator 7 has effectively undergone defrosting. When this stage is reached, the thermostat 21 cuts out the defrosting resistance elements 19 and enables the thermostat 50 to regain control of the compressor.

The compressor 6 is reactivated when, by measuring a temperature TR > T2, the thermostat 50 determines that the preservation compartment 3 requires cold.

A second automatically zeroed timer or timing circuit 52 is also provided, which after a preset time starts the timer 51 by energising the circuit 54. In this manner a check is made at predetermined time intervals as to whether defrosting is required or not. If the sensor 53 does not resonate, the compressor 6 is stopped (as is the fan 11 if provided) and the defrosting resistance elements 19 are powered. On termination of defrosting, the thermostat 21 cuts out these latter and restarts the compressor 6 (and the fan if provided).

Figure 5, in which the same reference numerals are used with an apostrophe to indicate parts equal or corresponding to those of the preceding Figures, relates to a circuit which uses a solenoid change-over valve 70 for producing forced defrosting of the evaporator. The valve in question enables the functions of the evaporator and condenser to be changed over. This means that when the valve is in one state, the evaporator and the condenser operate as such with the former generating cold and the latter dispersing the heat absorbed by the former, whereas in the other state there is a reversal of the functions in the sense that the "evaporator" becomes hot whereas the "condenser" becomes cold.

When the thermostat 50' determines that the preservation compartment requires no further cold it cuts out the compressor 6'. If the piezoelectric detector 53' determines the need for defrosting it energises the solenoid valve 70 and cuts out the thermostat 50'. With the energising of the solenoid valve 70 the compressor 6' is restarted. When the defrosting temperature is attained, the thermostat 21' acts to cut-in the thermostat 50' and de-energise the solenoid valve 70, which stops the compressor and leaves it under the control of the thermostat 50'. The timer 51' operates in the manner already described in relation to Figure 4, and determines the aforesaid actions.

Figure 6, in which the same reference numerals are used but with a double apostrophe to indicate parts equal or corresponding to those of the preceding Figures, relates to a circuit for the natural defrosting of the evaporator, i.e. in which defrosting is effected by the heat of the environment. When the thermostat 50' ' cuts out the compressor 6' ' and if the piezoelectric detector 53' ' determines the need for evaporator defrosting, the thermostat 50' ' is deactivated by means of the device 54' '. The environmental heat then causes defrosting of the evaporator. When defrosting is complete, the thermostat 21' ' reactivates the thermostat 50' ', which regains control of the compressor 6' '. The operation of the remaining part of the circuit is obvious from the aforegoing description.

Claims

1. Improvements in refrigerators, in particular domestic refrigerators, comprising:

a) at least one refrigerated compartment;

b) a refrigeration circuit with an evaporator, a condenser and a compressor;

c) means for controlling the compartment temperature, and

d) a piezoelectric frost detector associated with the evaporator,

characterized in that the means for controlling the temperature of the compartment determine the activation of the piezoelectric frost detector for a certain time interval at a preset temperature value corresponding to adequate refrigeration of the compartment and in that if during said activation the piezoelectric detector detects the need for defrosting the evaporator, the compressor is stopped temporarily until a defrosting probe associated with the evaporator measure another preset temperature value which denotes that defrosting has taken place.

2. Improvements as claimed in claim 1 for a refrigerator in which air circulation is generated by a fan, characterized in that the piezoelectric detector performs the function of stopping the fan at the same time the compressor is stopped.

3. Improvements as claimed in claim 1 or 2 in which the refrigerator is provided with at least one evaporator defrosting resistance element, characterized in that when defrosting is required, the defrosting resistance element is energised, its disconnection being controlled by the defrosting probe.

4. Improvements as claimed in claims 1 to 3, characterized in that the piezoelectric detector is also activated at constant time intervals.

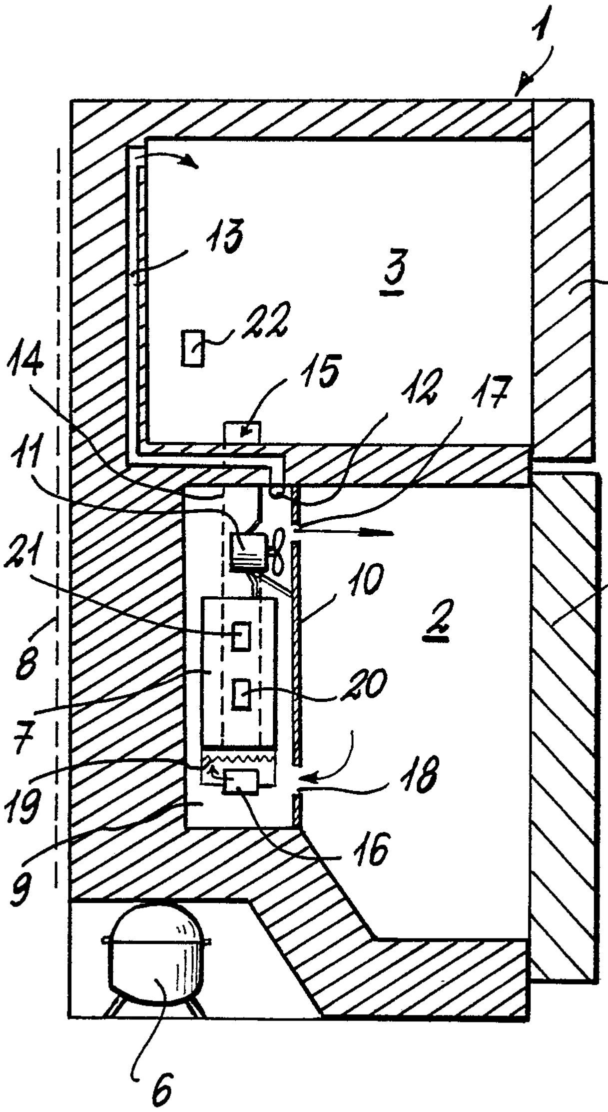

Fig. 1

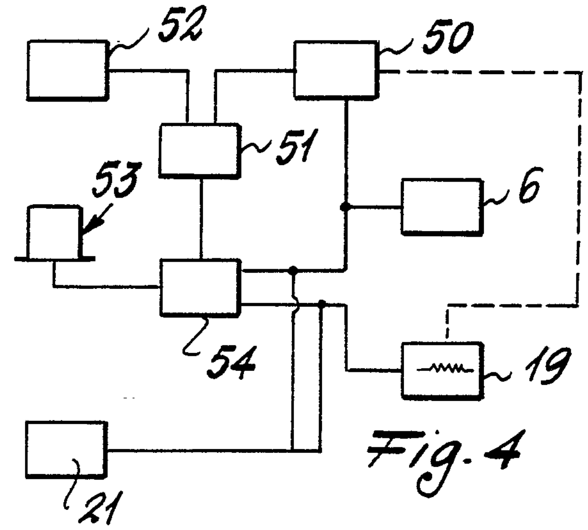

Fig. 4

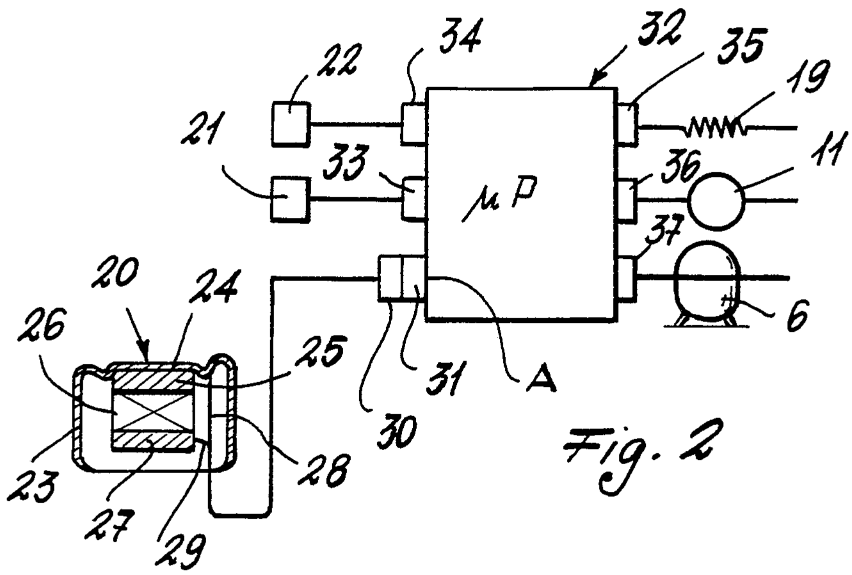

Fig. 2

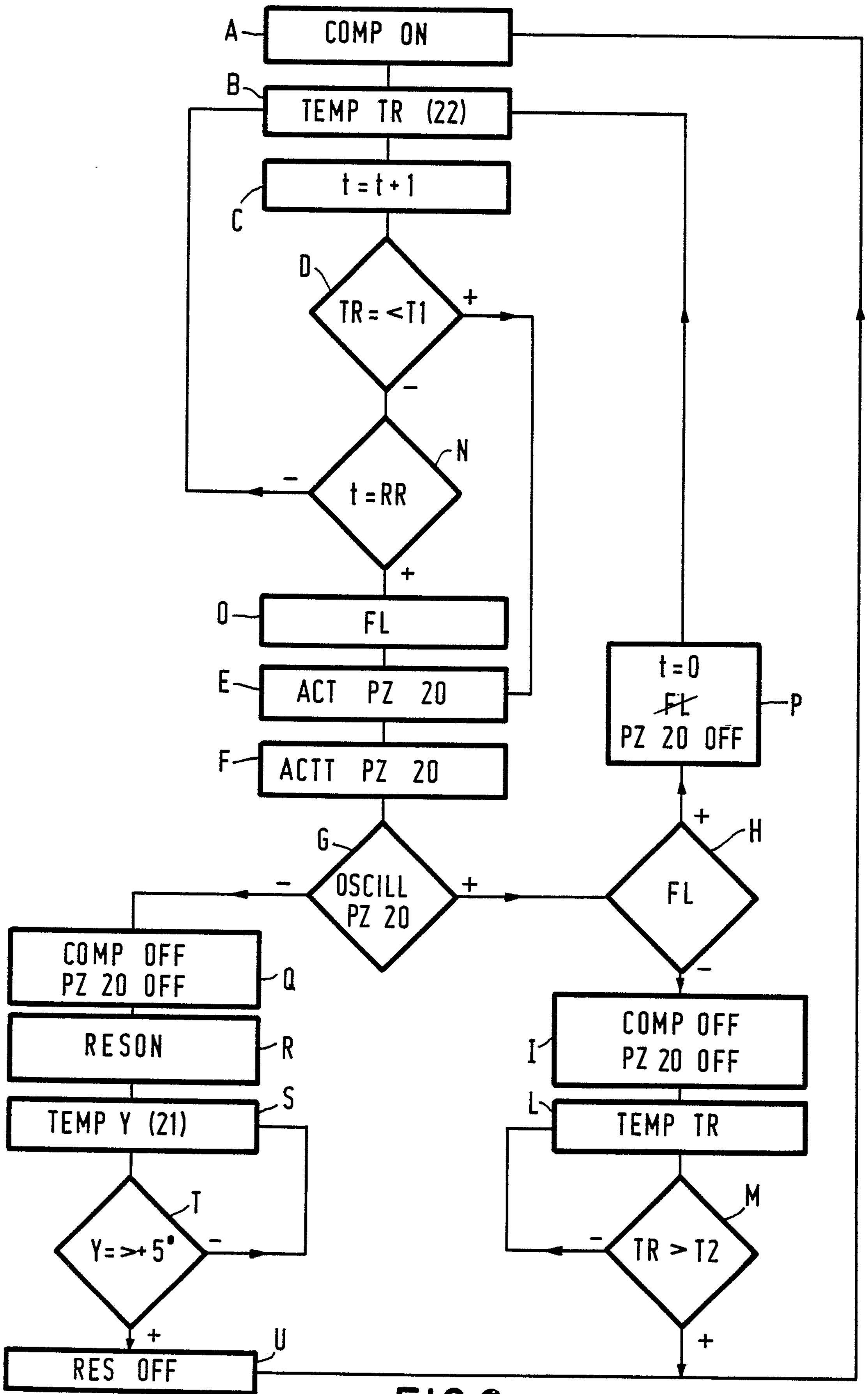
A
COMP ON
B
TEMP TR (22)
t = t + 1
C
D
TR = < T1
+
−
N
t = RR
−
+
O
FL
E
ACT PZ 20
F
ACTT PZ 20
G
OSCILL PZ 20
−
+
t = 0
FL
PZ 20 OFF
P
+
H
FL
−
COMP OFF
PZ 20 OFF
Q
RESON
R
TEMP Y (21)
S
T
Y = > + 5°
−
+
U
RES OFF
I
COMP OFF
PZ 20 OFF
L
TEMP TR
M
TR > T2
−
+

FIG.3

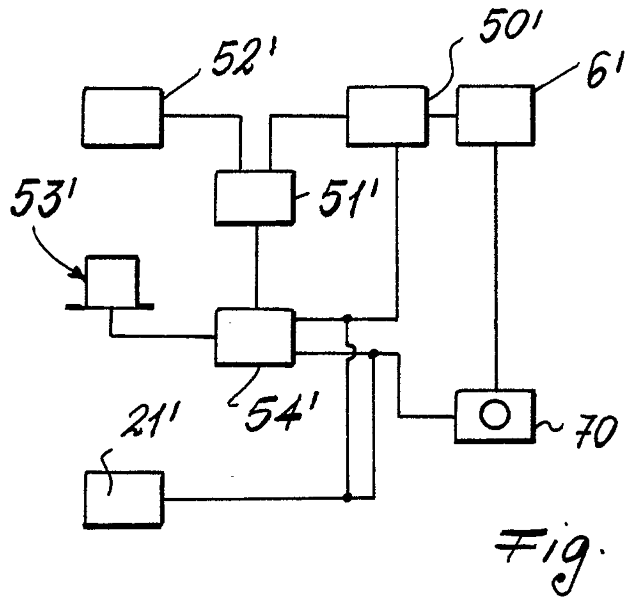

Fig. 5

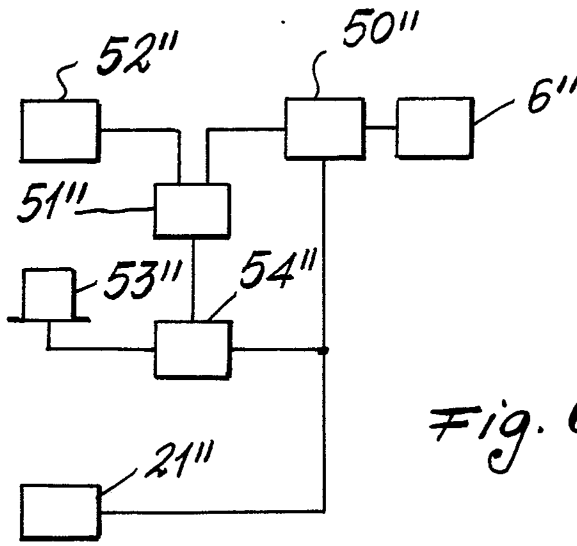

Fig. 6

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EUROPEAN SEARCH REPORT

Application number

EP 86 20 0907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 067 523 (HONEYWELL) * Page 1, line 27 - page 7, line 19; figures 1-4 *	1	F 25 D 21/00
A	DE-A-2 750 165 (MATSUSHITA) * Page 6, paragraph 4 - page 15, paragraph 2; figures 1-14 *	1	
A	DE-C-3 205 370 (BOSCH-SIEMENS) * Column 3, line 24 - column 6, line 5; figures 1-4 *	1	
A	FR-A-2 404 415 (KYSOR) * Page 6, line 24 - page 9, line 15; figures 3,4 *	1-3	
A	US-A-3 023 589 (JACOBS) * Column 1, line 32 - column 2, line 63; figures 1-3 *	1-3	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 25 D
A	DE-B-1 137 052 (ROBERT BOSCH)		
A	US-A-3 641 781 (KIYOICHI NIJO)		
A	US-A-2 904 968 (SPENCER)		
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-09-1986	BOETS A.F.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application number

EP 86 20 0907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	WO-A-8 300 211 (ALSENZ) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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THE HAGUE	09-09-1986	BOETS A.F.J.

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